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## Cost-Effectiveness Results Summary

# City of Mill Valley

## Climate Zone 3

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## Sources

1 Existing Single Family Building Upgrades (May 23, 2024)

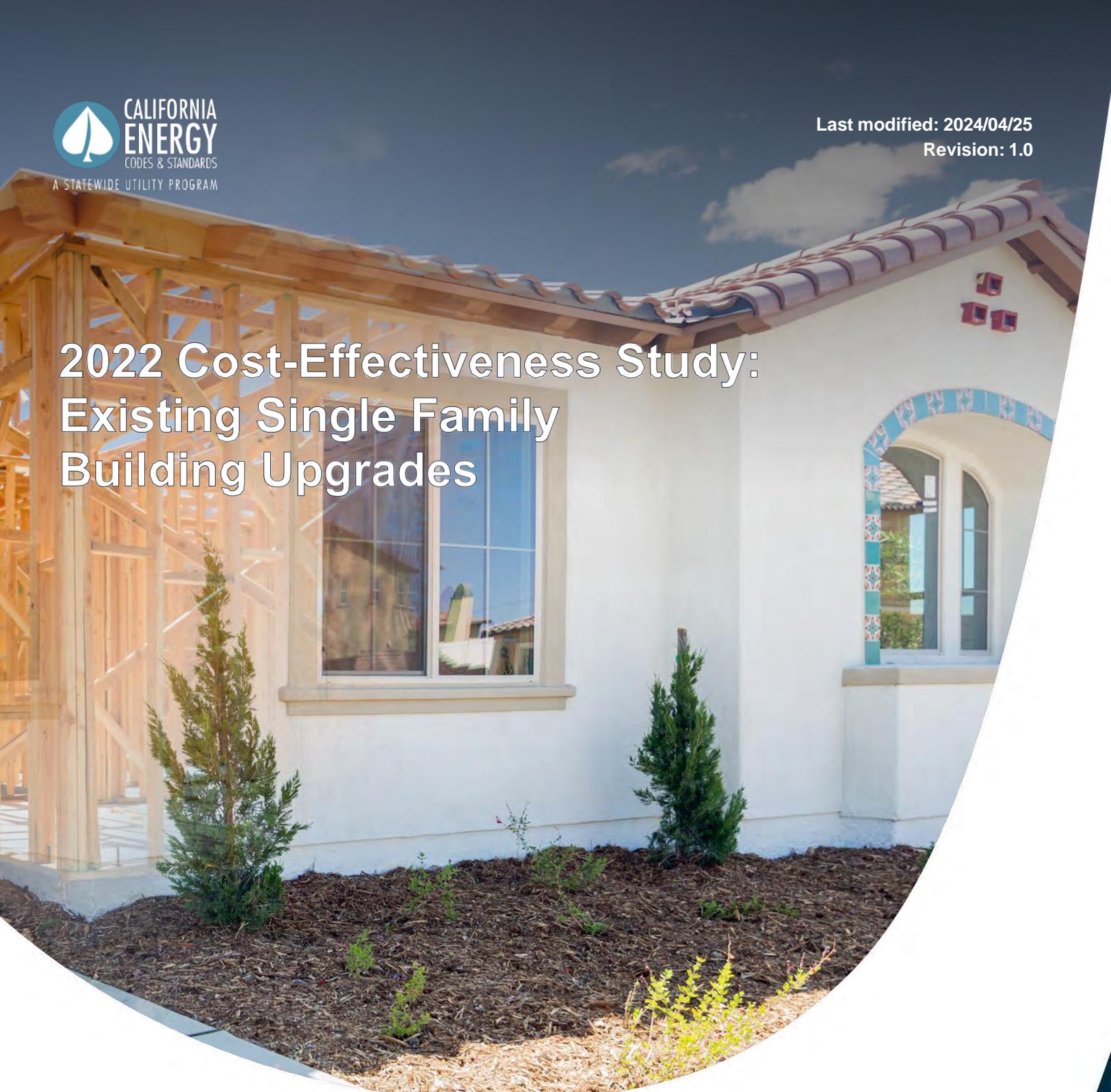
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# 2022 Cost-Effectiveness Study: Existing Single Family Building Upgrades

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## Acronym List

2023 PV\$ – Present value costs in 2023

ACH50 – Air Changes per Hour at 50 pascals pressure differential

ACM – Alternative Calculation Method

ADU – Accessory Dwelling Unit

AFUE – Annual Fuel Utilization Efficiency

B/C – Lifecycle Benefit-to-Cost Ratio

BEopt – Building Energy Optimization Tool

BSC – Building Standards Commission

CA IOUs – California Investor-Owned Utilities

CASE – Codes and Standards Enhancement

CBEEC-Res – Computer program developed by the California Energy Commission for use in demonstrating compliance with the California Residential Building Energy Efficiency Standards

CEER – Combined Energy Efficiency Rating

CFI – California Flexible Installation

CFM – Cubic Feet per Minute

CO<sub>2</sub> – Carbon Dioxide

CPAU – City of Palo Alto Utilities

CPUC – California Public Utilities Commission

CZ – California Climate Zone

DFHP – Dual Fuel Heat Pump

DHW – Domestic Hot Water

DOE – Department of Energy

DWHR – Drain Water Heat Recovery

EDR – Energy Design Rating

EER – Energy Efficiency Ratio

EF – Energy Factor



GHG – Greenhouse Gas

HERS Rater – Home Energy Rating System Rater

HPA – High Performance Attic

HPSH – Heat Pump Space Heater

HPWH – Heat Pump Water Heater

HSPF – Heating Seasonal Performance Factor

HVAC – Heating, Ventilation, and Air Conditioning

IECC – International Energy Conservation Code

IOU – Investor Owned Utility

kBtu – British thermal unit (x1000)

kWh – Kilowatt Hour

LBNL – *Lawrence Berkeley National Laboratory*

LCC – Life Cycle Cost

LLAHU – Low Leakage Air Handler Unit

VLLDCS – Verified Low Leakage Ducts in Conditioned Space

LSC – Long-term Systemwide Cost

MF – Multifamily

MSHP – Mini-Split Heat Pump

NEEA – Northwest Energy Efficiency Alliance

NEM – Net Energy Metering

NPV – Net Present Value

NREL – *National Renewable Energy Laboratory*

PG&E – Pacific Gas and Electric Company

POU – Publicly-Owned-Utilities

PV – Photovoltaic

SCE – Southern California Edison

SDG&E – San Diego Gas and Electric

SEER – Seasonal Energy Efficiency Ratio

SF – Single Family

SMUD – Sacramento Municipal Utility District

SoCalGas – Southern California Gas Company

TDV – Time Dependent Valuation

Therm – Unit for quantity of heat that equals 100,000 British thermal units

Title 24 – Title 24, Part 6

TOU – Time-Of-Use

UEF – Uniform Energy Factor

VCHP – Variable Capacity Heat Pump, Title 24 compliance credit

ZNE – Zero-net Energy

### Summary of Revisions

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## Executive Summary

The California Codes and Standards (C&S) Reach Codes program provides technical support to local governments considering adopting a local ordinance (reach code) intended to support meeting local and/or statewide energy efficiency and greenhouse gas (GHG) reduction goals. The program facilitates adoption and implementation of the code when requested by local jurisdictions by providing resources such as cost-effectiveness studies, model language, sample findings, and other supporting documentation.

This report documents cost-effective measure upgrades in existing single family buildings that exceed the minimum state requirements. It evaluates efficiency measures such as adding insulation, replacing windows, and duct upgrades, fuel substitution measures that upgrade space heating and water heating to heat pumps, and solar photovoltaics (PV) across all 16 California climate zones. A 1,665 square foot single family home prototype with an attached garage was evaluated in this study.

This analysis used two different metrics to assess the cost-effectiveness of the proposed upgrades. Both methodologies require estimating and quantifying the incremental costs and energy savings associated with each energy efficiency measure over a 30-year analysis period. On-Bill cost-effectiveness is a customer-based lifecycle cost (LCC) approach that values energy based upon estimated site energy usage and customer utility bill savings using today's electricity and natural gas utility tariffs. Long-term Systemwide Cost (LSC) is the California Energy Commission's LCC methodology for the 2025 Title 24, Part 6 (Title 24) code cycle (previously referred to as Time Dependent Valuation (TDV)), which is intended to capture the long-term projected cost of energy including costs for providing energy during peak periods of demand, carbon emissions, grid transmission and distribution impacts. This is the methodology used by the Energy Commission in evaluating cost-effectiveness for efficiency measures in Title 24 code development.

The following summarizes key results from the study:

### Conclusions and Discussion:

1. Envelope measures. Improving envelope performance is very cost-effective in many older homes. In addition to reducing utility costs, these measures provide many other benefits such as improving occupant comfort and satisfaction and increasing a home's ability to maintain temperatures during extreme weather events and power outages. Below is a discussion of the results of specific measures.
  - a. Adding attic insulation is cost-effective based on both LSC and On-Bill in many climate zones in homes with no more than R-19 existing attic insulation levels. Increasing attic insulation from R-30 to R-49 was still found to be cost-effective based on at least one metric in the colder and hotter climates of Climate Zone 10 (SDG&E territory only) through 16.
  - b. Insulating existing uninsulated walls is very cost-effective based on both metrics everywhere except Climate Zones 6 and 7 (in Climate Zone 8 it's only cost-effective based on LSC).
  - c. Adding R-19 or R-30 floor insulation is cost-effective based on LSC in the older two vintages (Pre-1978 and 1978-1991) in all CZ except CZ 6-10.
  - d. Replacing old single pane windows with new high-performance windows has a very high cost and is typically not done for energy savings alone. However, energy savings are substantial and justify cost-effectiveness of this measure based on at least one metric in Climate Zones 4, 8 through 12 (PG&E territory only), and 13 through 16.
  - e. At time of roof replacement, a cool roof with an aged solar reflectance of 0.25 was found to be cost-effective in Climate Zones 4, 6 through 12 (PG&E territory only), and 13 through 15. When the roof deck is replaced during a roof replacement, adding a radiant barrier is low cost and provides substantial cooling energy savings, and was found to be cost-effective in almost all climate zones and homes.
2. Duct measures: Many older homes have old, leaky duct systems that should be replaced when they reach the end of life, typically 20-30 years. In this case, installing new ducts was found to be cost-effective based on at least one metric (both in most cases) everywhere except mild Climate Zone 7 and Climate Zones 5 and 6 in

the 1978-1991 vintage. If duct systems still have remaining life they should be sealed and tested to meet 10% leakage or lower; however, duct upgrades alone were only found to be cost-effective for newer homes in Climate Zones 10 (SDG&E territory only), 11, and 13 through 16. Duct upgrades may be able to be coupled with other measures to reduce the cost.

3. Heat pump space heating: HPSHs were found to be LSC cost-effective in many cases. The Dual Fuel Heat Pump (existing furnace) was LSC cost-effective everywhere except Climate Zone 15. The HPSH was LSC cost-effective everywhere except Climate Zones 8 and 15.
  - a. Challenges to On-Bill cost-effectiveness include higher first costs and higher first-year utility costs due to higher electricity tariffs relative to gas tariffs. SMUD and CPAU are two exceptions where first year utility costs are lower for heat pumps than for gas equipment. Table 11 shows the impact of utility rates on cost-effectiveness of HPSH where the standard and high efficiency HPSH and the HPSH + PV measures are cost-effective under SMUD but not PG&E. Even with higher first year utility bills, there were some cases that still proved On-Bill cost-effective including the DFHP with an existing furnace in the central valley and northern coastal PG&E territories, the ducted MSHP in the central valley as well as Climate Zone 14 in SDG&E territory, and the HPSH + PV measure in CZ 3-5 (PGE), 7-11, and 12 (SMUD) – 15.
  - b. The ductless MSHPs were only found to be cost-effective based on either metric in Climate Zones 1 and 16. Ductless MSHPs have a high incremental cost because it is a more sophisticated system than the base model of a wall furnace with a window AC unit. However, the ductless MSHP would provide greater comfort benefits if properly installed to directly condition all habitable spaces (as is required under the VCHP compliance credit as evaluated in this study) which may be an incentive for a homeowner to upgrade their system.
  - c. Higher efficiency equipment lowered utility costs in all cases and improved cost-effectiveness in many cases, particularly with a ducted MSHP.
4. Heat pump water heating: All the HPWH measures were LSC cost-effective in all climate zones. Most measures were not On-Bill cost-effective with the exception of the HPWH + PV which was cost-effective On-Bill in CPAU, SMUD, and SDG&E territories in addition to Climate Zones 11, 13, 14, and 15. The HPWH measures share many of the same challenges as the HPSH measures to achieving cost-effectiveness including high first costs and utility rates and assumptions. Table 13 shows the impact of utility rates on cost-effectiveness where some HPWH measures are cost-effective under SMUD utility rates but are not cost-effective anywhere under PG&E rates in Climate Zone 12.
  - a. Various HPWH locations were also explored, however there are some factors outside of cost-effectiveness that should also be considered.
    - i. HPWHs in the conditioned space can provide benefits such as free-cooling during the summer, reduced tank losses, and shorter pipe lengths, and in some cases show improved cost-effectiveness over garage located HPWHs. However, there are various design considerations such as noise, comfort concerns, an additional heating load in the winter, and condensate removal. Ducting the inlet and exhaust air resolves comfort concerns but adds costs and complexity. Split heat pump water heaters address these concerns, but currently there are limited products on the market and there is a cost premium relative to the packaged products.
    - ii. Since HPWHs extract heat from the air and transfer it to water in the storage tank, they must have adequate ventilation to operate properly. Otherwise, the space cools down over time, impacting the HPWH operating efficiency. This is not a problem with garage installations but needs to be considered for water heaters located in interior or exterior closets. For the 2025 Title 24 code the CEC is proposing that all HPWH installations meet mandatory ventilation requirements (California Energy Commission, 2023).
5. The contractor surveys revealed overall higher heat pump costs than what has been found in previous analyses. This could be due to incentive availability raising demand for heat pumps and thereby increasing the price. This price increase may be temporary and may come down once the market stabilizes. There are also

new initiatives to obtain current costs including the TECH Clean California program<sup>1</sup> that publishes heat pump data and costs; however, at the time of this analysis, the TECH data did not contain incremental costs because it only had the heat pump costs but not the gas base case costs.

6. Table 18 shows how CARE rates and escalation rate assumptions will impact cost-effectiveness.
  - a. Applying CARE rates in the IOU territories has the overall impact to increase utility cost savings for an all-electric building compared to a code compliant mixed fuel building, improving On-Bill cost-effectiveness. This is due to the CARE discount on electricity being higher than that on gas. The reverse occurs with efficiency measures where lower utility rates reduce savings and subsequently reduce cost-effectiveness.
  - b. If gas tariffs are assumed to increase substantially over time, in-line with the escalation assumption from the 2025 LSC development, cost-effectiveness substantially improves for the heat pump measures over the 30-year analysis period and many cases become cost-effective that were not found to be cost-effective under the CPUC / 2022 TDV escalation scenario. There is much uncertainty surrounding future tariff structures as well as escalation values. While it's clear that gas rates will increase, how much and how quickly is not known. Future electricity tariff structures are expected to evolve over time, and the CPUC has an active proceeding to adopt an income-graduated fixed charge that benefits low-income customers and supports electrification measures for all customers.<sup>2</sup> The CPUC will make a decision in mid-2024 and the new rates are expected to be in place later that year or in 2025. While the anticipated impact of this rate change is lower volumetric electricity rates, the rate design is not finalized. While lower volumetric electricity rates provide many benefits, it also will make building efficiency measures harder to justify as cost-effective due to lower utility bill cost savings.
7. Under NBT, utility cost savings for PV are substantially less than what they were under prior net energy metering rules (NEM 2.0); however, savings are sufficient to be On-Bill cost-effective in all climate zones except Climate Zones 1 through 3, 5, and 6.
  - a. Combining a heat pump with PV allows the additional electricity required by the heat pump to be offset by the PV system while also increasing on-site utilization of PV generation rather than exporting the electricity back to the grid at a low rate.
  - b. While not evaluated in this study, coupling PV with battery systems can be very advantageous under NBT increasing utility cost savings because of improved on-site utilization of PV generation and fewer exports to the grid.

#### Recommendations:

1. There are various approaches for jurisdictions who are interested in reach codes for existing buildings. Some potential approaches are listed below along with key considerations.
  - a. Prescriptive measures: Non-preempted measures that are found to be cost-effective may be prescriptively required in a reach code. One example of this type of ordinance is a cool roof requirement at time of roof replacement. Another example is requiring specific cost-effective measures for larger remodels, such as high-performance windows when new windows are installed or duct sealing and testing when ducts are in an unconditioned space.
  - b. Replacement equipment: This flavor of reach code sets certain requirements at time of equipment replacement. This study evaluated space heating and water heating equipment. Where a heat pump measure was found to be cost-effective based on either LSC or On-Bill, this may serve as the basis of a reach code given the following considerations.
    - i. Where reach codes reduce energy usage and are not just fuel switching, cost-effectiveness calculations are required and must be based on equipment that does not exceed the federal minimum efficiency requirements.
    - ii. Where reach codes are established using cost-effectiveness based on LSC, utility bill impacts and the owner's first cost should also be reviewed and considered.

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<sup>1</sup> [TECH Public Reporting Home Page \(techcleanca.com\)](https://www.techcleanca.com)

<sup>2</sup> <https://www.cpuc.ca.gov/industries-and-topics/electrical-energy/electric-costs/demand-response-dr/demand-flexibility-rulemaking>

- iii. A gas path should also be prescriptively allowed to safely satisfy federal preemption requirements considering the CRA v. Berkeley case.<sup>3</sup> Additional requirements may apply to the gas path, as described in Section 3.3, as long as the paths are reasonably energy or cost equivalent.
    - c. “Flexible Path”, minimum energy savings target: This flexible approach establishes a target for required energy savings based on a measure or a set of measures that were found to be cost-effective based on either LSC or On-Bill. A points menu compares various potential upgrades ranging from efficiency, PV, and fuel substitution measures, based on site or source energy savings. The applicant must select upgrades that individually or in combination meet the minimum energy savings target. The maximum target value shown in the Cost-effectiveness Explorer is based on a combination of cost-effective, non-preempted measures.
2. Equipment replacement ordinances should consider appropriate exceptions for scenarios where it will be challenging to meet the requirements, such as location of the HPWH, total project cost limitations, or the need for service panel upgrades that wouldn’t have been required as part of the proposed scope of work in absence of the reach code.
3. Consider extending relevant proposals made by the CEC for the 2025 Title 24 code (California Energy Commission, 2023) in ordinances that apply under the 2022 Title 24 code, such as the following:
  - a. Mandatory ventilation requirements for HPWH installations (Section 110.3(c)7). The cost-effectiveness analysis can be found in the Multifamily Domestic Hot Water CASE report (Statewide Team, 2023).
  - b. Requirement for HERS verified refrigerant charge verification for heat pumps in all climate zones (Table 150.1-A<sup>4</sup>). The cost-effectiveness analysis can be found in the Residential HVAC Performance CASE report (Statewide Team, 2023).
4. When evaluating reach code strategies, the Reach Codes Team recommends that jurisdictions consider combined benefits of energy efficiency alongside electrification. Efficiency and electrification have symbiotic benefits and are both critical for decarbonization of buildings. As demand on the electric grid is increased through electrification, efficiency can reduce the negative impacts of additional electricity demand on the grid, reducing the need for increased generation and storage capacity, as well as the need to upgrade upstream transmission and distribution equipment.
5. Education and training can play a critical role in ensuring that heat pumps are installed, commissioned, and controlled properly to mitigate grid impacts and maximize occupant satisfaction. Below are select recommended strategies.
  - a. The Quality Residential HVAC Services Program<sup>5</sup> is an incentive program to train California contractors in providing quality installation and maintenance while advancing energy-efficient technologies in the residential HVAC industry. Jurisdictions can market this to local contractors to increase the penetration of contractors skilled in heat pump design and installation.
  - b. Educate residents and contractors of available incentives, tax credits, and financing opportunities.
  - c. Educate contractors on code requirements. Energy Code Ace provides free tools, training, and resources to help Californians comply with the energy code. Contractors can access interactive compliance forms, fact sheets, and live and recorded trainings, among other things, on the website: <https://energycodeace.com/>. Jurisdictions can reach out to Energy Code Ace directly to discuss offerings.
6. Health and safety
  - a. Combustion Appliance Safety and Indoor Air Quality: Implementation of some of the recommended measures will affect the pressure balance of the home which can subsequently impact the safe operation of existing combustion appliances as well as indoor air quality. Buildings with older gas appliances can present serious health and safety problems which may not be addressed in a remodel

<sup>3</sup> <https://www.publichealthlawcenter.org/sites/default/files/2024-01/CRA-v-Berkeley-Ninth-Circuit-Opinion-Jan2024.pdf>

<sup>4</sup> This requirement does not show up in the Express Terms for alterations in Section 150.2(b)1F, but the Statewide Reach Codes Team expects that it will be added to the next release of the proposed code language in the 45-day language as it aligns with the proposal made by the Codes and Standards Enhancement Team (Statewide CASE Team, 2023).

<sup>5</sup> <https://qualityhvac.frontierenergy.com/>

if the appliances are not being replaced. It is recommended that the building department require inspection and testing of all combustion appliances located within the pressure boundary of the building after completion of retrofit work that involves air sealing or insulation measures.

- b. Jurisdictions may consider requiring mechanical ventilation in homes where air sealing has been conducted. In older buildings, outdoor air is typically introduced through leaks in the building envelope. After air sealing a building, it may be necessary to forcefully bring in fresh outdoor air using supply and/or exhaust fans to minimize potential issues associated with indoor air quality.

Local jurisdictions may also adopt ordinances that amend different Parts of the California Building Standards Code or may elect to amend other state or municipal codes. The decision regarding which code to amend will determine the specific requirements that must be followed for an ordinance to be legally enforceable. For example, reach codes that amend Part 6 of the CA Building Code and require energy performance beyond state code minimums must demonstrate the proposed changes are cost-effective and obtain approval from the Energy Commission as well as the Building Standards Commission (BSC). Amendments to Part 11, such as requirements for increased water efficiency or electric vehicle infrastructure only require BSC approval. Although a cost-effectiveness study is only required to amend Part 6 of the CA Building Code, this study provides valuable context for jurisdictions pursuing other ordinance paths to understand the economic impacts of any policy decision. This study documents the estimated costs, benefits, energy impacts and greenhouse gas emission reductions that may result from implementing an ordinance based on the results to help residents, local leadership, and other stakeholders make informed policy decisions.

This report documents the key results and conclusions from the Reach Codes Team analysis. A full dataset of all results can be downloaded at <https://localenergycodes.com/content/resources>. Results alongside policy options can also be explored using the Cost-effectiveness Explorer at <https://explorer.localenergycodes.com/>. Model ordinance language and other resources are posted on the C&S Reach Codes Program website at [LocalEnergyCodes.com](https://LocalEnergyCodes.com). Local jurisdictions that are considering adopting an ordinance may contact the program for further technical support at [info@localenergycodes.com](mailto:info@localenergycodes.com).

## 1 Introduction

This report documents cost-effective measure upgrades in existing single family buildings that exceed the minimum state requirements, the 2022 Building Energy Efficiency Standards, effective January 1, 2023. Local jurisdictions in California may consider adopting local energy ordinances to achieve energy savings beyond what will be accomplished by enforcing building efficiency requirements that apply statewide. This report was developed in coordination with the California Statewide Investor-Owned Utilities (IOUs) Codes and Standards Program, key consultants, and engaged cities—collectively known as the Statewide Reach Codes Team.

The focus of this study is on existing single family buildings and does not apply to low or high-rise multifamily buildings. Each jurisdiction must establish the appropriate structure and threshold for triggering the proposed requirements. Some common jurisdictional structures include triggering the requirements at major remodels, additions, or date-certain (upgrades must be completed by a specific date). Some of these measures could be triggered with a permit for another specific measure, such as a re-roofing project. The analysis includes scenarios of individual measures and identifies cost-effective options based on the existing conditions of the building in all 16 California Climate Zones (CZ) (see Cost-Effectiveness Results for a graphical depiction of climate zone locations).

This report documents the key results and conclusions from the Reach Codes Team analysis. A full dataset of all results can be downloaded at <https://localenergycodes.com/content/resources>. Results alongside policy options can also be explored using the Cost-effectiveness Explorer at <https://explorer.localenergycodes.com/>.

The California Codes and Standards (C&S) Reach Codes program provides technical support to local governments considering adopting a local ordinance (reach code) intended to support meeting local and/or statewide energy efficiency and greenhouse gas reduction goals. The program facilitates adoption and implementation of the code when requested by local jurisdictions by providing resources such as cost-effectiveness studies, model language, sample findings, and other supporting documentation.

The California Building Energy Efficiency Standards Title 24, Part 6 (Title 24) (CEC, 2019) is maintained and updated every three years by two state agencies: the California Energy Commission (the Energy Commission) and the Building Standards Commission (BSC). In addition to enforcing the code, local jurisdictions have the authority to adopt local energy efficiency ordinances—or reach codes—that exceed the minimum standards defined by Title 24 (as established by Public Resources Code Section 25402.1(h)2 and Section 10-106 of the Building Energy Efficiency Standards). Local jurisdictions must demonstrate that the requirements of the proposed ordinance are cost-effective and do not result in buildings consuming more energy than is permitted by Title 24. In addition, the jurisdiction must obtain approval from the Energy Commission and file the ordinance with the BSC for the ordinance to be legally enforceable.

The Department of Energy (DOE) sets minimum efficiency standards for equipment and appliances that are federally regulated under the National Appliance Energy Conservation Act, including heating, cooling, and water heating equipment (E-CFR, 2020). Since state and local governments are prohibited from adopting higher minimum efficiencies than the federal standards require, the focus of this study is to identify and evaluate cost-effective packages that do not include high efficiency heating, cooling, and water heating equipment. High efficiency appliances are often the easiest and most affordable measure to increase energy performance. While federal preemption limits reach code mandatory requirements for covered appliances, in practice, builders may install any package of compliant measures to achieve the performance requirements.

## 2 Methodology and Assumptions

### 2.1 Analysis for Reach Codes

This section describes the approach to calculating cost-effectiveness including benefits, costs, metrics, and utility rate selection.

#### 2.1.1 Modeling

The Reach Codes Team performed energy simulations using the 2025 research version of the Residential California Building Energy Code Compliance software (CBECC). The 2025 version of CBECC was used instead of the 2022 version to take advantage of updated weather files and metrics. Site energy results are similar between CBECC-Res 2022 and 2025; however, the 2025 compliance metrics applies assumptions reflective of an electrified future, such as high escalation for natural gas retail rates, which favors electric buildings. In addition, in 2025 the weather stations were changed in Climate Zones 4 and 6 from San Jose to Paso Robles and Torrance to Los Angeles International Airport, respectively.

Three unique building vintages are considered: pre-1978, 1978-1991, and 1992-2010. The vintages were defined based on review of historic Title 24 code requirements and defining periods with distinguishing features. Prospective energy efficiency measures were identified and modeled to determine the projected site energy (therm and kWh), source energy, GHG emissions, and LSC (long-term systemwide cost) impacts. Annual utility costs were calculated using hourly data output from CBECC, and current (as of 11/01/2023) electricity and natural gas tariffs for each of the investor-owned utilities (IOUs) appropriate for that climate zone.

Equivalent CO<sub>2</sub> emission reductions were calculated based on outputs from the CBECC-Res simulation software. Electricity emissions vary by region and by hour of the year. CBECC-Res applies two distinct hourly profiles, one for Climate Zones 1 through 5 and 11 through 13 and another for Climate Zones 6 through 10 and 14 through 16. Natural gas emissions do not vary hourly. To compare the mixed-fuel and all-electric cases side-by-side, GHG emissions are presented as lbs CO<sub>2</sub>-equivalent (CO<sub>2e</sub>) emissions.

The Statewide Reach Codes Team designed the analysis approach and selected measures for evaluation based on the 2019 existing building single family reach code analysis (Statewide Reach Codes Team, 2021) and work to support the 2025 Title 24 code development cycle as well as from outreach to architects, builders, and engineers.

#### 2.1.2 Prototype Characteristics

The Energy Commission defines building prototypes which it uses to evaluate the cost-effectiveness of proposed changes to Title 24 requirements. Average home size has steadily increased over time,<sup>6</sup> and the Energy Commission single family new construction prototypes are larger than many existing single family homes across California. For this analysis, a 1,665 square foot prototype was evaluated. Table 1 describes the basic characteristics of the single family prototype. Additions are not evaluated in this analysis as they are already addressed in Section 150.2 of Title 24, Part 6. The CEC has proposed changes to the 2025 Energy Code that would remove the allowance of gas space heating and water heating equipment for additions and instead require additions to follow the same space heating and water heating equipment requirements as new construction (California Energy Commission, 2023). The proposed prescriptive requirements for single family new construction homes are heat pump space heaters and water heaters, with gas equipment only allowed in the performance approach.

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<sup>6</sup> <https://www.census.gov/const/C25Ann/sfttotalmedavgsqft.pdf>

**Table 1. Prototype Characteristics**

	Specification
Existing Conditioned Floor Area	1,665 ft <sup>2</sup>
Num. of Stories	1
Num. of Bedrooms	3
Window-to-Floor Area Ratio	13%
Attached Garage	2-car garage

Three building vintages were evaluated to determine sensitivity of existing building performance on cost-effectiveness of upgrades. For example, it is widely recognized that adding attic insulation in an older home with no insulation is cost-effective, however, newer homes will likely have existing attic insulation reducing the cost-effectiveness of an incremental addition of insulation. The building characteristics for each vintage were determined based on either prescriptive requirements from Title 24 that were in effect or standard construction practice during that time period. Homes built under 2001 Title 24 are subject to prescriptive envelope code requirements very similar to homes built under the 2005 code cycle, which was in effect until January 1, 2010.

Table 2 summarizes the assumptions for each of the three vintages. Additionally, the analysis assumed the following features when modeling the prototype buildings. Efficiencies were defined by year of the most recent equipment replacement based on standard equipment lifetimes.

- Individual space conditioning and water heating systems, one per single family building.
- Split-system air conditioner with natural gas furnace.
  - Scenarios with an existing natural gas wall furnace without AC were also evaluated.
- Small storage natural gas water heater.
  - Scenarios with an existing electric resistance storage water heater were also evaluated.
- Gas cooktop, oven, and clothes dryer.

The methodology applied in the analyses begins with a design that matches the specifications as described in Table 2 for each of the three vintages. Prospective energy efficiency measures were modeled to determine the projected energy performance and utility cost impacts relative to the baseline vintage. In some cases, where logical, measures were packaged together.

**Table 2. Efficiency Characteristics for Three Vintage Cases**

Building Component Efficiency Feature	Vintage Case		
	Pre-1978	1978-1991	1992-2010
<b>Envelope</b>			
Exterior Walls	2x4, 16-inch on center wood frame, R-0 <sup>a</sup>	2x4 16 inch on center wood frame, R-11	2x4 16 inch on center wood frame, R-13
Foundation Type & Insulation	Uninsulated slab (CZ 2-15) Raised floor, R-0 (CZ 1 & 16)	Uninsulated slab (CZ 2-15) Raised floor, R-0 (CZ 1 & 16)	Uninsulated slab (CZ 2-15) Raised floor, R-19 (CZ 1 & 16)
Ceiling Insulation & Attic Type	Vented attic, R-5 @ ceiling level for CZ 6 & 7, Vented attic, R-11 @ ceiling level (all other CZs)	Vented attic, R-19 @ ceiling level	Vented attic, R-30 @ ceiling level
Roofing Material & Color	Asphalt shingles, dark (0.10 reflectance, 0.85 emittance)	Asphalt shingles, dark (0.10 reflectance, 0.85 emittance)	Asphalt shingles, dark (0.10 reflectance, 0.85 emittance)
Radiant Barrier	No	No	No
Window Type: U-factor/SHGC <sup>b</sup>	Metal, single pane: 1.16/0.76	Metal, dual pane: 0.79/0.70	Vinyl, dual pane Low-E: 0.55/0.40
House Infiltration at 50 Pascals	15 ACH50	10 ACH50	7 ACH50
<b>HVAC Equipment</b>			
Heating Efficiency	78 AFUE (assumes 2 replacements)	78 AFUE (assumes 1 replacement)	78 AFUE
Cooling Efficiency	10 SEER (assumes 2 replacements)	10 SEER (assumes 1 replacement)	13 SEER, 11 EER
Duct Location & Details	Attic, R-2.1, 30% leakage at 25 Pa	Attic, R-2.1, 25% leakage at 25 Pa	Attic, R-4.2, 15% leakage at 25 Pa
Whole Building Mechanical Ventilation	None	None	None
<b>Water Heating Equipment</b>			
Water Heater Efficiency	0.575 Energy Factor (assumes 2 replacements)	0.575 Energy Factor (assumes 1 replacement)	0.575 Energy Factor
Water Heater Type	40-gallon gas storage	40-gallon gas storage	40-gallon gas storage
Pipe Insulation	None	None	None
Hot Water Fixtures	Standard, non-low flow	Standard, non-low flow	Standard, non-low flow

<sup>a</sup> Pre-1978 wall modeled with R-5 cavity insulation to better align wall system performance with monitored field data and not overestimate energy use.

<sup>b</sup> Window type selections were made based on conversations with window industry expert, Ken Nittler. If a technology was entering the market during the time period (e.g., Low-E during 1992-2010 or dual-pane during 1978-1991) that technology was included in the analysis. This provides a conservative assumption for overall building performance and additional measures may be cost-effective for buildings with lower performing windows, for example buildings with metal single pane windows in the 1978-1991 vintage.

## 2.1.3 Cost-Effectiveness Approach

### 2.1.3.1 Benefits

This analysis used two different metrics to assess the cost-effectiveness of the proposed upgrades. Both methodologies require estimating and quantifying the incremental costs and energy savings associated with each energy efficiency measure. The main difference between the methodologies is the way they value energy impacts (the numerator in the benefit cost calculation):

**Utility Bill Impacts (On-Bill):** This customer-based lifecycle cost (LCC) approach values energy based upon estimated site energy usage and customer utility bill savings using the latest electricity and natural gas utility tariffs available at the time of writing this report. Total savings are estimated over a 30-year duration and include discounting of future utility costs, as well as assumed energy cost inflation over time.

**Long-term Systemwide Cost (LSC):** Formerly known as Time Dependent Valuation (TDV) energy cost savings, LSC reflects the Energy Commission’s current LCC methodology, which is intended to capture the total value or cost of energy use over 30 years. This method accounts for the hourly cost of marginal generation, transmission and distribution, fuel, capacity, losses, and cap-and-trade-based CO2 emissions (California Energy Commission, 2023). This is the methodology used by the Energy Commission in evaluating cost-effectiveness for efficiency measures in the 2025 Energy Code.

### 2.1.3.2 Costs

The Reach Codes Team assessed the incremental costs of the measures and packages over a 30-year analysis period. Incremental costs represent the equipment, installation, replacement, and maintenance costs of the proposed measure relative to the 2022 Title 24 Standards minimum requirements or standard industry practices. Present value of replacement cost is included only for measures with lifetimes less than the 30-year evaluation period. In cases where at the end of the analysis period the measure has useful life remaining, the value of this remaining life is calculated and credited in the total lifetime cost.

### 2.1.3.3 Metrics

Cost-effectiveness is presented using net present value (NPV) and benefit-to-cost (B/C) ratio metrics.

**NPV:** Equation 1 demonstrates how lifetime NPV is calculated. If the NPV of a measure or package is positive, it is considered cost-effective. A negative value represents a net increase in costs over the 30-year lifetime.

**B/C Ratio:** This is the ratio of the present value of all benefits to the present value of all costs over 30 years (present value benefits divided by present value costs). A value of one indicates the NPV of the savings over the life of the measure is equivalent to the NPV of the lifetime incremental cost of that measure. A value greater than one represents a positive return on investment. The B/C ratio is calculated according to Equation 2.

#### Equation 1

$$NPV = \sum_{t=0}^{30} \frac{B_t - C_t}{(1+r)^t}$$

#### Equation 2

$$B/C \text{ Ratio} = \frac{\sum_{t=0}^{30} \frac{B_t}{(1+r)^t}}{\sum_{t=0}^{30} \frac{C_t}{(1+r)^t}}$$

Improving the efficiency of a project often requires an initial incremental investment. In most cases the benefit is represented by annual On-Bill utility or LSC savings, and the cost is represented by incremental first cost and future replacement costs. Some packages result in initial construction cost savings relative to the assumed base case scenario, and either energy cost savings (positive benefits), or increased energy costs (negative benefits). In cases where both construction costs and energy-related savings are negative, the construction cost savings are treated as the ‘benefit’ while the increased energy costs are the ‘cost.’ In cases where a measure or package is cost-effective immediately (i.e., upfront construction cost savings and lifetime energy cost savings), B/C ratio cost-effectiveness is represented by “>1”.

The lifetime costs or benefits are calculated according to Equation 3.

### Equation 3

$$N\text{ppppppppppppp vvvvvvvpp oooo vvlooppplllpp ccooppvp oopp bppppppoolpp} = \sum_{cc=0}^{AA} \frac{(AAAAAAAAA A cccccc c cco o bbbbaAbbbbcbcc)_{tt}}{(1+oo)^{tt}}$$

Where:

1.  $n$  = analysis term in years
2.  $r$  = discount rate

The following summarizes the assumptions applied in this analysis to both methodologies.

3. Analysis term of 30 years
4. Real discount rate of three percent

Both base case measures and alternative energy efficiency measures may have different lifetime assumptions which impact life cycle economics. Future costing of many of the evaluated electrification measures are only based on current cost assumption, which may be overly conservative as the expected growth in heat pump-based technologies is growing rapidly and will likely lead to future cost reductions (at least relative to current fossil fueled equipment) as production volumes increase.

### 2.1.4 Utility Rates

In coordination with the CA IOU rate team (comprised of representatives from Pacific Gas and Electric (PG&E), Southern California Edison (SCE) and San Diego Gas and Electric (SDG&E)) and two Publicly-Owned-Utilities (POUs) (Sacramento Municipal Utility District (SMUD) and City of Palo Alto Utilities (CPAU)), the Reach Codes Team determined appropriate utility rates for each climate zone to calculate utility costs and determine On-Bill cost-effectiveness for the proposed measures and packages. The utility tariffs, summarized in Chapter 6.2, were determined based on the appropriate rate for each case in each territory. Utility rates were applied to each climate zone based on the predominant IOU serving the population of each zone, with a few climate zones evaluated multiple times under different utility scenarios. Climate Zones 10 and 14 were evaluated with both SCE for electricity and Southern California Gas Company (SoCalGas) for gas and SDG&E tariffs for both electricity and gas since each utility has customers within these climate zones. Climate Zone 5 is evaluated under both PG&E and SoCalGas natural gas rates. Two POU or municipal utility rates were also evaluated: SMUD in Climate Zone 12 and CPAU in Climate Zone 4.

For cases with onsite generation (i.e. solar photovoltaics (PV)), the approved NBT tariffs were applied along with monthly service fees and hourly export compensation rates for 2024.<sup>7</sup> In December 2022, the California Public Utilities Commission (CPUC) issued a decision adopting NBT as a successor to NEM 2.0 that went into effect April of 2023<sup>8</sup>.

Utility rates are assumed to escalate over time according to the assumptions from the CPUC 2021 En Banc hearings on utility costs through 2030 (California Public Utilities Commission, 2021a). Escalation rates through the remainder of the 30-year evaluation period are based on the escalation rate assumptions within the 2022 TDV factors. The Statewide Natural Gas Residential Average Rate for 2023 through 2030 is projected to be 4.6%. The Electric Residential Average Rate for PG&E, SCE and SDG&E for 2023 through 2030 is projected to be 1.8%, 1.6% and 2.8% respectively. A second set of escalation rates were also evaluated to demonstrate the impact that utility cost changes have on cost-effectiveness over time. This utility rate escalation sensitivity analysis, presented in Section 3.2.4, was based on those used within the 2025 LSC factors (LSC replaces TDV in the 2025 code cycle) which assumed steep

<sup>7</sup> Hourly export compensation rates were based on the NBT spreadsheet model created by E3 for the CPUC. <https://www.cpuc.ca.gov/-/media/cpuc-website/divisions/energy-division/documents/net-energy-metering-nem/nemrevisit/nbt-model--12142022.xlsx>

<sup>8</sup> <https://www.cpuc.ca.gov/nemrevisit>

increases in gas rates in the latter half of the analysis period. See Appendix 6.2.7 Fuel Escalation Assumptions for details.

Future electricity tariff structures are expected to evolve over time, and the CPUC has an active proceeding to adopt an income-graduated fixed charge that benefits low-income customers and supports electrification measures.<sup>10</sup> These were not included in this analysis but may be evaluated later in 2024 once the rates are finalized.

### 2.1.5 Measure Cost Data Collection Approach

To support this effort, a detailed cost study was completed in the summer of 2023 to gather data from a range of contractors to inform actual installed costs in the areas they provide services. These areas include HVAC, plumbing, envelope and air-sealing, and PV installation. Home performance contractors were also approached to collect this data. Collecting this type of data is challenging, both due to contractor reticence to share cost information and due to the timing of the survey which unfortunately coincided with the summer busy season for most contractors, especially HVAC installers. With these known challenges, the outreach effort focused on leveraging existing relationships between the analysis team and contractors to both gain access and provide assurance that all cost data would remain confidential and aggregated. Contractors that provided feedback were nominally compensated for their time.

The collected cost data was intended to represent recent costs for a “typical” retrofit installation. Each home in which a contractor does work has different site-specific issues that will likely affect costs. In addition, different jurisdictions have different levels of building department installation oversight and permit fees. Finally, each contractor typically has a different manufacturer product line they prefer to install. All these factors will influence installed costs<sup>11</sup>.

The most detailed and broad cost request was for the HVAC contractors, as there are a wide range of equipment replacement scenarios available for an existing ducted gas furnace with central split-system air conditioning. Options range from a base case scenario (like for like swap out), split-system heat pump replacement, dual fuel heat pumps (DFHP), ducted mini-split heat pumps, non-ducted mini-splits, etc. For plumbing contractors, a range of scenarios existed for water heater replacements including like-for-like replacement, HPWHs (in different locations- garage, indoor), need for electrical upgrade for HPWH installation, need for HPWH ducting, etc. Envelope measures focused on attic and wall insulation, window replacement, re-roofing (with Cool Roof materials or not), and attic ceiling plane air-sealing. PV costing included different system sizes, panel upgrades costs, and battery costs. Home performance contractors were asked to provide as much data as they could on the different measure options. All costing information requested was intended to represent most recent installations, in an effort to capture current pricing as best as possible.

The contractors that responded with their cost estimates work in different regions of the state, operate in different markets with (potentially) different local efficiency incentives, do varying amounts of work based on the size of their company, target different market demographic sectors, and install different brands of equipment. All these factors will contribute to price variability. The Team considered applying climate zone specific cost adjustments to reflect some of these differences, but ultimately decided not to since a climate zone is not a monolithic entity with uniform customer pricing throughout. The Team recognizes that “zip code” pricing is a reality, but for simplicity, as well as consistency with Title 24, Part 6 code development costing approaches, applied uniform statewide costs to all measures.

## 2.2 Measure Details and Cost

This section describes the details of the measures and documents incremental costs. All measure costs were obtained from the contractor survey unless otherwise noted. All contractor provided costs reflect the cost to the customer and

<sup>10</sup> <https://www.cpuc.ca.gov/industries-and-topics/electrical-energy/electric-costs/demand-response-dr/demand-flexibility-rulemaking>

<sup>11</sup> One HVAC contractor mentioned that equipment brand alone may contribute to a +/-%5 variation in the total bid cost.

include equipment, labor, permit fees, and required HERS testing. Additional details of the measures can be found in Appendix Section **Error! Reference source not found.**

All measures are evaluated assuming they are not otherwise required by Title 24. For example, duct sealing is required by code whenever HVAC equipment is altered. For this analysis duct sealing was evaluated for those projects where it is not already triggered by code (i.e., no changes to the heating or cooling equipment). Where appropriate, measure requirements align with those defined in Title 24. In some cases, cost-effective measures were identified that exceed Title 24 requirements, such as attic insulation, cool roofs, and duct sealing.

## 2.2.1 Building Envelope & Duct Measures

The following are descriptions of each of the efficiency upgrade measures applied in this analysis.

**Attic Insulation:** Add attic insulation in buildings with vented attic spaces to meet either R-38 or R-49. The pre-1978 vintage assumes an existing condition of R-11, the 1978-1991 vintage assumes an existing condition of R-19, and the 1992-2010 vintage assumes R-30 as the existing insulation level. For pre-1978 vintage homes this measure was also evaluated to include air sealing of the attic. A 14% leakage reduction was modeled such that 15 ACH50 was reduced to 12.9 ACH50 in this measure. The costs for this measure include removing existing insulation.

**Air Sealing and Weather-stripping:** Apply air sealing practices throughout all accessible areas of the building. For this study, it was assumed that older vintage homes would be leakier than newer buildings and that approximately 30 percent improvement in air leakage is achievable through air sealing of all accessible areas. For modeling purposes, it was assumed that air sealing can reduce infiltration levels from 15 to ten air changes per hour at 50 Pascals pressure difference (ACH50) in the oldest vintages (pre-1978), to ten to seven ACH50 for the 1978-1991 vintage, and seven to five ACH50 in the 1992-2010 vintage.

**Cool Roof:** For steep slope roofs, install a roofing product rated by the Cool Roof Rating Council (CRRC) with an aged solar reflectance of 0.20 or 0.25 and thermal emittance of 0.75 or higher. This measure only applies to buildings that are installing a new roof as part of the scope of the remodel; the cost and energy savings associated with this upgrade reflects the incremental step between a standard roofing product with one that is CRRC rated with an aged solar reflectance of 0.20 or 0.25. This is similar to cool roof requirements in 2022 Title 24 Section 150.2(b)1li but assumes a higher solar reflectance.

**Radiant Barrier:** Add radiant barrier to any existing home vintage. This measure only applies to buildings that are installing a new roof as part of the scope of the remodel; the cost and energy savings associated with this upgrade reflects the incremental step between a standard roofing product with one that includes a laminated radiant barrier.

**Raised Floor Insulation:** In existing homes with raised floors and no insulation (pre-1978 and 1978-1991 vintages), add R-19 insulation. An upgraded R-30 floor insulation, assuming no current insulation, was evaluated in the pre-1978 and 1978-1991 vintages.

**Wall Insulation:** Blow-in R-13 wall insulation in existing homes without wall insulation (pre-1978 vintages).

**Window Replacement:** Replace existing windows with a non-metal dual-pane product, which has a U-factor equal to 0.28 Btu/hour-ft<sup>2</sup>-°F or lower and a Solar Heat Gain Coefficient (SHGC) equal to 0.23 or lower, except in heating dominated climates (Climate Zones 1, 3, 5, and 16) where an SHGC of 0.35 was evaluated.

**Duct Sealing, New Ducts, and Duct Insulation:** Air seal all ductwork to meet the requirements of the 2022 Title 24, Part 6 Section 150.2(b)1E. For this analysis, final duct leakage values of ten percent (proposed revised leakage rate for 2022 Title 24) was evaluated. The pre-1978 and 1978-1992 vintages assume leaky existing ducts (25-30% leakage). The 1992-2010 vintage assumes moderately leaky existing ducts (15-20% leakage).

Replacing existing ductwork with entirely new ductwork to meet Sections 150.2(b)1Di and 150.2(b)1Diia of the 2022 Title 24 was also evaluated. This assumed new ducts meet 5% duct leakage and the option of R-6 and R-8 duct insulation in all climate zones.

Table 3 summarizes the cost assumptions for the building envelope and HVAC duct improvement measures evaluated. All the measures in Table 3 assume a 30-year effective useful life.

**Table 3. Measure Cost Assumptions – Efficiency & Duct Measures**

Measure	Performance Level	Incremental Cost – Single Family Building		
		Pre 1978	1978 – 1991	1992 - 2010
Wall Insulation	R-13	\$2,950	N/A	N/A
Raised Floor Insulation	R-19	\$3,633	\$3,633	N/A
	R-30	\$4,113	\$4,113	\$4,113
Attic Insulation	R-38	\$6,762	\$2,555	\$1,781
	R-49	\$7,446	\$3,612	\$1,827
Air Sealing	10 ACH50	\$4,684	N/A	N/A
	7 ACH50	N/A	\$4,684	N/A
	5 ACH50	N/A	N/A	\$4,684
Cool Roof	0.25 Aged Solar Reflectance CZs 1-3,5-7,16	\$2,407	\$2,407	\$2,407
	0.25 Aged Solar Reflectance CZs 4, 8-15	\$1,203	\$1,203	\$1,203
Window U-factor/SHGC	0.28 U-factor. 0.23 SHGC in CZs 2,4,6-15.	\$11,463	\$11,463	\$11,463
	0.28 U-factor. 0.35 SHGC in CZs 1,3,5,26	\$11,871	\$11,871	\$11,871
Radiant Barrier	Add Radiant Barrier	\$893	\$893	\$893
Duct Sealing	10% nominal airflow	\$2,590	\$2,590	\$1,400
All New Duct System	R-6 ducts; 5% duct leakage	\$4,808	\$4,808	\$4,808
	R-8 ducts; 5% duct leakage	\$6,311	\$6,311	\$6,311

### 2.2.2 PV Measures

Installation of on-site PV is required in the 2022 Title 24 code for new construction homes, but there are no PV requirements for additions or alterations to existing buildings. PV was evaluated in CBECC-Res according to the California Flexible Installation (CFI) 1 assumptions and 98% solar access. To meet CFI eligibility, the requirements of 2022 Reference Appendices JA11.2.2 (California Energy Commission, 2021b) must be met. A 3 kW PV system was modeled both as a standalone measure as well as coupled with heat pump installations.

The costs for installing PV are summarized in Table 4. They include the first cost to purchase and install the system, future inverter replacement costs, and annual maintenance costs. Upfront solar PV system costs are estimated from the contractor surveys to be \$4.58/W<sub>DC</sub> and are reduced by 30 percent to account for the federal income Residential Clean Energy Credit. The solar panels are estimated to have an effective useful life of 30 years and the inverter 25 years. The inverter replacement cost of \$7,000 (future value) is also from the contractor surveys. System maintenance costs are taken from the 2019 PV CASE Report (California Energy Commission, 2017) and are assumed to be

\$0.31/W<sub>DC</sub> present value. These costs do not include costs associated with electrical panel upgrades, which will be necessary in some instances.

**Table 4. Measure Descriptions & Cost Assumptions – PV**

Measure	Performance Level	Incremental Cost		
		Pre 1978	1978 – 1991	1992 - 2010
PV	3 kW		\$9,608	

### 2.2.3 Equipment Fuel Substitution Measures – Heat Pump Equipment

The fuel substitution measures are evaluated as replacements at the end of the life of the existing equipment. This means the baseline compared against is usually a like-for-like change-out of the natural gas equipment, and the upgrade is a heat pump.

For most of the space heating and water heating cases, costs for electrical service panel upgrades are not included as it is assumed many existing homes have the service capacity to support converting one appliance from gas to electric. For homes with existing air conditioners, any incremental electric capacity necessary to support a heat pump space heater is marginal. The same applies for homes with existing electric resistance equipment. Section 3.2.4 presents the impacts for select cases where an upgrade to the electric panel is required.

#### Heat Pump Space Heating

All the heat pump space heater (HPSH) measures are described below. All were evaluated with HERS verified refrigerant charge aligned with the proposed code requirements for the 2025 Title 24 code. Dual fuel heat pumps (DFHPs) were controlled to lockout furnace operation above 35°F.

DFHP (Existing Furnace): Replace existing ducted air conditioner (AC) with an electric heat pump and install controls to operate the heat pump to use the existing gas furnace for backup heat. A minimum federal efficiency (14.3 SEER2, 11.7 EER2, 7.5 HSPF2) heat pump was evaluated. Savings are compared to a new AC (14.3 SEER2, 11.7 EER2) alongside the existing furnace (78 AFUE).

DFHP (New Furnace): Replace existing ducted AC and natural gas furnace with an electric heat pump and new gas furnace plus controls to operate the heat pump and use the new gas furnace for backup heat. A minimum federal efficiency (14.3 SEER2, 11.7 EER2, 7.5 HSPF2) heat pump and furnace (80 AFUE) were evaluated to replace existing equipment. Savings are compared to a new ducted AC and natural gas furnace (14.3 SEER2, 11.7 EER2, 80 AFUE).

Heat Pump Space Heater: Replace existing ducted AC and natural gas furnace with an electric heat pump. Minimum federal efficiency (14.3 SEER2, 11.7 EER2, 7.5 HSPF2) and higher efficiency (17 SEER2, 12.48 EER2, 9.5 HSPF2) heat pumps were evaluated. Savings are compared to a new ducted natural gas furnace and AC (14.3 SEER2, 11.7 EER2, 80 AFUE).

Ducted Mini-Split Heat Pump (MSHP): Replace existing ducted AC and natural gas furnace with a ducted high efficiency MSHP (16.5 SEER2, 12.48 EER2, 9.5 HSPF2). Savings are compared to a new ducted AC and natural gas furnace (14.3 SEER2, 11.7 EER2, 80 AFUE).

Ductless MSHP: In a home without AC, replace existing wall furnace with a ductless MSHP. A standard efficiency unit meeting minimum federal efficiency standards (14.3 SEER2, 11.7 EER2, 7.5 HSPF2) was evaluated by modeling the variable capacity heat pump (VCHP) compliance credit in CBECC-Res. A premium, higher efficiency upgrade was also

evaluated using CBECC-Res’ detailed VCHP model<sup>12</sup> by simulating the performance of a representative high efficiency product (14.3 SEER2, 11.7 EER2, 7.5 HSPF2). Savings are compared to a new natural gas wall furnace with fan distribution (75% AFUE) and window AC (9 CEER).

Over the 30-year analysis period, certain changes are assumed when the equipment is replaced that impact both lifetime costs and energy use. Table 5 presents the lifetime scenario for the DFHP (existing furnace) measure. The analysis assumed a 20-year effective useful lifetime (EUL) for a furnace, a 15-year EUL for an air conditioner and a 15-year EUL for a heat pump. Lifetimes are based on the Database for Energy Efficient Resources (DEER) (California Public Utilities Commission, 2021b). The existing furnace is assumed to be halfway through its EUL at the beginning of the analysis period. After 10 years when the furnace reaches the end of its life and needs to be replaced, it will be subject to new federal efficiency standards for residential gas furnaces that go into effect in 2028 requiring 95 AFUE<sup>13</sup>. 5 years later the air conditioner reaches the end of its life and is replaced with a new air conditioner.

For the DFHP upgrade case, after 10 years when the furnace fails it’s expected that the furnace will be abandoned in place since the heat pump serves primary heating and was sized to provide the full design heating load. In this case it is assumed that the fan motor would be replaced with a new aftermarket unit and would operate another 5 years until the heat pump fails and is replaced with a new heat pump and air handler.

The other ducted heat pump cases similarly apply a 95 AFUE furnace in the baseline when the furnace reaches its EUL after 20 years.

**Table 5. Lifetime Analysis Replacement Assumptions for DFHP (Existing Furnace) Scenario**

Year	Baseline	Upgrade
0	AC fails, install new AC, keep existing furnace	AC fails, install new HP, keep existing furnace
10	Furnace fails, install new 95AFUE furnace	Furnace fails, replace fan motor
15	AC fails, install new AC	HP fails, install new HP and air handler

Costs were applied based on the system capacity from heating and cooling load calculations in CBECC-Res as presented in Table 6. Air conditioner nominal capacity was calculated as the CBECC-Res cooling load, rounded up to the nearest half ton. Heat pump nominal capacity was calculated as the maximum of either the CBECC-Res heating or cooling load, rounded up to the nearest half ton. In both cases a minimum capacity of 1.5-ton was applied as this represents the typical smallest available split system heat pump equipment. Load calculations demonstrated that Climate Zones 2 - 15 were cooling-dominated while Climate Zones 1 and 16 were heating-dominated. In the heating dominated climate zones the heat pump needed to be upsized relative to an air conditioner that only provides cooling.

<sup>12</sup> The detailed VCHP option allows for the user to input detailed specifications based on the published National Energy Efficiency Partnership (NEEP) manufacturer specific performance data. It is not currently available for compliance analysis.

<sup>13</sup> <https://www.energy.gov/articles/doe-finalizes-energy-efficiency-standards-residential-furnaces-save-americans-15-billion#:~:text=These%20furnace%20efficiency%20standards%20were,heat%20for%20the%20living%20space.>

**Table 6. System Sizing by Climate Zone**

Climate Zone	Air Conditioner Capacity (tons)	Heat Pump Capacity (tons)
1	1.5	3.0
2	3.5	3.5
3	2.5	2.5
4	3.5	3.5
5	3.0	3.0
6	3.0	3.0
7	3.0	3.0
8	4.0	4.0
9	4.0	4.0
10	4.0	4.0
11	4.5	4.5
12	4.0	4.0
13	4.5	4.5
14	4.0	4.0
15	5.0	5.0
16	3.5	4.0

Table 7 presents estimated first and lifetime costs for the various ducted baseline and heat pump scenarios for 4-ton equipment. Costs include all material and installation labor including providing new 240 V electrical service to the air handler location for all new air handler installations and decommissioning of the furnace for the cases where the furnace is removed. DFHP costs incorporate controls installation and commissioning to ensure the heat pump and the furnace communicate properly and don't operate at the same time. Future replacement costs do not include any initial costs associated with 240V electrical service or furnace decommissioning.

Table 8 presents estimated first and lifetime costs for the ductless baseline and 2 heat pump scenarios, also for 4-ton heat pump equipment. EULs are based on 20 years for the gas wall furnace, 10 years for the window AC, and 15 years for the heat pump.<sup>14</sup>

<sup>14</sup> The gas wall furnace and heat pump EULs were based on DEER (California Public Utilities Commission, 2021b). Gas wall furnace lifetime was assumed to be the same as for central gas furnace equipment. Room air conditioner EUL was based on the DOE's latest rulemaking for room air conditioned (Department of Energy, 2023). DOE determined an average lifetime of 9.3 years, which was rounded up to 10 years for this analysis.

**Table 7. Ducted HVAC Measure Cost Assumptions – 4-Ton Electric Replacements**

Case	AC + Coil	Gas Furnace /AC	DFHP (Existing Furnace)	DFHP (New Furnace)	Min. Eff. Heat Pump	High Eff. Heat Pump	Ducted MSHP
<b>Base Case</b>	-	-	AC + Coil	Gas Furnace /AC	Gas Furnace /AC	Gas Furnace /AC	Gas Furnace /AC
First Cost	\$10,402	\$16,653	\$12,362	\$20,676	\$17,825	\$20,802	\$18,075
Replacement Cost (Future Value)	\$19,365	\$19,365	\$19,025	\$19,025	\$16,825	\$19,802	\$18,075
Replacement Cost (Present Value)	\$13,346	\$11,639	\$12,334	\$12,897	\$10,800	\$12,710	\$11,601
Remaining Value at Year 30	\$0	(\$1,846)	\$0	(\$1,846)	\$0	\$0	\$0
Total Lifecycle Cost	\$23,748	\$26,446	\$24,696	\$31,727	\$28,625	\$33,512	\$29,676
<b>Incremental Cost</b>	-	-	<b>\$948</b>	<b>\$5,281</b>	<b>\$2,179</b>	<b>\$7,066</b>	<b>\$3,230</b>

**Table 8. Non-Ducted HVAC Measure Cost Assumptions – 4-Ton Electric Replacements**

	Wall Furnace + Window AC	Min. Eff. Ductless MSHP	High Eff. Ductless MSHP
First Cost	\$4,075	\$17,412	\$21,342
Replacement Cost (Future Value)	\$4,075	\$17,412	\$21,342
Replacement Cost (Present Value)	\$3,365	\$11,176	\$13,698
Remaining Value at Year 30	(\$532)	\$0	\$0
Total Lifecycle Cost	\$6,908	\$28,588	\$35,040
<b>Incremental Cost</b>	-	<b>\$21,680</b>	<b>\$28,132</b>

**Heat Pump Water Heating:**

The heat pump water heater (HPWH) measures are described below, and costs are presented in Table 9 and Table 10. The most typical scenario in California is a home with existing natural gas storage tank water heaters. However, there are also many existing homes with existing electric resistance storage tank water heaters and this work considers both baselines. This analysis evaluates the following 65-gallon replacement HPWHs:

1. HPWH that meets the federal minimum efficiency requirements of UEF 2.0
2. HPWH that meets the Northwest Energy Efficiency Alliance (NEEA)<sup>15</sup> Tier 3 rating (3.45 UEF)
3. HPWH that meets the NEEA Tier 4 rating and that has demand response (DR) or load shifting control capability (4.02 UEF)
4. 120V HPWH that meets the NEEA Tier 3 rating (3.3 UEF).

<sup>15</sup> Based on operational challenges experienced in the past, NEEA established rating test criteria to ensure newly installed HPWHs perform adequately, especially in colder climates. The NEEA rating requires an Energy Factor equal to the ENERGY STAR® performance level and includes requirements regarding noise and prioritizing heat pump use over supplemental electric resistance heating.

The four cases above were evaluated with the HPWH located within an attached garage. Additionally, three separate cases for the federal minimum efficiency HPWH were analyzed to consider the impacts of location on performance and cost-effectiveness. These locations included the following:

1. Exterior closet.
2. Interior closet, no ducting.
3. Interior closet, ducted to the outside.

Additional costs for providing electrical wiring to these locations and for providing ductwork were included. Savings are compared to a new 50-gallon natural gas storage water heater (UEF 0.63) or a new 50-gallon electric water heater (UEF 0.92).

For this analysis, a HPWH that just meets the federal minimum efficiency standards of close to 2.0 Uniform Energy Factor (UEF) was evaluated in order to satisfy preemption requirements. However, the Reach Codes Team is not aware of any 2.0 UEF products that are available on the market. The lowest UEF reported for certified products in the Northwest Energy Efficiency Alliance (NEEA)<sup>16</sup> database is 2.73. In fact, of the four certification tiers offered by NEEA for high efficiency HPWHs, those meeting Tier 3 or Tier 4 are the dominant products on the market today. According to NEEA all major HPWH manufacturers are represented in NEEA’s qualified product list<sup>17</sup> and there are fewer than 10 integrated products certified as Tier 1 or Tier 2, all of which have UEFs greater than 3.0.<sup>18</sup> Therefore, in this analysis, we refer to the NEEA rated HPWH as the “market standard” HPWH.

The HPWH costs for the 120V and NEEA certified units are based on a larger (60 or 65 gallon) HPWH, as most contractors are upsizing the HPWH tank size relative to an equal volume, but higher capacity gas storage water heater. Costs include all material and installation labor including providing a new 240 V electrical service to the water heater location (not needed for the 120V product). Water heating equipment lifetimes are based on DOE’s recent water heater rulemaking (Department of Energy, 2022) and assume 15-year EULs for both the baseline water heaters and the HPWHs.<sup>19</sup> Future replacement costs for 240V HPWHs do not include any initial costs associated with 240V electrical service, condensate disposal, etc.

**Table 9. Water Heating Measure Cost Assumptions – Existing Gas**

	Gas Storage Water Heater	240V Fed. Min. HPWH	240V Market Std. NEEA HPWH	240V Market Std. NEEA HPWH + DR	120V Market Std. NEEA HPWH	240V Fed. Min. HPWH, Exterior Closet	240V Fed. Min. HPWH, Interior Closet, Not Ducted	240V Fed. Min. HPWH, Interior Closet, Ducted
First Cost	\$2,951	\$7,283	\$8,144	\$8,144	\$5,844	\$7,702	\$7,363	\$8,442
Replacement Cost (Future Value)	\$2,951	\$6,413	\$7,274	\$7,274	\$5,101	\$6,413	\$6,413	\$6,413
Replacement Cost (Present Value)	\$1,894	\$4,116	\$4,669	\$4,669	\$3,274	\$4,116	\$4,116	\$4,116
Total Lifecycle Cost	\$4,845	\$11,399	\$12,813	\$12,813	\$9,118	\$11,818	\$11,479	\$12,558
<b>Incremental Cost</b>	-	<b>\$6,554</b>	<b>\$7,968</b>	<b>\$7,968</b>	<b>\$4,273</b>	<b>\$6,973</b>	<b>\$6,634</b>	<b>\$7,713</b>

<sup>16</sup> Based on operational challenges experienced in the past, NEEA established rating test criteria to ensure newly installed HPWHs perform adequately, especially in colder climates. The NEEA rating requires products comply with ENERGY STAR and includes requirements regarding noise and prioritizing heat pump use over supplemental electric resistance heating.

<sup>17</sup> <https://neea.org/success-stories/heat-pump-water-heaters>

<sup>18</sup> As of 12/21/23: <https://neea.org/img/documents/residential-unitary-HPWH-qualified-products-list.pdf>

<sup>19</sup> The recent DOE rulemaking references a lifetime of 14 years for gas storage water heaters and 14.8 years for electric storage water heaters. 15 years for each was used in this analysis for both types for simplification.

Table 10 presents similar costs to Table 9, except that the costs assume replacement of an existing 50-gallon electric storage water heater and does not include the 240 V electrical service cost.

**Table 10. Water Heating Measure Cost Assumptions – Existing Electric Resistance**

	Electric Storage Water Heater	240V Fed. Min. HPWH	240V Market Std. NEEA HPWH	240V Market Std. NEEA HPWH + DR	120V Market Std. NEEA HPWH	240V Fed. Min. HPWH, Exterior Closet	240V Fed. Min. HPWH, Interior Closet, Not Ducted	240V Fed. Min. HPWH, Interior Closet, Ducted
First Cost	\$2,583	\$6,413	\$7,274	\$7,274	\$5,101	\$6,413	\$6,413	\$7,492
Replacement Cost (Future Value)	\$2,583	\$6,413	\$7,274	\$7,274	\$5,101	\$6,413	\$6,413	\$6,413
Replacement Cost (Present Value)	\$1,658	\$4,116	\$4,669	\$4,669	\$3,274	\$4,116	\$4,116	\$4,116
Total Lifecycle Cost	\$4,241	\$10,529	\$11,943	\$11,943	\$8,375	\$10,529	\$10,529	\$11,608
<b>Incremental Cost</b>	-	<b>\$6,288</b>	<b>\$7,702</b>	<b>\$7,702</b>	<b>\$4,134</b>	<b>\$6,288</b>	<b>\$6,288</b>	<b>\$7,367</b>

### 3 Results

The primary objective of the evaluation is to identify cost-effective energy upgrade measures and packages for existing single family buildings, to support the design of local ordinances requiring upgrades, which may be triggered by different events, such as at the time of a significant remodel or at burnout of mechanical equipment. In this report, the 1992-2010 vintage is shown for the equipment measures because it is the most conservative case (lowest loads), while the pre-1978 vintage is shown for the envelope and duct measures because some of those measures only apply to the pre-1978 vintage. A full dataset of all results can be downloaded at <https://localenergycodes.com/content/resources>. Results alongside policy options can also be explored using the Cost-effectiveness Explorer at <https://explorer.localenergycodes.com/>.

### 3.1 Cost-Effectiveness Results

The extensive analysis for this type of report leads to an overwhelming number of scenarios including different base cases, house vintages, replacement options, and climate zones. To simplify the reporting, the Statewide Reach Codes Team has relied on graphical representation of select key cases indicating high level measure cost effectiveness from either an On-Bill perspective, an LSC perspective, both metrics, or neither. Figure 1 through Figure 13 present this reduced set of results of the LSC and On-Bill cost-effectiveness conclusions across the 16 climate zones. In the cases where there are multiple utilities serving a single climate zone, an asterisk "\*" label is added to separately show the alternate utility cases. These graphs provide a general sense of the findings. A full dataset of all results can be downloaded at <https://localenergycodes.com/content/resources>. Results alongside policy options can also be explored using the Cost-effectiveness Explorer at <https://explorer.localenergycodes.com/>.

#### 3.1.1 HPSH Measures

Figure 1 through Figure 5 show the cost-effectiveness of space heating equipment replacement measures for the 1992-2010 vintage including the following cases. The 1992-2010 vintage results are presented here as this is the most conservative scenario for HPSH measures. In general, where a HPSH measure is cost-effective for a new home it was also found to be cost-effective for older homes.

- Dual fuel heat pump with existing furnace as backup.
- Standard efficiency ducted central heat pump replacement.
- High efficiency ducted central heat pump replacement.
- Ducted mini-split heat pump replacement.
- Standard efficiency ducted central heat pump replacement with 3kW PV system.

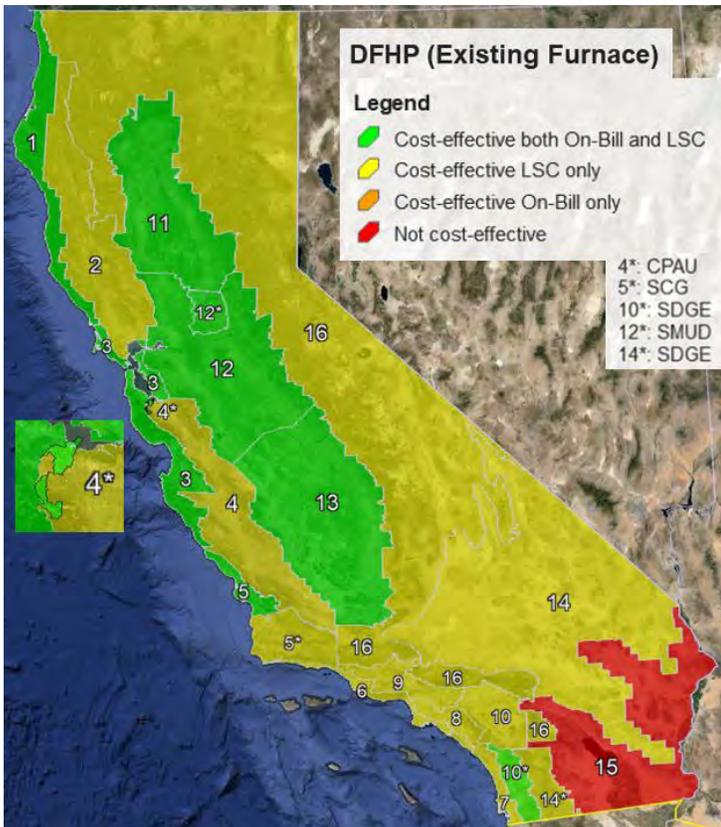


Figure 1: DFHP with Existing Furnace

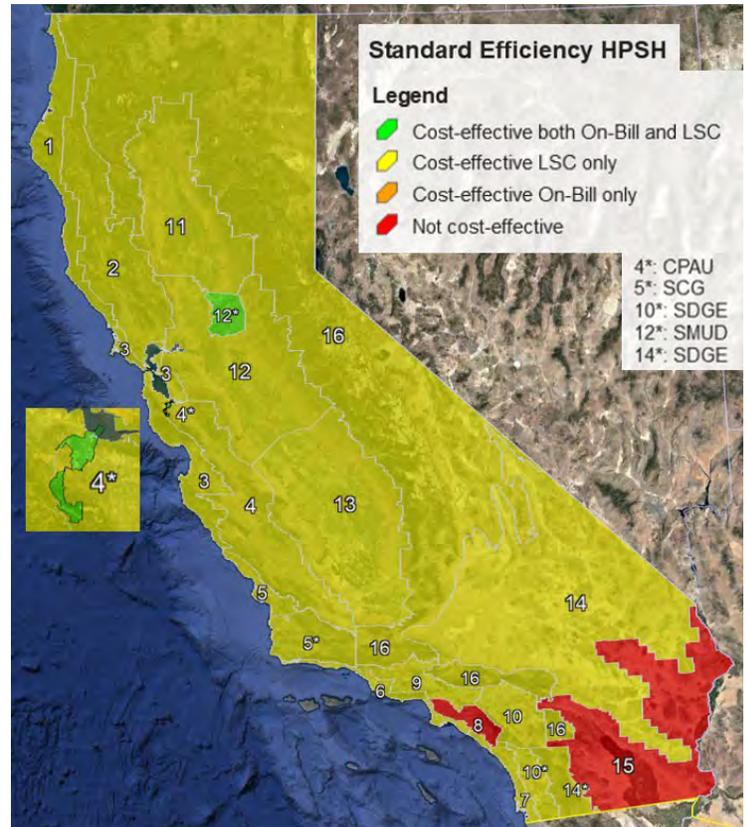


Figure 2: Standard Efficiency HPSH

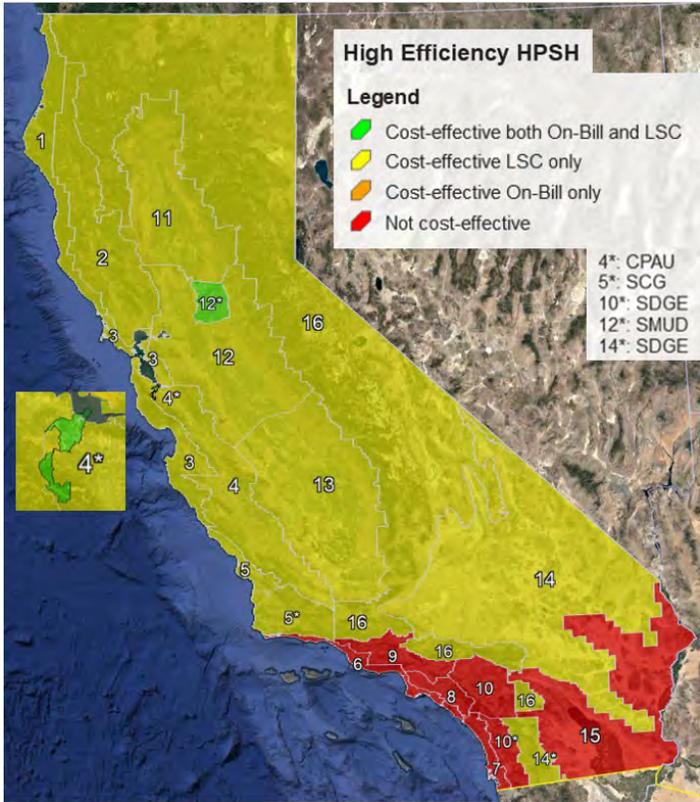


Figure 3: High Efficiency HPSH

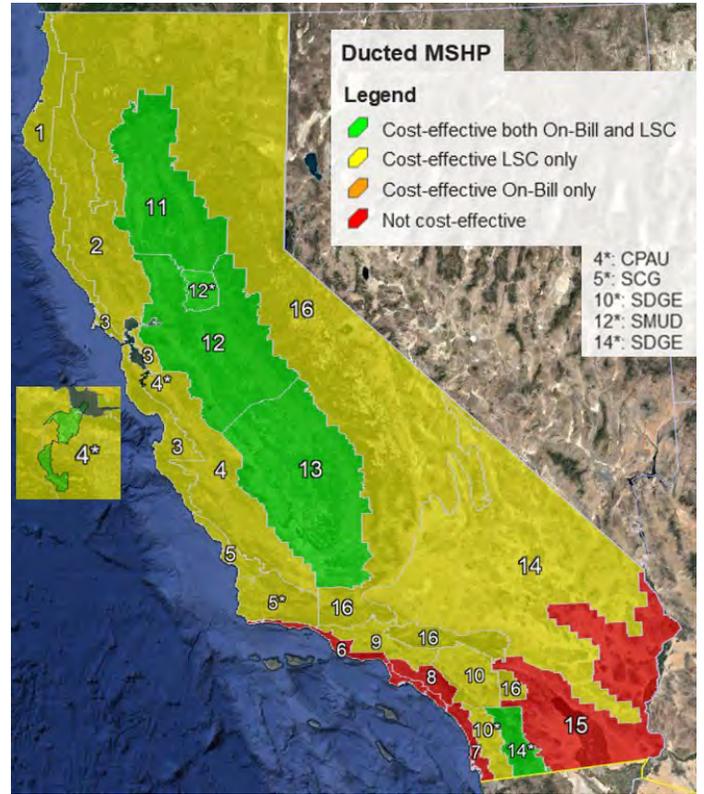


Figure 4: Ducted MSHP

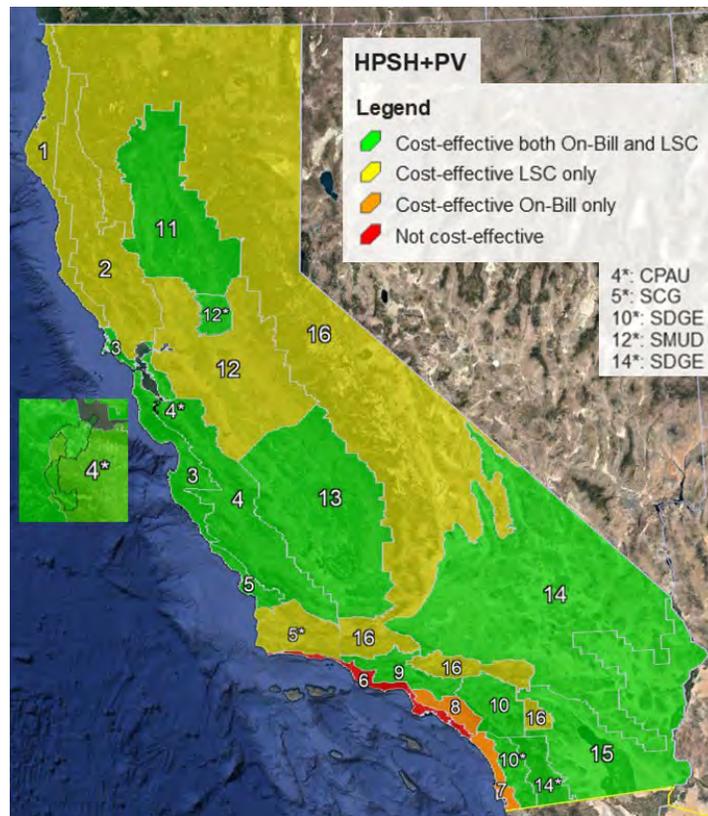


Figure 5: HPSH + PV

### 3.1.2 HPWH Measures

Figure 6 through Table 11 show the cost-effectiveness of water heater measures for the 1992-2010 vintage including the following cases. HPWH energy savings and LSC cost-effectiveness is not sensitive to home vintage but rather depends on the magnitude of hot water loads, which are typically driven by the number of occupants. On-Bill cost-effectiveness does vary slightly by vintage due to the impact of the electrification tariff relative to the load profile of the existing home. The impact is largest for the HPWH + PV case where On-Bill cost-effectiveness improves for older homes or homes with overall higher energy use resulting in less exports to the grid for a fixed size PV system.

- 240V federal minimum HPWH
- 240V market standard NEEA HPWH
- 120V market standard NEEA HPWH
- 240V federal minimum HPWH with 3kW PV

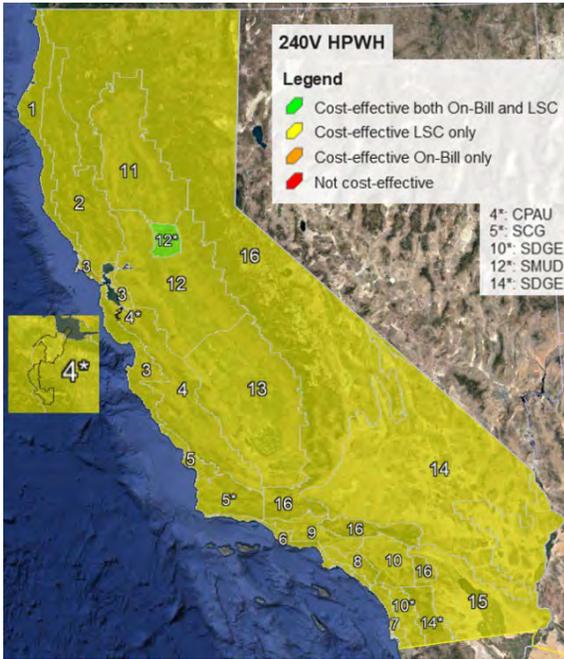


Figure 6: 240V Federal Minimum HPWH

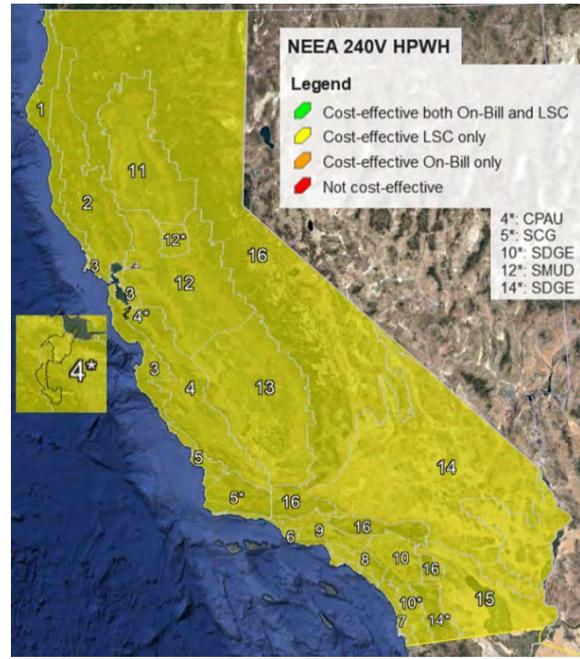


Figure 7: 240V Market Standard NEEA HPWH

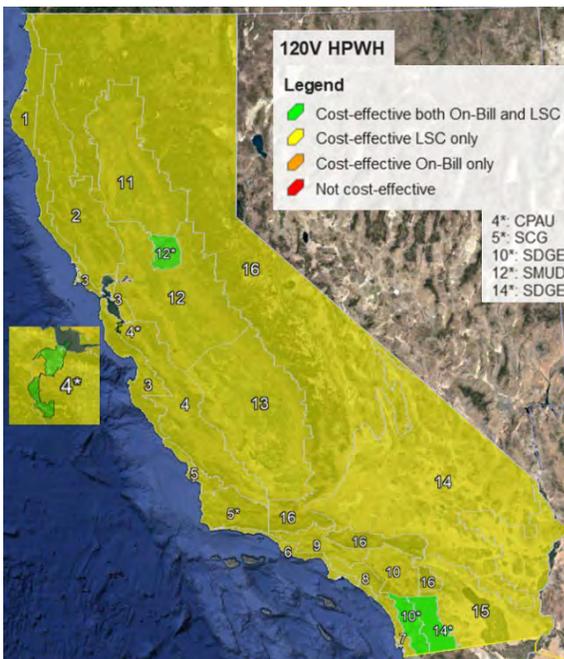


Figure 8: 120V Market Standard NEEA HPWH

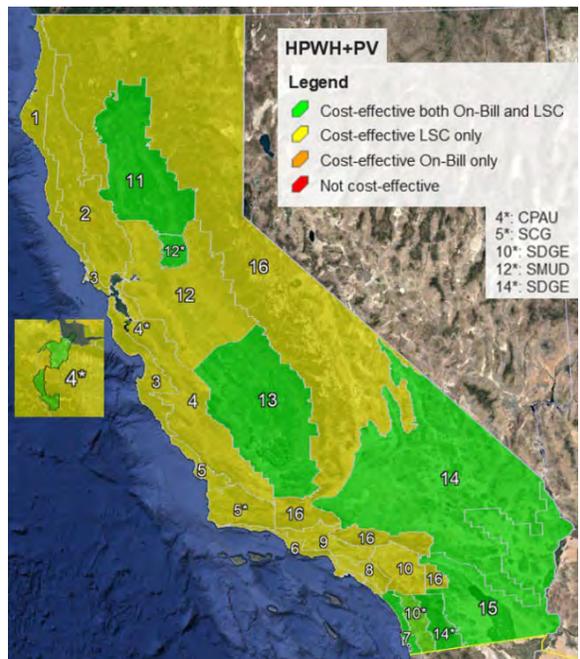
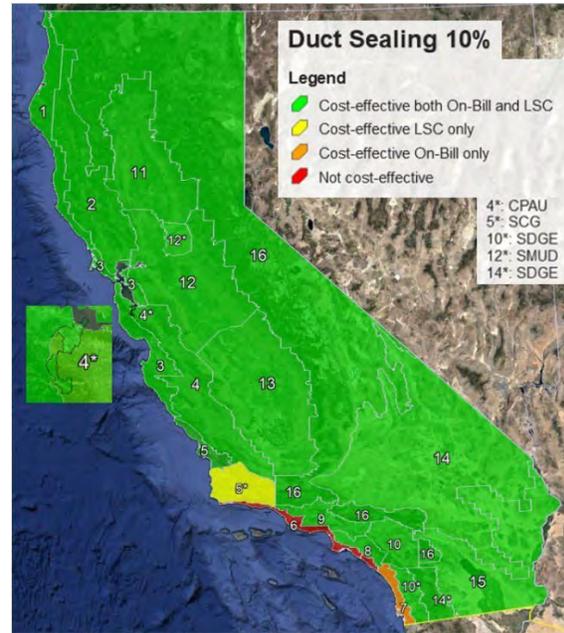
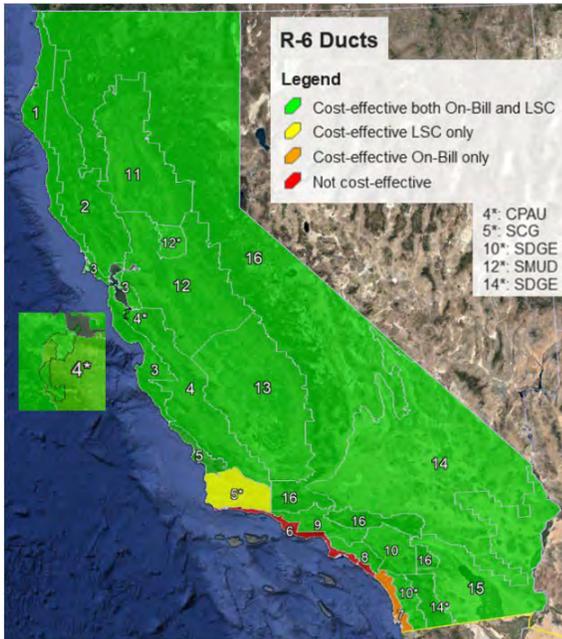


Figure 9: 240V Federal Minimum HPWH + PV

- Envelope and Duct Measures

Figure 10 through Figure 13 show the cost-effectiveness results of envelope and duct measures for the pre-1978 vintage including the following measures. The pre-1978 vintage is presented as representing the most favorable existing conditions for cost-effective upgrades. Newer homes with higher performing envelope may still benefit from these types of upgrade measures, but cost-effectiveness is reduced. Some measures, like R-13 wall insulation, aren't applicable to newer homes which would have been constructed originally with insulated walls.

- New R-6 ducts
- 10% duct leakage
- R-13 wall insulation
- R-49 attic insulation



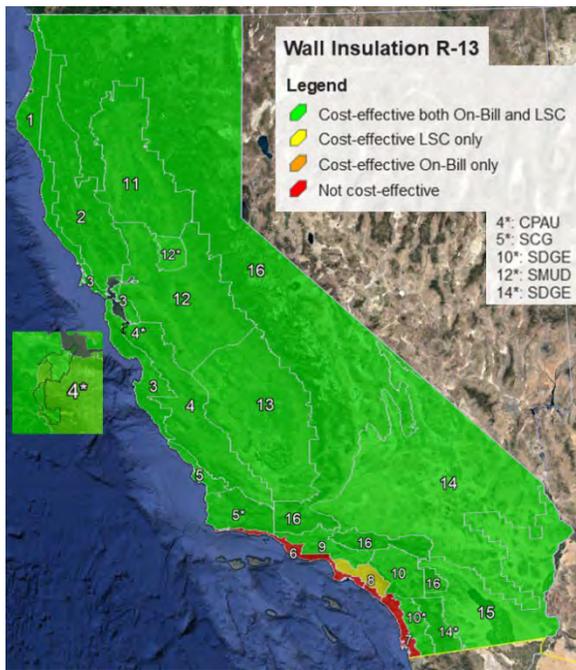


Figure 10: R-6 Ducts

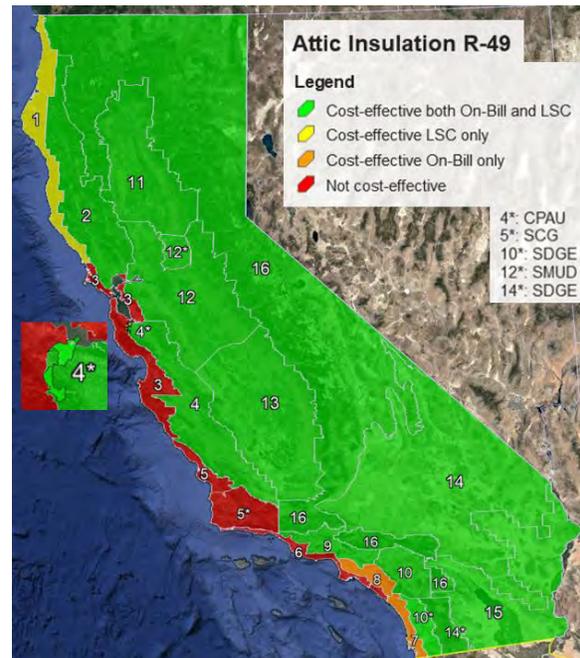


Figure 11: 10% Duct Leakage

Figure 12: R-13 Wall Insulation

Figure 13: R-49 Attic Insulation

### 3.2 Climate Zone Case Studies

To better understand the details of the results, a few climate zones were selected to provide a more detailed presentation of cost-effectiveness results. Section 3.2.1 through 3.2.3 show the first-year incremental cost, first-year utility savings, and NPV for a variety of cases. Section 3.2.4 shows the sensitivity of the cost effectiveness results due to varying utility escalation rates, the impact of CARE rates, future equipment cost assumptions, and the need for electrical panel upgrades. The climate zones were selected to be representative of areas of significant reach code activity. Please refer to the Cost-Effectiveness Explorer (Statewide Reach Codes, 2023) or the source dataset for the full analysis.

### 3.2.1 HPSH Cost-Effectiveness

Cost-effectiveness of heat pump space heating measures for Climate Zones 12 and 16 is summarized in Table 11 and Table 12 below. In Climate Zone 12, HPSH measures are cost-effective based on LSC in all cases except the ductless MSHP cases and are cost-effective On-Bill with SMUD rates in all cases except the DFHP case with a new furnace and the ductless MSHP cases. These measures are cost-effective On-Bill with PGE for the DFHP with an existing furnace and ducted MSHP measures. Climate Zone 16 provides an example of HPSH cost-effectiveness in a cold climate where almost all HPSH measures are cost effective based on LSC but not cost-effective On-Bill.

**Table 11. HPSH CZ 12 [1992-2010]**

Measure	First Incremental Cost	2025 LSC NPV	PGE		SMUD	
			First-year Utility Savings	On-Bill NPV	First-year Utility Savings	On-Bill NPV
DFHP Existing Furnace	\$1,960	\$7,093	(\$19)	\$1,633	\$247	\$7,693
DFHP New Furnace	\$4,023	\$3,915	(\$34)	(\$3,134)	\$234	\$2,979
HPSH (Std Efficiency)	\$1,172	\$6,990	(\$147)	(\$2,151)	\$246	\$6,812
HPSH (High Efficiency)	\$4,149	\$5,366	\$13	(\$3,368)	\$300	\$3,160
Ducted MSHP	\$1,421	\$9,136	\$10	\$378	\$298	\$6,951
Ductless MSHP (Std Efficiency)	\$13,336	(\$9,175)	\$30	(\$18,039)	\$276	(\$12,428)
Ductless MSHP (High Efficiency)	\$17,266	(\$6,753)	\$409	(\$15,853)	\$423	(\$15,532)
HPSH + PV	\$10,780	\$5,289	\$452	(\$59)	\$885	\$9,821

**Table 12. HPSH CZ 16 [1992-2010]**

Measure	First Incremental Cost	2025 LSC NPV	PGE	
			First-year Utility Savings	On-Bill NPV
DFHP Existing Furnace	\$2,397	\$7,289	(\$116)	(\$1,891)
DFHP New Furnace	\$4,757	\$2,457	(\$133)	(\$6,322)
HPSH (Std Efficiency)	\$2,725	\$11,142	(\$480)	(\$8,532)
HPSH (High Efficiency)	\$5,701	\$12,099	(\$204)	(\$7,125)
Ducted MSHP	\$2,155	\$16,554	(\$221)	(\$2,853)
Ductless MSHP (Std Efficiency)	\$13,336	(\$134)	(\$170)	(\$19,742)
Ductless MSHP (High Efficiency)	\$17,266	\$9,397	\$539	(\$10,031)
HPSH + PV	\$12,333	\$10,640	\$316	(\$1,949)

### 3.2.2 HPWH Cost-Effectiveness

Cost-effectiveness of heat pump water heating measures for Climate Zones 12 and 16 is summarized in Table 13 and Table 14 below. This sensitivity study looks at a wider range of HPWH tank locations and whether or not the unit has ducting for supply and exhaust air. All the HPWH measures in Climate Zones 12 and 16 are cost effective based on LSC.

**Table 13. HPWH CZ 12 [1992-2010]**

Measure	First Incremental Cost	2025 LSC NPV	PGE		SMUD	
			First-Year Utility Savings	On-Bill NPV	First-Year Utility Savings	On-Bill NPV
240V Fed. Min. HPWH	\$4,332	\$3,536	(\$213)	(\$8,738)	\$191	\$477
240V Market Std. NEEA HPWH	\$5,193	\$4,304	(\$82)	(\$7,164)	\$230	(\$56)
240V Market Std. NEEA HPWH + DR	\$5,193	\$5,536	(\$21)	(\$5,773)	\$248	\$362
120V Market Std. NEEA HPWH	\$2,893	\$9,730	(\$2)	(\$1,651)	\$254	\$4,203
240V Fed. Min. HPWH (Exterior Closet)	\$4,751	\$2,834	(\$224)	(\$9,431)	\$186	(\$78)
240V Fed. Min. HPWH (Interior Closet)	\$4,413	\$3,123	(\$71)	(\$6,138)	\$188	(\$235)
240V Fed. Min. HPWH (Interior Closet, ducted)	\$5,492	\$3,359	(\$202)	(\$9,505)	\$205	(\$231)
240V Fed. Min. HPWH + PV	\$13,940	\$3,567	\$577	(\$2,300)	\$831	\$3,486

**Table 14. HPWH CZ 16 [1992-2010]**

Measure	First Incremental Cost	2025 LSC NPV	PGE	
			First-Year Utility Savings	On-Bill NPV
240V Fed. Min. HPWH	\$4,332	\$4,186	(\$250)	(\$9,307)
240V Market Std. NEEA HPWH	\$5,193	\$4,088	(\$160)	(\$8,652)
240V Market Std. NEEA HPWH + DR	\$5,193	\$5,653	(\$79)	(\$6,804)
120V Market Std. NEEA HPWH	\$2,893	\$10,646	(\$13)	(\$1,602)
240V Fed. Min. HPWH (Exterior Closet)	\$4,751	\$3,317	(\$268)	(\$10,154)
240V Fed. Min. HPWH (Interior Closet)	\$4,413	\$5,004	(\$18)	(\$4,690)
240V Fed. Min. HPWH (Interior Closet, ducted)	\$5,492	\$4,857	(\$202)	(\$9,174)
240V Fed. Min. HPWH + PV	\$13,940	\$5,049	\$620	(\$1,043)

### 3.2.3 Envelope & Duct Improvement Cost-Effectiveness

Cost-effectiveness of envelope and duct measures for Climate Zones 3, 10, and 12 is summarized in Table 15 through Table 17.

**Table 15. Envelope and Duct Measures CZ 3 [Pre-1978]**

Measure	First Incremental Cost	2025 LSC NPV	PG&E	
			First-year Utility Savings	On-Bill NPV
R-6 Ducts	\$4,808	\$2,851	\$188	\$463
R-8 Ducts	\$6,311	\$1,747	\$198	(\$776)
10% Duct Sealing	\$2,590	\$1,956	\$104	\$397
R-13 Wall Insulation	\$2,950	\$3,476	\$144	\$1,221
R-38 Attic Insulation	\$6,762	(\$1,567)	\$127	(\$3,178)
R-49 Attic Insulation	\$7,446	(\$1,768)	\$139	(\$3,520)
R-30 Raised Floor Insulation	\$4,113	\$9,008	\$224	\$2,975
Cool Roof (0.20 Ref)	\$893	(\$2,419)	(\$18)	(\$1,811)

**Table 16. Envelope and Duct Measures CZ 10 [Pre-1978]**

Measure	First Incremental Cost	2025 LSC NPV	SCE/SCG		SDGE	
			First-year Utility Savings	On-Bill NPV	First-year Utility Savings	On-Bill NPV
R-6 Ducts	\$4,808	\$7,463	\$783	\$13,168	\$1,100	\$22,155
R-8 Ducts	\$6,311	\$6,326	\$800	\$12,076	\$1,125	\$21,268
10% Duct Sealing	\$2,590	\$3,438	\$370	\$5,969	\$518	\$10,166
R-13 Wall Insulation	\$2,950	\$1,795	\$179	\$1,476	\$250	\$3,494
R-38 Attic Insulation	\$6,762	\$664	\$416	\$2,951	\$582	\$7,654
R-49 Attic Insulation	\$7,446	\$796	\$467	\$3,435	\$655	\$8,756
R-30 Raised Floor Insulation	\$4,113	(\$999)	(\$29)	(\$4,235)	(\$46)	(\$4,687)
Cool Roof (0.20 Ref)	\$893	\$428	\$174	\$2,647	\$246	\$4,656

**Table 17. Envelope and Duct Measures CZ 12 [Pre-1978]**

Measure	First Incremental Cost	2025 LSC NPV	PG&E		SMUD	
			First-year Utility Savings	On-Bill NPV	First-year Utility Savings	On-Bill NPV
R-6 Ducts	\$4,808	\$11,609	\$804	\$14,727	\$413	\$5,816
R-8 Ducts	\$6,311	\$10,722	\$828	\$13,849	\$427	\$4,711
10% Duct Sealing	\$2,590	\$6,418	\$397	\$7,280	\$222	\$3,281
R-13 Wall Insulation	\$2,950	\$5,774	\$262	\$4,054	\$187	\$2,342
R-38 Attic Insulation	\$6,762	\$3,727	\$499	\$5,461	\$261	\$19
R-49 Attic Insulation	\$7,446	\$4,092	\$552	\$6,063	\$288	\$33
R-30 Raised Floor Insulation	\$4,113	\$5,245	\$27	(\$1,176)	\$156	\$1,175
Cool Roof (0.20 Ref)	\$893	(\$354)	\$154	\$2,123	\$44	(\$386)

### 3.2.4 Sensitivities

Table 18 shows the On-Bill NPV results of Climate Zone 12 with PG&E utility rates and the impacts of escalation rates, and CARE rates. The “Standard Results” in Table 18 assumes the escalation rates used in the analysis presented elsewhere in this report. Table 19 shows the impact of electrical panel upgrades. The “Standard Results” in Table 19 does not assume a panel upgrade is required.

**Table 18. Sensitivity Analysis Results for On-Bill NPV Cost-Effectiveness in Climate Zone 12, PG&E**

Measure	Vintage	Standard Results	2025 LSC Escalation	CARE
DFHP Existing Furnace	1992-2010	\$1,063	\$8,443	\$1,884
DFHP New Furnace	1992-2010	(\$6,770)	\$383	(\$5,846)
HPSH (Std Efficiency)	1992-2010	(\$2,151)	\$6,011	(\$220)
HPSH (High Efficiency)	1992-2010	(\$3,368)	\$4,987	(\$2,721)
Ducted MSHP	1992-2010	\$378	\$8,729	\$1,057
Ductless MSHP (Std Efficiency)	1992-2010	(\$18,039)	(\$10,732)	(\$17,623)
Ductless MSHP (High Efficiency)	1992-2010	(\$15,853)	(\$8,091)	(\$18,460)
HPSH + PV	1992-2010	(\$59)	\$8,822	(\$1,255)
240V Fed. Min. HPWH	1992-2010	(\$8,738)	(\$2,433)	(\$6,448)
240V Market Std. NEEA HPWH	1992-2010	(\$7,164)	(\$694)	(\$5,918)
240V Market Std. NEEA HPWH + DR	1992-2010	(\$5,773)	\$770	(5,014)
120V Market Std. NEEA HPWH	1992-2010	(\$1,651)	\$4,930	(1,038)
240V Fed. Min. HPWH (Exterior Closet)	1992-2010	(\$9,431)	(\$3,184)	(\$7,055)
240V Fed. Min. HPWH (Interior Closet)	1992-2010	(\$6,138)	(\$1,000)	(\$5,098)
240V Fed. Min. HPWH (Interior Closet, ducted)	1992-2010	(\$9,505)	(\$2,836)	(\$7,271)
240V Fed. Min. HPWH + PV	1992-2010	(\$2,300)	\$4,952	(\$4,858)
R-6 Ducts	Pre-1978	\$14,727	\$18,685	\$8,592
R-8 Ducts	Pre-1978	\$13,849	\$17,990	\$7,532
10% Duct Sealing	Pre-1978	\$7,280	\$9,752	\$4,294
R-13 Wall Insulation	Pre-1978	\$4,054	\$6,898	\$2,196
R-38 Attic Insulation	Pre-1978	\$5,461	\$8,126	\$1,668
R-49 Attic Insulation	Pre-1978	\$6,063	\$8,978	\$1,864
R-30 Raised Floor Insulation	Pre-1978	(\$1,776)	\$2,468	(\$1,602)
Cool Roof (0.20 Ref)	Pre-1978	\$2,123	\$1,848	\$851

**Table 19. Electric Panel Upgrade Sensitivity for CZ 12 [1992-2010]**

Measure	Standard Results		Electric Panel Upgrade	
	On-Bill NPV	LSC NPV	On-Bill NPV	LSC NPV
HPSH (Std Efficiency)	(\$2,151)	\$6,990	(\$4,931)	\$4,210
240V Fed. Min. HPWH	(\$8,738)	\$3,536	(\$11,624)	\$756

### 3.3 Gas Pathways for Heat Pump Replacements

Many jurisdictions are exploring policy options to accelerate the decarbonization of existing homes. A recent Ninth Circuit Court ruling in *California Rest. Ass'n v. City of Berkeley*<sup>20</sup> invalidated Berkeley's ordinance banning the installation of gas infrastructure in new construction. The ruling stated that the ordinance effectively banned covered products and was preempted by the Energy Policy and Conservation Act ("EPCA"), 42 U.S.C. § 6297(c). Given the possible impacts of that ruling, the Reach Codes Team analyzed policy options targeting equipment replacements that allow for the installation of either electric or gas-fueled equipment. These packages include gas equipment combined with additional efficiency measures resulting in options that are reasonably energy or LSC cost equivalent, to the extent feasible.

For space heating, the heat pump path is a DFHP (existing furnace).. The gas pathway is a new air conditioner with the following list of efficiency upgrades:

- 400 cfm/ton system airflow (HERS verified).
- 0.35 W/cfm fan efficacy (HERS verified).
- Refrigerant charge verification (HERS verified).
- R-8 ducts, 5% leakage (HERS verified).
- R-49 (from R-30) attic insulation.
- Air sealing of the ceiling from 7 to 6.5 ACH50.

The two pathways are presented in Figure 14 comparing total LSC energy use relative to the existing home for the 1992-2010 vintage. In most climate zones, the DFHP (existing furnace) path results in higher energy savings, in the milder climates the air conditioner path saves marginally more energy. A reach code that establishes requirements when an air conditioner is replaced or installed new, could allow for either a heat pump to be installed or an air conditioner as long as the performance measures listed above are met. Note that in this analysis a DFHP (existing furnace) was used; however, a reach code could require a different heat pump measure for the heat pump path. This approach aligns with the CEC's proposal for the 2025 Title 24 code cycle for heat pump alterations in single family homes (California Energy Commission, 2023).

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<sup>20</sup> *California Rest. Ass'n v. City of Berkeley*, 65 F.4th 1045 (9th Cir. 2023) amended by 89 F.4th 1094 (9th Cir. 2024).

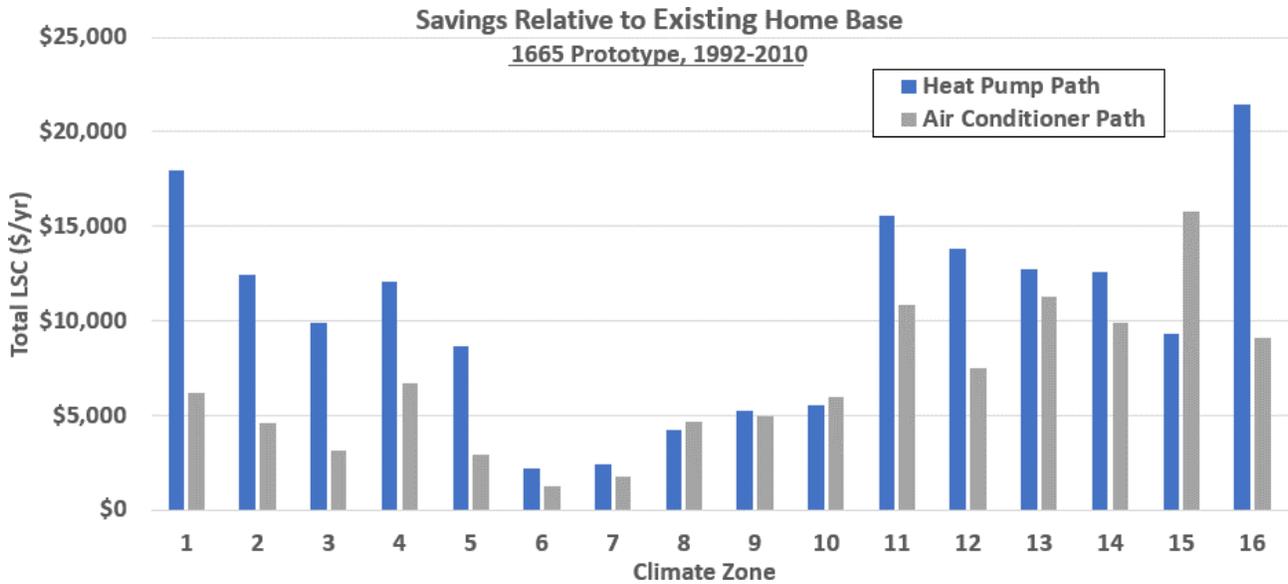


Figure 14. Heat pump space heater path compared to the air conditioner path.

For water heating, the federal minimum HPWH case was used to develop the package. The HPWH was compared to a new gas storage water heater with a 50% solar thermal backup system.

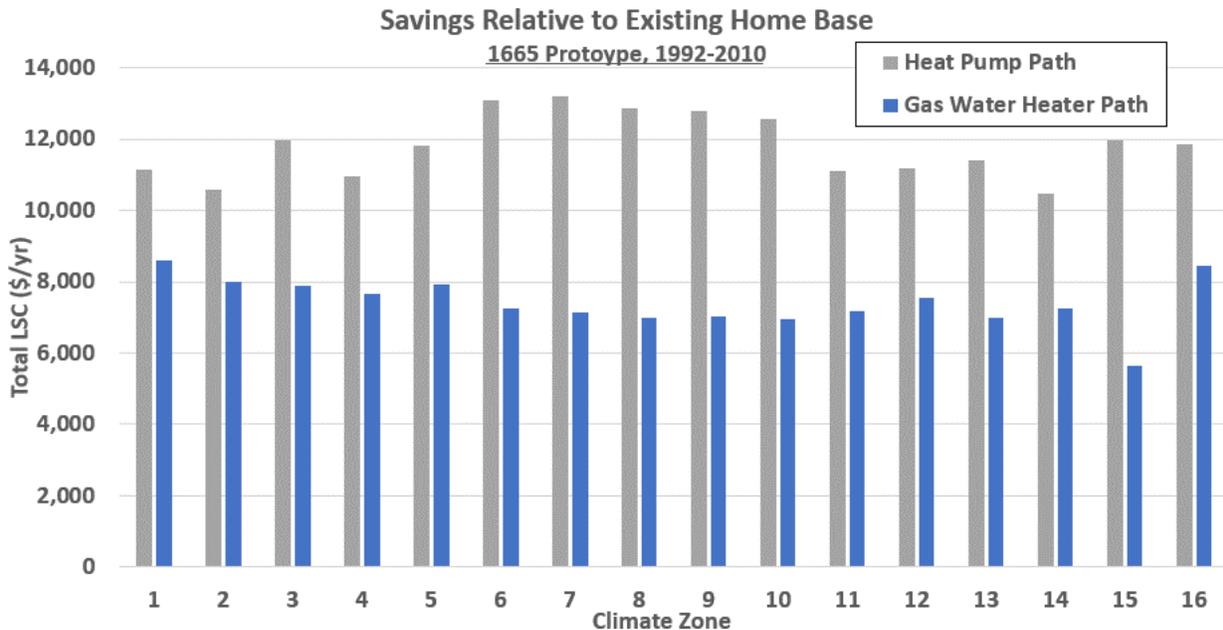


Figure 15. Heat pump water path compared to gas with solar thermal.

The two pathways are presented in Figure 15 comparing total LSC energy use relative to the existing home for the 1992-2010 vintage. In all climate zones, the heat pump path results in higher energy savings than the gas path. A reach code that establishes requirements when a water heater is replaced could allow for either a HPWH to be installed or a gas water heater in combination with a solar thermal system that meets the solar fraction requirements listed above.

## 4 Recommendations and Discussion

This analysis evaluated the feasibility and cost-effectiveness of retrofit measures in California existing homes built before 2010. The Statewide Reach Codes Team used both On-Bill and LSC-based LCC approaches to evaluate cost-effectiveness and quantify the energy cost savings associated with energy efficiency measures compared to the incremental costs associated with the measures.

### Conclusions and Discussion:

1. Envelope measures. Improving envelope performance is very cost-effective in many older homes. In addition to reducing utility costs these measures provide many other benefits such as improving occupant comfort and satisfaction and increasing a home's ability to maintain temperatures during extreme weather events and power outages. Below is a discussion of the results of specific measures.
  - a. Adding attic insulation is cost effective based on both LSC and On-Bill in many climate zones in homes with no more than R-19 existing attic insulation levels. Increasing attic insulation from R-30 to R-49 was still found to be cost-effective based on at least one metric in the colder and hotter climates of Climate Zone 10 (SDG&E territory only) through 16.
  - b. Insulating existing uninsulated walls is very cost-effective based on both metrics everywhere except Climate Zones 6 and 7 (in Climate Zone 8 it's only cost-effective based on LSC).
  - c. Adding R-19 or R-30 floor insulation is cost-effective based on LSC in the older two vintages (Pre-1978 and 1978-1991) in all climate zones except Climate Zones 6-10.
  - d. Replacing old single pane windows with new high-performance windows has a very high cost and is typically not done for energy savings alone. However, energy savings are substantial and justify cost-effectiveness of this measure based on at least one metric in Climate Zones 4, 8 through 12 (PG&E territory only), and 13 through 16.
  - e. At time of roof replacement, a cool roof with an aged solar reflectance of 0.25 was found to be cost-effective in Climate Zones 4, 6 through 12 (PG&E territory only), and 13 through 15. When the roof deck is replaced during a roof replacement, adding a radiant barrier is low cost and provides substantial cooling energy savings to be cost-effective in almost all climate zones and homes.
2. Duct measures: Many older homes have old, leaky duct systems that should be replaced when they reach the end of life, typically 20-30 years. In this case, installing new ducts was found to be cost-effective based on at least one metric (both in most cases) everywhere except mild Climate Zone 7 and Climate Zones 5 and 6 in the 1978-1991 vintage. If duct systems still have remaining life they should be sealed and tested to meet 10% leakage or lower; however, duct upgrades alone were only found to be cost-effective for newer homes in Climate Zones 10 (SDG&E territory only), 11, and 13 through 16. Duct upgrades may be able to be coupled with other measures to reduce the cost.
3. Heat pump space heating: HPSHs were found to be LSC cost-effective in many cases. The DFHP (existing furnace) was LSC cost-effective everywhere except Climate Zone 15. The HPSH was LSC cost-effective everywhere except Climate Zones 8 and 15.
  - a. Challenges to On-Bill cost-effectiveness include higher first costs and higher first-year utility costs due to higher electricity tariffs relative to gas tariffs. SMUD and CPAU are two exceptions where first year utility costs are lower for heat pumps than for gas equipment. Table 11 shows the impact of utility rates on cost-effectiveness of HPSH where the standard and high efficiency HPSH and the HPSH + PV measures are cost-effective under SMUD but not PG&E. Even with higher first year utility bills, there were some cases that still proved On-Bill cost-effective including the DFHP with an existing furnace in the central valley and northern coastal PG&E territories, the ducted MSHP in the central valley as well as Climate Zone 14 in SDG&E territory, and the HPSH + PV measure in CZ 3-5 (PGE), 7-11, and 12 (SMUD) – 15.
  - b. The ductless MSHPs, evaluated for homes with existing ductless systems, were only found to be cost-effective based on either metric in Climate Zones 1 and 16. Ductless MSHPs have a high incremental cost because it is a more sophisticated system than the base model of a wall furnace with a window AC unit. However, the ductless MSHP would provide greater comfort benefits if properly installed to

directly condition all habitable spaces (as is required under the VCHP compliance credit as evaluated in this study) which may be an incentive for a homeowner to upgrade their system.

- c. Higher efficiency equipment lowered utility costs in all cases and improved cost-effectiveness in many cases, particularly with a ducted MSHP.
4. Heat pump water heating: All the HPWH measures were LSC cost-effective in all climate zones. Most measures were not On-Bill cost-effective with the exception of the HPWH + PV which was cost-effective On-Bill in CPAU, SMUD, and SDG&E territories in addition to Climate Zones 11, 13, 14, and 15. The HPWH measures share many of the same challenges as the HPSH measures to achieving cost-effectiveness including high first costs and utility rates and assumptions. Table 13 shows the impact of utility rates on cost-effectiveness where some HPWH measures are cost-effective under SMUD utility rates but are not cost-effective anywhere under PG&E rates in Climate Zone 12.
    - a. Various HPWH locations were also explored, however there are some factors outside of cost-effectiveness that should also be considered.
      - i. HPWHs in the conditioned space can provide benefits such as free cooling during the summer, reduced tank losses, and shorter pipe lengths, and in some cases show improved cost-effectiveness over garage located HPWHs. However, there are various design considerations such as noise, comfort concerns, and condensate removal. Ducting the inlet and exhaust air resolves comfort concerns but adds costs and complexity. Split heat pump water heaters address these concerns, but currently there are limited products on the market and there is a cost premium relative to the packaged products.
      - ii. Since HPWHs extract heat from the air and transfer it to water in the storage tank, they must have adequate ventilation to operate properly. Otherwise, the space cools down over time, impacting the HPWH operating efficiency. This is not a problem with garage installations but needs to be considered for water heaters located in interior or exterior closets. For the 2025 Title 24 code the CEC is proposing that all HPWH installations meet mandatory ventilation requirements (California Energy Commission, 2023).
  5. The contractor surveys revealed overall higher heat pump costs than what has been found in previous analyses. This could be due to incentive availability raising demand for heat pumps and thereby increasing the price. This price increase may be temporary and may come down once the market stabilizes. There are also new initiatives to obtain current costs including the TECH Clean California program<sup>21</sup> that publishes heat pump data and costs; however, at the time of this analysis, the TECH data did not contain incremental costs because it only had the heat pump costs but not the gas base case costs.
  6. Table 18 shows how CARE rates and escalation rate assumptions will impact cost-effectiveness.
    - a. Applying CARE rates in the IOU territories has the overall impact to increase utility cost savings for an all-electric building compared to a code compliant mixed fuel building, improving On-Bill cost-effectiveness. This is due to the CARE discount on electricity being higher than that on gas. The reverse occurs with efficiency measures where lower utility rates reduce savings and subsequently reduce cost-effectiveness.
    - b. If gas tariffs are assumed to increase substantially over time, in-line with the escalation assumption from the 2025 LSC development, cost-effectiveness substantially improves for the heat pump measures over the 30-year analysis period and many cases become cost-effective that were not found to be cost-effective under the CPUC / 2022 TDV escalation scenario. There is much uncertainty surrounding future tariff structures as well as escalation values. While it's clear that gas rates will increase, how much and how quickly is not known. Future electricity tariff structures are expected to evolve over time, and the CPUC has an active proceeding to adopt an income-graduated fixed charge that benefits low-income customers and supports electrification measures for all customers.<sup>22</sup> The CPUC will decide in mid-2024 and the new rates are expected to be in place later that year or in 2025.

<sup>21</sup> [TECH Public Reporting Home Page \(techcleanca.com\)](https://www.techcleanca.com)

<sup>22</sup> <https://www.cpuc.ca.gov/industries-and-topics/electrical-energy/electric-costs/demand-response-dr/demand-flexibility-rulemaking>

While the anticipated impact of this rate change is lower volumetric electricity rates, the rate design is not finalized. While lower volumetric electricity rates provide many benefits, it also will make building efficiency measures harder to justify as cost-effective due to lower utility bill cost savings.

7. Under NBT, utility cost savings for PV are substantially less than what they were under prior net energy metering rules (NEM 2.0); however, savings are sufficient to be On-Bill cost-effective in all climate zones except Climate Zones 1 through 3 and 5 through 6.
  - a. Combining a heat pump with PV allows the additional electricity required by the heat pump to be offset by the PV system while also increasing on-site utilization of PV generation rather than exporting the electricity back to the grid at a low rate.
  - b. While not evaluated in this study, coupling PV with battery systems can be very advantageous under NBT increasing utility cost savings because of improved on-site utilization of PV generation and fewer exports to the grid.

Recommendations:

1. There are various approaches for jurisdictions who are interested in reach codes for existing buildings. Some potential approaches are listed below along with key considerations.
  - a. Prescriptive measures: Non-preempted measures that are found to be cost-effective may be prescriptively required in a reach code. One example of this type of ordinance is a cool roof requirement at time of roof replacement. Another example is requiring specific cost-effective measures for larger remodels, such as high-performance windows when new windows are installed or duct sealing and testing where ducts are in unconditioned space.
  - b. Replacement equipment: This flavor of reach code sets certain requirements at time of equipment replacement. This study evaluated space heating and water heating equipment. Where a heat pump measure was found to be cost-effective based on either LSC or On-Bill, this may serve as the basis of a reach code given the following considerations.
    - i. Where reach codes reduce energy usage and are not just fuel switching, cost-effectiveness calculations are required and must be based on equipment that does not exceed the federal minimum efficiency requirements.
    - ii. Where reach codes are established using cost-effectiveness based on LSC, utility bill impacts and the owner's first cost should also be reviewed and considered.
    - iii. A gas path should also be prescriptively allowed to safely satisfy federal preemption requirements considering the CRA v. Berkeley case.<sup>23</sup> Additional requirements may apply to the gas path, as described in Section 3.3, as long as the paths are reasonably energy or cost equivalent.
  - c. "Flexible Path", minimum energy savings target: This flexible approach establishes a target for required energy savings based on a measure or a set of measures that were found to be cost-effective based on either LSC or On-Bill. A points menu compares various potential upgrades ranging from efficiency, PV, and fuel substitution measures, based on site or source energy savings. The applicant must select upgrades that individually or in combination meet the minimum energy savings target. The measures used to set the target should be non-preempted measures.
2. Equipment replacement ordinances should consider appropriate exceptions for scenarios where it will be challenging to meet the requirements, such as location of the HPWH, total project cost limitations, or the need for service panel upgrades that wouldn't have been required as part of the proposed scope of work in absence of the reach code.
3. Consider extending relevant proposals made by the CEC for the 2025 Title 24 code (California Energy Commission, 2023) in ordinances that apply under the 2022 Title 24 code, such as the following:
  - a. Mandatory ventilation requirements for HPWH installations (Section 110.3(c)7).

<sup>23</sup> <https://www.publichealthlawcenter.org/sites/default/files/2024-01/CRA-v-Berkeley-Ninth-Circuit-Opinion-Jan2024.pdf>

- b. Requirement for HERS verified refrigerant charge verification for heat pumps in all climate zones (Table 150.1-A<sup>24</sup>).
4. When evaluating reach code strategies, the Reach Codes Team recommends that jurisdictions consider combined benefits of energy efficiency alongside electrification. Efficiency and electrification have symbiotic benefits and are both critical for decarbonization of buildings. As demand on the electric grid is increased through electrification, efficiency can reduce the negative impacts of additional electricity demand on the grid, reducing the need for increased generation and storage capacity, as well as the need to upgrade upstream transmission and distribution equipment.
5. Education and training can play a critical role in ensuring that heat pumps are installed, commissioned, and controlled properly to mitigate grid impacts and maximize occupant satisfaction. Below are select recommended strategies.
  - a. The Quality Residential HVAC Services Program<sup>25</sup> is an incentive program to train California contractors in providing quality installation and maintenance while advancing energy-efficient technologies in the residential HVAC industry. Jurisdictions can market this to local contractors to increase the penetration of contractors skilled in heat pump design and installation.
  - b. Educate residents and contractors of available incentives, tax credits, and financing opportunities.
  - c. Educate contractors on code requirements. Energy Code Ace provides free tools, trainings, and resource to help Californians comply with the energy code. Contractors can access interactive compliance forms, fact sheets, and live and recorded trainings, among other things, on the website: <https://energycodeace.com/>. Jurisdictions can reach out to Energy Code Ace directly to discuss offerings.
6. Health and safety
  - a. Combustion Appliance Safety and Indoor Air Quality: Implementation of some of the recommended measures will affect the pressure balance of the home which can subsequently impact the safe operation of existing combustion appliances as well as indoor air quality. Buildings with older gas appliances can present serious health and safety problems which may not be addressed in a remodel if the appliances are not being replaced. It is recommended that the building department require inspection and testing of all combustion appliances located within the pressure boundary of the building after completion of retrofit work that involves air sealing or insulation measures.
  - b. Jurisdictions may consider requiring mechanical ventilation in homes where air sealing has been conducted. In older buildings, outdoor air is typically introduced through leaks in the building envelope. After air sealing a building, it may be necessary to forcefully bring in fresh outdoor air using supply and/or exhaust fans to minimize potential issues associated with indoor air quality.

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<sup>24</sup> This requirement does not show up in the Express Terms for alterations in Section 150.2(b)1F, but the Statewide Reach Codes Team expects that it will be added to the next release of the proposed code language in the 45-day language as it aligns with the proposal made by the Codes and Standards Enhancement Team (Statewide CASE Team, 2023).

<sup>25</sup> <https://qualityhvac.frontierenergy.com/>

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## 6 Appendices

### 6.1 Map of California Climate Zones

Climate zone geographical boundaries are depicted in Figure 16. The map in Figure 16 along with a zip-code search directory is available at: [https://ww2.energy.ca.gov/maps/renewable/building\\_climate\\_zones.html](https://ww2.energy.ca.gov/maps/renewable/building_climate_zones.html)

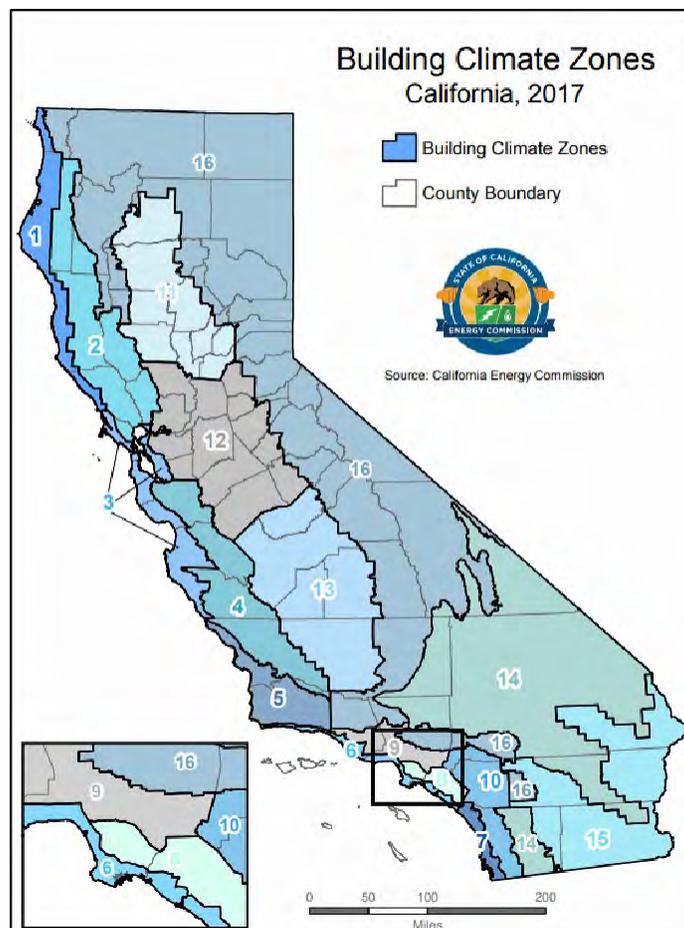


Figure 16. Map of California climate zones.

## 6.2 Utility Rate Schedules

The Reach Codes Team used the CA IOU and POU rate tariffs detailed below to determine the On-Bill savings for each package. The California Climate Credit was applied for both electricity and natural gas service for the IOUs using the 2023 credits shows below.<sup>26</sup> The credits were applied to reduce the total calculated annual bill, including any fixed fees or minimum bill amounts.

### 2023 Electric California Climate Credit Schedule

	February or March	April	May	June	July	Aug	Sept	Oct
<b>PG&amp;E</b>	\$38.39							\$38.39
<b>SCE</b>	\$71.00							\$71.00
<b>SDG&amp;E</b>	\$60.70							\$60.70

## Residential Natural Gas California Climate Credit

In 2023, the 2023 Natural Gas California Climate Credit will be distributed in February or March instead of April.

	2018†	2019	2020	2021	2022	2023	Total Value Received Per Household 2018-2023
<b>PG&amp;E</b>	\$30	\$25	\$27	\$25	\$48	\$52.78	<b>\$208</b>
<b>SDG&amp;E</b>	*	\$34	\$21	\$18	\$43	\$43.40	<b>\$162</b>
<b>Southwest Gas</b>	\$22	\$25	\$27	\$28	\$49	\$56.35	<b>\$207</b>
<b>SoCalGas</b>	*	\$50	\$26	\$22	\$44	\$50.77	<b>\$194</b>

Electricity rates reflect the most recently approved tariffs. Monthly gas rates were estimated based on recent gas rates (November 2023) and a curve to reflect how natural gas prices fluctuate with seasonal supply and demand. The seasonal curve was estimated from monthly residential tariffs between 2014 and 2023 (between 2017 and 2023 for CPAU). 12-month curves were created from monthly gas rates for each of the ten years (Seven years for CPAU). These annual curves were then averaged to arrive at an average normalized annual curve. This was conducted separately for baseline and excess energy rates. Costs used in this analysis were then derived by establishing the most recent baseline and excess rate from the latest tariff as a reference point (November 2023), and then using the normalized curve to estimate the cost for the remaining months relative to the reference point rate.

<sup>26</sup> <https://www.cpuc.ca.gov/industries-and-topics/natural-gas/greenhouse-gas-cap-and-trade-program/california-climate-credit>

### 6.2.1 Pacific Gas & Electric

The following pages provide details on the PG&E electricity and natural gas tariffs applied in this study. Table 20 describes the baseline territories that were assumed for each climate zone. A net surplus compensation rate of \$0.07051/ kWh was applied to any net annual electricity generation based on a one-year average of the rates between December 2022 and November 2023.

**Table 20. PG&E Baseline Territory by Climate Zone**

Climate Zone	Baseline Territory
CZ01	V
CZ02	X
CZ03	T
CZ04	X
CZ05	T
CZ11	R
CZ12	S
CZ13	R
CZ16	Y

The PG&E monthly gas rate in \$/therm was applied on a monthly basis according to the rates shown in Table 21. These rates are based on applying a normalization curve to the November 2023 tariff based on ten years of historical gas data. Corresponding CARE rates reflect the 20 percent discount per the GL-1 tariff.

**Table 21. PG&E Monthly Gas Rate (\$/therm)**

Month	Total Charge	
	Baseline	Excess
January	\$2.05	\$2.43
February	\$2.08	\$2.46
March	\$1.92	\$2.31
April	\$1.80	\$2.20
May	\$1.77	\$2.18
June	\$1.78	\$2.18
July	\$1.80	\$2.20
August	\$1.85	\$2.26
September	\$1.92	\$2.33
October	\$1.99	\$2.40
November	\$2.06	\$2.46
December	\$2.05	\$2.44

## Residential GAS Baseline Territories and Quantities <sup>1/</sup>

**Effective April 1, 2022 - Present**

BASELINE QUANTITIES (Therms Per Day Per Dwelling Unit)

Individually Metered			
Baseline Territories	Summer (April-October) <u>Effective Apr. 1, 2022</u>	Winter Off-Peak (Nov, Feb, Mar) <u>Effective Nov. 1, 2022</u>	Winter On-Peak (Dec, Jan) <u>Effective Dec. 1, 2022</u>
P	0.39	1.88	2.19
Q	0.56	1.48	2.00
R	0.36	1.24	1.81
S	0.39	1.38	1.94
T	0.56	1.31	1.68
V	0.59	1.51	1.71
W	0.39	1.14	1.68
X	0.49	1.48	2.00
Y	0.72	2.22	2.58

Master Metered			
Baseline Territories	Summer (April-October) <u>Effective Apr. 1, 2022</u>	Winter Off-Peak (Nov, Feb, Mar) <u>Effective Nov. 1, 2022</u>	Winter On-Peak (Dec, Jan) <u>Effective Dec. 1, 2022</u>
P	0.29	1.01	1.13
Q	0.56	0.67	0.77
R	0.33	0.87	1.16
S	0.29	0.61	0.65
T	0.56	1.01	1.10
V	0.59	1.28	1.32
W	0.26	0.71	0.87
X	0.33	0.67	0.77
Y	0.52	1.01	1.13

**Summer Season:** Apr-Oct  
**Winter Off-Peak:** Nov, Feb, Mar  
**Winter On-Peak:** Dec, Jan

Advice Letter: 4589-G  
 Decision 21-11-016  
 GRC 2020 Ph II [Application 19-11-019]  
 Filed: Nov 22, 2019



Revised Cal. P.U.C. Sheet No. 56550-E  
 Revised Cal. P.U.C. Sheet No. 56229-E  
 Cancelling

**ELECTRIC SCHEDULE E-TOU-C** Sheet 2  
 RESIDENTIAL TIME-OF-USE (PEAK PRICING 4 - 9 p.m. EVERY DAY)

**RATES:** **E-TOU-C TOTAL BUNDLED RATES**  
 (Cont'd.)

Total Energy Rates (\$ per kWh)	PEAK		OFF-PEAK	
<i>Summer</i>				
Total Usage	\$0.53933	(I)	\$0.45589	(I)
Baseline Credit (Applied to Baseline Usage Only)	(\$0.08851)	(R)	(\$0.08851)	(R)
<i>Winter</i>				
Total Usage	\$0.43862	(I)	\$0.40827	(I)
Baseline Credit (Applied to Baseline Usage Only)	(\$0.08851)	(R)	(\$0.08851)	(R)
Delivery Minimum Bill Amount (\$ per meter per day)	\$0.37612			
California Climate Credit (per household, per semi-annual payment occurring in the March* and October bill cycles)	(\$38.39)			

Total bundled service charges shown on customer's bills are unbundled according to the component rates shown below. Where the delivery minimum bill amount applies, the customer's bill will equal the sum of (1) the delivery minimum bill amount plus (2) for bundled service, the generation rate times the number of kWh used. For revenue accounting purposes, the revenues from the delivery minimum bill amount will be assigned to the Transmission, Transmission Rate Adjustments, Reliability Services, Public Purpose Programs, Nuclear Decommissioning, Competition Transition Charges, Energy Cost Recovery Amount, Wildfire Fund Charge, and New System Generation Charges based on kWh usage times the corresponding unbundled rate component per kWh, with any residual revenue assigned to Distribution.

\* Pursuant to D.23-02-014, disbursement of the April 2023 residential Climate Credit shall begin by March 1, 2023.

(Continued)

Advice Decision	7009-E	Issued by <b>Meredith Allen</b> Vice President, Regulatory Affairs	Submitted Effective Resolution	August 25, 2023 September 1, 2023
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**Pacific Gas and Electric Company**  
U 39

Oakland, California

Cancelling Revised  
Revised

Cal. P.U.C. Sheet No. 58551-E  
Cal. P.U.C. Sheet No. 58230-E

**ELECTRIC SCHEDULE E-TOU-C** Sheet 3  
RESIDENTIAL TIME-OF-USE (PEAK PRICING 4 - 9 p.m. EVERY DAY)

RATES:  
(Cont'd.)

**UNBUNDLING OF E-TOU-C TOTAL RATES**

Energy Rates by Component (\$ per kWh)	PEAK		OFF-PEAK	
<b>Generation:</b>				
Summer (all usage)	\$0.19776		\$0.13432	
Winter (all usage)	\$0.14916		\$0.12413	
<b>Distribution**:</b>				
Summer (all usage)	\$0.17029	(I)	\$0.15029	(I)
Winter (all usage)	\$0.11618	(I)	\$0.11286	(I)
<b>Conservation Incentive Adjustment (Baseline Usage)</b>			(\$0.02216)	(I)
<b>Conservation Incentive Adjustment (Over Baseline Usage)</b>			\$0.06835	(I)
<b>Transmission* (all usage)</b>			\$0.05254	
<b>Transmission Rate Adjustments* (all usage)</b>			\$0.00059	
<b>Reliability Services* (all usage)</b>			\$0.00069	
<b>Public Purpose Programs (all usage)</b>			\$0.02578	
<b>Nuclear Decommissioning (all usage)</b>			\$0.00135	
<b>Competition Transition Charges (all usage)</b>			\$0.00030	
<b>Energy Cost Recovery Amount (all usage)</b>			(\$0.00071)	
<b>Wildfire Fund Charge (all usage)</b>			\$0.00530	
<b>New System Generation Charge (all usage)**</b>			\$0.00346	
<b>Wildfire Hardening Charge (all usage)</b>			\$0.00254	
<b>Recovery Bond Charge (all usage)</b>			\$0.00528	(R)
<b>Recovery Bond Credit (all usage)</b>			(\$0.00528)	(I)
<b>Bundled Power Charge Indifference Adjustment (all usage)***</b>			\$0.01309	

\* Transmission, Transmission Rate Adjustments and Reliability Service charges are combined for presentation on customer bills.  
 \*\* Distribution and New System Generation Charges are combined for presentation on customer bills.  
 \*\*\* Direct Access, Community Choice Aggregation and Transitional Bundled Service Customers pay the applicable Vintaged Power Charge Indifference Adjustment. Generation and Bundled PCIA are combined for presentation on bundled customer bills.

(Continued)

Advice	7009-E	Issued by	Submitted	August 25, 2023
Decision		<b>Meredith Allen</b>	Effective	September 1, 2023
		Vice President, Regulatory Affairs	Resolution	



**Pacific Gas and Electric Company**

Oakland, California

Revised  
Cancelling Revised

Cal. P.U.C. Sheet No. 56547-E  
Cal. P.U.C. Sheet No. 56226-E

**ELECTRIC SCHEDULE E-ELEC**  
RESIDENTIAL TIME-OF-USE (ELECTRIC HOME)  
SERVICE FOR CUSTOMERS WITH QUALIFYING ELECTRIC TECHNOLOGIES

Sheet 2

RATES:(Cont'd.)

**TOTAL BUNDLED RATES**

Base Services Charge (\$ per meter per day)	\$0.49281			
Total Energy Rates (\$ per kWh)		<u>PEAK</u>	<u>PART-PEAK</u>	<u>OFF-PEAK</u>
Summer Usage		\$0.56589 (I)	\$0.40401 (I)	\$0.34733 (I)
Winter Usage		\$0.33438 (I)	\$0.31229 (I)	\$0.29843 (I)
California Climate Credit (per household, per semi-annual payment occurring in the March† and October bill cycles)	(\$38.39)			

Total bundled service charges shown on a customer's bills are unbundled according to the component rates shown below.

**UNBUNDLING OF TOTAL RATES**

Energy Rates by Component (\$ per kWh)	<u>PEAK</u>	<u>PART-PEAK</u>	<u>OFF-PEAK</u>
<b>Generation:</b>			
Summer Usage	\$0.28164	\$0.18253	\$0.13743
Winter Usage	\$0.11951	\$0.09954	\$0.08619
<b>Distribution**:</b>			
Summer Usage	\$0.17932 (I)	\$0.11655 (I)	\$0.10497 (I)
Winter Usage	\$0.10994 (I)	\$0.10782 (I)	\$0.10731 (I)
<b>Transmission* (all usage)</b>	\$0.05254	\$0.05254	\$0.05254
<b>Transmission Rate Adjustments* (all usage)</b>	\$0.00059	\$0.00059	\$0.00059
<b>Reliability Services* (all usage)</b>	\$0.00069	\$0.00069	\$0.00069
<b>Public Purpose Programs (all usage)</b>	\$0.02578	\$0.02578	\$0.02578
<b>Nuclear Decommissioning (all usage)</b>	\$0.00135	\$0.00135	\$0.00135
<b>Competition Transition Charges (all usage)</b>	\$0.00030	\$0.00030	\$0.00030
<b>Energy Cost Recovery Amount (all usage)</b>	(\$0.00071)	(\$0.00071)	(\$0.00071)
<b>Wildfire Fund Charge (all usage)</b>	\$0.00530	\$0.00530	\$0.00530
<b>New System Generation Charge (all usage)**</b>	\$0.00346	\$0.00346	\$0.00346
<b>Wildfire Hardening Charge (all usage)</b>	\$0.00254	\$0.00254	\$0.00254
<b>Recovery Bond Charge (all usage)</b>	\$0.00528 (R)	\$0.00528 (R)	\$0.00528 (R)
<b>Recovery Bond Credit (all usage)</b>	(\$0.00528) (I)	(\$0.00528) (I)	(\$0.00528) (I)
<b>Bundled Power Charge Indifference Adjustment (all usage)***</b>	\$0.01309	\$0.01309	\$0.01309

\* Transmission, Transmission Rate Adjustments and Reliability Service charges are combined for presentation on customer bills.  
 \*\* Distribution and New System Generation Charges are combined for presentation on customer bills.  
 \*\*\* Direct Access, Community Choice Aggregation and Transitional Bundled Service Customers pay the applicable Vintaged Power Charge Indifference Adjustment. Generation and Bundled PCIA are combined for presentation on bundled customer bills.  
 † Pursuant to D.23-02-014, disbursement of the April 2023 residential Climate Credit shall begin by March 1, 2023.

(Continued)

Advice	7009-E	Issued by	Submitted	August 25, 2023
Decision		<b>Meredith Allen</b>	Effective	September 1, 2023
		Vice President, Regulatory Affairs	Resolution	



Original Cal. P.U.C. Sheet No. 54738-E

**ELECTRIC SCHEDULE E-ELEC** Sheet 3 (N)  
**RESIDENTIAL TIME-OF-USE (ELECTRIC HOME)** (N)  
**SERVICE FOR CUSTOMERS WITH QUALIFYING ELECTRIC TECHNOLOGIES**

- SPECIAL CONDITIONS:
1. TIME PERIODS: Times of the year and times of the day are defined as follows: (N)
    - All Year:
    - Peak: 4:00 p.m. to 9:00 p.m. every day including weekends and holidays.
    - Partial-Peak: 3:00 p.m. to 4:00 p.m. and 9:00 p.m. to 12:00 a.m. every day including weekends and holidays.
    - Off-Peak: All other hours.
  2. SEASONAL CHANGES: The summer season is June 1 through September 30 and the winter season is October 1 through May 31. When billing includes use in both the summer and winter periods, charges will be prorated based upon the number of days in each period.
  3. ADDITIONAL METERS: If a residential dwelling unit is served by more than one electric meter, the customer must designate which meter is the primary meter and which is (are) the additional meter(s).
  4. BILLING: A customer's bill is calculated based on the option applicable to the customer.
 

**Bundled Service Customers** receive generation and delivery services solely from PG&E. The customer's bill is based on the Unbundling of Total Rates set forth above.

**Transitional Bundled Service (TBS) Customers** take TBS as prescribed in Rules 22.1 and 23.1, or take PG&E bundled service prior to the end of the six (6) month advance notice period required to elect PG&E bundled service as prescribed in Rules 22.1 and 23.1. TBS customers shall pay all charges shown in the Unbundling of Total Rates except for the Bundled Power Charge Indifference Adjustment and the generation charge. TBS customers shall also pay for their applicable Vintaged Power Charge Indifference Adjustment provided in the table below, and the short-term commodity prices as set forth in Schedule TBCC. (N)

(Continued)

<i>Advice</i>	6768-E		<i>Submitted</i>	<u>November 18, 2022</u>
<i>Decision</i>	D.21-11-016	<i>Issued by</i> <b>Meredith Allen</b>	<i>Effective</i>	<u>December 1, 2022</u>
		<i>Vice President, Regulatory Affairs</i>	<i>Resolution</i>	



Cancelling Revised Cal. P.U.C. Sheet No. 54734-E  
 Revised Cal. P.U.C. Sheet No. 53424-E

**ELECTRIC SCHEDULE D-CARE** Sheet 1  
 LINE-ITEM DISCOUNT FOR CALIFORNIA ALTERNATE RATES FOR ENERGY (CARE)  
 CUSTOMERS

**APPLICABILITY:** This schedule is applicable to single-phase and polyphase residential service in single-family dwellings and in flats and apartments separately metered by PG&E and domestic submetered tenants residing in multifamily accommodations, mobilehome parks and to qualifying recreational vehicle parks and marinas and to farm service on the premises operated by the person whose residence is supplied through the same meter, where the applicant qualifies for California Alternate Rates for Energy (CARE) under the eligibility and certification criteria set forth in Electric Rule 19.1. CARE service is available on Schedules E-1, E-8, E-TOU-B, E-TOU-C, E-TOU-D, EV2, E-ELEC, EM, ES, ESR, ET and EM-TOU. (T)

**TERRITORY:** This rate schedule applies everywhere PG&E provides electric service.

**RATES:** Customers taking service on this rate schedule whose otherwise applicable rate schedule has no Delivery Minimum Bill Amount (Schedule E-ELEC) will receive a CARE percentage discount of 35.000% on their total bundled charges (except for the California Climate Credit, which will not be discounted). Customers taking service on this rate schedule whose otherwise applicable rate schedule has a Delivery Minimum Bill Amount (all other schedules) will receive a CARE percentage discount ("A" or "C" below) on their total bundled charges on their otherwise applicable rate schedule (except for the California Climate Credit, which will not be discounted) and also will receive a percentage discount ("B" or "D" below) on the delivery minimum bill amount, if applicable. The CARE discount will be calculated for direct access and community choice aggregation customers based on the total charges as if they were subject to bundled service rates. Discounts will be applied as a residual reduction to distribution charges, after D-CARE customers are exempted from the Wildfire Fund Charge, Recovery Bond Charge, Recovery Bond Credit, and the CARE surcharge portion of the public purpose program charge used to fund the CARE discount. These conditions also apply to master-metered customers and to qualified sub-metered tenants where the master-meter customer is jointly served under PG&E's Rate Schedule D-CARE and either Schedule EM, ES, ESR, ET, or EM-TOU. (N)  
 |  
 |  
 (N)  
 (T)  
 |  
 (T)  
 (T)

For master-metered customers where one or more of the submetered tenants qualifies for CARE rates under the eligibility and certification criteria set forth in Rule 19.1, 19.2, or 19.3, the CARE discount is equal to a percentage ("C" below) of the total bundled charges, multiplied by the number of CARE units divided by the total number of units. In addition, master-metered customers eligible for D-CARE will receive a percentage discount ("D" below) on the delivery minimum bill amount, if applicable.

It is the responsibility of the master-metered customer to advise PG&E within 15 days following any change in the number of dwelling units and/or any decrease in the number of qualifying CARE applicants that results when such applicants move out of their submetered or non-submetered dwelling unit, or submetered permanent-residence RV or permanent-residence boat.

(L)  
 |  
 (L)

(Continued)



**Pacific Gas and Electric Company**

U 39

San Francisco, California

Cancelling Revised

Revised Revised

Cal. P.U.C. Sheet No. Cal. P.U.C. Sheet No.

56208-E 56020-E

**ELECTRIC SCHEDULE D-CARE**

Sheet 2

LINE-ITEM DISCOUNT FOR CALIFORNIA ALTERNATE RATES FOR ENERGY (CARE) CUSTOMERS

RATES: (Cont'd)	A. D-CARE Discount:	34.985	% (Percent)	(I)
	B. Delivery Minimum Bill Discount:	50.000	% (Percent)	
	C. Master-Meter D-CARE Discount:	34.985	% (Percent)	(I)
	D. Master-Meter Delivery Minimum Bill Discount:	50.000	% (Percent)	

- SPECIAL CONDITIONS:**
- 1. OTHERWISE APPLICABLE SCHEDULE:** The Special Conditions of the Customer's otherwise applicable rate schedule will apply to this schedule.
  - 2. ELIGIBILITY:** To be eligible to receive D-CARE the applicant must qualify under the criteria set forth in PG&E's Electric Rules 19.1, 19.2, and 19.3 and meet the certification requirements thereof to the satisfaction of PG&E. Qualifying Direct Access, Community Choice Aggregation Service, and Transitional Bundled Service customers are also eligible to take service on Schedule D-CARE. Applicants may qualify for D-CARE at their primary residence only. Customers or sub-metered tenants participating in the Family Electric Rate Assistance (FERA) program cannot concurrently participate in the CARE program.

Advice Decision 6968-E

Issued by **Meredith Allen**  
Vice President, Regulatory Affairs

Submitted June 23, 2023  
Effective July 1, 2023  
Resolution \_\_\_\_\_

### 6.2.2 Southern California Edison

The following pages provide details on the SCE electricity tariffs applied in this study. Table 22 describes the baseline territories that were assumed for each climate zone. A net surplus compensation rate of \$ 0.06030/ kWh was applied to any net annual electricity generation based on a one-year average of the rates between December 2022 and November 2023

**Table 22: SCE Baseline Territory by Climate Zone**

Climate Zone	Baseline Territory
CZ06	6
CZ08	8
CZ09	9
CZ10	10
CZ14	14
CZ15	15

Summer Daily Allocations (June through September)

Baseline Region Number	Daily kWh Allocation	All-Electric Allocation
5	17.2	17.9
6	11.4	8.8
8	12.6	9.8
9	16.5	12.4
10	18.9	15.8
13	22.0	24.6
14	18.7	18.3
15	46.4	24.1
16	14.4	13.5

Winter Daily Allocations (October through May)

Baseline Region Number	Daily kWh Allocation	All-Electric Allocation
5	18.7	29.1
6	11.3	13.0
8	10.6	12.7
9	12.3	14.3
10	12.5	17.0
13	12.6	24.3
14	12.0	21.3
15	9.9	18.2
16	12.6	23.1

Schedule TOU-D  
TIME-OF-USE  
DOMESTIC  
 (Continued)

Sheet 12 (T)

**SPECIAL CONDITIONS**

- Applicable rate time periods are defined as follows:

Option 4-9 PM, Option 4-9 PM-CPP, Option PRIME, Option PRIME-CPP :

TOU Period	Weekdays		Weekends and Holidays	
	Summer	Winter	Summer	Winter
On-Peak	4 p.m. - 9 p.m.	N/A	N/A	N/A
Mid-Peak	N/A	4 p.m. - 9 p.m.	4 p.m. - 9 p.m.	4 p.m. - 9 p.m.
Off-Peak	All other hours	9 p.m. - 8 a.m.	All other hours	9 p.m. - 8 a.m.
Super-Off-Peak	N/A	8 a.m. - 4 p.m.	N/A	8 a.m. - 4 p.m.
CPP Event Period	4 p.m. - 9 p.m.	4 p.m. - 9 p.m.	N/A	N/A

(T)



Southern California Edison  
Rosemead, California (U 338-E)

Revised Cancellng Revised Cal. PUC Sheet No. 85111-E  
Revised Cal. PUC Sheet No. 74502-E

Schedule TOU-D  
TIME-OF-USE  
DOMESTIC  
(Continued) Sheet 2

RATES

Customers receiving service under this Schedule will be charged the applicable rates under Option 4-9 PM, Option 4-9 PM-CPP, Option 5-8 PM, Option 5-8 PM-CPP, Option PRIME, Option PRIME-CPP Option A, Option A-CPP, Option B, or Option B-CPP, as listed below. CPP Event Charges will apply to all energy usage during CPP Event Energy Charge periods and CPP Non-Event Energy Credits will apply as a reduction on CPP Non-Event Energy Credit Periods during Summer Season days, 4:00 p.m. to 9:00 p.m., as described in Special Conditions 1 and 3, below:

	Delivery Services Total <sup>1</sup>	Generation <sup>2</sup>	
		UG <sup>3</sup>	DWREC <sup>4</sup>
<b>Option 4-9 PM / Option 4-9 PM-CPP</b>			
Energy Charge - \$/kWh			
Summer Season - On-Peak	0.28829 (R)	0.28543 (I)	0.00000
Mid-Peak	0.28829 (R)	0.17707 (I)	0.00000
Off-Peak	0.24482 (R)	0.11382 (I)	0.00000
Winter Season - Mid-Peak	0.28829 (R)	0.21752 (I)	0.00000
Off-Peak	0.24482 (R)	0.13851 (I)	0.00000
Super-Off-Peak	0.22919 (R)	0.11890 (I)	0.00000
Baseline Credit <sup>****</sup> - \$/kWh	(0.09759) (I)	0.00000	
Fixed Recovery Charge - \$/kWh	0.00090 (R)		
Basic Charge - \$/day			
Single-Family Residence	0.031		
Multi-Family Residence	0.024		
Minimum Charge <sup>**</sup> - \$/day			
Single Family Residence	0.348		
Multi-Family Residence	0.348		
Minimum Charge (Medical Baseline) <sup>**</sup> - \$/day			
Single Family Residence	0.173		
Multi-Family Residence	0.173		
California Climate Credit <sup>10</sup>	(71.00) (I)		
California Alternate Rates for Energy Discount - %	100.00*		
Family Electric Rate Assistance Discou	100.00		
<b>Option 4-9 PM-CPP</b>			
CPP Event Energy Charge - \$/kWh		0.80000	
Summer CPP Non-Event Credit			
On-Peak Energy Credit - \$/kWh		(0.15170)	
Maximum Available Credit - \$/kWh <sup>****</sup>			
Summer Season		(0.67183) (R)	

\* Represents 100% of the discount percentage as shown in the applicable Special Condition of this Schedule.  
 \*\* The Minimum Charge is applicable when the Delivery Service Energy Charge, plus the applicable Basic Charge is less than the Minimum Charge.  
 \*\*\* The ongoing Competition Transition Charge CTC of (\$0.00003) per kWh is recovered in the UG component of Generation.  
 \*\*\*\* The Baseline Credit applies up to 100% of the Baseline Allocation, regardless of Time-of-Use time period. Additional Baseline Allocations apply for Customers with Heat Pump Water Heaters served under this Option. The Baseline Allocations are set forth in Preliminary Statement, Part H.  
 \*\*\*\*\*The Maximum Available Credit is the capped credit amount for CPP Customers dual participating in other demand response programs.  
 1 Total = Total Delivery Service rates are applicable to Bundled Service, Direct Access (DA) and Community Choice Aggregation Service (CCA Service) Customers, except DA and CCA Service Customers are not subject to the DWRBC rate component of this Schedule but instead pay the DWRBC as provided by Schedule DA-CRS or Schedule CCA-CRS.  
 2 Generation = The Gen rates are applicable only to Bundled Service Customers. See Special Condition below for PCIA recovery.  
 3 DWREC = Department of Water Resources (DWR) Energy Credit – For more information on the DWR Energy Credit, see the Billing Calculation Special Condition of this Schedule.  
 4 Applied on an equal basis, per household, semi-annually. See the Special Conditions of this Schedule for more information.

(Continued)

(To be inserted by utility)

Advice 4929-E  
Decision \_\_\_\_\_

Issued by  
Michael Backstrom  
Vice President

(To be inserted by Cal. PUC)

Date Submitted Dec 28, 2022  
Effective Jan 1, 2023  
Resolution E-5217

2H13



Southern California Edison  
Rosemead, California (U 338-E)

Cancelling Revised Cal. PUC Sheet No. 86132-E  
Revised Cal. PUC Sheet No. 85624-E

Schedule TOU-D  
TIME-OF-USE  
DOMESTIC  
(Continued)

Sheet 6

RATES (Continued)

Option PRIME / Option PRIME-CPP	Delivery Service Total <sup>1</sup>	Generation <sup>2</sup>	
		UG <sup>3</sup>	DWREC <sup>4</sup>
Energy Charge - \$/kWh/Meter/Day			
Summer Season			
On-Peak	0.22789 (I)	0.42789 (I)	0.00000
Mid-Peak	0.22789 (I)	0.15221 (I)	0.00000
Off-Peak	0.15191 (I)	0.10162 (I)	0.00000
Winter Season			
Mid-Peak	0.23353 (I)	0.38028 (I)	0.00000
Off-Peak	0.14530 (I)	0.08630 (I)	0.00000
Super-Off-Peak	0.14530 (I)	0.08630 (I)	0.00000
Fixed Recovery Charge - \$/kWh	0.00280 (I)		
Basic Charge - \$/Meter/Day	0.427 (I)		
EV Meter Credit (Separately Metered E)	(0.323) (N)		
EV Submeter Credit - \$/Meter/Day	(0.111) (R)		
California Climate Credit <sup>10</sup>	(71.00)		
California Alternate Rates for Energy Discount - %	100.00*		
Family Electric Rate Assistance Discou	100.00		
Medical Line Item Discount - %	100.000		
<b>Option PRIME-CPP</b>			
CPP Event Energy Charge - \$/kWh		0.80000	
Summer CPP Non-Event Credit			
On-Peak Energy Credit - \$/kWh		(0.15170)	
Maximum Available Credit - \$/kWh****			
Summer Season		(0.71812) (R)	

\* Represents 100% of the discount percentage as shown in the applicable Special Condition of this Schedule.  
 \*\* The ongoing Competition Transition Charge (CTC) of (\$0.00003) per kWh is recovered in the UG component of Generation.  
 \*\*\*\* The Maximum Available Credit is the capped credit amount for CPP Customers dual participating in other demand response programs.  
 1 Total = Total Delivery Service rates are applicable to Bundled Service, Direct Access (DA) and Community Choice Aggregation Service (CCA Service) Customers, except DA and CCA Service Customers are not subject to the DWRBC rate component of this Schedule but instead pay the DWRBC as provided by Schedule DA-CRS or Schedule CCA-CRS.  
 2 Generation = The Gen rates are applicable only to Bundled Service Customers. See Special Condition below for PCIA recovery.  
 3 DWREC = Department of Water Resources (DWR) Energy Credit – For more information on the DWR Energy Credit, see the Billing Calculation Special Condition of this Schedule.  
 4 Applied on an equal basis, per household, semi-annually. See the Special Conditions of this Schedule for more information.

(Continued)

(To be inserted by utility)  
 Advice 5041-E  
 Decision \_\_\_\_\_

Issued by  
**Michael Backstrom**  
 Vice President

(To be inserted by Cal. PUC)  
 Date Submitted May 30, 2023  
 Effective Jun 1, 2023  
 Resolution \_\_\_\_\_

6/19



Southern California Edison  
Rosemead, California (U 338-E)

Revised Cal. PUC Sheet No. 85618-E  
Cancelling Revised Cal. PUC Sheet No. 85109-E

Schedule D-CARE  
CALIFORNIA ALTERNATE RATES FOR ENERGY  
DOMESTIC SERVICE

Sheet 1

APPLICABILITY

Applicable to domestic service to CARE households residing in a permanent Single-Family Accommodation or Multifamily Accommodation where the customer meets all the Special Conditions of this Schedule. Customers enrolled in the CARE program are not eligible for the Family Electric Rate Assistance (FERA) program.

Pursuant to Special Condition 12 herein, customers receiving service under this Schedule are eligible to receive the California Climate Credit as shown in the Rates section below.

TERRITORY

Within the entire territory served.

RATES

The applicable charges set forth in Schedule D shall apply to Customers served under this Schedule.

CARE Discount:

A 29.8 percent discount is applied to a CARE Customer's bill prior to the application of the Public Utilities Commission Reimbursement Fee (PUCRF) and any applicable user fees, taxes, and late payment charges. CARE Customers are required to pay the PUCRF and any applicable user fees, taxes, and late payment charges in full. In addition, CARE Customers are exempt from paying the CARE Surcharge of \$0.00888 per kWh and the Wildfire Fund Non-Bypassable Charge of \$0.00530 per kWh. (R)  
The 29.8 percent discount, in addition to these exemptions result in an average effective CARE Discount of 32.5 percent.

(Continued)

(To be inserted by utility)

Advice 4977-E  
Decision 23-01-002  
TH12 22-12-031

Issued by  
Michael Backstrom  
Vice President

(To be inserted by Cal. PUC)

Date Submitted Feb 27, 2023  
Effective Mar 1, 2023  
Resolution \_\_\_\_\_

### 6.2.3 Southern California Gas

Following are the SoCalGas natural gas tariffs applied in this study. Table 23 describes the baseline territories that were assumed for each climate zone.

**Table 23. SoCalGas Baseline Territory by Climate Zone**

Climate Zone	Baseline Territory
CZ05	2
CZ06	1
CZ08	1
CZ09	1
CZ10	1
CZ14	2
CZ15	1

The SoCalGas monthly gas rate in \$/therm was applied on a monthly basis according to the rates shown in Table 24. These rates are based on applying a normalization curve to the November 2023 tariff based on ten years of historical gas data. Long-term historical natural gas rate data was only available for SoCalGas' procurement charges.<sup>27</sup> The baseline and excess transmission charges were found to be consistent over the course of a year and applied for the entire year based on 2023 rates. CARE rates reflect the 20 percent discount per the GR tariff.

**Table 24. SoCalGas Monthly Gas Rate (\$/therm)**

Month	Procurement Charge	Transportation Charge		Total Charge	
		Baseline	Excess	Baseline	Excess
January	\$0.72	\$0.86	\$1.31	\$1.92	\$2.36
February	\$0.50	\$0.86	\$1.31	\$1.57	\$2.02
March	\$0.44	\$0.86	\$1.31	\$1.48	\$1.93
April	\$0.39	\$0.86	\$1.31	\$1.39	\$1.84
May	\$0.41	\$0.86	\$1.31	\$1.43	\$1.87
June	\$0.46	\$0.86	\$1.31	\$1.49	\$1.93
July	\$0.47	\$0.86	\$1.31	\$1.51	\$1.96
August	\$0.51	\$0.86	\$1.31	\$1.58	\$2.03
September	\$0.46	\$0.86	\$1.31	\$1.52	\$1.96
October	\$0.45	\$0.86	\$1.31	\$1.48	\$1.92
November	\$0.48	\$0.86	\$1.31	\$1.54	\$1.99
December	\$0.57	\$0.86	\$1.31	\$1.63	\$2.08

Southern California Gas Company									
Residential Rates									
Nov-23									
Customer Type	Commodity	Rate	Procurement Charge	Transportation Charge	New Rate Effective	New Rate Effective	Absolute Rate Change	% Change	
	Rate Schedule	Charge	Type	¢/therm	¢/therm	11/1/2023	10/1/2023		
Residential Individually Metered									
	Schedule No. GR	GR	Baseline	67.806	86.490	154.296	125.096	29.200	23.3%
	Res. Service	GR	Non Baseline	67.806	131.037	198.843	169.726	29.117	17.2%
		GT-R	Baseline	00.000	86.490	86.490	87.038	-00.548	-0.6%
		GT-R	Non Baseline	00.000	131.037	131.037	131.668	-00.631	-0.5%

<sup>27</sup> The SoCalGas procurement and transmission charges were obtained from the following site: <https://www.socalgas.com/for-your-business/energy-market-services/gas-prices/RES2023.xlsx> (live.com)

### 6.2.4 San Diego Gas & Electric

Following are the SDG&E electricity and natural gas tariffs applied in this study. Table 25 describes the baseline territories that were assumed for each climate zone. A net surplus compensation rate of \$0.04542/ kWh was applied to any net annual electricity generation based on a one-year average of the rates between December 2022 and November 2023.

**Table 25. SDG&E Baseline Territory by Climate Zone**

Climate Zone	Baseline Territory
CZ07	Coastal
CZ10	Inland
CZ14	Mountain

The SDG&E monthly gas rate in \$/therm was applied on a monthly basis according to the rates shown in Table 26. These rates are based on applying a normalization curve to the November 2023 tariff based on ten years of historical gas data. CARE rates reflect the 20 percent discount per the G-CARE tariff.

**Table 26. SDG&E Monthly Gas Rate (\$/therm)**

Month	Total Charge	
	Baseline	Excess
January	\$2.34	\$2.63
February	\$2.28	\$2.57
March	\$2.21	\$2.51
April	\$2.14	\$2.45
May	\$2.18	\$2.48
June	\$2.23	\$2.55
July	\$2.26	\$2.57
August	\$2.32	\$2.62
September	\$2.26	\$2.59
October	\$2.21	\$2.55
November	\$2.24	\$2.57
December	\$2.38	\$2.70

**Baseline Usage:** The following quantities of gas used in individually metered residences are to be billed at the baseline rates:

<u>All Customers:</u>	<u>Daily Therm Allowance</u>
Summer (May to Oct)	0.359
Winter On-Peak (Dec, Jan & Feb)	1.233
Winter Off-Peak (Nov, Mar, & Apr)	0.692



San Diego Gas & Electric Company  
San Diego, California

Revised Cal. P.U.C. Sheet No. 37022-E  
Canceling Revised Cal. P.U.C. Sheet No. 36337-E

**SCHEDULE TOU-DR1**  
**RESIDENTIAL TIME-OF-USE**

Sheet 2

**RATES**

**Total Rates:**

Description – TOU DR1	UDC Total Rate	DWR BC + WF-NBC	EECC Rate + DWR Credit	Total Rate
<b>Summer:</b>				
On-Peak	0.25752	R 0.00530	I 0.57043	I 0.83325
Off-Peak	0.25752	R 0.00530	I 0.25697	I 0.51979
Super Off-Peak	0.25752	R 0.00530	I 0.09233	I 0.35515
<b>Winter:</b>				
On-Peak	0.43809	I 0.00530	I 0.19307	I 0.63646
Off-Peak	0.43809	I 0.00530	I 0.10855	I 0.55194
Super Off-Peak	0.43809	I 0.00530	I 0.08402	I 0.52741
Summer Baseline Adjustment Credit up to 130% of Baseline	(0.11724)	R		(0.11724) R
Winter Baseline Adjustment Credit up to 130% of Baseline	(0.11724)	R		(0.11724) R
Minimum Bill (\$/day)	0.380	I		0.380 I

Description – TOU DR1-CARE	UDC Total Rate	DWR BC + WF-NBC	EECC Rate + DWR Credit	Total Rate	Total Effective Care Rate
<b>Summer – CARE Rates:</b>					
On-Peak	0.25682	R 0.00000	I 0.57043	I 0.82725	I 0.55366
Off-Peak	0.25682	R 0.00000	I 0.25697	I 0.51379	I 0.33965
Super Off-Peak	0.25682	R 0.00000	I 0.09233	I 0.34915	I 0.22725
<b>Winter – CARE Rates:</b>					
On-Peak	0.43739	I 0.00000	I 0.19307	I 0.63046	I 0.41930
Off-Peak	0.43739	I 0.00000	I 0.10855	I 0.54594	I 0.36160
Super Off-Peak	0.43739	I 0.00000	I 0.08402	I 0.52141	I 0.34485
Summer Baseline Adjustment Credit up to 130% of Baseline	(0.11724)	R		(0.11724) R	(0.08004) R
Winter Baseline Adjustment Credit up to 130% of Baseline	(0.11724)	R		(0.11724) R	(0.08004) R
Minimum Bill (\$/day)	0.190	I		0.190 I	0.190 I

**Note:**

- Total Rates consist of UDC, Schedule DWR-BC (Department of Water Resources Bond Charge), Schedule WF-NBC (CA Wildfire Fund charge) and Schedule EECC (Electric Energy Commodity Cost) rates, with the EECC rates reflecting a DWR Credit. EECC rates are applicable to bundled customers only. See Special Condition 16 for PCIA (Power Charge Indifference Adjustment) recovery.
- Total Rates presented are for customers that receive commodity supply and delivery service from Utility.
- DWR-BC and WF-NBC charges do not apply to CARE customers.
- As identified in the rates tables, customer bills will also include line-item summer and winter credits for usage up to 130% of baseline to provide the rate capping benefits adopted by Assembly Bill 1X and Senate Bill 695.
- WF-NBC rate is 0.00530 + DWR-BC Bond Charge is 0.00000.

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(Continued)

2C8 Issued by Submitted Dec 30, 2022  
 Advice Ltr. No. 4129-E **Dan Skopec** Effective Jan 1, 2023  
 Decision No. \_\_\_\_\_ Senior Vice President Regulatory Affairs Resolution No. E-5217

Time Periods

All time periods listed are applicable to local time. The definition of time will be based upon the date service is rendered.

TOU Periods – Weekdays	Summer	Winter
On-Peak	4:00 p.m. – 9:00 p.m.	4:00 p.m. – 9:00 p.m.
Off-Peak	6:00 a.m. – 4:00 p.m.; 9:00 p.m. - midnight	6:00 a.m. – 4:00 p.m. Excluding 10:00 a.m. – 2:00 p.m. in March and April; 9:00 p.m. - midnight
Super Off-Peak	Midnight – 6:00 a.m.	Midnight – 6:00 a.m. 10:00 a.m. – 2:00 p.m. in March and April
TOU Period – Weekends and Holidays	Summer	Winter
On-Peak	4:00 p.m. – 9:00 p.m.	4:00 p.m. – 9:00 p.m.
Off-Peak	2:00 p.m. – 4:00 p.m.; 9:00 p.m. - midnight	2:00 p.m. – 4:00 p.m.; 9:00 p.m. - midnight
Super Off-Peak	Midnight – 2:00 p.m.	Midnight – 2:00 p.m.

Seasons: Summer June 1 – October 31  
 Winter November 1 – May 31

15. Baseline Usage: The following quantities of electricity are used to calculate the baseline adjustment credit.

	Baseline Allowance For Climatic Zones*			
	Coastal	Inland	Mountain	Desert
<b>Basic Allowance</b>				
Summer (June 1 to October 31)	9.0	10.4	13.6	15.9
Winter (November 1 to May 31)	9.2	9.6	12.9	10.9
<b>All Electric**</b>				
Summer (June 1 to October 31)	6.0	8.7	15.2	17.0
Winter (November 1 to May 31)	8.8	12.2	22.1	17.1

\* Climatic Zones are shown on the Territory Served, Map No. 1.

\*\* All Electric allowances are available upon application to those customers who have permanently installed space heating or who have electric water heating and receive no energy from another source.



San Diego Gas & Electric Company  
San Diego, California

Revised Cal. P.U.C. Sheet No. 37217-E

Canceling Revised Cal. P.U.C. Sheet No. 37016-E

**SCHEDULE EV-TOU-5**

Sheet 1

COST-BASED DOMESTIC TIME-OF-USE FOR HOUSEHOLDS WITH ELECTRIC VEHICLES

APPLICABILITY

Service under this schedule is specifically limited to customers who require service for charging of a currently registered Motor Vehicle, as defined by the California Motor Vehicle Code, which is: 1) a battery electric vehicle (BEV) or plug-in hybrid electric vehicle (PHEV) recharged via a recharging outlet at the customer's premises; or 2) a natural gas vehicle (NGV) refueled via a home refueling appliance (HRA) at the customer's premises. This schedule is not available to customers with a conventional charge sustaining (battery recharged solely from the vehicle's on-board generator) hybrid electric vehicle (HEV).

Residential customers taking service on Schedule NBT, who are required to utilize EV-TOU-5 as their otherwise applicable schedule (OAS) for electric service, do not require a qualifying motor vehicle, as described above to participate on Schedule EV-TOU-5.

N  
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N

Customers on this schedule may also qualify for a semi-annual California Climate Credit \$(60.70) per Schedule GHG-ARR.

TERRITORY

Within the entire territory served by the utility.

RATES

**Total Rates:**

Description – EV-TOU-5 Rates	UDC Total Rate	DWR BC + WF-NBC	EECC Rate + DWR Credit	Total Rate
Basic Service Fee	16.00			16.00
<b>Summer</b>				
On-Peak	0.28032	I 0.00530	I 0.53067	I 0.81629
Off-Peak	0.28032	I 0.00530	I 0.19567	I 0.48129
Super Off-Peak	0.05588	I 0.00530	I 0.09233	I 0.15351
<b>Winter</b>				
On-Peak	0.28032	I 0.00530	I 0.22587	I 0.51149
Off-Peak	0.28032	I 0.00530	I 0.16213	I 0.44775
Super Off-Peak	0.05588	I 0.00530	I 0.08402	I 0.14520

(Continued)

1C5

Issued by

Submitted Jan 30, 2023

Advice Ltr. No. 4154-E

Effective Mar 1, 2023

Decision No. D.22-12-056

Resolution No.



San Diego Gas & Electric Company  
San Diego, California

Revised Cal. P.U.C. Sheet No. 37019-E  
Canceling Revised Cal. P.U.C. Sheet No. 35912-E

**SCHEDULE EV-TOU-5**

Sheet 4

COST-BASED DOMESTIC TIME-OF-USE FOR HOUSEHOLDS WITH ELECTRIC VEHICLES

**Notes:** Transmission Energy charges include the Transmission Revenue Balancing Account Adjustment (TRBAA) of \$(0.00242) per kWh and the Transmission Access Charge Balancing Account Adjustment (TACBAA) of \$(0.01631) per kWh. PPP Energy charges includes Low Income PPP rate (LI-PPP) \$0.01669/kWh, Non-low Income PPP rate (Non-LI-PPP) \$0.00333/kWh (pursuant to PU Code Section 399.8, the Non-LI-PPP rate may not exceed January 1, 2000 levels), Procurement Energy Efficiency Surcharge Rate of \$0.00422 /kWh, California Solar Initiative rate (CSI) of \$0.00000/kWh and Self-Generation Incentive Program rate (SGIP) \$0.00122/kWh. The basic service fee of \$16 per month is applied to a customer's bill and a 50% discount is applied for CARE, Medical Baseline, or Family Electric Rate Assistance Program (FERA) customers resulting in their basic service fees to be \$8 per month.

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**Rate Components**

The Utility Distribution Company Total Rates (UDC Total) shown above are comprised of the following components (if applicable): (1) Transmission (Trans) Charges, (2) Distribution (Distr) Charges, (3) Public Purpose Program (PPP) Charges, (4) Nuclear Decommissioning (ND) Charge, (5) Ongoing Competition Transition Charges (CTC), (6) Local Generation Charge (LGC), (7) Reliability Services (RS), and (8) the Total Rate Adjustment Component (TRAC).

Certain Direct Access customers are exempt from the TRAC, as defined in Rule 1 – Definitions.

**Franchise Fee Differential**

A Franchise Fee Differential of 5.78% will be applied to the monthly billings calculated under this schedule for all customers within the corporate limits of the City of San Diego. Such Franchise Fee Differential shall be so indicated and added as a separate item to bills rendered to such customers.

**Time Periods:**

All time periods listed are applicable to actual "clock" time)

TOU Period – Weekdays	Summer	Winter
On-Peak	4:00 p.m. – 9:00 p.m.	4:00 p.m. – 9:00 p.m.
Off-Peak	6:00 a.m. – 4:00 p.m.; 9:00 p.m. – midnight	6:00 a.m. – 4:00 p.m. Excluding 10:00 a.m.–2:00 p.m. in March and April; 9:00 p.m. - midnight
Super-Off-Peak	Midnight – 6:00 a.m.	Midnight – 6:00 a.m. 10:00 a.m. – 2:00 p.m. in March and April

TOU Period – Weekends and Holidays	Summer	Winter
On-Peak	4:00 p.m. – 9:00 p.m.	4:00 p.m. – 9:00 p.m.
Off-Peak	2:00 p.m. – 4:00 p.m.; 9:00 p.m. – midnight	2:00 p.m. – 4:00 p.m. 9:00 p.m. - midnight
Super-Off-Peak	Midnight – 2:00 p.m.	Midnight – 2:00 p.m.

**Seasons:**

Summer June 1 – October 31  
Winter November 1 – May 31

(Continued)

4C8

Advice Ltr. No. 4129-E  
Decision No. \_\_\_\_\_

Issued by  
**Dan Skopec**  
Senior Vice President  
Regulatory Affairs

Submitted Dec 30, 2022  
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Resolution No. E-5217



San Diego Gas & Electric Company  
San Diego, California

Original Cal. P.U.C. Sheet No. 37195-E

Canceling Cal. P.U.C. Sheet No.

**SCHEDULE TOU-ELEC**

Sheet 1

DOMESTIC TIME-OF-USE FOR HOUSEHOLDS WITH ELECTRIC VEHICLES, ENERGY STORAGE,  
OR ELECTRIC HEAT PUMPS

APPLICABILITY

Service under this schedule is available on a voluntary basis for all residential customers who meet one or more of the following criteria: 1) require service for charging of a currently registered Motor Vehicle, as defined by the California Motor Vehicle Code, which is: a) a battery electric vehicle (BEV) or plug-in hybrid electric vehicle (PHEV) recharged via a recharging outlet at the customer's premises; or b) a natural gas vehicle (NGV) refueled via a home refueling appliance (HRA) at the customer's premises; 2) have a behind-the-meter energy storage device that is interconnected through Electric Rule 21; or 3) have an electric heat pump for water heating or climate control. This schedule is not available to customers with a conventional charge sustaining (battery recharged solely from the vehicle's on-board generator) hybrid electric vehicle (HEV).

This schedule is also available to customers who meet the above criteria as well as qualify for the California Alternate Rates for Energy (CARE) Program as outlined in Schedule E-CARE, and/or Medical Baseline as outlined in Special Condition (SC) 5. The rates for CARE customers and/or Medical Baseline are identified in the rate tables below as TOU-ELEC-CARE and TOU-ELEC-MB rates, respectively.

There is a cap of 10,000 customers who may take service on this rate, as defined in SC 10.

Pursuant to D.22-11-022, customers that opt-in to schedule TOU-ELEC within its first year of being offered have the option to return to their previous rate schedule prior to the 12-month requirement. See SC4 Terms of Service for all requirements.

Customers on this schedule may also qualify for a semi-annual California Climate Credit \$(60.70) per Schedule GHG-ARR.

TERRITORY

Within the entire territory served by the utility.

RATES

**Total Rates:**

Description – TOU-ELEC Rates	UDC Total Rate	DWR BC + WF-NBC	EECC Rate	Total Rate
Monthly Service Fee	16.00			16.00
<b>Summer</b>				
On-Peak	0.22228	0.00530	0.51568	0.74326
Off-Peak	0.22228	0.00530	0.14844	0.37402
Super Off-Peak	0.22228	0.00530	0.09785	0.32543
<b>Winter</b>				
On-Peak	0.22228	0.00530	0.27460	0.50218
Off-Peak	0.22228	0.00530	0.13323	0.36081
Super Off-Peak	0.22228	0.00530	0.08905	0.31663

(Continued)

1H6 Issued by Submitted Jan 31, 2023  
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San Diego Gas & Electric Company  
San Diego, California

Original Cal. P.U.C. Sheet No. 37196-E

Canceling Cal. P.U.C. Sheet No.

**SCHEDULE TOU-ELEC**

Sheet 2

**DOMESTIC TIME-OF-USE FOR HOUSEHOLDS WITH ELECTRIC VEHICLES, ENERGY STORAGE,  
OR ELECTRIC HEAT PUMPS**

**RATES (Continued)**

Description – TOU-ELEC CARE Rates	UDC Total Rate	DWR BC + WF-NBC	EECC Rate	Total Rate	Total Effective CARE Rate
Monthly Service Fee	16.00			16.00	16.00
<b>Summer – CARE Rates:</b>					
On-Peak	0.22158	0.00000	0.51588	0.73726	0.49222
Off-Peak	0.22158	0.00000	0.14644	0.36802	0.24013
Super Off-Peak	0.22158	0.00000	0.09785	0.31943	0.20696
<b>Winter – CARE Rates:</b>					
On-Peak	0.22158	0.00000	0.27460	0.49618	0.32763
Off-Peak	0.22158	0.00000	0.13323	0.35481	0.23111
Super Off-Peak	0.22158	0.00000	0.08905	0.31063	0.20095

Description – TOU-ELEC MB Rates	UDC Total Rate	DWR BC + WF-NBC	EECC Rate	Total Rate	Total Effective MB Rate
Monthly Service Fee	16.00			16.00	16.00
<b>Summer – MB Rates:</b>					
On-Peak	0.22228	0.00000	0.51588	0.73796	0.59037
Off-Peak	0.22228	0.00000	0.14644	0.36872	0.29498
Super Off-Peak	0.22228	0.00000	0.09785	0.32013	0.25610
<b>Winter – MB Rates:</b>					
On-Peak	0.22228	0.00000	0.27460	0.49688	0.39750
Off-Peak	0.22228	0.00000	0.13323	0.35551	0.28441
Super Off-Peak	0.22228	0.00000	0.08905	0.31133	0.24906

Note:

- (1) Total Rates consist of UDC, Schedule DWR-BC (Department of Water Resources Bond Charge), Schedule WF-NBC (CA Wildfire Fund charge) and Schedule EECC (Electric Energy Commodity Cost) rates. EECC rates are applicable to bundled customers only. See Special Condition 9 for PCIA (Power Charge Indifference Adjustment) recovery.
- (2) Total Rates presented are for customers that receive commodity supply and delivery service from Utility. Differences in total rates paid by Direct Access (DA) and Community Choice Aggregation (CCA) customers are identified in Schedule DA-CRS and CCA-CRS, respectively.
- (3) DWR-BC and WF-NBC charges do not apply to CARE or Medical Baseline customers.
- (4) WF-NBC rate is 0.00530 + DWR-BC Bond Charge is 0.00000

2H5 Issued by Submitted Jan 31, 2023  
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 Decision No. D.22-11-022 Resolution No.



San Diego Gas & Electric Company  
San Diego, California

Original Cal. P.U.C. Sheet No. 37197-E

Canceling Cal. P.U.C. Sheet No.

**SCHEDULE TOU-ELEC**

Sheet 3

**DOMESTIC TIME-OF-USE FOR HOUSEHOLDS WITH ELECTRIC VEHICLES, ENERGY STORAGE,  
OR ELECTRIC HEAT PUMPS**

**RATES (CONTINUED)**

**UDC Rates**

Description - TOU-ELEC	Transm	Distr	PPP	ND	CTC	LGC	RS	TRAC	UDC Total
Monthly Service Fee (\$/Mo)		16.00							16.00
<b>Summer:</b>									
On-Peak	0.07340	0.10796	0.02546	0.00007	0.00153	0.01383	0.00003	0.00000	0.22228
Off-Peak	0.07340	0.10796	0.02546	0.00007	0.00153	0.01383	0.00003	0.00000	0.22228
Super Off-Peak	0.07340	0.10796	0.02546	0.00007	0.00153	0.01383	0.00003	0.00000	0.22228
<b>Winter:</b>									
On-Peak	0.07340	0.10796	0.02546	0.00007	0.00153	0.01383	0.00003	0.00000	0.22228
Off-Peak	0.07340	0.10796	0.02546	0.00007	0.00153	0.01383	0.00003	0.00000	0.22228
Super Off-Peak	0.07340	0.10796	0.02546	0.00007	0.00153	0.01383	0.00003	0.00000	0.22228

Description - TOU-ELEC - CARE Rates	Transm	Distr	PPP	ND	CTC	LGC	RS	TRAC	UDC Total
Monthly Service Fee (\$/Mo)		16.00							16.00
<b>Summer CARE Rates:</b>									
On-Peak	0.07340	0.10726	0.02546	0.00007	0.00153	0.01383	0.00003	0.00000	0.22158
Off-Peak	0.07340	0.10726	0.02546	0.00007	0.00153	0.01383	0.00003	0.00000	0.22158
Super Off-Peak	0.07340	0.10726	0.02546	0.00007	0.00153	0.01383	0.00003	0.00000	0.22158
<b>Winter CARE Rates:</b>									
On-Peak	0.07340	0.10726	0.02546	0.00007	0.00153	0.01383	0.00003	0.00000	0.22158
Off-Peak	0.07340	0.10726	0.02546	0.00007	0.00153	0.01383	0.00003	0.00000	0.22158
Super Off-Peak	0.07340	0.10726	0.02546	0.00007	0.00153	0.01383	0.00003	0.00000	0.22158

Description - TOU-ELEC - MB Rates	Transm	Distr	PPP	ND	CTC	LGC	RS	TRAC	UDC Total
Monthly Service Fee (\$/Mo)		16.00							16.00
<b>Summer - MB Rates</b>									
On-Peak	0.07340	0.10796	0.02546	0.00007	0.00153	0.01383	0.00003	0.00000	0.22228
Off-Peak	0.07340	0.10796	0.02546	0.00007	0.00153	0.01383	0.00003	0.00000	0.22228
Super Off-Peak	0.07340	0.10796	0.02546	0.00007	0.00153	0.01383	0.00003	0.00000	0.22228
<b>Winter - MB Rates</b>									
On-Peak	0.07340	0.10796	0.02546	0.00007	0.00153	0.01383	0.00003	0.00000	0.22228
Off-Peak	0.07340	0.10796	0.02546	0.00007	0.00153	0.01383	0.00003	0.00000	0.22228
Super Off-Peak	0.07340	0.10796	0.02546	0.00007	0.00153	0.01383	0.00003	0.00000	0.22228

(Continued)

3H11 Issued by \_\_\_\_\_ Submitted Jan 31, 2023  
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 Decision No. D.22-11-022 Resolution No. \_\_\_\_\_



San Diego Gas & Electric Company  
San Diego, California

Original Cal. P.U.C. Sheet No. 37198-E

Canceling Cal. P.U.C. Sheet No.

Sheet 4

**SCHEDULE TOU-ELEC**  
**DOMESTIC TIME-OF-USE FOR HOUSEHOLDS WITH ELECTRIC VEHICLES, ENERGY STORAGE,**  
**OR ELECTRIC HEAT PUMPS**

**Notes:** Transmission Energy charges include the Transmission Revenue Balancing Account Adjustment (TRBAA) of \$(0.00242) per kWh and the Transmission Access Charge Balancing Account Adjustment (TACBAA) of \$(0.01631) per kWh. PPP Energy charges includes Low Income PPP rate (LI-PPP) \$0.01669/kWh, Non-low Income PPP rate (Non-LI-PPP) \$0.00333/kWh (pursuant to PU Code Section 399.8, the Non-LI-PPP rate may not exceed January 1, 2000 levels), Procurement Energy Efficiency Surcharge Rate of \$0.00422 /kWh, California Solar Initiative rate (CSI) of \$0.00000/kWh and Self-Generation Incentive Program rate (SGIP) \$0.00122/kWh.

**Rate Components**

The Utility Distribution Company Total Rates (UDC Total) shown above are comprised of the following components (if applicable): (1) Transmission (Trans) Charges, (2) Distribution (Distr) Charges, (3) Public Purpose Program (PPP) Charges, (4) Nuclear Decommissioning (ND) Charge, (5) Ongoing Competition Transition Charges (CTC), (6) Local Generation Charge (LGC), (7) Reliability Services (RS), and (8) the Total Rate Adjustment Component (TRAC).

Certain Direct Access customers are exempt from the TRAC, as defined in Rule 1 – Definitions.

**Franchise Fee Differential**

A Franchise Fee Differential of 5.78% will be applied to the monthly billings calculated under this schedule for all customers within the corporate limits of the City of San Diego. Such Franchise Fee Differential shall be so indicated and added as a separate item to bills rendered to such customers.

**Time Periods:**

All time periods listed are applicable to actual "clock" time)

TOU Period – Weekdays	Summer	Winter
On-Peak	4:00 p.m. – 9:00 p.m.	4:00 p.m. – 9:00 p.m.
Off-Peak	6:00 a.m. – 4:00 p.m.; 9:00 p.m. – midnight	6:00 a.m. – 4:00 p.m. Excluding 10:00 a.m.–2:00 p.m. in March and April; 9:00 p.m. - midnight
Super-Off-Peak	Midnight – 6:00 a.m.	Midnight – 6:00 a.m. 10:00 a.m. – 2:00 p.m. in March and April

TOU Period – Weekends and Holidays	Summer	Winter
On-Peak	4:00 p.m. – 9:00 p.m.	4:00 p.m. – 9:00 p.m.
Off-Peak	2:00 p.m. – 4:00 p.m.; 9:00 p.m. – midnight	2:00 p.m. – 4:00 p.m. 9:00 p.m. - midnight
Super-Off-Peak	Midnight – 2:00 p.m.	Midnight – 2:00 p.m.

**Seasons:**

Summer June 1 – October 31  
Winter November 1 – May 31

(Continued)

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San Diego Gas & Electric Company  
San Diego, California

Revised Cal. P.U.C. Sheet No. 35718-E

Canceling Revised Cal. P.U.C. Sheet No. 32576-E

**SCHEDULE E-CARE**

Sheet 1

CALIFORNIA ALTERNATE RATES FOR ENERGY

APPLICABILITY

This schedule provides a California Alternate Rates for Energy (CARE) discount to each of the following types of customers listed below that meet the requirements for CARE eligibility as defined in Rule 1, Definitions, and herein, and is taken in conjunction with the customer's otherwise applicable service schedule.

- 1) Customers residing in a permanent single-family accommodation, separately metered by the Utility.
- 2) Multi-family dwelling units and mobile home parks supplied through one meter on a single premises where the individual unit is submetered.
- 3) Non-profit group living facilities.
- 4) Agricultural employee housing facilities.

TERRITORY

Within the entire territory served by the Utility.

DISCOUNT

- 1) **Residential CARE:** Qualified residential CARE customers will receive a total effective discount according to the following:

	2015	2016	2017	2018	2019	2020 and beyond
<b>Effective Discount</b>	<b>40%</b>	<b>39%</b>	<b>38%</b>	<b>38%</b>	<b>36% R</b>	<b>35%</b>

Pursuant to Commission Decision (D.) 15-07-001, the average effective CARE discount for residential customers will decrease 1% each year until an average effective discount of 35% is reached in 2020.

The average effective CARE discount consists of: (a) exemptions from paying the CARE Surcharge, Department of Water Resources Bond Charge (DWR-BC), Vehicle-Grid Integration (VGI) costs, and California Solar Initiative (CSI); (b) a 50% minimum bill relative to Non-CARE; (c) the California Wildfire Fund Charge (WF-NBC) and (d) a separate line-item bill discount for all qualified residential CARE customers with the exclusion of CARE Medical Baseline customers taking service on tiered rates schedules. D.15-07-001 retained the rate subsidies in Non-CARE Medical Baseline tiered rates and thereby a separate line-item discount is provided for these CARE Medical Baseline customers

(Continued)

1C5

Advice Ltr. No. 3928-E

Issued by  
**Dan Skopec**  
Vice President

Submitted Dec 30, 2021  
Effective Jan 1, 2022



**RESIDENTIAL ELECTRIC SERVICE**

UTILITY RATE SCHEDULE E-1

**A. APPLICABILITY:**

This Rate Schedule applies to separately metered single-family residential dwellings receiving Electric Service from the City of Palo Alto Utilities.

**B. TERRITORY:**

This rate schedule applies everywhere the City of Palo Alto provides Electric Service.

**C. UNBUNDLED RATES:**

<u>Per kilowatt-hour (kWh)</u>	<u>Commodity</u>	<u>Distribution</u>	<u>Public Benefits</u>	<u>Total</u>
Tier 1 usage	\$ 0.09999	\$ 0.06954	\$ 0.00568	\$ 0.17521
Tier 2 usage Any usage over Tier 1	0.13873	0.10225	0.00568	0.24666
<u>Minimum Bill (\$/day)</u>				0.4181

**D. SPECIAL NOTES:**

**1. Calculation of Cost Components**

The actual bill amount is calculated based on the applicable rates in Section C above and adjusted for any applicable discounts, surcharges and/or taxes. On a Customer’s bill statement, the bill amount may be broken down into appropriate components as calculated under Section C.

**2. Calculation of Usage Tiers**

Tier 1 Electricity usage shall be calculated and billed based upon a level of 11 kWh per day, prorated by Meter reading days of Service. As an example, for a 30-day bill, the Tier 1 level would be 330 kWh. For further discussion of bill calculation and proration, refer to Rule and Regulation 11.

*{End}*

**CITY OF PALO ALTO UTILITIES**

Issued by the City Council



CITY OF  
**PALO ALTO**  
UTILITIES

Supersedes Sheet No E-1-1  
dated 7-1-2022

Sheet No **E-1-1**  
Effective 7-1-2023

## 6.2.6 Sacramento Municipal Utilities District (Electric Only)

Following are the SMUD electricity tariffs applied in this study. The rates effective January 2023 were used.

### Residential Time-of-Day Service Rate Schedule R-TOD

#### II. Firm Service Rates

##### A. Time-of-Day (5-8 p.m.) Rate

	Effective as of January 1, 2023	Effective as of January 1, 2024	Effective as of May 1, 2024	Effective as of January 1, 2025	Effective as of May 1, 2025
<b>Time-of-Day (5-8 p.m.) Rate (RT02)</b>					
<b>Non-Summer Season (October - May)</b>					
System Infrastructure Fixed Charge <i>per month per meter</i>	\$23.50	\$24.15	\$24.80	\$25.50	\$26.20
Electricity Usage Charge					
Peak \$/kWh	\$0.1547	\$0.1590	\$0.1633	\$0.1678	\$0.1724
Off-Peak \$/kWh	\$0.1120	\$0.1151	\$0.1183	\$0.1215	\$0.1248
<b>Summer Season (June - September)</b>					
System Infrastructure Fixed Charge <i>per month per meter</i>	\$23.50	\$24.15	\$24.80	\$25.50	\$26.20
Electricity Usage Charge					
Peak \$/kWh	\$0.3279	\$0.3369	\$0.3462	\$0.3557	\$0.3655
Mid-Peak \$/kWh	\$0.1864	\$0.1914	\$0.1967	\$0.2021	\$0.2077
Off-Peak \$/kWh	\$0.1350	\$0.1387	\$0.1425	\$0.1464	\$0.1505

##### B. Optional Critical Peak Pricing Rate

- The CPP Rate base prices per time-of-day period are the same as the prices per time-of-day period for TOD (5-8 p.m.).
- The CPP Rate provides a discount per kWh on the Mid-Peak and Off-Peak prices during summer months.
- During CPP Events, customers will be charged for energy used at the applicable time-of-day period rate plus the CPP Rate Event Price per kWh as shown on [www.smud.org](http://www.smud.org).
- During CPP Events, energy exported to the grid will be compensated at the CPP Rate Event Price per kWh as shown on [www.smud.org](http://www.smud.org).
- The CPP Rate Event Price and discount will be updated annually at SMUD's discretion and posted on [www.smud.org](http://www.smud.org).

##### C. Plug-In Electric Vehicle Credit (rate categories RT02 and RTC1)

This credit is for residential customers who have a licensed passenger battery electric plug-in or plug-in hybrid electric vehicle.

Credit applies to all electricity usage charges from midnight to 6:00 a.m. daily.

Electric Vehicle Credit..... **-\$0.0150/kWh**

#### III. Electricity Usage Surcharges

Refer to the following rate schedules for details on these surcharges.

- A. **Hydro Generation Adjustment (HGA).** Refer to Rate Schedule HGA.

#### IV. Rate Option Menu

- A. **Energy Assistance Program Rate.** Refer to Rate Schedule EAPR.
- B. **Medical Equipment Discount Program.** Refer to Rate Schedule MED.
- C. **Joint Participation in Medical Equipment Discount and Energy Assistance Program Rate.** Refer to Rate Schedule MED.

**A. Time-of-Day (5-8 p.m.) Rate (rate category RT02)**

1. The TOD (5-8 p.m.) Rate is the standard rate for SMUD’s residential customers. Eligible customers can elect the Fixed Rate under Rate Schedule R as an alternative rate.
2. The TOD (5-8 p.m.) Rate is an optional rate for customers who have an eligible renewable electrical generation facility under Rate Schedule NEMI that was approved for installation by SMUD prior to January 1, 2018.
3. This rate has five kilowatt-hour (kWh) prices, depending on the time-of-day and season as shown below. Holidays are detailed in Section V. Conditions of Service.

<b>Summer (Jun 1 - Sept 30)</b>	<b>Peak</b>	Weekdays between 5:00 p.m. and 8:00 p.m.
	<b>Mid-Peak</b>	Weekdays between noon and midnight except during the Peak hours.
	<b>Off-Peak</b>	All other hours, including weekends and holidays <sup>1</sup> .
<b>Non-Summer (Oct 1 - May 31)</b>	<b>Peak</b>	Weekdays between 5:00 p.m. and 8:00 p.m.
	<b>Off-Peak</b>	All other hours, including weekends and holidays <sup>1</sup> .

<sup>1</sup> See Section V. Conditions of Service

### 6.2.7 Fuel Escalation Assumptions

The average annual escalation rates in Table 28 were used in this study. These are based on assumptions from the CPUC 2021 En Banc hearings on utility costs through 2030 (California Public Utilities Commission, 2021a). Escalation rates through the remainder of the 30-year evaluation period are based on the escalation rate assumptions within the 2022 TDV factors. No data was available to estimate electricity escalation rates for CPAU and SMUD, therefore electricity escalation rates for PG&E and statewide natural gas escalation rates were applied. Table 29 presents the average annual escalation rates used in the utility rate escalation sensitivity analysis shown in Section 3.2.4. Rates were applied for the same 30-year period and are based on the escalation rate assumptions within the 2025 LSC factors from 2027 through 2053.<sup>28</sup> These rates were developed for electricity use statewide (not utility-specific) and assume steep increases in gas rates in the latter half of the analysis period. Data was not available for the years 2024, 2025, and 2026 and so the CPUC En Banc assumptions were applied for those years using the average rate across the three IOUs for statewide electricity escalation.

**Table 28: Real Utility Rate Escalation Rate Assumptions, CPUC En Banc and 2022 TDV Basis**

	Statewide Natural Gas Residential Average Rate (%/year, real)	Electric Residential Average Rate (%/year, real)		
		PG&E	SCE	SDG&E
2024	4.6%	1.8%	1.6%	2.8%
2025	4.6%	1.8%	1.6%	2.8%
2026	4.6%	1.8%	1.6%	2.8%
2027	4.6%	1.8%	1.6%	2.8%
2028	4.6%	1.8%	1.6%	2.8%
2029	4.6%	1.8%	1.6%	2.8%
2030	4.6%	1.8%	1.6%	2.8%
2031	2.0%	0.6%	0.6%	0.6%
2032	2.4%	0.6%	0.6%	0.6%
2033	2.1%	0.6%	0.6%	0.6%
2034	1.9%	0.6%	0.6%	0.6%
2035	1.9%	0.6%	0.6%	0.6%
2036	1.8%	0.6%	0.6%	0.6%
2037	1.7%	0.6%	0.6%	0.6%
2038	1.6%	0.6%	0.6%	0.6%
2039	2.1%	0.6%	0.6%	0.6%
2040	1.6%	0.6%	0.6%	0.6%
2041	2.2%	0.6%	0.6%	0.6%
2042	2.2%	0.6%	0.6%	0.6%
2043	2.3%	0.6%	0.6%	0.6%
2044	2.4%	0.6%	0.6%	0.6%
2045	2.5%	0.6%	0.6%	0.6%
2046	1.5%	0.6%	0.6%	0.6%
2047	1.3%	0.6%	0.6%	0.6%
2048	1.6%	0.6%	0.6%	0.6%
2049	1.3%	0.6%	0.6%	0.6%
2050	1.5%	0.6%	0.6%	0.6%
2051	1.8%	0.6%	0.6%	0.6%
2052	1.8%	0.6%	0.6%	0.6%
2053	1.8%	0.6%	0.6%	0.6%

<sup>28</sup><https://www.energy.ca.gov/files/2025-energy-code-hourly-factors>. Actual escalation factors were provided by consultants E3.

**Table 29: Real Utility Rate Escalation Rate Assumptions, 2025 LSC Basis**

Year	Statewide Natural Gas Residential Average Rate (%/year, real)	Statewide Electricity Residential Average Rate (%/year, real)
2024	4.6%	2.1%
2025	4.6%	2.1%
2026	4.6%	2.1%
2027	4.2%	0.6%
2028	3.2%	1.9%
2029	3.6%	1.6%
2030	6.6%	1.3%
2031	6.7%	1.0%
2032	7.7%	1.2%
2033	8.2%	1.1%
2034	8.2%	1.1%
2035	8.2%	0.9%
2036	8.2%	1.1%
2037	8.2%	1.1%
2038	8.2%	1.0%
2039	8.2%	1.1%
2040	8.2%	1.1%
2041	8.2%	1.1%
2042	8.2%	1.1%
2043	8.2%	1.1%
2044	8.2%	1.1%
2045	8.2%	1.1%
2046	8.2%	1.1%
2047	3.1%	1.1%
2048	-0.5%	1.1%
2049	-0.6%	1.1%
2050	-0.5%	1.1%
2051	-0.6%	1.1%
2052	-0.6%	1.1%
2053	-0.6%	1.1%

## Get In Touch

The adoption of reach codes can differentiate jurisdictions as efficiency leaders and help accelerate the adoption of new equipment, technologies, code compliance, and energy savings strategies.

As part of the Statewide Codes & Standards Program, the Reach Codes Subprogram is a resource available to any local jurisdiction located throughout the state of California.

Our experts develop robust toolkits as well as provide specific technical assistance to local jurisdictions (cities and counties) considering adopting energy reach codes. These include Cost-effectiveness research and analysis, model ordinance language and other code development and implementation tools, and specific technical assistance throughout the code adoption process.

If you are interested in finding out more about local energy reach codes, the Reach Codes Team stands ready to assist jurisdictions at any stage of a reach code project.



Visit [LocalEnergyCodes.com](https://LocalEnergyCodes.com) to access our resources and sign up for newsletters.



Contact [info@localenergycodes.com](mailto:info@localenergycodes.com) for no-charge assistance from expert Reach Code advisors



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# 2022 Cost-Effectiveness Study: Single Family New Construction



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## Legal Notice

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## Acronym List

2023 PV\$ – Present value costs in 2023

ACH50 – Air Changes per Hour at 50 pascals pressure differential

ACM – Alternative Calculation Method

ADU – Accessory Dwelling Unit

AFUE – Annual Fuel Utilization Efficiency

B/C – Lifecycle Benefit-to-Cost Ratio

BEopt – Building Energy Optimization Tool

BSC – Building Standards Commission

CA IOUs – California Investor-Owned Utilities

CASE – Codes and Standards Enhancement

CBEECC-Res – Computer program developed by the California Energy Commission for use in demonstrating compliance with the California Residential Building Energy Efficiency Standards

CFI – California Flexible Installation

CFM – Cubic Feet per Minute

CO<sub>2</sub> – Carbon Dioxide

CPAU – City of Palo Alto Utilities

CPUC – California Public Utilities Commission

CZ – California Climate Zone

DHW – Domestic Hot Water

DOE – Department of Energy

DWHR – Drain Water Heat Recovery

EDR – Energy Design Rating

EER – Energy Efficiency Ratio

EF – Energy Factor



GHG – Greenhouse Gas

HERS Rater – Home Energy Rating System Rater

HPA – High Performance Attic

HPWH – Heat Pump Water Heater

HSPF – Heating Seasonal Performance Factor

IECC – International Energy Conservation Code

IOU – Investor Owned Utility

kBtu – kilo-British thermal unit

kWh – Kilowatt Hour

LBNL – *Lawrence Berkeley National Laboratory*

LCC – Lifecycle Cost

LLAHU – Low Leakage Air Handler Unit

LSC – Long-term System Cost (2025 Title 24, Part 6 compliance metric)

MF – Multifamily

NEEA – Northwest Energy Efficiency Alliance

NEM – Net Energy Metering

NPV – Net Present Value

NREL – *National Renewable Energy Laboratory*

PG&E – Pacific Gas and Electric Company

POU – Publicly-Owned-Utilities

PV – Photovoltaic

SCE – Southern California Edison

SDG&E – San Diego Gas and Electric

SEER – Seasonal Energy Efficiency Ratio

SF – Single Family

SMUD – Sacramento Municipal Utility District

SoCalGas – Southern California Gas Company

TDV – Time Dependent Valuation (2022 Title 24, Part 6 compliance metric)

Therm – Unit for quantity of heat that equals 100,000 British thermal units

Title 24 – Title 24, Part 6

TOU – Time-Of-Use

UEF – Uniform Energy Factor

VLLDCS – Verified Low Leakage Ducts in Conditioned Space

ZNE – Zero-net Energy

### Summary of Revisions

Date	Description	Reference (page or section)
9/12/2022	Original Release (1.0)	N/A
3/25/2024	Updated analysis (1.1)	<ul style="list-style-type: none"> <li>• New simulation results with latest CBECC-Res version (Section 2.1.1)</li> <li>• Updated utility cost estimates using recent utility tariff and net billing tariff (Section 2.1.3)</li> <li>• New measure costs for heat pumps, batteries, and PV (Section 3.3)</li> <li>• Revised packages (Section 3.4)</li> <li>• Revised Results, Summary, References, and Appendices (Sections 4-7)</li> </ul>
4/26/2024	Corrected errors (1.2)	<ul style="list-style-type: none"> <li>• Corrected incorrect results in Tables 16-19, 23, 26</li> </ul>
5/30/2024	Corrected errors (1.3)	<ul style="list-style-type: none"> <li>• Corrected incorrect results in Tables 15-18, 22-28</li> </ul>

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## Executive Summary

The California Codes and Standards (C&S) Reach Codes program provides technical support to local governments considering adopting a local ordinance (reach code) intended to support meeting local and/or statewide energy efficiency and greenhouse gas (GHG) reduction goals. The program facilitates adoption and implementation of the code when requested by local jurisdictions by providing resources such as cost-effectiveness studies, model language, sample findings, and other supporting documentation.

This report documents cost-effectiveness analysis results for traditional new detached single family and detached accessory dwelling unit (ADUs) building types. It evaluates mixed fuel and all-electric package options in all sixteen California climate zones (CZs). Packages include combinations of efficiency measures, on-site renewable energy, and battery energy storage.

This analysis used two different metrics to assess the cost-effectiveness of the proposed upgrades. Both methodologies require estimating and quantifying the incremental costs and energy savings associated with each energy efficiency measure over a 30-year analysis period. On-Bill cost-effectiveness is a customer-based lifecycle cost (LCC) approach that values energy based upon estimated site energy usage and customer utility bill savings using today's electricity and natural gas utility tariffs. Time Dependent Valuation (TDV) is the California Energy Commission's LCC methodology, which is intended to capture the long-term projected cost of energy, including costs for providing energy during peak periods of demand, carbon emissions, grid transmission and distribution impacts. This is the methodology used by the Energy Commission in evaluating cost-effectiveness for efficiency measures in Title 24, Part 6.

The following are key takeaways and recommendations from the analysis.

### Conclusions and Discussion:

- All-electric buildings have lower GHG emissions than mixed fuel buildings, due to the clean power sources currently available from California's power providers as well as accounting for increased penetration of renewables in the future. Almost all the all-electric packages evaluated resulted in greater GHG emission savings than the mixed fuel packages, with the exception of the mixed fuel package with battery storage in climate zones with low heating loads.
- The Reach Codes Team found code-compliant all-electric new construction to be feasible and cost-effective based on TDV for single family homes in all cases except Climate Zone 16.
- All-electric single family new construction was On-Bill cost-effective in all cases except Climate Zones 1, 3, 14, and 16.
- The all-electric ADU home was cost-effective based on TDV in all cases except in Climate Zones 3, 4, 13, and 14 where the higher cost of installing a ducted heat pump water heater (HPWH) instead of the prescriptively required gas tankless water heater exceed the resulting energy cost savings. In the other climate zones there were first cost savings for installing a heat pump space heater instead of a gas furnace, contributing to an overall TDV cost-effective result.
- Few cases were cost-effective On-Bill for the ADU.
- All-electric code minimum construction results in an increase in first lifetime costs relative to a mixed fuel home, except for CPAU and SMUD where electricity rates are much lower than for the investor-owned utilities (IOUs). The addition of efficiency measures, market dominant HPWHs that meet the Northwest Energy Efficiency Alliance's (NEEA's) Advanced Water Heating Specification<sup>1</sup>, high efficiency heat pumps, increased solar photovoltaics (PV), and batteries all reduce utility costs, and the combination of these options was found to reduce annual utility costs relative to a mixed fuel home in all cases.

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<sup>1</sup> Refer to Section 0 for an explanation of HPWHs certified through NEEA's Advanced Water Heating Specification, their market status, and how they compare to federal minimum efficiency standards.

- Under the Net Billing Tariff (NBT)<sup>2</sup>, utility cost savings for increasing PV system size beyond code minimum are substantially less than what they were under prior net energy metering rules (NEM 2.0); however, savings are sufficient to be On-Bill cost-effective in all climate zones for the all-electric single family home except climate zones 1, 3, and 16. Coupling PV with battery systems increases utility cost savings as a result of improved on-site utilization of PV generation and fewer exports to the grid.
- Applying California Alternate Rates for Energy (CARE) rates in the IOU territories improves On-Bill cost-effectiveness for all-electric buildings, as compared to the same case under standard rates, due to higher utility cost savings compared to a code compliant mixed fuel building also on a CARE rate. This is due to the CARE discount on electricity being higher than that on gas.
- If gas tariffs are assumed to increase substantially over time, in line with the escalation assumption from the 2025 LSC development, all-electric new construction was found to be On-Bill cost-effective in almost all single family and most ADU scenarios over the 30-year analysis period. There is much uncertainty surrounding future tariff structures as well as escalation values. While it's clear that gas rates are anticipated to increase, how much and how quickly is not known. Electricity tariff structures are expected to evolve over time, and the California Public Utilities Commission (CPUC) has an active proceeding to adopt an income-graduated fixed charge that benefits low-income customers and supports electrification measures<sup>3</sup>. The CPUC will make a decision in mid-2024 and the new rates are expected to be in place later that year or in 2025. While the anticipated impact of this rate change is lower volumetric electricity rates, the rate design is not finalized. While lower volumetric electricity rates provide many benefits like incentivizing electrification, it also will make building efficiency measures harder to justify as cost-effective due to lower utility bill cost savings.

#### Recommendations:

- A reach code with a single performance target based on source energy (EDR1) can be structured to strongly encourage electrification. This approach requires equivalent performance for all buildings and allows mixed fuel buildings which minimizes the risk of violating federal preemption. Below are examples of how a reach code for single family homes could be set up based on the results summarized in Table 27.
  - A jurisdiction in Climate Zone 12 could set a performance target at an EDR1 margin of 11.5 (the EDR1 margin for the all-electric Code Minimum package). Any all-electric home meeting or exceeding the prescriptive requirements would comply, and a mixed fuel home would likely need to incorporate a combination of efficiency measures and a battery system to comply.
  - Similarly, a jurisdiction in Climate Zone 7 may consider setting a performance target of 2.8 EDR1 margin (also the EDR1 margin for the all-electric Code Minimum package). Any all-electric home meeting or exceeding the prescriptive requirements would comply, but a mixed fuel home would likely be able to comply with only a suite of above-code efficiency measures (no battery). Alternatively, a higher EDR1 margin target of 5 would incentivize more energy efficiency or additional PV for all-electric construction, and mixed fuel construction would likely need to incorporate a battery system to comply.
  - A jurisdiction in Climate Zone 16 may want to set a performance target at an EDR1 margin of 20.4 (the EDR1 margin for the mixed fuel efficiency + PV + battery package). This would establish a target that a mixed fuel home could On-Bill cost-effectively meet, likely only after incorporating a combination of efficiency measures and a battery system, and that an all-electric home could easily meet.
- The 2022 Title 24 code's new source energy metric combined with the heat pump baseline encourage all-electric construction, providing an incentive that allows for some amount of prescriptively required building efficiency to be traded off, still meeting minimum code compliance. This compliance benefit for all-electric homes highlights a unique opportunity for jurisdictions to incorporate efficiency into all-electric reach codes. Efficiency and electrification have symbiotic benefits and are both critical for decarbonization of buildings. As demand on the electric grid is increased through electrification, efficiency can reduce the negative impacts of

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<sup>2</sup> Refer to Section 2.1.3 for discussion on NBT and NEM

<sup>3</sup> <https://www.cpuc.ca.gov/industries-and-topics/electrical-energy/electric-costs/demand-response-dr/demand-flexibility-rulemaking>

additional electricity demand on the grid, reducing the need for increased generation and storage capacity, as well as the need to upgrade upstream transmission and distribution equipment. The Reach Codes Team recommends that jurisdictions adopting a reach code for single family buildings also include an efficiency requirement with EDR1 margins at minimum consistent with the all-electric code minimum package results in Table 27.

- The code compliance margins for the ADU all-electric code minimum package are lower than for the single family prototype; code compliance and cost-effectiveness can be more challenging for smaller dwelling units. As a result, the Reach Codes Team does not recommend EDR1 targets above those reported for the all-electric Code Minimum package in Table 28.

This report presents measures or measure packages that local jurisdictions may consider adopting to achieve energy savings and emissions reductions beyond what will be accomplished by enforcing minimum state requirements, the 2022 Building Energy Efficiency Standards (Title 24, Part 6), effective January 1, 2023.

Local jurisdictions may also adopt ordinances that amend different Parts of the California Building Standards Code or may elect to amend other state or municipal codes. The decision regarding which code to amend will determine the specific requirements that must be followed for an ordinance to be legally enforceable. For example, jurisdictions may amend Part 11 instead of Part 6 of the CA Building Code requiring review and approval by the Building Standards Commission (BSC) but not the California Energy Commission (Energy Commission). Reach codes that amend Part 6 of the CA Building Code and require energy performance beyond state code minimums must demonstrate the proposed changes are cost-effective and obtain approval from the Energy Commission. Although a cost-effectiveness study is only required to amend Part 6 of the CA Building Code, this study provides valuable context for jurisdictions pursuing other ordinance paths to understand the economic impacts of any policy decision. This study documents the estimated costs, benefits, energy impacts and greenhouse gas emission reductions that may result from implementing an ordinance based on the results to help residents, local leadership, and other stakeholders make informed policy decisions.

Model ordinance language and other resources are posted on the C&S Reach Codes Program website at [LocalEnergyCodes.com](https://www.localenergycodes.com). Local jurisdictions that are considering adopting an ordinance may contact the program for further technical support at [info@localenergycodes.com](mailto:info@localenergycodes.com). In addition, jurisdictions in a CCA territory with rates or rate structures that are significantly different than IOU rates may email the program at [info@localenergycodes.com](mailto:info@localenergycodes.com) to request a custom analysis.

# 1 Introduction

This report documents cost-effective combinations of measures that exceed the minimum state requirements, the 2022 Building Energy Efficiency Standards, effective January 1, 2023, for newly constructed single family buildings. This report was developed in coordination with the California Statewide Investor-Owned Utilities (CA IOUs) Codes and Standards Program, key consultants, and engaged cities—collectively known as the Reach Codes Team.

The analysis considers traditional detached single family and detached accessory dwelling unit (ADUs) building types and evaluates mixed fuel and all-electric package options in all sixteen California climate zones (CZs).<sup>4</sup> Packages include combinations of efficiency measures, on-site renewable energy, and battery energy storage.

This report documents the key results and conclusions from the Reach Codes Team analysis. A full dataset of all results can be downloaded from the Local Energy Codes [Resources](#)<sup>5</sup> webpage. Results alongside policy options and the potential citywide impacts for specific jurisdictions can also be explored using the Cost-effectiveness Explorer at <https://explorer.localenergycodes.com/>.

The California Building Energy Efficiency Standards Title 24, Part 6 (Title 24) (California Energy Commission, 2021a) is maintained and updated every three years by two state agencies: the California Energy Commission (Energy Commission) and the Building Standards Commission (BSC). In addition to enforcing the code, local jurisdictions have the authority to adopt local energy efficiency ordinances—or reach codes—that exceed the minimum standards defined by Title 24 (as established by Public Resources Code Section 25402.1(h)2 and Section 10-106 of the Building Energy Efficiency Standards). Local jurisdictions must demonstrate that the requirements of the proposed ordinance are cost-effective and do not result in buildings consuming more energy than is permitted by Title 24. In addition, the jurisdiction must obtain approval from the Energy Commission and file the ordinance with the BSC for the ordinance to be legally enforceable.

The Department of Energy (DOE) sets minimum efficiency standards for equipment and appliances that are federally regulated under the National Appliance Energy Conservation Act, including heating, cooling, and water heating equipment (E-CFR, 2020). Since state and local governments are prohibited from adopting higher minimum efficiencies than the federal standards require — herein referred to as federal preemption — the focus of this study is to identify and evaluate cost-effective packages that do not include high efficiency heating, cooling, and water heating equipment. High efficiency appliances are often the easiest and most affordable measures to increase energy performance. While federal preemption limits reach code mandatory requirements for covered appliances, in practice, builders may install any package of compliant measures to achieve the performance requirements.

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<sup>4</sup> See Appendix 7.1 Map of California Climate Zones for a graphical depiction of climate zone locations.

<sup>5</sup> <https://localenergycodes.com/content/resources/?q=newly%20constructed%20buildings:%20efficiency%20and%20electrification>

## 2 Methodology and Assumptions

### 2.1 Analysis for Reach Codes

This section describes the approach to calculating cost-effectiveness including benefits, costs, metrics, and utility rate selection.

#### 2.1.1 Modeling

The Reach Codes Team performed energy simulations using software approved for 2022 Title 24 Code compliance analysis, CBECC-Res 2022.3.0.

The general approach applied in this analysis is to evaluate performance and determine cost-effectiveness of various energy efficiency upgrade measures, individually and as packages, in single family buildings. Using the 2022 baseline as the starting point, prospective measures and packages were identified and modeled in each of the prototypes to determine the projected energy use (therm and kWh) and compliance impacts. A large set of parametric runs were conducted to evaluate various options and develop packages of measures that met or exceeded minimum code performance. The analysis utilized a Python based parametric tool to automate and manage the generation of CBECC-Res input files. This allowed for quick evaluation of various efficiency measures across multiple climate zones and prototypes and improved quality control. The batch process functionality of CBECC-Res was utilized to simulate large groups of input files at once.

#### 2.1.2 Cost-effectiveness

##### 2.1.2.1 Benefits

This analysis used two different metrics to assess cost-effectiveness of the proposed upgrades. Both methodologies require estimating and quantifying the incremental costs and energy savings associated with each energy efficiency measure. The main difference between the methodologies is the manner in which they value energy and thus the cost savings of reduced or avoided energy use:

**Utility Bill Impacts (On-Bill):** Customer-based lifecycle cost (LCC) approach that values energy based upon estimated site energy usage and customer utility bill savings using today's electricity and natural gas utility tariffs. Total savings are estimated over a 30-year duration and include discounting of future costs and energy cost inflation.

**Time Dependent Valuation (TDV):** Energy Commission LCC methodology, which is intended to capture the total value or cost of energy use over 30 years. This method accounts for long-term projected costs, such as the cost of providing energy during peak periods of demand, and other societal costs, such as projected costs for carbon emissions as well as grid transmission and distribution impacts. This metric values energy use differently depending on the fuel source (natural gas, electricity, and propane), time of day, and season. For example, electricity used (or saved) during peak periods has a much higher value than electricity used (or saved) during off-peak periods due to the less inefficient energy generation sources providing peak electricity (Horii, Cutter, Kapur, Arent, & Conotyannis, 2014). This is the methodology used by the Energy Commission in evaluating cost-effectiveness for efficiency measures in Title 24, Part 6.

##### 2.1.2.2 Costs

The Reach Codes Team assessed the incremental costs of the measures and packages over a 30-year lifecycle. Incremental costs represent the equipment, installation, replacement, and maintenance costs of the proposed measure relative to the 2022 Title 24 Standards minimum requirements or standard industry practices. Present value of replacement cost is included only for measures with lifetimes less than the 30-year evaluation period.

In calculating On-Bill cost-effectiveness, incremental first costs were assumed to be financed into a mortgage or loan with a 30-year loan term and four percent interest rate. Financing was not applied to future replacement or maintenance costs. In calculating TDV cost-effectiveness, incremental first costs were not assumed to be financed into a mortgage or loan.

**2.1.2.3 Metrics**

Cost-effectiveness is presented using net present value (NPV) and benefit-to-cost (B/C) ratio metrics.

**NPV Savings:** The lifetime NPV savings is reported as a cost-effectiveness metric; Equation 1 demonstrates how this is calculated. If the net savings of a measure or package is positive, it is considered cost-effective. Negative savings represent net costs.

**B/C Ratio:** Ratio of the present value of all benefits to the present value of all costs over 30 years (present value of benefits divided by present value of costs). The criteria benchmark for cost-effectiveness is a B/C ratio greater than one. A value of one indicates the present value of the savings over the analysis period is equivalent to the present value of the lifetime incremental cost of that measure. A value greater than one represents a positive return on investment. The B/C ratio is calculated according to Equation 2.

**Equation 1**

$$NNNNN \text{ SSSSSSSSSSSSS} = NNPPPPSSPPSSPP \text{ SSSSvvvvPP } 0000 \text{ vSSooPPPPSSUIPP } bbPPSSPPooSSPP - NNPPPPSSPPSSPP \text{ SSSSvvvvPP } 0000 \text{ vSSooPPPPSSUIPP } ccooSSPP$$

**Equation 2**

$$BBPPSSPPooSSPP - PPoo - CCooSSPP \text{ RRSSPPSSoo} = \frac{NNPPPPSSPPSSPP \text{ SSSSvvvvPP } 0000 \text{ vSSooPPPPSSUIPP } bbPPSSPPooSSPP}{NNPPPPSSPPSSPP \text{ SSSSvvvvPP } 0000 \text{ vSSooPPPPSSUIPP } ccooSSPP}$$

Improving the efficiency of a project often requires an initial incremental investment. In most cases the benefit is represented by annual On-Bill utility or TDV savings, and the cost is represented by incremental first cost and replacement costs. However, some packages result in initial construction cost savings (negative incremental cost), and either energy cost savings (positive benefits), or increased energy costs (negative benefits). In cases where both construction costs and energy-related savings are negative, the construction cost savings are treated as the ‘benefit’ while the increased energy costs are the ‘cost.’ In cases where a measure or package is cost-effective immediately (i.e., upfront construction cost savings and lifetime energy cost savings), B/C ratio cost-effectiveness is represented by “>1”.

The lifetime costs or benefits are calculated according to Equation 3.

**Equation 3**

$$NNNN \text{ } 0000 \text{ vSSooPPPPSSUIPP } ccooSSPP \text{ } ooPP \text{ } bbPPSSPPooSSPP = \sum_{cc=0}^{AA} \frac{(AAAAAAAAA \text{ } A \text{ } ccccccc \text{ } c \text{ } cco \text{ } o \text{ } bbbbAAbbbbccc)_{tt}}{(1+oo)}$$

Where: *n* = analysis term in years

*r* = discount rate

The following summarizes the assumptions applied in this analysis to both methodologies.

- Analysis term of 30 years*
- Real discount rate of three percent*

TDV is a normalized monetary format and there is a unique procedure for calculating the present value benefit of TDV energy savings. The present value of the energy cost savings in dollars is calculated by multiplying the TDV savings (reported by the CBECC-Res simulation software) by a NPV factor developed by the Energy Commission (see (Energy + Environmental Economics, 2020)). The 30-year residential NPV factor is \$0.173/kTDV kBtu for the 2022 code cycle.

**Equation 4**

$$TTTTNN \text{ } NNNN \text{ } 0000 \text{ vSSooPPPPSSUIPP } bbPPSSPPooSSPP = TTTTTN \text{ } PPSSPPPPSSee \text{ } SSSSSSSSSSSSS * NNNNNN \text{ } ooSccPPooPP$$

### 2.1.3 Utility Rates

In coordination with the CA IOU rate team (comprised of representatives from Pacific Gas and Electric (PG&E), Southern California Edison (SCE) and San Diego Gas and Electric (SDG&E)) and two Publicly-Owned-Utilities (POUs) (Sacramento Municipal Utility District (SMUD) and City of Palo Alto Utilities (CPAU)), the Reach Codes Team determined appropriate utility rates for each climate zone in order to calculate utility costs and determine On-Bill cost-effectiveness for the proposed measures and packages. The utility tariffs, summarized in Table 1, were determined based on the most prevalent active rate in each territory. Utility rates were applied to each climate zone based on the predominant IOU serving the population of each zone, with a few climate zones evaluated multiple times under different utility scenarios. Climate Zones 10 and 14 were evaluated with both SCE/SoCalGas and SDG&E tariffs since each utility has customers within these climate zones. Climate Zone 5 is evaluated under both PG&E and SoCalGas natural gas rates. Two POU or municipal utility rates were also evaluated: SMUD in Climate Zone 12 and CPAU in Climate Zone 4.

Some community choice aggregations (CCAs) have utility rates that are very similar to IOU rates, often within \$0.02 per kWh. For these CCA customers, total utility costs will be very similar to those calculated in this study and the results from this study will generally apply. The study results cannot be easily applied to CCAs with rates that do not closely track the IOU rates or municipal utilities outside of SMUD and CPAU.

First-year utility costs were calculated using hourly electricity and natural gas output from CBEC-Res and applying the utility tariffs summarized in Table 1. Annual costs were also estimated for IOU customers eligible for the CARE tariff discounts on both electricity and natural gas bills. Appendix 7.2 Utility Rate Schedules includes details of each utility tariff. For cases with onsite generation (i.e. solar photovoltaics (PV)), the approved Net Billing Tariff (NBT) was applied along with monthly service fees and hourly export compensation rates for 2024<sup>6</sup>. In December 2022, the California Public Utilities Commission (CPUC) issued a decision adopting NBT as a successor to prior net energy metering rules (NEM 2.0) that went into effect April of 2023.<sup>7</sup> The ADU was assumed to have separate electric and gas meters from the main house.

**Table 1: Utility Tariffs Used Based on Climate Zone**

**IOUs**

Climate Zones	Electric / Gas Utility	Electricity Tariff	Natural Gas Tariff
1-5,11-13,16	PG&E / PG&E	E-ELEC	G1
5	PG&E / SoCalGas	E-ELEC	GR
6, 8-10, 14, 15	SCE / SoCalGas	TOU-D-PRIME	GR
7, 10, 14	SDG&E / SDG&E	EV-TOU-5 (TOU-ELEC for ADU cases without PV systems <sup>8</sup> )	GR

**POUs**

Climate Zones	Electric / Gas Utility	Electricity Tariff	Natural Gas Tariff
4	CPAU / CPAU	E-1	G1
12	SMUD / PG&E	R-TOD	G1

Utility rates are assumed to escalate over time according to the CPUC 2021 En Banc hearings on utility costs through 2030 (California Public Utilities Commission, 2021a). Escalation rates through the remainder of the 30-year evaluation period are based on the escalation rate assumptions within the 2022 TDV factors. A second set of escalation rates were also evaluated to demonstrate the impact that utility cost changes over time have on cost-effectiveness. This

<sup>6</sup> <https://www.cpuc.ca.gov/-/media/cpuc-website/divisions/energy-division/documents/net-energy-metering-nem/nemrevisit/nbt-model--12142022.xlsb>

<sup>7</sup> <https://www.cpuc.ca.gov/nemrevisit>

<sup>8</sup> See Section 3.2 Prototype Characteristics for a description of ADU cases that don't require solar PV prescriptively.

utility rate escalation sensitivity analysis, presented in Section 4.6.3, was based on those used within the 2025 Long-term System Cost (LSC) factors (LSC replaces TDV in the 2025 code cycle) which assumed steep increases in gas rates in the latter half of the analysis period. See Appendix 7.2.7 Fuel Escalation Assumptions for details.

## 2.2 Greenhouse Gas Emissions

The analysis reports the greenhouse gas (GHG) emission estimates based on assumptions within CBECC-Res. There are 8,760 hourly multipliers accounting for time-dependent energy use and carbon based on source emissions, including renewable portfolio standard projections. There are two strings of multipliers—one for Northern California climate zones, and another for Southern California climate zones.<sup>9</sup> GHG emissions are reported as average annual metric tons of CO<sub>2</sub> equivalent over the 30-year measure analysis period.

## 2.3 Energy Design Rating

The 2019 Title 24 Code introduced California’s Energy Design Rating (EDR) as the primary metric to demonstrate compliance with the energy code for single family buildings. This EDR was based on the hourly TDV energy use from a building that is compliant with the 2006 International Energy Conservation Code (IECC) as the Reference Building. The Reference Building has an EDR score of 100 while a zero-net energy (ZNE) home has an EDR score of zero. While the Reference Building is used to set the scale for the rating, the Proposed Design is still compared to the Standard Design based on the Title 24 prescriptive baseline assumptions to determine compliance. In the 2022 Title 24 Code a second new EDR metric was introduced based on hourly source energy. The two EDR metrics are described below:

*EDR1 is calculated based on source energy.*

*EDR2 is calculated based on TDV energy.*

EDR1 has only one component, “Total EDR1” which represents source energy use for the entire building. EDR2 is composed of two components for compliance purposes: the “Efficiency EDR2”, which represents the energy efficiency features of a home, and the PV/Flexibility EDR2, which includes the effects of PV and battery storage systems. “Total EDR2” combines all energy use of the building including both the Efficiency and PV/Flexibility impacts. While the Efficiency EDR2 does not include the full impact of a battery system, it can include a self-utilization credit for batteries if certain conditions are met.

For a new, single family building to comply with the 2022 Title 24 Code, three criteria must be met:

1. The Proposed Total EDR1 must be equal to or less than the Total EDR1 of the Standard Design, and
2. The Proposed Efficiency EDR2 must be equal to or less than the Efficiency EDR2 of the Standard Design, and
3. The Proposed Total EDR2 must be equal to or less than the Total EDR2 of the Standard Design.

This concept, consistent with California’s “loading order” which prioritizes energy efficiency ahead of renewable generation, requires projects to meet a minimum Efficiency EDR2 before PV is credited but allows for PV to be traded off with additional efficiency when meeting the Total EDR2. A project may improve building efficiency beyond the minimum required and subsequently reduce the PV generation capacity necessary to achieve the required Total EDR2. However, it may not increase the size of the PV system and trade this off with a reduction of efficiency measures.

Results from this analysis are presented as EDR Margin, a reduction in the EDR score relative to the Standard Design. EDR Margin is a better metric to use than absolute EDR in the context of a reach code because absolute values vary based on the home design and characteristics such as size and orientation. This approach aligns with how compliance is reported for the 2019 and 2022 Title 24 Code. The EDR Margin is calculated according to Equation 5.

### Equation 5

<sup>9</sup> CBECC-Res multipliers are the same for CZs 1-5 and 11-13 (Northern California), while there is another set of multipliers for CZs 6-10 and 14-16 (Southern California).

*EETTRR MMSSPPSSSSSS = SSPPSSSSSSSSPPSS TTPPSSSSSSSS EETTRR - NNPPooPPooSSPPSS TTPPSSSSSSSS EETTRR*

### 3 Prototypes, Measure Packages, and Costs

This section describes the prototypes and the scope of analysis drawing from previous research where necessary, including the 2019 low-rise residential single family reach code study (Statewide Reach Codes Team, 2019).

#### 3.1 Prior Reach Code Research

In 2019, the Reach Codes Team analyzed the cost-effectiveness of residential single family new construction projects for mixed fuel and all-electric packages (Statewide Reach Codes Team, 2019). Using this analysis, several cities and counties in California adopted local energy code amendments encouraging or requiring that low-rise residential new construction be all-electric. As there were few changes to the single family requirements, this analysis for the 2022 code cycle leveraged the work completed for the 2019 reports. Initial efficiency packages were based on the final packages from the 2019 research and were revised to reflect measure specifications and costs based on new data.

#### 3.2 Prototype Characteristics

The Energy Commission defines building prototypes which it uses to evaluate the cost-effectiveness of proposed changes to Title 24 requirements. For the 2022 code cycle the Energy Commission used two single family prototypes, both of which were used in this analysis. Additional details on the prototypes can be found in the Alternative Calculation Method (ACM) Approval Manual (California Energy Commission, 2018).

Additionally, a detached new construction ADU prototype was developed to reflect recent trends in California construction related to the high cost of housing (TRC, 2021). ADUs are additional dwelling units typically built on the property of an existing single-family parcel. ADUs are defined as new construction in the energy code when they are ground-up developments, do not convert an existing space to livable space, and are not attached to the primary dwelling. The evaluated prototype is not representative of an attached ADU constructed as an addition to an existing home.

The Reach Codes Team leveraged prior research to define the detached ADU baseline and measure packages. The house size and number of bedrooms were based on data from a survey conducted by UC Berkeley’s Center for Community Innovation (UC Berkeley Center for Community Innovation, 2021). The survey found that the average square footage for new ADUs statewide is 615 square feet and that the majority (61 percent) of new ADUs have one bedroom.

Table 2 describes the basic characteristics of each prototype. The prototypes have equal geometry on all walls, windows and roof to be orientation neutral.

**Table 2: Prototype Characteristics**

Characteristic	Single Family One-Story	Single Family Two-Story	ADU
Conditioned Floor Area	2,100 ft <sup>2</sup>	2,700 ft <sup>2</sup>	625 ft <sup>2</sup>
Num. of Stories	1	2	1
Num. of Bedrooms	3	4	1
Window-to-Floor Area Ratio	20%	20%	19.2%

The Energy Commission’s protocol for the two single family prototypes is to weigh the simulated energy impacts by a factor that represents the distribution of single-story and two-story homes being built statewide. Consistent with this protocol, this study assumed 50 percent single-story and 50 percent two-story. Simulation results in this study are

characterized and presented according to this ratio, which is approximately equivalent to a 2,400-square foot (ft<sup>2</sup>) house.<sup>10</sup> ADU results are presented separately.

The methodology used in the analyses for each of the prototypical building types begins with a design that precisely meets the minimum 2022 prescriptive requirements (zero compliance margin). Table 150.1-A in the 2022 Standards (California Energy Commission, 2021a) lists the prescriptive measures that determine the baseline design in each climate zone. Other features are consistent with the Standard Design in the ACM Reference Manual (California Energy Commission, 2022), and are designed to meet, but not exceed, the minimum requirements. See Appendix 7.4 for a list of prescriptive values relevant to the measures explored in this analysis.

Table 3 describes additional characteristics as they were applied to the base case, or baseline, energy model in this analysis. In a shift from the 2019 Standards, the 2022 Standards apply a prescriptive fuel source for space heating and water, where one is gas-fueled and one is a heat pump depending on climate zone. This establishes a prescriptive heat pump baseline. In most climate zones the prescriptive base case includes a heat pump water heater and a natural gas furnace for space heating. In Climate Zones 3, 4, 13, and 14 this is reversed, where the base case has a heat pump space heater and natural gas tankless water heater.

Table 4 summarizes the PV capacities for the base case packages.

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<sup>10</sup> 2,400 ft<sup>2</sup> = (50% x 2,100 ft<sup>2</sup>) + (50% x 2,700 ft<sup>2</sup>)

**Table 3: Base case Characteristics of the Prototypes**

Characteristic	Single Family	ADU
Space Heating/Cooling <sup>1,2</sup>	<u>CZs 1-2,5-12,15-16</u> : Natural gas furnace, split AC 80 AFUE, 14.3 SEER2, 11.7 EER2 <u>CZs 3-4,13-14</u> : Split heat pump – 7.5 HSPF2, 14.3 SEER2, 11.7 EER2	Same as single family
Air Distribution	<u>Ductwork located in vented attic</u>	Same as single family
Water Heater <sup>1,2</sup>	<u>CZs 1-2,5-12,15-16</u> : Heat pump water heater (HPWH) UEF = 2.0 located in the garage <u>CZs 3-4,13-14</u> : Natural gas tankless – UEF = 0.81	Same equipment type as SF except HPWH is located inside the conditioned space with the supply air ducted from outside and exhaust air ducted to outside. <sup>3</sup>
Hot Water Distribution	Code minimum <u>CZs 1,16</u> : Basic compact distribution credit	Same as single family
Cooking	Natural Gas	Same as single family
Clothes Drying	Natural Gas	Same as single family
PV System	Sized to offset 100% of electricity use for space cooling, ventilation, lighting, appliance, & other miscellaneous electric loads. Size differs by climate zone ranging from 2.64 kW to 5.21 kW, see Table 4.	PV is not required when the PV system size required based on the prescriptive calculations is less than 1.8 kW, as is the case in Climate Zones 1-9, 12, 14, and 16. In the other climate zones the PV size ranges from 1.73 kW to 2.51 kW, see Table 4. <sup>4</sup>
Foundation	Slab-on-grade	Same as single family

<sup>1</sup> Equipment efficiencies are equal to minimum federal appliance efficiency standards.

<sup>2</sup> AFUE = annual fuel utilization efficiency. SEER = seasonal energy efficiency ratio. EER = energy efficiency ratio. HSPF = heating seasonal performance factor. UEF = uniform energy factor.

<sup>3</sup> This version of CBECC-Res used in this analysis did not have the capability to directly model ducted HPWHs even though this configuration is called out as the Standard Design in the 2022 ACM (California Energy Commission, 2022). This was modeled by indicating that the tank is located within the conditioned space with the compressor unit located outside.

<sup>4</sup> Exception 2 to Section 150.1(l)14 states that “no PV system is required when the minimum PV system size specified by section 150.1(c)14 is less than 1.8 kWdc.” In this analysis this exception is applied based on the sizes calculated per Equation 150.1-C of Section 150.1(c)14. The performance software sizes the PV system based on the estimated energy use, which differs slightly from the prescriptive sizing. As a result, the baseline PV capacity from the performance software for Climate Zone 10 is less than 1.8 kWdc.

**Table 4: Base Package PV Capacities (kW-DC)**

Climate Zone	Base Package	
	Single Family	ADU
CZ01	3.57	0
CZ02	3.03	0
CZ03	2.83	0
CZ04	2.91	0
CZ05	2.64	0
CZ06	2.65	0
CZ07	2.83	0
CZ08	3.11	0
CZ09	2.96	0
CZ10	3.17	1.73
CZ11	3.90	2.06
CZ12	3.14	0
CZ13	4.05	2.09
CZ14	3.15	0
CZ15	5.21	2.51
CZ16	2.93	0

### 3.3 Measure Definitions and Costs

Measures evaluated in this study fall into two categories: those associated with general efficiency — onsite generation (solar PV), and demand flexibility (batteries) — and those associated with building electrification. Furthermore, general efficiency measures are broken into those that are federally preempted and those that are not; see Section 1 for background information on preemption and Section 3.4 for details of measure packages evaluated in this study. The Reach Codes Team selected measures based on cost-effectiveness as well as decades of experience with residential architects, builders, and engineers along with general knowledge of the relative consumer acceptance of many measures.

The following sections describe the details and incremental cost assumptions for each of the measures. Incremental costs represent the equipment, installation, replacement, and maintenance costs of the proposed measures relative to the base case.<sup>11</sup> Replacement costs are applied for roofs, mechanical equipment, PV inverters and battery systems over the 30-year evaluation period. Maintenance costs are estimated for PV systems, but not any other measures. Costs were estimated to reflect costs to the building owner. All costs are provided as present value in 2023 (2023 PV\$).

The Reach Codes Team obtained measure costs from distributors, contractors, literature review, and online sources such as Home Depot and RS Means. Contractor markups are incorporated. These are the Reach Codes Team’s best estimates of average costs statewide. However, it’s recognized that local costs may differ, and that inflation and supply chain issues may also impact costs.

#### 3.3.1 Efficiency, Solar PV, and Batteries

The following are descriptions of each of the efficiency, PV, and battery measures evaluated under this analysis and applied in at least one of the packages presented in this report, including how they compare to the current prescriptive requirements. Throughout this report, “Efficiency” measures refer specifically to the following non-preempted

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<sup>11</sup> All first costs are assumed to be financed in a mortgage and interest costs due to financing are included in the incremental costs. See Section 2.1.2 for details.

measures. These measures are in addition to or in place of the relevant 2022 base case prototype characteristics outlined in Table 3, and their applicability to measure packages are summarized in Table 39 through Table 41. Table 5 summarizes the incremental cost assumptions for each of these measures.

**Reduced Infiltration (ACH50):** Reduce infiltration in single family homes from the default infiltration assumption of five (5) air changes per hour at 50 Pascals (ACH50)<sup>12</sup> by 40 percent to 3 ACH50. HERS rater field verification and diagnostic testing of building air leakage according to the procedures outlined in the 2022 Reference Appendices RA3.8 (California Energy Commission, 2021b).

**Lower U-Factor Fenestration:** Reduce window U-factor to 0.24. The prescriptive U-factor is 0.30 in all climate zones.

**Higher SHGC Fenestration:** Increase solar heat gain coefficient (SHGC) to 0.50 in climate zones where heating loads dominate (1, 3, 5 and 16). The baseline SHGC applied in the Standard Design is 0.35 in these climate zones.

**Cool Roof:** Install a roofing product that's rated by the Cool Roof Rating Council to have an aged solar reflectance (ASR) equal to or greater than 0.25. Steep-sloped roofs were assumed in all cases. The prescriptive ASR is 0.20 for Climate Zones 10 through 15.

**Increased Ceiling Insulation:** Increase ceiling level insulation in a vented attic to R-38, R-49, or R-60 insulation.

**Slab Insulation:** Install R-10 perimeter slab insulation at a depth of 16-inches. This measure doesn't apply to Climate Zone 16 where slab insulation is required prescriptively.

**Low Pressure Drop Ducts:** Upgrade the duct distribution system to reduce external static pressure and meet a maximum fan efficacy of 0.35 Watts per cfm (compared to the prescriptively required 0.45 W/cfm). This may involve upsizing ductwork, reducing the total effective length of ducts, and/or selecting low pressure drop components such as filters. Fan watt draw must be verified by a HERS rater according to the procedures outlined in the 2022 Reference Appendices RA3.3 (California Energy Commission, 2021b). This applies to the single family prototype only.

**Buried Radial Duct Design:** Bury all ductwork in ceiling insulation by laying the ducts across the ceiling joists or in-between ceiling joists directly on the ceiling drywall. Duct design is based on a radial design where individual ducts are run to each supply register. This allows for smaller diameter ducts, reducing duct losses and more easily meeting fully or deeply buried conditions.<sup>13</sup> Duct burial and duct system design must be verified by a HERS rater according to the procedures outlined in the 2022 Reference Appendices RA3.1.4.1.5 and RA3.1.4.1.6 (California Energy Commission, 2021b). This applies to the single family prototype only.

**Ductless Mini-Split Heat Pump:** In the ADU prototype install a ductless mini-split heat pump with three indoor heads. The system is evaluated as meeting the criteria for the variable capacity heat pump (VCHP) credit, introduced in the 2019 code cycle, which must be verified by a HERS rater according to the procedures outlined in the 2022 Reference Appendices RA3.4.4.3 (California Energy Commission, 2021b). This credit requires verification of refrigerant charge, that all equipment is entirely within conditioned space, that airflow is directly supplied to all habitable space, and that wall mounted thermostats serve any zones greater than 150 square feet. This measure is non-preempted because it does not require the installation of equipment with efficiencies above federal minimum requirements.

**Compact Hot Water Distribution:** Design the hot water distribution system to meet minimum requirements for the basic compact hot water distribution credit according to the procedures outlined in the 2022 Reference Appendices RA4.4.6 (California Energy Commission, 2021b). In many single family homes this may require moving the water heater from an exterior to an interior garage wall. CBECC-Res software assumes a 30% reduction in distribution losses for the basic credit. This is prescriptively required in Climate Zones 1 and 16 only.

**Solar PV:** Installation of on-site PV is required in the 2022 residential code unless an exception is met. The PV sizing methodology in each package was developed to offset annual building electricity use and avoid oversizing. In all cases,

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<sup>12</sup> Whole house leakage tested at a pressure difference of 50 Pascals between indoors and outdoors.

<sup>13</sup> The duct systems in the Central Valley Research Homes Project Final Project Report are illustrative of this approach (Proctor, Wilcox, & Chitwood, 2018).

PV is evaluated in CBECC-Res according to the California Flexible Installation (CFI) 1 assumptions. To meet CFI eligibility, the requirements of 2022 Reference Appendices JA11.2.2 (California Energy Commission, 2021b) must be met.

The Reach Codes Team used two options within the CBECC-Res software for sizing the PV system. The first option, “Standard Design PV”, was applied in the base case simulations and packages where the PV system size was not changed from the minimum system size required<sup>14</sup>. For the PV packages, the second option, “Specify PV System Scaling”, was used. In these cases, a scaling of 100 was applied, indicating that the PV system be sized to offset 100% of the estimated electricity use of the Proposed Design case.

One exception to the PV requirement is when the minimum PV system size required is less than 1.8 kW. This exception applies to the ADU models in Climate Zones 1-9, 12, 14, and 16. For these cases no PV system is required by code and no PV system was modeled in the base case simulations.

**Battery Energy Storage:** A 10 kWh battery system was evaluated in CBECC-Res with control type set to “Basic” and with default efficiencies of 95% for both charging and discharging. 10kWh battery capacity is representative of systems installed in single family homes based on the Self-Generation Incentive Program (SGIP) participant data. The “Basic” control option charges the battery system anytime PV generation is greater than the house load and discharges the battery whenever the house load exceeds PV generation. The battery does not discharge to the grid, maximizing on-site utilization of the PV system and in turn utility bill benefits under NBT. To qualify for the battery storage compliance credit the battery system must meet the requirements outlined in the 2022 Reference Appendices JA12 (California Energy Commission, 2021b). Batteries are not prescriptively required in any climate zone.

**Table 5: Incremental Cost Assumptions: Efficiency, PV, and Battery Measures**

Measure	Performance Level	Incremental Cost (2023 PV\$) <sup>1</sup>		Source & Notes
		Single Family	ADU	
Reduced Infiltration	3.0 vs 5.0 ACH50	\$591	\$362	\$0.115/ft <sup>2</sup> based on NREL’s BEopt cost database plus \$250 HERS rater verification.
Window U-factor	0.24 vs 0.30	\$2,280	\$285	\$4.23/ft <sup>2</sup> window area based on analysis conducted for the 2019 and 2022 Title 24 cycles (Statewide CASE Team, 2018).
Window SHGC	0.50 vs 0.35	\$0	\$0	Based on feedback from Statewide CASE Team that higher SHGC does not necessarily have any incremental cost (Statewide CASE Team, 2017).
Cool Roof	0.25 vs 0.20 aged solar reflectance	\$219	\$53	\$0.07per ft <sup>2</sup> of roof area first incremental cost for asphalt shingle product based on the 2022 Nonresidential High Performance Envelope CASE Report (Statewide CASE Team, 2020a). Total costs assume present value of replacement at year 20 and residual cost for remaining product life at end of 30-year analysis period. Higher reflectance values for lower cost are achievable for tile roof products
Attic Insulation	R-49 vs R-30	\$872	n/a	Based on costs from the 2022 Residential Additions & Alterations CASE Report (Statewide CASE Team, 2020b).
	R-60 vs R-30	\$1,420	n/a	
	R-60 vs R-38	\$1,096	n/a	
Slab Edge Insulation	R-10 vs R-0	\$651	\$449	\$4 per linear foot of slab perimeter based on internet research. Assumes 16in depth.

<sup>14</sup> The Standard Design PV system is sized to offset the electricity use of the building loads which are typically electric in a mixed fuel home, which includes all loads except space heating, water heating, clothes drying, and cooking.

Measure	Performance Level	Incremental Cost (2023 PV\$) <sup>1</sup>		Source & Notes
		Single Family	ADU	
Low Pressure Drop Ducts	0.35 vs 0.45 W/cfm	\$99	n/a	Costs assume one-hour labor for single family and half-hour for the ADU. Labor rate of \$88 per hour is from 2022 RS Means for sheet metal workers and includes a weighted average City Cost Index for labor for California.
Buried Ducts	Buried, radial design	\$281	n/a	No cost for laying ducts on attic floor versus suspending, in some cases there will be cost savings. Neutral cost for radiant design versus trunk and branch design. A \$250 HERS Rater verification fee is included.
Duct Insulation	R-8 vs R-6	\$201	n/a	Based on costs from the 2022 Residential Additions & Alterations CASE Report (Statewide CASE Team, 2020b).
Ductless Mini-Split Heat Pump	Ductless system meeting the VCHP credit vs. ducted split heat pump	n/a	\$1,571	Costs were developed based on data from E3's 2019 report Residential Building Electrification in California (Energy & Environmental Economics, 2019) and the 2022 All-Electric Multifamily CASE Report (Statewide CASE Team, 2020c). Equipment costs are from the CASE Report for the 10-story multifamily prototype assuming similar sized equipment between the multifamily dwelling unit and the ADU. Thermostat, wiring, electrical, and ducting costs are from the E3 study. A \$250 HERS Rater verification fee is also included. Where this measure is applied to the mixed fuel home with a gas furnace, this cost is in addition to the cost difference for a heat pump versus a gas furnace/split AC reported in Section 3.3.2.
Compact Hot Water Distribution	Basic credit – homes with gas tankless	\$196	\$0	For single family homes with a gas tankless water heater (mixed fuel homes in Climate Zones 3, 4, 13, 14) assumes adding 20-foot venting at \$14.69 per linear foot to locate water heater on interior garage wall, less 20-foot savings for PEX and pipe insulation at \$5.98 per linear foot. Costs obtained from online retailers. For single family homes with a HPWH there is an incremental cost savings from less pipe being required. For the ADU it is assumed the credit can be met without any changes to design and there is no cost impact.
	Basic credit – homes with HPWH	-\$134	\$0	
PV System	First Cost	\$3.11/W	\$3.11/W	First costs are from LBNL's Tracking the Sun 2022 (Barbose, Galen; Darghouth, Naim; O'Shaughnessy, Eric; Forrester, Sydney, 2022) and represent median costs in California in 2022 of \$3.78/WDC for residential systems. The first cost was reduced by the solar energy Investment Tax Credit of 30%. <sup>2</sup> Inverter replacement cost of \$0.14/WDC present value includes replacements at year 11 at \$0.15/WDC (nominal) and at year 21 at \$0.12/WDC (nominal) per the 2019 PV CASE Report (California Energy Commission, 2017). System maintenance costs of \$0.31/WDC present value assume \$0.02/WDC (nominal) annually per the 2019 PV CASE Report (California Energy Commission, 2017).
	Inverter replacement	\$0.14/W	\$0.14/W	
	Maintenance	\$0.31/W	\$0.31/W	
	Replacement cost	\$648/kWh	\$648/kWh	

Measure	Performance Level	Incremental Cost (2023 PV\$) <sup>1</sup>		Source & Notes
		Single Family	ADU	
Battery (10 kWh)	First cost	\$782/kWh	\$782/kWh	<p>First costs of \$1,101/kWh are from SGIP residential participant cost data for single family projects between 2020 and 2023. The first cost is reduced by 30% due to the Investment Tax Credit<sup>2</sup> and also by \$0.15/Wh due to the base SGIP incentive<sup>3</sup>. The SGIP incentive is only accounted for in IOU territories and not for SMUD and CPAU analyses.</p> <p>Replacement cost at years 10 and 20 was calculated based on the first cost reduced by 7% annually over the next 10 years for a future value cost of \$533/kWh. The 7% reduction is based on SDG&amp;E's Behind-the-Meter Battery Market Study (E-Source companies, 2020). For projects constructed in 2024 or 2025, the first replacement at year 10 would occur in 2034 or 2035. This replacement cost includes an average Investment Tax Credit of 22% in 2034 and 0% in 2035<sup>2</sup>.</p>

<sup>1</sup>All first costs are assumed to be financed in a mortgage and interest costs due to financing are included in the incremental costs. See Section 2.1.2 for details. Interest costs were not included for calculating TDV cost-effectiveness.

<sup>2</sup>As part of the Inflation Reduction Act in August 2022 the Section 25D Investment Tax Credit was extended and raised to 30% through 2032 with a step-down beginning in 2033. <https://www.seia.org/sites/default/files/2022-08/Inflation%20Reduction%20Act%20Summary%20PDF%20FINAL.pdf>

<sup>3</sup>SGIP incentives vary by 'steps' which reflect utility-specific funding across program implementation years. See: [https://www.selfgenca.com/home/program\\_metrics/](https://www.selfgenca.com/home/program_metrics/)

### 3.3.2 Electrification

This analysis compared a code compliant mixed fuel prototype, which uses natural gas for three appliances (cooking, clothes drying and either space heating or water heating), with a code compliant all-electric prototype. The associated costs included the relative costs between natural gas and electric appliances, differences between in-house electricity and natural gas infrastructure, and the associated infrastructure costs for providing natural gas to the building. To estimate costs the Reach Codes Team leveraged costs from the 2019 reach code cost-effectiveness studies for residential new construction (Statewide Reach Codes Team, 2019) and detached accessory dwelling units (Statewide Reach Codes Team, 2021b), 2022 RS Means, PG&E data, published utility schedules and rules, and online research.

#### 3.3.2.1 Utility Infrastructure

This section addresses utility infrastructure costs during construction; appliance-specific infrastructure costs are addressed in Section 0. Table 6 presents total costs for natural gas infrastructure for a single family building within CA gas IOU territory, including distribution and service line extensions, meter installation, and plan review. These costs are applied as cost savings for an all-electric home when compared to a mixed fuel home. This is the component with the highest degree of variability for all-electric homes, as they are project-dependent and may be significantly impacted by such factors as utility territory, site characteristics, distance to the nearest natural gas main and main location, joint trenching, whether work is conducted by the utility or a private contractor, and number of dwelling units per development. All gas utilities participating in this study were solicited for cost information. The CA IOU costs for single family homes presented are based on cost data provided by PG&E.

Extension of service lines from a main distribution line to the home were provided separately for a new subdivision in an undeveloped area (\$1,300) as well as an infill development (\$6,750). The service extension is typically more costly in an infill scenario due to the disruption of existing roads, sidewalks, and other structures. For this analysis an average of the new subdivision and infill development costs was used, representing 80 percent of the new subdivision and 20 percent infill. In the case of distribution line extensions, the estimated cost is for new greenfield development.

For the single family analysis, based on the Reach Codes Team's conversations with the industry it is assumed that no upgrades to the electrical panel are required and that a 200 Amp panel is typically installed for both mixed fuel and all-electric homes.

**Table 6: Single Family IOU Total Natural Gas Infrastructure Costs**

Item	Cost
Distribution Line Extension	\$1,020
Service Line Extension	\$2,390
Meter	\$300
Plan Review Costs	\$850
<b>Total</b>	<b>\$4,560</b>

CPAU provides gas service to its customers and therefore separate costs were evaluated based on CPAU gas service connection fees.<sup>15</sup> Table 7 presents the breakdown of gas infrastructure costs used in this analysis for CPAU. There is no main distribution line component since Palo Alto has little greenfield space remaining and most of the development is infill.

<sup>15</sup> CPAU Schedule G-5 effective 09-01-2019: <https://www.cityofpaloalto.org/files/assets/public/utilities/utilities-engineering/general-specifications/gas-service-connection-fees.pdf>

**Table 7: Single Family CPAU Total Natural Gas Infrastructure Costs**

Item	Cost
Service Extension	\$5,892
Meter	\$1,012
Plan Review Costs	\$924
<b>Total</b>	<b>\$7,828</b>

Electricity infrastructure costs for single family homes were not estimated as part of this work as they are expected to be the same for both all-electric and mixed fuel construction. This will change in July 2024 based on the CPUC’s recent decision to eliminate electric line extension subsidies for new construction projects that use natural gas and/or propane.<sup>16</sup> This will increase the utility infrastructure costs for mixed fuel homes, relative to all-electric homes, improving the cost-effectiveness of all-electric construction. The Reach Codes Team intends to quantify this impact in future studies.

Table 8 presents utility infrastructure costs for the detached ADU, both mixed fuel and all-electric designs. These costs are directly from the 2019 detached ADU reach code report (Statewide Reach Codes Team, 2021b) and were obtained from stakeholder interviews and RS Means. For the ADU scenario it’s assumed that natural gas infrastructure already exists on the lot and is being extended to the location of the ADU typically at the back of the lot. There are incremental cost savings for an all-electric ADU from not extending the natural gas service; however, there is also a small incremental cost for upgrading the electric service to accommodate the additional electrical load. The Reach Codes Team found that a new detached ADU would require that the building owner upgrade the service connection to the lot in both the mixed fuel ADU design and the all-electric design. The most common size for this upgrade is to upsize the existing panel to 225A, which would not represent an incremental cost from the mixed fuel project to the all-electric project. Feeder wiring to the ADU and the ADU subpanel, on the other hand, will need to be slightly upgraded for the all-electric design.

**Table 8: ADU Utility Infrastructure Total and Incremental Costs**

Mixed Fuel Measure	Mixed Fuel Total Cost	All-Electric Measure	All-Electric Total Cost	All-Electric Incremental Cost
Site natural gas service extension	\$1,998	No site natural gas service	\$0	(\$1,998)
Site electrical service connection upgrade 225A	\$3,500	Site electrical service connection upgrade 225A	\$3,500	\$0
100A feeder to ADU with breaker	\$933	125A feeder to ADU with breaker	\$1,206	\$273
100A ADU subpanel	\$733	125A ADU subpanel	\$946	\$213
<b>Totals</b>	<b>\$7,164</b>		<b>\$5,652</b>	<b>(\$1,512)</b>

### 3.3.2.2 Equipment

This section provides descriptions and costs of the equipment applied to electrify mixed fuel homes in the all-electric packages. The equipment meets but does not exceed federal efficiency requirements to avoid federal preemption concerns.

<sup>16</sup> <https://www.cpuc.ca.gov/news-and-updates/all-news/cpuc-eliminates-last-remaining-utility-subsidies-for-new-construction-of-buildings-using-gas-2023>

For the water heating and space conditioning equipment analyzed, cost analyses incorporated the equipment’s effective useful lifetime (EUL), which are summarized in Table 9. The EUL for the heat pump, furnace, and air conditioner are based on the Database for Energy Efficient Resources (DEER) (California Public Utilities Commission, 2021b). Water heating equipment lifetimes are based on DOE’s recent water heater rulemaking (Department of Energy, 2022). Replacement costs are applied when equipment reaches its EUL within the 30-year evaluation period, and in such cases are included in the total lifetime costs. Residual value of the gas furnace and gas tankless at the end of the 30-year analysis period was accounted for to represent the remaining life of the equipment.

In this analysis, replacement costs assume a like-for-like replacement of equipment type and fuel (as listed in Table 9). However, this may be precluded in the future due to efforts to prohibit the sale of gas equipment currently being considered or undertaken by air districts (ex. BAAQMD, SCAQMD) and the California Air Resources Board (ex. zero NOx appliance rules).

**Table 9: Effective Useful Lifetime (EUL) of Water Heating & Space Conditioning Equipment**

Measure	EUL (Years)
Gas Furnace	20
Air Conditioner	15
Heat Pump	15
Gas Tankless Water Heater	20
Heat Pump Water Heater	15

**Space Conditioning:** This measure covers replacing a prescriptive air conditioner and gas furnace with a minimum efficiency heat pump in applicable climate zones (1, 2, 5 to 12, 15 and 16; see Table 3). Typical incremental costs for this equipment were based on contractor feedback and price variation by system capacity from the AC Wholesalers website and the RS Means cost database (RSMeans, 2022). Costs were applied based on the system capacity from heating and cooling load calculations in CBECC-Res as presented in Table 10. Air conditioner nominal capacity was calculated as the CBECC-Res cooling load, rounded up to the nearest half ton. Heat pump nominal capacity was calculated as the maximum of either the CBECC-Res heating or cooling load, rounded up to the nearest half ton. In both cases a minimum capacity of 1.5-ton was applied as this represents the typical smallest available split system heat pump equipment. Load calculations demonstrated that Climate Zones 2, 5 to 12, and 15 were cooling-dominated while Climate Zones 1 and 16 were heating-dominated. In the heating dominated climate zones the heat pump for the single family home needs to be upsized relative to an air conditioner that only provides cooling.

Replacement costs were estimated based on a contractor survey conducted by the Statewide Reach Codes Team in 2023 (Statewide Reach Codes Team, tbd), less any gas and electric infrastructure costs, and the equipment lifetimes listed in Table 9. Resultant incremental costs are presented in Table 11.

This measure, and thus the incremental cost, does not apply to climate zones where heat pump space conditioning is already prescriptively required (Climate Zones 3, 4, 13, and 14).

**Table 10: Space Conditioning System Nominal Capacities**

Climate Zone	Single Family		ADU	
	Air Conditioner Capacity (tons)	Heat Pump Capacity (tons)	Air Conditioner Capacity (tons)	Heat Pump Capacity (tons)
1	1.5	2.5	1.5	1.5
2	3	3	1.5	1.5
3	-	-	-	-
4	-	-	-	-
5	3	3	1.5	1.5
6	3	3	1.5	1.5
7	3	3	1.5	1.5
8	2.5	2.5	1.5	1.5
9	2.5	2.5	1.5	1.5
10	2.5	2.5	1.5	1.5
11	3	3	1.5	1.5
12	2.5	2.5	1.5	1.5
13	-	-	-	-
14	-	-	-	-
15	4	4	1.5	1.5
16	2	3.5	1.5	1.5

**Table 11: Space Conditioning System Incremental Costs (2023 PV\$)**

Climate Zone	Single Family		ADU	
	First Cost	Total Lifetime Cost (Financed)	First Cost	Total Lifetime Cost (Financed)
1	\$803	\$2,705	(\$2,120)	(\$1,717)
2	(\$1,044)	(\$44)	(\$2,120)	(\$1,717)
3	-	-	-	-
4	-	-	-	-
5	(\$1,044)	(\$44)	(\$2,120)	(\$1,717)
6	(\$1,044)	(\$44)	(\$2,120)	(\$1,717)
7	(\$1,044)	(\$44)	(\$2,120)	(\$1,717)
8	(\$1,445)	(\$673)	(\$2,120)	(\$1,717)
9	(\$1,445)	(\$673)	(\$2,120)	(\$1,717)
10	(\$1,445)	(\$673)	(\$2,120)	(\$1,717)
11	(\$1,044)	(\$44)	(\$2,120)	(\$1,717)
12	(\$1,445)	(\$673)	(\$2,120)	(\$1,717)
13	-	-	-	-
14	-	-	-	-
15	(\$1,032)	\$368	(\$2,120)	(\$1,717)
16	\$2,331	\$5,123	(\$2,120)	(\$1,717)

**Water Heater:** This measure covers replacing a prescriptive gas tankless water heater with a minimum efficiency HPWH in applicable climate zones (3, 4, 13, and 14; see Table 3). Typical incremental costs were based on costs from prior reach code work and recent contractor feedback. Incremental first costs assume a 65-gal HPWH and incremental replacement costs account for equipment lifetimes listed in Table 9. Replacement costs assume no change in cost from the first cost estimates before accounting for inflation, less any gas and electric infrastructure costs. For the ADU analysis the water heater is evaluated within the conditioned space with the supply air ducted from the outside and exhaust air ducted to the outside. A mechanical contractor provided a cost estimate of \$943 for ducting through the attic in an ADU where the water heater is in an interior room. This cost is included in the equipment and installation total for the ADU. Resultant incremental costs are presented in Table 12.

**Table 12: Heat Pump Water Heating System Incremental Costs (2023 PV\$)**

Item	ADU		Single Family	
	First Cost	Total Lifetime Cost (Financed)	First Cost	Total Lifetime Cost (Financed)
Equipment & Installation	\$2,243	\$3,930	\$1,300	\$2,267
Electric Service Upgrade	\$43	\$48	\$45	\$51
In-House Gas Piping	(\$580)	(\$651)	(\$580)	(\$651)
<b>Total</b>	<b>\$1,706</b>	<b>\$3,327</b>	<b>\$765</b>	<b>\$1,666</b>

For this electrification analysis, a HPWH that just meets the federal minimum efficiency standards<sup>17</sup> of close to 2.0 Uniform Energy Factor (UEF) was evaluated in order to satisfy preemption requirements. However, the Reach Codes Team is not aware of any 2.0 UEF products that are available on the market. The Northwest Energy Efficiency Alliance (NEEA) established its own rating system for high efficiency HPWHs<sup>18</sup> and maintains a database of qualified products. The lowest UEF currently reported in the database is 2.73. In fact, of the four rating tiers offered by NEEA, those meeting Tier 3 or Tier 4 are the dominant products on the market today. According to NEEA all major HPWH manufacturers are represented in NEEA’s qualified product list<sup>19</sup> and there are fewer than 10 integrated products certified as Tier 1 or Tier 2, all of which have UEFs greater than 3.0.<sup>20</sup>

NEEA Tier 3 water heaters were included in the high-efficiency measure packages (see Section 3.4).

**Clothes Dryer and Range:** After review of various sources, the Reach Codes Team concluded that the cost difference between gas and electric resistance equipment for clothes dryers and stoves is negligible and that the lifetimes of the two technologies are similar. Resultant incremental costs are presented in Table 13. Note that while induction stoves may be a more likely installation option in many homes, CBECC-Res does not currently differentiate between electric technologies for stoves and therefore they were not considered in this analysis. Relative to electric resistance, induction stoves use less energy and improve performance and user satisfaction, at an additional cost.

**Electric Service Upgrade (appliance-specific):** The 2022 Title 24 Code requires electric readiness for gas appliances; as a result, the incremental costs to provide electrical service for electric appliances are minimal. The incremental costs accounted for in this study — shown in Table 13 — are calculated as the cost to install 220V service for the electric appliances less the cost for the electric ready requirements and for installing 110V service for the

<sup>17</sup> The Department of Energy establishes minimum energy conservation standards for consumer products, as directed in the Energy Policy and Conservation Act. See <https://www.ecfr.gov/current/title-10/chapter-II/subchapter-D/part-430/subpart-C/section-430.32>.

<sup>18</sup> Based on operational challenges experienced in the past, NEEA established rating test criteria to ensure newly installed HPWHs perform adequately, especially in colder climates. The NEEA rating requires products comply with ENERGY STAR and includes requirements regarding noise and prioritizing heat pump use over supplemental electric resistance heating.

<sup>19</sup> <https://neea.org/success-stories/heat-pump-water-heaters>

<sup>20</sup> As of 3/8/2024: <https://neea.org/img/documents/residential-unitary-HPWH-qualified-products-list.pdf>

comparable gas appliance. Incremental costs are applied for the space conditioner, water heater, and cooking range. Based on builder surveys, it's assumed that in a typical mixed fuel home both electric and gas service are provided to the dryer location and therefore no incremental costs for the dryer were applied. Costs assume 50A service for the range and 30A service for the space conditioner and water heater. Costs are assumed to be the same for the single family and ADU analyses.

**In-House Natural Gas Infrastructure (from meter to appliances):** Installation cost to run a natural gas line from the meter to the appliance location was estimated at \$580 per appliance, as shown in Table 13. These costs were based on material costs from Home Depot and labor costs from 2022 RS Means. The material costs were about 1/3 higher in RS Means than Home Depot, so the Reach Codes Team used the lower costs from Home Depot. The Reach Codes Team conducted a pipe sizing analysis for the two single family and one ADU prototype homes to estimate the length and diameter of gas piping required assuming the home included a gas furnace, gas tankless water heater, gas range, and gas dryer. Total estimated costs were very similar for each of the three prototypes and an average cost per appliance of \$580 was determined. Costs are assumed to be the same for the single family and ADU analyses.

**Table 13: Single Family All-Electric Appliance Incremental Costs**

Item	ADU & Single Family	
	First Cost	Total Lifetime Cost (Financed)
<b><i>Electric Resistance vs Gas Cooking</i></b>		
Equipment & Installation	\$0	\$0
Electric Service Upgrade	\$100	\$113
In-House Gas Piping	(\$580)	(\$651)
<b>Total</b>	<b>(\$480)</b>	<b>(\$539)</b>
<b><i>Electric Resistance vs Gas Clothes Drying</i></b>		
Equipment & Installation	\$0	\$0
Electric Service Upgrade	\$0	\$0
In-House Gas Piping	(\$580)	(\$651)
<b>Total</b>	<b>(\$580)</b>	<b>(\$651)</b>

### 3.4 Measure Packages

The Reach Codes Team evaluated two packages for mixed fuel homes and five packages for all-electric homes for each prototype and climate zone, as described below.

1. All-Electric Code Minimum: This package applied the prescriptive requirements of the 2022 Title 24 Code and replaced gas equipment with minimum efficiency electric equipment.
2. Efficiency Only, all-electric: This package used only efficiency measures that don't trigger federal preemption issues including envelope, water heating distribution, and duct distribution efficiency measures. For ADUs, this also included ductless variable capacity heat pumps (VCHPs). This package was evaluated for the all-electric homes only.
3. Efficiency + High Efficiency (Preempted) Equipment, all-electric and mixed fuel: This package builds off the Efficiency Only package, adding water heating and space conditioning equipment that is more efficient than federal standards. The Reach Codes Team considers this more reflective of how builders meet above code requirements in practice. This package was evaluated to compare compliance results against the other non-preempted packages (see Table 27 and Table 28), however cost-effectiveness was not evaluated for this package since it cannot serve as the basis for adoption of a local ordinance. Specifically, it applied:
  - a. Water heating, all-electric: Heat pump water heaters with a NEEA Tier 3 rating (3.45 UEF).
  - b. Water heating, mixed fuel: High efficiency (0.95 UEF) gas tankless.

- c. Space conditioning, single family: High efficiency (16 SEER2/8 HSPF2) heat pumps. In mixed fuel packages, for climate zones with prescriptive gas heating, high efficiency (16 SEER2/95 AFUE) units were applied.
4. Efficiency + PV, all-electric: This package also builds on the Efficiency Only package, excluding preempted equipment. Instead, PV capacity was added to offset all of the estimated annual electricity use. This package was evaluated for the all-electric homes only.
5. Efficiency + PV + Battery, all-electric and mixed fuel: Using the Efficiency + PV package as a starting point for the all-electric analysis, a battery system was added. For mixed fuel homes the package of efficiency measures differed from the all-electric homes in some climate zones to arrive at a cost-effective solution.

To reiterate previous statements, the non-preempted measures used in all of the above packages (except for the All-Electric Code Minimum package) are referred to as “Efficiency measures”. As noted above, these measures may differ by prototype (single family vs. ADU) and by package. See Table 40 and Table 41 for the details of these measures.

## 4 Results

Section 4.1 presents compliance results for all-electric versus mixed fuel code minimum packages to provide a broad overview of how these different approaches impact code compliance. Sections 4.2 to 4.5 present EDR results along with other savings data for packages of particular interest, as well as cost-effectiveness results for all packages. Section 4.5 presents results for sensitivity analyses. All results reflect savings over a 30-year analysis period and are compared against the 2022 prescriptive baseline.

### 4.1 Compliance Results: All-Electric vs. Mixed Fuel Code Minimum

The Reach Codes Team evaluated the compliance impacts of a prescriptive all-electric home as well as a traditional mixed fuel home with four gas appliances (space heating, water heating, cooking, clothes drying). Compliance is relative to the 2022 prescriptive base case home with three gas appliances which, by definition, has a compliance margin of zero in all climate zones. The impacts for the all-electric single family home and the ADU are presented in Figure 1 and Figure 2, respectively. The all-electric single family and ADU home prototypes are code compliant with both EDR1 (source energy) and efficiency EDR2 (TDV energy) in all climate zones, though the compliance margin is highly variable across climate zones. The four gas appliance single family home is presented in Figure 3. This case is not code compliant in any climate zone.

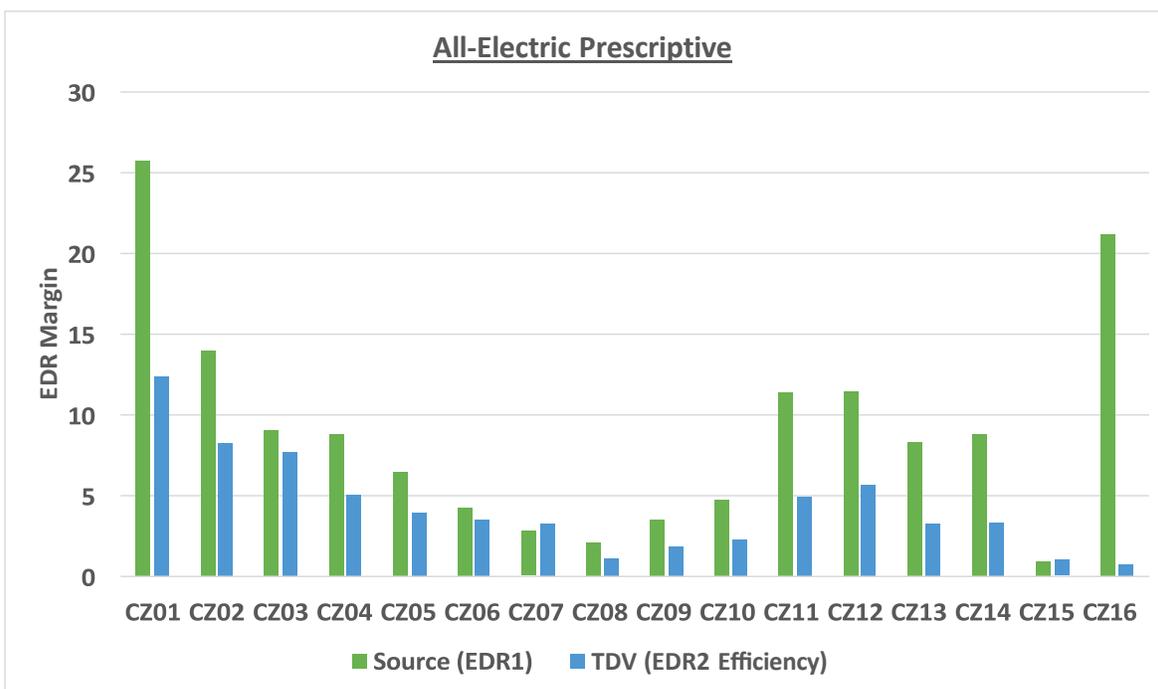


Figure 1: Single family all-electric home compliance impacts.

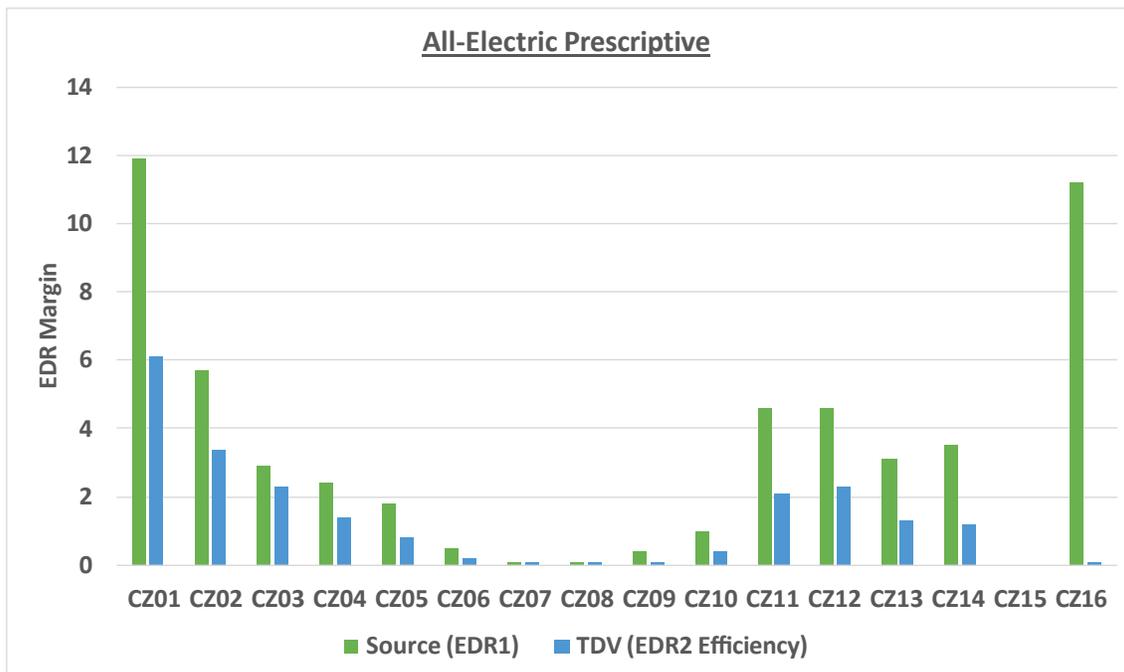


Figure 2: ADU all-electric home compliance impacts.

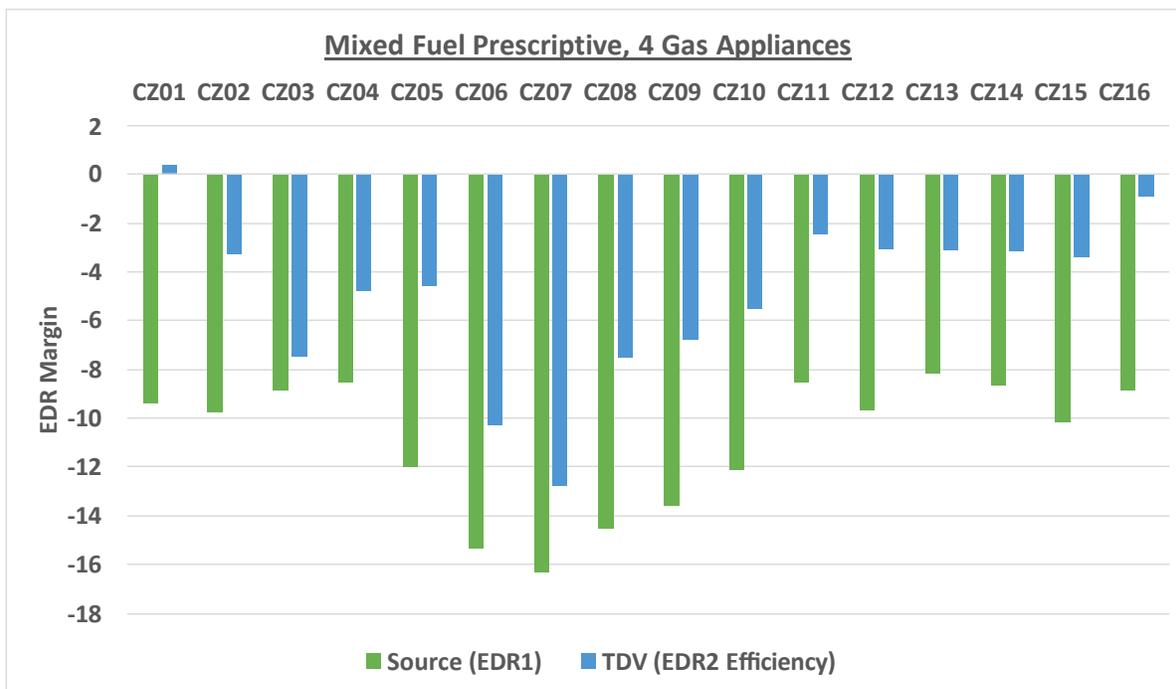


Figure 3: Single family four gas appliance home compliance impacts.

This analysis illustrates a couple of interesting points:

1. The 2022 compliance metrics are important drivers encouraging electrification. The compliance penalties associated with the four gas appliance home scenarios are significant and will require deep efficiency measures to overcome.
2. The 2022 Title 24 Code’s new source energy metric combined with the heat pump baseline encourage all-electric construction, providing a compliance benefit that allows for some amount of prescriptively required building efficiency to be traded off and still comply when using the performance method.

## 4.2 All-Electric Code Minimum Results

Table 14 shows results for the single family all-electric Code Minimum measure package. Utility cost savings are negative, indicating an increase in utility costs for the all-electric building, everywhere except in CPAU and SMUD territories. In all cases the incremental cost is negative, which reflects cost savings for the all-electric building due to elimination of gas infrastructure costs. The package is cost-effective based on TDV in all cases but one (Climate Zone 16); it's not cost-effective On-Bill in Climate Zones 1, 3, 14, and 16.

Table 15 shows the all-electric Code Minimum package results for the ADU. Utility savings and incremental costs reflect the same general trend as single family homes; CPAU territory is the only case where utility costs decrease. Cost-effectiveness is less favorable than the single family application, with TDV cost-effectiveness not met in Climate Zones 3, 4, 13, and 14, and On-Bill cost-effectiveness met only in Climate Zones 4 in CPAU territory, 10 in SCE/SCG territory, 12 in SMUD/PG&E territory, 11 and 15. Cost-effectiveness in Climate Zones 3, 4, 13, and 14 is worse than in the other climate zones due to the higher cost of converting from a gas tankless to a ducted HPWH (see Table 3) which isn't offset enough by the energy savings. Cost savings due to elimination of gas infrastructure costs are also lower for the ADU relative to the single family home.

**Table 14: Single Family Cost-Effectiveness: All-Electric Code Minimum**

Climate Zone	Electric /Gas Utility	Total EDR1 Margin	Efficiency EDR2 Margin	Annual Elec Savings (kWh)	Annual Gas Savings (therms)	Utility Cost Savings		Incremental Cost <sup>1</sup>		On-Bill		TDV	
						First Year	Lifecycle (2022\$)	First Year	Lifecycle (2022\$)	B/C Ratio	NPV	B/C Ratio	NPV
CZ01	PGE	25.8	12.4	(4,308)	398	(\$431)	(\$3,873)	(\$4,816)	(\$3,605)	0.9	(\$268)	>1	\$5,702
CZ02	PGE	14.0	8.3	(2,888)	246	(\$327)	(\$4,000)	(\$6,664)	(\$6,355)	1.6	\$2,355	>1	\$7,711
CZ03	PGE	9.1	7.7	(2,433)	171	(\$303)	(\$4,734)	(\$4,854)	(\$4,644)	0.98	(\$90)	25.3	\$3,887
CZ04	PGE	8.8	5.0	(2,232)	163	(\$251)	(\$3,665)	(\$4,854)	(\$4,644)	1.3	\$979	>1	\$4,494
CZ04	CPAU	8.8	5.0	(2,232)	163	(\$36)	\$2,123	(\$8,122)	(\$8,314)	>1	\$10,437	>1	\$7,762
CZ05	PGE	6.5	4.0	(1,960)	133	(\$292)	(\$4,981)	(\$6,664)	(\$6,355)	1.3	\$1,373	6.1	\$4,633
CZ05	PGE/SCG	6.5	4.0	(1,960)	133	(\$277)	(\$4,532)	(\$6,664)	(\$6,355)	1.4	\$1,823	6.1	\$4,633
CZ06	SCE/SCG	4.2	3.5	(1,432)	84	(\$231)	(\$4,015)	(\$6,664)	(\$6,355)	1.6	\$2,339	4.7	\$4,353
CZ07	SDGE	2.8	3.2	(1,293)	69	(\$266)	(\$5,731)	(\$6,664)	(\$6,355)	1.1	\$624	4.2	\$4,211
CZ08	SCE/SCG	2.1	1.1	(1,293)	67	(\$228)	(\$4,192)	(\$7,065)	(\$6,983)	1.7	\$2,792	4.2	\$4,674
CZ09	SCE	3.6	1.9	(1,453)	84	(\$237)	(\$4,153)	(\$7,065)	(\$6,983)	1.7	\$2,831	5.5	\$5,013
CZ10	SCE/SCG	4.8	2.3	(1,683)	107	(\$258)	(\$4,342)	(\$7,065)	(\$6,983)	1.6	\$2,642	7.4	\$5,287
CZ10	SDGE	4.8	2.3	(1,683)	107	(\$265)	(\$5,158)	(\$7,065)	(\$6,983)	1.4	\$1,825	7.4	\$5,287
CZ11	PGE	11.4	4.9	(2,712)	226	(\$306)	(\$3,803)	(\$6,664)	(\$6,355)	1.7	\$2,552	>1	\$7,153
CZ12	PGE	11.5	5.6	(2,554)	212	(\$294)	(\$3,773)	(\$7,065)	(\$6,983)	1.9	\$3,210	>1	\$7,504
CZ12	SMUD/PGE	11.5	5.6	(2,554)	212	\$79	\$4,731	(\$7,065)	(\$6,983)	>1	\$11,714	>1	\$7,504
CZ13	PGE	8.3	3.2	(2,095)	154	(\$224)	(\$3,164)	(\$4,854)	(\$4,644)	1.5	\$1,480	>1	\$4,490
CZ14	SCE/SCG	8.8	3.3	(2,291)	159	(\$322)	(\$5,166)	(\$4,854)	(\$4,644)	0.9	(\$522)	>1	\$4,105
CZ14	SDGE	8.8	3.3	(2,291)	159	(\$344)	(\$6,361)	(\$4,854)	(\$4,644)	0.7	(\$1,717)	>1	\$4,105
CZ15	SCE/SCG	0.9	1.0	(1,167)	53	(\$217)	(\$4,152)	(\$6,652)	(\$5,942)	1.4	\$1,791	3.0	\$3,439
CZ16	PG&E	21.3	0.7	(4,729)	403	(\$548)	(\$6,581)	(\$3,289)	(\$1,187)	0.2	(\$5,394)	0.4	(\$1,339)

<sup>1</sup> Though uncommon, incremental costs can be negative, reflecting initial construction cost savings. When paired with increased energy costs (negative benefits), the construction cost savings are treated as the 'benefit' while the increased energy costs are the 'cost,' which may yield positive cost effectiveness. See Section 2.1.2.3 for more information.

Table 15: ADU Cost-Effectiveness: All-Electric Code Minimum

Climate Zone	Electric /Gas Utility	Total EDR1 Margin	Efficiency EDR2 Margin	Annual Elec Savings (kWh)	Annual Gas Savings (therms)	Utility Cost Savings		Incremental Cost <sup>1</sup>		On-Bill		TDV	
						First Year	Lifecycle (2022\$)	First Year	Lifecycle (2022\$)	B/C Ratio	NPV	B/C Ratio	NPV
CZ01	PGE	11.9	6.1	(1,641)	114	(\$353)	(\$6,682)	(\$4,692)	(\$4,605)	0.7	(\$2,077)	3.9	\$2,986
CZ02	PGE	5.7	3.4	(1,245)	75	(\$312)	(\$6,347)	(\$4,692)	(\$4,605)	0.7	(\$1,742)	2.7	\$2,515
CZ03	PGE	2.9	2.3	(1,672)	123	(\$377)	(\$7,138)	(\$863)	\$442	0.0	(\$7,581)	0.0	(\$1,489)
CZ04	PGE	2.4	1.4	(1,612)	118	(\$366)	(\$6,964)	(\$863)	\$442	0.0	(\$7,406)	0.0	(\$801)
CZ04	CPAU	2.4	1.4	(1,612)	118	\$25	\$3,035	(\$863)	\$442	6.9	\$2,592	0.0	(\$801)
CZ05	PGE	1.8	0.8	(1,026)	49	(\$302)	(\$6,517)	(\$4,692)	(\$4,605)	0.7	(\$1,912)	2.0	\$2,021
CZ05	PGE/SCG	1.8	0.8	(1,026)	49	(\$257)	(\$5,178)	(\$4,692)	(\$4,605)	0.9	(\$574)	2.0	\$2,021
CZ06	SCE/SCG	0.5	0.2	(904)	38	(\$243)	(\$4,923)	(\$4,692)	(\$4,605)	0.9	(\$318)	2.1	\$2,135
CZ07	SDGE	0.1	0.1	(884)	37	(\$337)	(\$7,903)	(\$4,692)	(\$4,605)	0.6	(\$3,298)	2.2	\$2,205
CZ08	SCE/SCG	0.1	0.1	(878)	36	(\$241)	(\$4,894)	(\$4,692)	(\$4,605)	0.9	(\$289)	2.3	\$2,274
CZ09	SCE	0.4	0.1	(903)	38	(\$243)	(\$4,914)	(\$4,692)	(\$4,605)	0.9	(\$310)	2.4	\$2,321
CZ10	SCE/SCG	1.0	0.4	(952)	43	(\$189)	(\$3,629)	(\$4,692)	(\$4,605)	1.3	\$976	2.8	\$2,577
CZ10	SDGE	1.0	0.4	(952)	43	(\$249)	(\$5,689)	(\$4,692)	(\$4,605)	0.8	(\$1,084)	2.8	\$2,577
CZ11	PGE	4.6	2.1	(1,209)	71	(\$224)	(\$4,405)	(\$4,692)	(\$4,605)	1.1	\$200	3.5	\$2,870
CZ12	PGE	4.6	2.3	(1,183)	69	(\$306)	(\$6,315)	(\$4,692)	(\$4,605)	0.7	(\$1,710)	3.0	\$2,684
CZ12	SMUD/PGE	4.6	2.3	(1,183)	69	(\$65)	(\$808)	(\$4,692)	(\$4,605)	5.7	\$3,797	3.0	\$2,684
CZ13	PGE	3.1	1.3	(1,611)	112	(\$218)	(\$3,689)	(\$863)	\$442	0.0	(\$4,131)	0.0	(\$858)
CZ14	SCE/SCG	3.5	1.2	(1,714)	115	(\$375)	(\$6,933)	(\$863)	\$442	0.0	(\$7,375)	0.0	(\$1,089)
CZ14	SDGE	3.5	1.2	(1,714)	115	(\$483)	(\$10,348)	(\$863)	\$442	0.0	(\$10,790)	0.0	(\$1,089)
CZ15	SCE/SCG	0.0	0.0	(864)	36	(\$172)	(\$3,359)	(\$4,692)	(\$4,605)	1.4	\$1,246	2.6	\$2,477
CZ16	PG&E	11.2	0.1	(1,781)	122	(\$379)	(\$7,167)	(\$4,692)	(\$4,605)	0.6	(\$2,562)	2.1	\$2,133

<sup>1</sup> Though uncommon, incremental costs can be negative, reflecting initial construction cost savings. When paired with increased energy costs (negative benefits), the construction cost savings are treated as the 'benefit' while the increased energy costs are the 'cost,' which may yield positive cost effectiveness. See Section 2.1.2.3 for more information.

### 4.3 All-Electric Efficiency, PV, and Battery Results

Table 16 and Table 17 compare cost-effectiveness results for the all-electric packages for the single family and ADU prototypes, respectively, with the exception of the all-electric Efficiency + High Efficiency (Preempted) Equipment package (cost-effectiveness was not evaluated for this package but see Table 27 and Table 28 for a comparison of compliance impacts). In almost all cases the single family packages are cost-effective based on TDV. For ADUs, all climate zones show an increase in TDV-cost effectiveness for the Efficiency + PV case but a decrease when a battery is added. On-Bill cost-effectiveness generally improves with the addition of efficiency measures for single family, but not for ADUs, which generally follows the same trend as TDV cost-effectiveness. A summary of measures included in each package is provided in Appendix 7.3 Summary of Measures by Package. The efficiency measures added to the all-electric package to meet minimum code requirements are described in Table 39 and Table 41.

**Table 16: Single Family Cost-Effectiveness: Comparison of All-Electric Efficiency Only, PV, and Battery Packages**

Climate Zone	Electric /Gas Utility	All-Electric Code Minimum				All-Electric Efficiency Only				All-Electric-Efficiency + PV				All-Electric Efficiency + PV + Battery			
		On-Bill		TDV		On-Bill		TDV		On-Bill		TDV		On-Bill		TDV	
		B/C Ratio	NPV	B/C Ratio	NPV	B/C Ratio	NPV	B/C Ratio	NPV	B/C Ratio	NPV	B/C Ratio	NPV	B/C Ratio	NPV	B/C Ratio	NPV
CZ01	PGE	0.9	(\$268)	>1	\$5,702	>1	\$2,945	>1	\$8,168	0.9	(\$1,313)	1.8	\$9,817	1.0	\$1,012	1.2	\$4,391
CZ02	PGE	1.6	\$2,355	>1	\$7,711	8.9	\$3,870	>1	\$9,325	1.5	\$2,242	4.2	\$12,452	1.3	\$4,962	1.5	\$8,190
CZ03	PGE	0.98	(\$90)	25.3	\$3,887	1.1	\$168	>1	\$3,939	0.8	(\$903)	2.8	\$6,465	1.1	\$2,114	1.1	\$1,347
CZ04	PGE	1.3	\$979	>1	\$4,494	1.7	\$1,054	>1	\$4,849	1.1	\$204	3.5	\$7,893	1.2	\$3,709	1.3	\$4,506
CZ04	CPAU	>1	\$10,437	>1	\$7,762	>1	\$10,021	>1	\$8,117	>1	\$14,776	>1	\$11,161	0.9	(\$1,076)	1.5	\$6,724
CZ05	PGE	1.3	\$1,373	6.1	\$4,633	1.6	\$1,975	>1	\$4,985	2.2	\$1,457	8.5	\$7,927	1.3	\$5,551	1.2	\$3,296
CZ05	PGE/SCG	1.4	\$1,823	6.1	\$4,633	1.9	\$2,424	>1	\$4,985	2.6	\$1,907	8.5	\$7,927	1.4	\$6,001	1.2	\$3,296
CZ06	SCE/SCG	1.6	\$2,339	4.7	\$4,353	1.6	\$1,813	>1	\$4,119	109.5	\$2,638	152.4	\$6,727	1.5	\$7,153	1.2	\$2,276
CZ07	SDGE	1.1	\$624	4.2	\$4,211	1.2	\$839	8.3	\$4,070	5.7	\$469	>1	\$6,079	2.0	\$13,798	1.1	\$1,186
CZ08	SCE/SCG	1.7	\$2,792	4.2	\$4,674	1.8	\$2,574	17.7	\$4,642	>1	\$3,329	>1	\$7,492	1.7	\$8,899	1.2	\$2,085
CZ09	SCE	1.7	\$2,831	5.5	\$5,013	1.9	\$2,699	>1	\$5,087	>1	\$3,634	>1	\$8,007	1.7	\$9,151	1.3	\$3,630
CZ10	SCE/SCG	1.6	\$2,642	7.4	\$5,287	2.0	\$2,668	>1	\$5,376	>1	\$3,765	>1	\$8,347	1.7	\$10,088	1.3	\$3,901
CZ10	SDGE	1.4	\$1,825	7.4	\$5,287	1.8	\$2,438	>1	\$5,376	>1	\$2,539	>1	\$8,347	2.4	\$19,463	1.3	\$3,901
CZ11	PGE	1.7	\$2,552	>1	\$7,153	>1	\$4,159	>1	\$8,524	1.8	\$2,984	4.6	\$11,310	1.4	\$7,781	1.5	\$8,757
CZ12	PGE	1.9	\$3,210	>1	\$7,504	4.6	\$3,742	>1	\$8,084	1.9	\$2,561	5.5	\$11,063	1.3	\$6,021	1.5	\$8,216
CZ12	SMUD/PGE	>1	\$11,714	>1	\$7,504	>1	\$10,665	>1	\$8,084	5.8	\$13,407	5.5	\$11,063	0.9	(\$1,237)	1.4	\$7,166
CZ13	PGE	1.5	\$1,480	>1	\$4,490	>1	\$2,876	>1	\$5,773	1.7	\$2,334	3.7	\$8,341	1.4	\$7,848	1.4	\$7,005
CZ14	SCE/SCG	0.9	(\$522)	>1	\$4,105	1.8	\$811	>1	\$5,461	1.6	\$2,558	3.6	\$9,965	1.6	\$10,569	1.4	\$6,204
CZ14	SDGE	0.7	(\$1,717)	>1	\$4,105	1.5	\$643	>1	\$5,461	1.2	\$922	3.6	\$9,965	2.1	\$20,099	1.4	\$6,204
CZ15	SCE/SCG	1.4	\$1,791	3.0	\$3,439	8.0	\$3,267	>1	\$4,669	>1	\$3,940	>1	\$6,120	2.0	\$13,576	0.99	(\$80)
CZ16	PG&E	0.2	(\$5,394)	0.4	(\$1,339)	0.2	(\$1,946)	1.7	\$1,894	0.8	(\$3,199)	1.6	\$6,711	1.0	\$206	1.1	\$1,690

Table 17: ADU Cost-Effectiveness: Comparison of All-Electric Efficiency Only, PV, and Battery Packages

Climate Zone	Electric /Gas Utility	All-Electric Code Minimum				All-Electric Efficiency Only				All-Electric Efficiency + PV				All-Electric Efficiency + PV + Battery			
		On-Bill		TDV		On-Bill		TDV		On-Bill		TDV		On-Bill		TDV	
		B/C Ratio	NPV	B/C Ratio	NPV	B/C Ratio	NPV	B/C Ratio	NPV	B/C Ratio	NPV	B/C Ratio	NPV	B/C Ratio	NPV	B/C Ratio	NPV
CZ01	PGE	0.7	(\$2,077)	3.9	\$2,986	0.6	(\$1,727)	>1	\$2,900	1.2	\$2,003	1.5	\$5,010	0.997	(\$79)	0.9	(\$2,884)
CZ02	PGE	0.7	(\$1,742)	2.7	\$2,515	0.5	(\$2,541)	>1	\$1,945	1.4	\$3,532	1.8	\$6,360	1.1	\$1,302	0.98	(\$410)
CZ03	PGE	0.0	(\$7,581)	0.0	(\$1,489)	0.0	(\$8,981)	0.0	(\$2,680)	0.8	(\$2,489)	1.1	\$1,436	0.8	(\$4,949)	0.8	(\$5,369)
CZ04	PGE	0.0	(\$7,406)	0.0	(\$801)	0.0	(\$8,705)	0.4	(\$1,762)	0.9	(\$1,480)	1.3	\$3,589	0.9	(\$3,501)	0.8	(\$3,849)
CZ04	CPAU	6.9	\$2,592	0.0	(\$801)	1.3	\$944	0.4	(\$1,762)	1.7	\$8,498	1.3	\$3,589	0.7	(\$9,161)	0.8	(\$4,899)
CZ05	PGE	0.7	(\$1,912)	2.0	\$2,021	0.4	(\$3,310)	1.4	\$650	1.6	\$4,015	1.9	\$5,436	1.1	\$1,265	0.9	(\$1,611)
CZ05	PGE/SCG	0.9	(\$574)	2.0	\$2,021	0.6	(\$1,972)	1.4	\$650	1.8	\$5,353	1.9	\$5,436	1.2	\$3,836	0.9	(\$1,611)
CZ06	SCE/SCG	0.9	(\$318)	2.1	\$2,135	0.6	(\$1,579)	2.1	\$1,103	2.0	\$5,866	2.2	\$6,551	1.1	\$2,799	0.95	(\$852)
CZ07	SDGE	0.6	(\$3,298)	2.2	\$2,205	0.4	(\$4,255)	1.8	\$941	1.8	\$5,667	1.9	\$5,493	1.5	\$10,358	0.9	(\$1,804)
CZ08	SCE/SCG	0.9	(\$289)	2.3	\$2,274	0.6	(\$1,432)	2.1	\$1,179	2.0	\$6,364	2.3	\$7,936	1.2	\$4,058	0.97	(\$609)
CZ09	SCE	0.9	(\$310)	2.4	\$2,321	0.6	(\$1,494)	2.3	\$1,280	2.0	\$6,568	2.4	\$7,709	1.2	\$4,314	0.99	(\$279)
CZ10	SCE/SCG	1.3	\$976	2.8	\$2,577	0.96	(\$106)	3.7	\$1,593	2.2	\$734	6.7	\$3,496	0.9	(\$860)	0.7	(\$3,944)
CZ10	SDGE	0.8	(\$1,084)	2.8	\$2,577	0.6	(\$1,787)	3.7	\$1,593	0.0	(\$1,465)	6.7	\$3,496	1.3	\$5,079	0.7	(\$3,944)
CZ11	PGE	1.1	\$200	3.5	\$2,870	0.96	(\$96)	>1	\$2,531	0.7	(\$602)	3.2	\$4,037	0.9	(\$1,125)	0.9	(\$1,893)
CZ12	PGE	0.7	(\$1,710)	3.0	\$2,684	0.5	(\$2,538)	>1	\$1,878	1.6	\$4,644	1.9	\$6,675	1.1	\$2,970	1.0	\$178
CZ12	SMUD/PGE	5.7	\$3,797	3.0	\$2,684	13	\$1,980	>1	\$1,878	1.7	\$5,737	1.9	\$6,675	0.6	(\$9,432)	0.96	(\$872)
CZ13	PGE	0.0	(\$4,131)	0.0	(\$858)	0.0	(\$4,502)	0.6	(\$1,223)	0.3	(\$4,759)	1.1	\$305	0.8	(\$4,729)	0.7	(\$5,491)
CZ14	SCE/SCG	0.0	(\$7,375)	0.0	(\$1,089)	0.0	(\$7,929)	0.5	(\$1,684)	1.1	\$1,555	1.5	\$5,935	1.0	\$1,222	0.9	(\$1,525)
CZ14	SDGE	0.0	(\$10,790)	0.0	(\$1,089)	0.0	(\$10,375)	0.5	(\$1,684)	1.2	\$2,956	1.5	\$5,935	1.4	\$10,678	0.9	(\$1,525)
CZ15	SCE/SCG	1.4	\$1,246	2.6	\$2,477	2.4	\$1,243	>1	\$2,342	>1	\$1,729	52.2	\$3,560	1.2	\$2,631	0.8	(\$2,812)
CZ16	PG&E	0.6	(\$2,562)	2.1	\$2,133	0.5	(\$2,378)	>1	\$2,282	1.6	\$5,433	2.0	\$7,875	1.2	\$3,618	1.0	\$611

### 4.4 Mixed Fuel Results

Table 18 and Table 19 show results for the mixed fuel Efficiency + PV + Battery package for Single Family and ADU prototypes, respectively. On a TDV basis, this package is cost-effective only in Climate Zone 1 for single family and in no cases for ADUs. However, this package is cost-effective On-Bill for the single family home in all climate zones except 4 in CPAU territory and 12 in SMUD/PG&E territory. On-Bill cost-effectiveness for the ADU home, on the other hand, is seen only in Climate Zones 2, 5, 7 through 9, 10 in SDG&E territory, 12 in PG&E territory, 14, and 16.

**Table 18: Single Family Cost-Effectiveness: Mixed Fuel Efficiency + PV + Battery**

Climate Zone	Electric /Gas Utility	Total EDR1 Margin	Efficiency EDR2 Margin	Annual Elec Savings (kWh)	Annual Gas Savings (therms)	Utility Cost Savings		Incremental Cost		On-Bill		TDV	
						First Year	Lifecycle (2022\$)	First Year	Lifecycle (2022\$)	B/C Ratio	NPV	B/C Ratio	NPV
CZ01	PGE	22.6	18.8	1,571	116	\$1,084	\$26,667	\$11,160	\$20,166	1.3	\$6,501	1.0	\$500
CZ02	PGE	14.1	7.4	1,257	34	\$913	\$21,353	\$10,268	\$18,868	1.1	\$2,486	0.9	(\$1,282)
CZ03	PGE	12.8	4.3	858	7	\$785	\$18,003	\$8,708	\$16,900	1.1	\$1,104	0.7	(\$4,777)
CZ04	PGE	13.2	4.3	790	6	\$803	\$18,394	\$9,623	\$17,938	1.0	\$456	0.8	(\$3,925)
CZ04	CPAU	13.2	4.3	790	6	\$123	\$2,877	\$10,673	\$19,172	0.2	(\$16,295)	0.7	(\$4,975)
CZ05	PGE	14.8	4.9	1,178	13	\$905	\$20,821	\$9,441	\$17,885	1.2	\$2,936	0.8	(\$3,468)
CZ05	PGE/SCG	14.8	4.9	1,178	13	\$900	\$20,690	\$9,441	\$17,885	1.2	\$2,805	0.8	(\$3,468)
CZ06	SCE/SCG	18.3	5.5	888	6	\$864	\$19,539	\$9,266	\$17,587	1.1	\$1,951	0.8	(\$3,941)
CZ07	SDGE	18.7	4.8	832	4	\$1,134	\$27,505	\$9,214	\$17,537	1.6	\$9,867	0.7	(\$4,817)
CZ08	SCE/SCG	17.1	3.0	777	2	\$920	\$20,754	\$9,134	\$17,410	1.2	\$3,344	0.7	(\$4,341)
CZ09	SCE	16.2	3.1	833	3	\$922	\$20,804	\$9,152	\$17,435	1.2	\$3,369	0.8	(\$3,839)
CZ10	SCE/SCG	14.4	2.7	846	2	\$958	\$21,608	\$8,489	\$16,733	1.3	\$4,875	0.7	(\$3,859)
CZ10	SDGE	14.4	2.7	846	2	\$1,288	\$31,210	\$8,489	\$16,733	1.9	\$14,477	0.7	(\$3,859)
CZ11	PGE	12.9	5.1	1,025	26	\$1,031	\$23,949	\$9,828	\$18,296	1.3	\$5,653	0.9	(\$1,066)
CZ12	PGE	13.2	4.8	1,098	23	\$923	\$21,415	\$10,065	\$18,616	1.2	\$2,800	0.9	(\$1,194)
CZ12	SMUD/PGE	13.2	4.8	1,098	23	\$253	\$6,133	\$11,115	\$19,850	0.3	(\$13,717)	0.9	(\$2,244)
CZ13	PGE	12.3	4.2	1,006	5	\$1,016	\$23,250	\$9,831	\$18,236	1.3	\$5,013	0.9	(\$2,354)
CZ14	SCE/SCG	13.4	5.4	1,514	6	\$1,093	\$24,697	\$10,741	\$19,342	1.3	\$5,354	0.9	(\$1,910)
CZ14	SDGE	13.4	5.4	1,514	6	\$1,421	\$34,477	\$10,741	\$19,342	1.8	\$15,135	0.9	(\$1,910)
CZ15	SCE/SCG	13.5	3.8	531	2	\$1,140	\$25,708	\$8,586	\$16,630	1.6	\$9,078	0.6	(\$5,490)
CZ16	PG&E	20.4	14.2	1,228	114	\$1,070	\$26,218	\$12,086	\$20,964	1.3	\$5,254	0.98	(\$444)

**Table 19: ADU Cost-Effectiveness: Mixed Fuel Efficiency + PV + Battery**

Climate Zone	Electric /Gas Utility	Total EDR1 Margin	Efficiency EDR2 Margin	Annual Elec Savings (kWh)	Annual Gas Savings (therms)	Utility Cost Savings		Incremental Cost		On-Bill		TDV	
						First Year	Lifecycle (2022\$)	First Year	Lifecycle (2022\$)	B/C Ratio	NPV	B/C Ratio	NPV
CZ01	PGE	18.5	7.7	3,666	20	\$1,078	\$24,880	\$15,432	\$25,919	0.96	(\$1,040)	0.7	(\$6,719)
CZ02	PGE	16.6	3.5	3,472	11	\$1,042	\$23,928	\$13,846	\$23,790	1.0	\$138	0.8	(\$4,128)
CZ03	PGE	11.8	1.2	2,679	0	\$781	\$17,816	\$11,879	\$21,215	0.8	(\$3,399)	0.6	(\$6,826)
CZ04	PGE	13.3	1.6	2,799	0	\$859	\$19,588	\$12,213	\$21,598	0.9	(\$2,011)	0.7	(\$5,306)
CZ04	CPAU	13.3	1.6	2,799	0	\$391	\$8,911	\$13,263	\$22,833	0.4	(\$13,922)	0.7	(\$6,356)
CZ05	PGE	16.9	1.1	3,309	2	\$1,031	\$23,539	\$12,668	\$22,274	1.1	\$1,265	0.8	(\$4,765)
CZ05	PGE/SCG	16.9	1.1	3,309	2	\$1,031	\$23,520	\$12,668	\$22,274	1.1	\$1,246	0.8	(\$4,765)
CZ06	SCE/SCG	19.8	1.2	3,285	1	\$953	\$21,468	\$12,496	\$22,043	0.97	(\$575)	0.8	(\$3,877)
CZ07	SDGE	20.3	1.2	3,278	0	\$1,296	\$31,370	\$12,869	\$22,545	1.4	\$8,825	0.8	(\$4,633)
CZ08	SCE/SCG	20.4	0.5	3,505	0	\$1,040	\$23,434	\$12,952	\$22,678	1.0	\$755	0.8	(\$3,522)
CZ09	SCE	19.6	0.5	3,497	0	\$1,030	\$23,213	\$12,691	\$22,327	1.0	\$886	0.8	(\$3,318)
CZ10	SCE/SCG	19.0	0.6	729	0	\$537	\$12,107	\$8,436	\$16,606	0.7	(\$4,499)	0.5	(\$7,344)
CZ10	SDGE	19.0	0.6	729	0	\$813	\$19,671	\$8,436	\$16,606	1.2	\$3,065	0.5	(\$7,344)
CZ11	PGE	17.6	3.0	871	10	\$663	\$15,273	\$9,218	\$17,568	0.9	(\$2,295)	0.7	(\$5,528)
CZ12	PGE	16.7	2.7	3,594	9	\$1,112	\$25,496	\$13,764	\$23,710	1.1	\$1,786	0.8	(\$3,321)
CZ12	SMUD/PGE	16.7	2.7	3,594	9	\$537	\$12,380	\$14,844	\$24,944	0.5	(\$12,564)	0.8	(\$4,371)
CZ13	PGE	14.5	2.2	273	0	\$551	\$12,569	\$7,979	\$15,904	0.8	(\$3,335)	0.5	(\$6,903)
CZ14	SCE/SCG	14.5	3.2	3,499	0	\$1,006	\$22,671	\$12,815	\$22,325	1.0	\$346	0.8	(\$3,423)
CZ14	SDGE	14.5	3.2	3,499	0	\$1,351	\$32,711	\$12,815	\$22,325	1.5	\$10,386	0.8	(\$3,423)
CZ15	SCE/SCG	19.2	1.8	551	0	\$683	\$15,387	\$8,478	\$16,574	0.9	(\$1,187)	0.5	(\$7,021)
CZ16	PG&E	18.3	6.3	3,680	24	\$1,117	\$25,838	\$13,872	\$23,801	1.1	\$2,037	0.8	(\$3,759)

## 4.5 Greenhouse Gas Reductions

Table 20 and Table 21 present greenhouse gas reductions for the single family and ADU prototypes, respectively. Savings represent average annual savings over the 30-year lifetime of the analysis. Greenhouse gas reductions are greatest for the all-electric Efficiency + PV + Battery package in all cases. For the single family homes, the all-electric Code Minimum case reduces greenhouse gas emissions as much or greater than the mixed fuel Efficiency + PV + Battery package in Climate Zones 1 through 4, 11 through 13, and 16—showcasing the benefit of all-electric construction over even the most ambitious of mixed fuel construction packages evaluated in this study. The trend differs for the ADU where the mixed fuel Efficiency + PV + Battery package results in more greenhouse gas savings than the all-electric Code Minimum in all climate zones except Climate Zones 3, 4, and 13. In most of the climate zones (1, 2, 5 through 12, 15, and 16) the all-electric ADU involves electrification of space heating, cooking, and clothes drying. The space heating loads for the ADU are very low, even in the colder climates, and as a result the greenhouse gas savings from efficiency measures, PV and battery are greater than just code minimum electrification. This is also the case for single family homes in Climate Zones 5 through 10, and 15 where space heating loads are low.

**Table 20: Single Family Greenhouse Gas Reductions (metric tons)**

Climate Zone	Single Family All-Electric				Single Family Mixed Fuel		
	Code Minimum	Efficiency Only	Efficiency + High Efficiency Equipment	Efficiency + PV	Efficiency + PV + Battery	Efficiency + High Efficiency Equipment	Efficiency + PV + Battery
CZ01	1.5	1.7	1.8	1.8	2.3	0.8	1.1
CZ02	0.9	1.0	1.1	1.1	1.6	0.5	0.7
CZ03	0.7	0.7	0.8	0.8	1.3	0.2	0.5
CZ04	0.7	0.7	0.8	0.8	1.3	0.2	0.5
CZ05	0.4	0.5	0.6	0.6	1.1	0.2	0.6
CZ06	0.3	0.3	0.3	0.4	0.9	0.1	0.5
CZ07	0.2	0.2	0.3	0.3	0.8	0.1	0.5
CZ08	0.2	0.2	0.3	0.3	0.8	0.1	0.5
CZ09	0.3	0.3	0.3	0.4	0.9	0.1	0.5
CZ10	0.3	0.4	0.4	0.5	1.0	0.1	0.5
CZ11	0.8	0.9	1.0	1.0	1.5	0.4	0.7
CZ12	0.7	0.8	0.9	0.9	1.4	0.4	0.6
CZ13	0.6	0.7	0.8	0.8	1.3	0.2	0.6
CZ14	0.6	0.7	0.8	0.9	1.4	0.2	0.6
CZ15	0.2	0.2	0.3	0.3	0.7	0.1	0.5
CZ16	1.4	1.7	1.7	1.9	2.3	1.0	1.1

**Table 21: ADU Greenhouse Gas Reductions (metric tons)**

Climate Zone	ADU All-Electric					ADU Mixed Fuel	
	Code Minimum	Efficiency Only	Efficiency + High Efficiency Equipment	Efficiency + PV	Efficiency + PV + Battery	Efficiency + High Efficiency Equipment	Efficiency + PV + Battery
CZ01	0.4	0.5	0.5	0.6	1.0	0.2	0.5
CZ02	0.2	0.3	0.3	0.4	0.8	0.1	0.5
CZ03	0.5	0.5	0.6	0.7	1.0	0.1	0.3
CZ04	0.5	0.5	0.5	0.7	1.0	0.1	0.4
CZ05	0.1	0.2	0.2	0.3	0.7	0.0	0.4
CZ06	0.1	0.1	0.1	0.3	0.6	0.0	0.4
CZ07	0.1	0.1	0.1	0.3	0.6	0.0	0.4
CZ08	0.1	0.1	0.1	0.3	0.6	0.0	0.5
CZ09	0.1	0.1	0.1	0.3	0.7	0.0	0.5
CZ10	0.1	0.1	0.2	0.2	0.6	0.0	0.4
CZ11	0.2	0.3	0.3	0.3	0.7	0.1	0.4
CZ12	0.2	0.3	0.3	0.4	0.7	0.1	0.5
CZ13	0.4	0.5	0.5	0.5	0.9	0.1	0.3
CZ14	0.4	0.5	0.5	0.7	1.1	0.1	0.5
CZ15	0.1	0.1	0.1	0.2	0.6	0.0	0.4
CZ16	0.4	0.5	0.5	0.7	1.0	0.2	0.6

## 4.6 Sensitivity Analysis

In response to jurisdictional interest, several cases were evaluated under circumstances different than those presented above in order to assess their impact on cost-effectiveness. Altered circumstances include:

1. CARE versus standard tariffs. This comparison is presented for the all-electric Code Minimum and the mixed fuel Efficiency + PV+ Battery packages and shows the impact on On-Bill cost-effectiveness for income qualified utility customers.
2. Infill versus new subdivision single family developments. This comparison applied to the all-electric Code Minimum package demonstrates how cost-effectiveness is impacted due to the magnitude of cost savings for all-electric construction from elimination of the natural gas infrastructure.
3. Utility rate escalation factors. The impact on On-Bill cost-effectiveness is presented for the all-electric Code Minimum package from varying the assumptions for escalation of electricity and natural gas utility rates over the 30-year analysis period.

### 4.6.1 CARE Rate Comparison

Table 22 and Table 23 present a comparison of On-Bill cost-effectiveness results for CARE tariffs relative to standard IOU tariffs for the all-electric Code Minimum package for the single family and ADU prototypes, respectively. Applying the CARE rates lowers both electric and gas utility bills for the consumer. In the case of the all-electric home, the net impact of CARE rates is improved cost-effectiveness relative to the standard tariffs. This is because the discount on electricity is greater than that for natural gas. The opposite trend occurs for the mixed fuel packages, where the lower CARE rates result in lower utility cost savings and subsequently lower benefit-to-cost ratios.

**Table 22: On-Bill Cost-Effectiveness with CARE Tariffs: All-Electric Code Minimum**

Climate Zone	Electric /Gas Utility	Single Family				ADU			
		Standard		CARE		Standard		CARE	
		B/C Ratio	NPV	B/C Ratio	NPV	B/C Ratio	NPV	B/C Ratio	NPV
CZ01	PGE	0.9	(\$268)	>1	\$3,886	0.7	(\$2,077)	1.2	\$696
CZ02	PGE	1.6	\$2,355	5.1	\$5,107	0.7	(\$1,742)	1.1	\$580
CZ03	PGE	0.98	(\$90)	1.7	\$1,968	0.0	(\$7,581)	0.0	(\$4,596)
CZ04	PGE	1.3	\$979	2.3	\$2,619	0.0	(\$7,406)	0.0	(\$4,526)
CZ05	PGE	1.3	\$1,373	2.2	\$3,467	0.7	(\$1,912)	1.1	\$237
CZ05	PGE/SCG	1.4	\$1,823	2.5	\$3,841	0.9	(\$574)	1.4	\$1,321
CZ06	SCE/SCG	1.6	\$2,339	2.3	\$3,535	0.9	(\$318)	1.4	\$1,225
CZ07	SDGE	1.1	\$624	2.1	\$3,309	0.6	(\$3,298)	0.9	(\$627)
CZ08	SCE/SCG	1.7	\$2,792	2.3	\$3,945	0.9	(\$289)	1.4	\$1,231
CZ09	SCE	1.7	\$2,831	2.4	\$4,074	0.9	(\$310)	1.4	\$1,230
CZ10	SCE/SCG	1.6	\$2,642	2.4	\$4,083	1.3	\$976	1.7	\$1,923
CZ10	SDGE	1.4	\$1,825	3.0	\$4,642	0.8	(\$1,084)	1.3	\$1,114
CZ11	PGE	1.7	\$2,552	5.0	\$5,077	1.1	\$200	1.6	\$1,634
CZ12	PGE	1.9	\$3,210	5.0	\$5,587	0.7	(\$1,710)	1.1	\$545
CZ13	PGE	1.5	\$1,480	2.7	\$2,924	0.0	(\$4,131)	0.0	(\$2,754)
CZ14	SCE/SCG	0.9	(\$522)	1.3	\$1,191	0.0	(\$7,375)	0.0	(\$4,754)
CZ14	SDGE	0.7	(\$1,717)	2.0	\$2,295	0.0	(\$10,790)	0.0	(\$6,496)
CZ15	SCE/SCG	1.4	\$1,791	1.9	\$2,831	1.4	\$1,246	1.8	\$2,031
CZ16	PG&E	0.2	(\$5,394)	0.8	(\$351)	0.6	(\$2,562)	1.1	\$453

**Table 23: On-Bill Cost-Effectiveness with CARE Tariffs: Mixed Fuel Efficiency + PV+ Battery Package**

Climate Zone	Electric /Gas Utility	Single Family				ADU			
		Standard		CARE		Standard		CARE	
		B/C Ratio	NPV	B/C Ratio	NPV	B/C Ratio	NPV	B/C Ratio	NPV
CZ01	PGE	1.3	\$6,501	0.9	(\$2,072)	0.96	(\$1,040)	0.7	(\$9,009)
CZ02	PGE	1.1	\$2,486	0.7	(\$5,286)	1.0	\$138	0.7	(\$7,683)
CZ03	PGE	1.1	\$1,104	0.6	(\$5,980)	0.8	(\$3,399)	0.6	(\$9,288)
CZ04	PGE	1.0	\$456	0.6	(\$6,790)	0.9	(\$2,011)	0.6	(\$8,586)
CZ05	PGE	1.2	\$2,936	0.7	(\$4,995)	1.1	\$1,265	0.7	(\$6,642)
CZ05	PGE/SCG	1.2	\$2,805	0.7	(\$5,100)	1.1	\$1,246	0.7	(\$6,657)
CZ06	SCE/SCG	1.1	\$1,951	0.7	(\$5,232)	0.97	(\$575)	0.7	(\$5,976)
CZ07	SDGE	1.6	\$9,867	1.1	\$1,601	1.4	\$8,825	0.9	(\$2,435)
CZ08	SCE/SCG	1.2	\$3,344	0.7	(\$4,574)	1.0	\$755	0.8	(\$5,331)
CZ09	SCE	1.2	\$3,369	0.7	(\$4,547)	1.0	\$886	0.8	(\$5,198)
CZ10	SCE/SCG	1.3	\$4,875	0.8	(\$3,354)	0.7	(\$4,499)	0.5	(\$8,010)
CZ10	SDGE	1.9	\$14,477	1.3	\$4,789	1.2	\$3,065	0.8	(\$3,001)
CZ11	PGE	1.3	\$5,653	0.8	(\$3,358)	0.9	(\$2,295)	0.5	(\$8,074)
CZ12	PGE	1.2	\$2,800	0.7	(\$5,212)	1.1	\$1,786	0.7	(\$6,653)
CZ13	PGE	1.3	\$5,013	0.8	(\$4,024)	0.8	(\$3,335)	0.5	(\$8,497)
CZ14	SCE/SCG	1.3	\$5,354	0.8	(\$3,665)	1.0	\$346	0.7	(\$5,727)
CZ14	SDGE	1.8	\$15,135	1.2	\$4,127	1.5	\$10,386	0.9	(\$1,393)
CZ15	SCE/SCG	1.6	\$9,078	0.95	(\$877)	0.93	(\$1,187)	0.6	(\$6,708)
CZ16	PG&E	1.3	\$5,254	0.8	(\$3,523)	1.1	\$2,037	0.7	(\$6,282)

### 4.6.2 Utility Infrastructure Cost Sensitivity

Table 24 compares cost-effectiveness results for the natural gas service line extension cost scenarios that inform the average values presented in Table 8. The average cost scenario reflects the cost-effectiveness results for the single family all-electric Code Minimum package presented in Table 16. Relative to a new subdivision, gas infrastructure cost savings are higher for the infill development case, which translates to higher cost-effectiveness. This is shown by positive cost-effectiveness in all metrics except one – On-Bill for Climate Zone 16 – for infill development. Compared to the average cost scenario, there are two cases – On-Bill for Climate Zone 4 in PG&E territory and Climate Zone 7 – where the all-electric Code Minimum package is no longer cost-effective based on the new subdivision costs.

**Table 24: Single Family Cost-Effectiveness Comparison with Range of Natural Gas Utility Infrastructure Costs: All-Electric Code Minimum**

Climate Zone	Electric /Gas Utility	Average				New Subdivision				Infill Development			
		On-Bill		TDV		On-Bill		TDV		On-Bill		TDV	
		B/C Ratio	NPV	B/C Ratio	NPV	B/C Ratio	NPV	B/C Ratio	NPV	B/C Ratio	NPV	B/C Ratio	NPV
CZ01	PGE	0.9	(\$268)	>1	\$5,702	0.6	(\$1,492)	>1	\$4,612	2.2	\$4,628	>1	\$10,062
CZ02	PGE	1.6	\$2,355	>1	\$7,711	1.3	\$1,131	>1	\$6,621	2.8	\$7,250	>1	\$12,071
CZ03	PGE	0.98	(\$90)	25.3	\$3,887	0.7	(\$1,314)	18.5	\$2,797	2.0	\$4,806	52.6	\$8,247
CZ04	PGE	1.3	\$979	>1	\$4,494	0.9	(\$245)	>1	\$3,404	2.6	\$5,875	>1	\$8,854
CZ04	CPAU	>1	\$10,437	>1	\$7,762	>1	\$10,437	>1	\$7,762	>1	\$10,437	>1	\$7,762
CZ05	PGE	1.3	\$1,373	6.1	\$4,633	1.0	\$149	4.9	\$3,543	2.3	\$6,269	11.0	\$8,993
CZ05	PGE/SCG	1.4	\$1,823	6.1	\$4,633	1.1	\$599	4.9	\$3,543	2.5	\$6,719	11.0	\$8,993
CZ06	SCE/SCG	1.6	\$2,339	4.7	\$4,353	1.3	\$1,115	3.8	\$3,263	2.8	\$7,235	8.4	\$8,713
CZ07	SDGE	1.1	\$624	4.2	\$4,211	0.9	(\$600)	3.4	\$3,121	2.0	\$5,519	7.5	\$8,571
CZ08	SCE/SCG	1.7	\$2,792	4.2	\$4,674	1.4	\$1,568	3.5	\$3,584	2.8	\$7,687	7.3	\$9,034
CZ09	SCE	1.7	\$2,831	5.5	\$5,013	1.4	\$1,607	4.6	\$3,923	2.9	\$7,726	9.5	\$9,373
CZ10	SCE/SCG	1.6	\$2,642	7.4	\$5,287	1.3	\$1,418	6.1	\$4,197	2.7	\$7,537	12.6	\$9,647
CZ10	SDGE	1.4	\$1,825	7.4	\$5,287	1.1	\$601	6.1	\$4,197	2.3	\$6,721	12.6	\$9,647
CZ11	PGE	1.7	\$2,552	>1	\$7,153	1.3	\$1,328	>1	\$6,063	3.0	\$7,448	>1	\$11,513
CZ12	PGE	1.9	\$3,210	>1	\$7,504	1.5	\$1,986	>1	\$6,414	3.1	\$8,106	>1	\$11,864
CZ12	SMUD/PGE	>1	\$11,714	>1	\$7,504	>1	\$10,490	>1	\$6,414	>1	\$16,610	>1	\$11,864
CZ13	PGE	1.5	\$1,480	>1	\$4,490	1.1	\$256	>1	\$3,400	3.0	\$6,376	>1	\$8,850
CZ14	SCE/SCG	0.9	(\$522)	>1	\$4,105	0.7	(\$1,746)	>1	\$3,015	1.8	\$4,374	>1	\$8,465
CZ14	SDGE	0.7	(\$1,717)	>1	\$4,105	0.5	(\$2,941)	>1	\$3,015	1.5	\$3,179	>1	\$8,465
CZ15	SCE/SCG	1.4	\$1,791	3.0	\$3,439	1.1	\$567	2.4	\$2,349	2.6	\$6,687	5.6	\$7,799
CZ16	PG&E	0.2	(\$5,394)	0.4	(\$1,339)	0.0	(\$6,618)	0.0	(\$2,429)	0.9	(\$498)	2.4	\$3,021

### 4.6.3 Utility Rate Escalation

In this sensitivity analysis, an alternative set of annual utility escalation rates was applied to the gas and electricity savings in select measure packages to show the impact that utility cost changes over time have on cost-effectiveness. This set of rates, detailed in Section 7.2.7, reflects those used by the Energy Commission in their development of the LSC factors for the 2025 code cycle (LSC replaces TDV in the 2025 code cycle). The rates assume steep increases in gas rates starting in 2030. Increased gas rates range from 2% to 6.7% higher than annual rates used in the 2022 code cycle; electricity rates are only marginally (about 0.5%) higher each year.

On-Bill cost-effectiveness results are shown for in Table 25 for the all-electric Code Minimum scenario and Table 26 for the mixed fuel Efficiency + PV + Battery measure package. The alternative rates described above (“2025 LSC”) are shown alongside those reported elsewhere in this report (“CPUC / 2022 TDV”, described in Section 2.1.3) for comparison. In all cases, the 2025 LSC escalation rates improve cost-effectiveness. In some cases, this improvement is enough to change the result from not cost-effective to cost-effective, these cases are summarized below:

- *All-Electric Code Minimum package*
  - *Climate Zones 1, 3, 14, and 16 for the single family home*
  - *Climate Zones 1, 5 in PG&E/SCG territory, 6, 8, 9, 10 in SDG&E territory, and 16 for the ADU home*
- *Mixed fuel Efficiency + PV + Battery package*
  - *Climate Zones 1, 6, and 15 for the ADU home*

**Table 25: On-Bill Cost-Effectiveness, 2025 LSC Basis: All-Electric Code Minimum**

Climate Zone	Electric /Gas Utility	Single Family				ADU			
		CPUC / 2022 TDV		2025 LSC		CPUC / 2022 TDV		2025 LSC	
		B/C Ratio	NPV	B/C Ratio	NPV	B/C Ratio	NPV	B/C Ratio	NPV
CZ01	PGE	0.9	(\$268)	>1	\$13,867	0.7	(\$2,077)	1.2	\$833
CZ02	PGE	1.6	\$2,355	>1	\$10,458	0.7	(\$1,742)	0.95	(\$228)
CZ03	PGE	0.98	(\$90)	>1	\$4,883	0.0	(\$7,581)	0.0	(\$4,465)
CZ04	PGE	1.3	\$979	>1	\$5,728	0.0	(\$7,406)	0.0	(\$4,466)
CZ04	CPAU	>1	\$10,437	>1	\$17,647	6.9	\$2,592	20.7	\$8,704
CZ05	PGE	1.3	\$1,373	5.3	\$5,148	0.7	(\$1,912)	0.8	(\$1,386)
CZ05	PGE/SCG	1.4	\$1,823	13.5	\$5,884	0.9	(\$574)	1.2	\$807
CZ06	SCE/SCG	1.6	\$2,339	4.0	\$4,751	0.9	(\$318)	1.2	\$630
CZ07	SDGE	1.1	\$624	1.9	\$3,008	0.6	(\$3,298)	0.7	(\$2,394)
CZ08	SCE/SCG	1.7	\$2,792	3.0	\$4,650	0.9	(\$289)	1.1	\$591
CZ09	SCE	1.7	\$2,831	4.0	\$5,233	0.9	(\$310)	1.2	\$634
CZ10	SCE/SCG	1.6	\$2,642	5.4	\$5,700	1.3	\$976	1.9	\$2,147
CZ10	SDGE	1.4	\$1,825	7.4	\$6,038	0.8	(\$1,084)	1.0	\$102
CZ11	PGE	1.7	\$2,552	>1	\$9,997	1.1	\$200	1.6	\$1,669
CZ12	PGE	1.9	\$3,210	>1	\$10,077	0.7	(\$1,710)	0.9	(\$430)
CZ12	SMUD/PGE	>1	\$11,714	>1	\$19,028	5.7	\$3,797	>1	\$5,367
CZ13	PGE	1.5	\$1,480	>1	\$5,987	0.0	(\$4,131)	0.0	(\$1,228)
CZ14	SCE/SCG	0.9	(\$522)	6.0	\$3,876	0.0	(\$7,375)	0.0	(\$4,363)
CZ14	SDGE	0.7	(\$1,717)	>1	\$4,799	0.0	(\$10,790)	0.0	(\$6,285)
CZ15	SCE/SCG	1.4	\$1,791	2.2	\$3,214	1.4	\$1,246	1.9	\$2,210
CZ16	PG&E	0.2	(\$5,394)	>1	\$8,516	0.6	(\$2,562)	1.2	\$629

**Table 26: On-Bill Cost-Effectiveness, 2025 LSC Basis: Mixed Fuel Efficiency + PV + Battery**

Climate Zone	Electric /Gas Utility	Single Family				ADU			
		CPUC / 2022 TDV		2025 LSC		CPUC / 2022 TDV		2025 LSC	
		B/C Ratio	NPV	B/C Ratio	NPV	B/C Ratio	NPV	B/C Ratio	NPV
CZ01	PGE	1.3	\$6,501	1.6	\$12,598	0.96	(\$1,040)	1.0	\$993
CZ02	PGE	1.1	\$2,486	1.3	\$4,914	1.0	\$138	1.1	\$1,816
CZ03	PGE	1.1	\$1,104	1.1	\$2,287	0.8	(\$3,399)	0.9	(\$2,462)
CZ04	PGE	1.0	\$456	1.1	\$1,645	0.9	(\$2,011)	0.95	(\$980)
CZ04	CPAU	0.2	(\$16,295)	0.2	(\$15,990)	0.4	(\$13,922)	0.4	(\$13,453)
CZ05	PGE	1.2	\$2,936	1.3	\$4,506	1.1	\$1,265	1.1	\$2,574
CZ05	PGE/SCG	1.2	\$2,805	1.2	\$4,291	1.1	\$1,246	1.1	\$2,543
CZ06	SCE/SCG	1.1	\$1,951	1.2	\$3,420	0.97	(\$575)	1.0	\$847
CZ07	SDGE	1.6	\$9,867	1.6	\$9,930	1.4	\$8,825	1.4	\$8,570
CZ08	SCE/SCG	1.2	\$3,344	1.3	\$4,750	1.0	\$755	1.1	\$2,288
CZ09	SCE	1.2	\$3,369	1.3	\$4,812	1.0	\$886	1.1	\$2,407
CZ10	SCE/SCG	1.3	\$4,875	1.4	\$6,334	0.7	(\$4,499)	0.8	(\$3,703)
CZ10	SDGE	1.9	\$14,477	1.9	\$14,289	1.2	\$3,065	1.2	\$2,904
CZ11	PGE	1.3	\$5,653	1.4	\$7,967	0.9	(\$2,295)	0.94	(\$1,126)
CZ12	PGE	1.2	\$2,800	1.3	\$4,806	1.1	\$1,786	1.1	\$3,458
CZ12	SMUD/PGE	0.3	(\$13,717)	0.4	(\$12,515)	0.5	(\$12,564)	0.5	(\$11,582)
CZ13	PGE	1.3	\$5,013	1.4	\$6,448	0.8	(\$3,335)	0.8	(\$2,674)
CZ14	SCE/SCG	1.3	\$5,354	1.4	\$7,138	1.0	\$346	1.1	\$1,827
CZ14	SDGE	1.8	\$15,135	1.8	\$15,116	1.5	\$10,386	1.5	\$10,107
CZ15	SCE/SCG	1.6	\$9,078	1.7	\$10,819	0.9	(\$1,187)	0.99	(\$182)
CZ16	PG&E	1.3	\$5,254	1.5	\$10,999	1.1	\$2,037	1.2	\$4,285

## 5 Summary

The purpose of this study was to examine and document the code compliance and cost-effectiveness impacts of improving performance among single family new construction – both standard sized homes and ADUs. To this end, the Reach Codes Team evaluated packages of energy efficiency measures as well as packages combining energy efficiency with solar PV generation and battery storage, simulated them in building modeling software, and gathered costs to determine the cost-effectiveness of multiple scenarios. The Reach Codes Team coordinated with multiple utilities, cities, and building community experts to develop a set of assumptions considered reasonable in the current market. Changing assumptions, such as the period of analysis, measure selection, cost assumptions, energy escalation rates, or utility tariffs are likely to change results.

Table 27 (single family) and Table 28 (ADU) summarize results for each prototype and depict the EDR1 compliance margins achieved for each climate zone and package. Because local reach codes must both exceed the energy code (i.e., have a positive compliance margin in the performance approach) and be cost-effective, the Reach Codes Team highlighted cells meeting these two requirements to help clarify the upper boundary for potential reach code policies. All results presented in this study have a positive compliance margin.

- Cells highlighted in **green** depict a positive compliance margin and cost-effective results using both On-Bill and TDV approaches.
- Cells highlighted in **yellow** depict a positive compliance and cost-effective results using either the On-Bill or TDV approach.
- Cells **not highlighted** depict a package that was not cost-effective using either the On-Bill or TDV approach.
- Cells highlighted in **grey** depict the high efficiency equipment packages where cost-effectiveness was not evaluated.

The following are key takeaways and recommendations from the analysis.

### Conclusions and Discussion:

- All-electric buildings have lower GHG emissions than mixed fuel buildings, due to the clean power sources currently available from California’s power providers as well as accounting for increased penetration of renewables in the future. Almost all the all-electric packages evaluated resulted in greater GHG emission savings than the mixed fuel packages, with the exception of the mixed fuel package with battery storage in climate zones with low heating loads.
- The Reach Codes Team found code-compliant, all-electric new construction to be feasible and cost-effective based on TDV for single family homes in all cases except Climate Zone 16.
- All-electric code minimum single family new construction was On-Bill cost-effective in all cases except Climate Zones 1, 3, 14, and 16.
- The all-electric code minimum ADU home was cost-effective based on TDV in all cases except in Climate Zones 3, 4, 13, and 14 where the higher cost of installing a ducted HPWH instead of the prescriptively required gas tankless water heater outweigh the resulting energy cost savings. In the other climate zones there were first cost savings for installing a heat pump space heater instead of gas furnace, contributing to an overall TDV cost-effective result.
- Few cases were cost-effective On-Bill for the ADU.
- All-electric code minimum construction results in an increase in lifetime utility costs relative to a mixed fuel home, except for CPAU and SMUD where electricity rates are much lower than for the IOUs. The addition of efficiency measures, market dominant HPWHs that meet NEEA’s Advanced Water Heating Specification, high efficiency heat pumps, increased PV, and batteries all reduce utility costs, and the combination of these options was found to reduce annual utility costs relative to a mixed fuel home in all cases.
- Under NBT, utility cost savings for increasing PV system size beyond code minimum are substantially less than under prior net energy metering rules (NEM 2.0); however, savings are sufficient to be On-Bill cost-

effective in all climate zones for the all-electric single family home except climate zones 1, 3, and 16. Coupling PV with battery systems increases utility cost savings as a result of improved on-site utilization of PV generation and fewer exports to the grid.

- Applying CARE rates in the IOU territories improves On-Bill cost-effectiveness for all-electric buildings, as compared to the same case under standard rates, due to higher utility cost savings compared to a code compliant mixed fuel building also on a CARE rate, improving On-Bill cost-effectiveness. This is due to the CARE discount on electricity being higher than that on gas.
- If gas tariffs are assumed to increase substantially over time, in-line with the escalation assumption from the 2025 LSC development, all-electric new construction was found to be On-Bill cost-effective in all single family and most ADU scenarios over the 30-year analysis period. There is much uncertainty surrounding future tariff structures as well as escalation values. While it's clear that gas rates will increase, how much and how quickly is not known. Electricity tariff structures are expected to evolve over time, and the CPUC has an active proceeding to adopt an income-graduated fixed charge that benefits low-income customers and supports electrification measures.<sup>21</sup> The CPUC will make a decision in mid-2024 and the new rates are expected to be in place later that year or in 2025. While the anticipated impact of this rate change is lower volumetric electricity rates, the rate design is not finalized. While lower volumetric electricity rates provide many benefits including incentivizing electrification, it also will make building efficiency measures harder to justify as cost-effective due to lower utility bill cost savings.

#### Recommendations:

- A reach code with a single performance target based on source energy (EDR1) can be structured to strongly encourage electrification. This approach requires equivalent performance for all buildings and allows mixed fuel buildings which minimizes the risk of violating federal preemption. Below are examples of how a reach code for single family homes could be setup based on the results summarized in Table 27.
  - A jurisdiction in Climate Zone 12 could set a performance target at an EDR1 margin of 11.5 (the EDR1 margin for the all-electric Code Minimum package). Any all-electric home meeting or exceeding the prescriptive requirements would comply, and a mixed fuel home would likely need to incorporate a combination of efficiency measures and a battery system to comply.
  - Similarly, a jurisdiction in Climate Zone 7 may consider setting a performance target of 2.8 EDR1 margin (also the EDR1 margin for the all-electric Code Minimum package). Any all-electric home meeting or exceeding the prescriptive requirements would comply, but a mixed fuel home would likely be able to comply with only a suite of above-code efficiency measures (no battery). Alternatively, a higher EDR1 margin target of 5 would incentivize more energy efficiency or additional PV for all-electric construction, and mixed fuel construction would likely need to incorporate a battery system to comply.
  - A jurisdiction in Climate Zone 16 may want to set a performance target at an EDR1 margin of 20.4 (the EDR1 margin for the mixed fuel efficiency + PV + battery package). This would establish a target that a mixed fuel home could On-Bill cost-effectively meet, likely only after incorporating a combination of efficiency measures and a battery system, and that an all-electric home could easily meet.
- The 2022 Title 24 code's new source energy metric combined with the heat pump baseline encourage all-electric construction, providing an incentive that allows for some amount of prescriptively required building efficiency to be traded off, still meeting minimum code compliance. This compliance benefit for all-electric homes highlights a unique opportunity for jurisdictions to incorporate efficiency into all-electric reach codes. Efficiency and electrification have symbiotic benefits and are both critical for decarbonization of buildings. As demand on the electric grid is increased through electrification, efficiency can reduce the negative impacts of additional electricity demand on the grid, reducing the need for increased generation and storage capacity, as well as the need to upgrade upstream transmission and distribution equipment. The Reach Codes Team recommends that jurisdictions adopting a reach code for single family buildings also include an efficiency

<sup>21</sup> <https://www.cpuc.ca.gov/industries-and-topics/electrical-energy/electric-costs/demand-response-dr/demand-flexibility-rulemaking>

requirement with EDR1 margins at minimum consistent with the all-electric code minimum package results in Table 27.

- The code compliance margins for the ADU all-electric code minimum package are lower than for the single family prototype; code compliance and cost-effectiveness can be more challenging for smaller dwelling units. As a result, the Reach Codes Team does not recommend EDR1 targets above those reported for the all-electric Code Minimum package in Table 28.

Local jurisdictions may also adopt ordinances that amend different Parts of the California Building Standards Code or may elect to amend other state or municipal codes. The decision regarding which code to amend will determine the specific requirements that must be followed for an ordinance to be legally enforceable. For example, jurisdictions may amend Part 11 instead of Part 6 of the CA Building Code requiring review and approval by the BSC but not the Energy Commission. Reach codes that amend Part 6 of the CA Building Code and require energy performance beyond state code minimums must demonstrate the proposed changes are cost-effective and obtain approval from the Energy Commission.

This report documents the key results and conclusions from the Reach Codes Team analysis. A full dataset of all results can be downloaded at <https://localenergycodes.com/content/resources>. Results alongside policy options can also be explored using the Cost-effectiveness Explorer at <https://explorer.localenergycodes.com/>.

**Table 27: Summary of Single Family EDR1 Margins and Cost-Effectiveness**

Climate Zone	Electric /Gas Utility	All-Electric					Mixed Fuel	
		Code Minimum	Efficiency	Efficiency + High Efficiency Equipment	Efficiency + PV	Efficiency + PV + Battery	Efficiency + High Efficiency Equipment	Efficiency + PV + Battery
CZ01	PGE	25.8	29.1	31.4	32.6	41.4	14.8	22.6
CZ02	PGE	14.0	16.3	18.0	18.9	28.3	9.1	14.1
CZ03	PGE	9.1	10.6	12.2	13.1	24.2	3.6	12.8
CZ04	PGE	8.8	10.4	11.9	12.8	24.6	3.8	13.2
CZ04	CPAU	8.8	10.4	11.9	12.8	24.6	3.8	13.2
CZ05	PGE	6.5	7.9	10.2	10.8	23.3	5.2	14.8
CZ05	PGE/SCG	6.5	7.9	10.2	10.8	23.3	5.2	14.8
CZ06	SCE/SCG	4.2	5.3	6.6	8.4	24.6	4.0	18.3
CZ07	SDGE	2.8	3.6	4.9	6.9	23.6	3.2	18.7
CZ08	SCE/SCG	2.1	2.9	4.2	5.6	21.3	2.7	17.1
CZ09	SCE/SCG	3.6	4.4	5.7	7.1	21.8	3.2	16.2
CZ10	SCE/SCG	4.8	5.8	7.2	8.5	21.9	3.9	14.4
CZ10	SDGE	4.8	5.8	7.2	8.5	21.9	3.9	14.4
CZ11	PGE	11.4	13.4	15.0	15.6	24.5	7.7	12.9
CZ12	PGE	11.5	13.3	14.8	15.5	25.2	7.2	13.2
CZ12	SMUD/PGE	11.5	13.3	14.8	15.5	25.2	7.2	13.2
CZ13	PGE	8.3	10.3	11.9	12.3	22.3	4.1	12.3
CZ14	SCE/SCG	8.8	11.5	13.2	14.3	24.7	4.7	13.4
CZ14	SDGE	8.8	11.5	13.2	14.3	24.7	4.7	13.4
CZ15	SCE/SCG	0.9	2.4	3.7	3.8	15.7	3.5	13.5
CZ16	PG&E	21.3	25.6	27.0	29.1	37.5	16.3	20.4

Table 28: Summary of ADU EDR1 Margins and Cost-Effectiveness

Climate Zone	Electric /Gas Utility	All-Electric					Mixed Fuel	
		Code Minimum	Efficiency	Efficiency + High Efficiency Equipment	Efficiency + PV	Efficiency + PV + Battery	Efficiency + High Efficiency Equipment	Efficiency + PV + Battery
CZ01	PGE	11.9	15.7	18.5	19.3	33.5	9.9	18.5
CZ02	PGE	5.7	7.9	9.7	10.8	25.4	5.6	16.6
CZ03	PGE	2.9	4.0	5.9	7.1	22.8	3.0	11.8
CZ04	PGE	2.4	3.9	5.5	6.8	23.5	3.7	13.3
CZ04	CPAU	2.4	3.9	5.5	6.8	23.5	3.7	13.3
CZ05	PGE	1.8	2.9	4.8	6.4	23.6	2.7	16.9
CZ05	PGE/SCG	1.8	2.9	4.8	6.4	23.6	2.7	16.9
CZ06	SCE/SCG	0.5	1.3	2.6	5.0	25.4	1.8	19.8
CZ07	SDGE	0.1	0.9	2.1	5.0	25.9	1.5	20.3
CZ08	SCE/SCG	0.1	0.7	1.8	4.2	25.4	1.6	20.4
CZ09	SCE	0.4	1.1	2.3	4.5	24.9	1.9	19.6
CZ10	SCE/SCG	1.0	2.0	3.5	5.4	25.3	2.5	19.0
CZ10	SDGE	1.0	2.0	3.5	5.4	25.3	2.5	19.0
CZ11	PGE	4.6	7.0	8.6	9.6	25.0	5.4	17.6
CZ12	PGE	4.6	6.6	8.3	9.3	24.4	5.0	16.7
CZ12	SMUD/PGE	4.6	6.6	8.3	9.3	24.4	5.0	16.7
CZ13	PGE	3.1	5.5	6.9	7.8	25.1	3.9	14.5
CZ14	SCE/SCG	3.5	6.3	8.0	9.6	26.8	4.3	14.5
CZ14	SDGE	3.5	6.3	8.0	9.6	26.8	4.3	14.5
CZ15	SCE/SCG	0.0	2.2	2.6	4.4	24.8	2.3	19.2
CZ16	PG&E	11.2	14.7	15.7	18.3	32.0	8.3	18.3

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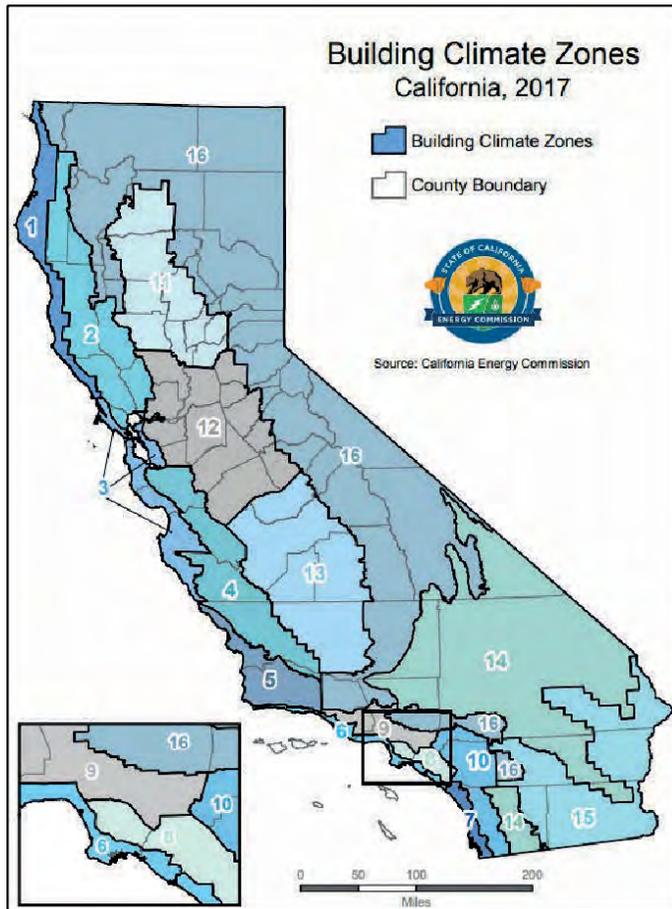
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## 7 Appendices

### 7.1 Map of California Climate Zones

Climate zone geographical boundaries are depicted in Figure 4. The map in Figure 4 along with a zip-code search directory is available at: [https://ww2.energy.ca.gov/maps/renewable/building\\_climate\\_zones.html](https://ww2.energy.ca.gov/maps/renewable/building_climate_zones.html)

**Figure 4: Map of California climate zones.**



## 7.2 Utility Rate Schedules

The Reach Codes Team used the CA IOU and POU rate tariffs detailed below to determine the On-Bill savings for each package. The California Climate Credit was applied for both electricity and natural gas service for the IOUs using the 2023 credits shows below.<sup>22</sup> The credits were applied to reduce the total calculated annual bill, including any fixed fees or minimum bill amounts.

### 2023 Electric California Climate Credit Schedule

	February or March	April	May	June	July	Aug	Sept	Oct
<b>PG&amp;E</b>	\$38.39							\$38.39
<b>SCE</b>	\$71.00							\$71.00
<b>SDG&amp;E</b>	\$60.70							\$60.70

## Residential Natural Gas California Climate Credit

In 2023, the 2023 Natural Gas California Climate Credit will be distributed in February or March instead of April.

	2018†	2019	2020	2021	2022	2023	Total Value Received Per Household 2018-2023
<b>PG&amp;E</b>	\$30	\$25	\$27	\$25	\$48	\$52.78	<b>\$208</b>
<b>SDG&amp;E</b>	*	\$34	\$21	\$18	\$43	\$43.40	<b>\$162</b>
<b>Southwest Gas</b>	\$22	\$25	\$27	\$28	\$49	\$56.35	<b>\$207</b>
<b>SoCalGas</b>	*	\$50	\$26	\$22	\$44	\$50.77	<b>\$194</b>

Electricity rates reflect the most recently approved tariffs. Monthly gas rates were estimated based on recent gas rates (November 2023) and a curve to reflect how natural gas prices fluctuate with seasonal supply and demand. The seasonal curve was estimated from monthly residential tariffs between 2014 and 2023 (between 2017 and 2023 for CPAU). 12-month curves were created from monthly gas rates for each of the ten years (seven years for CPAU). These annual curves were then averaged to arrive at an average normalized annual curve. This was conducted separately for baseline and excess energy rates. Costs used in this analysis were then derived by establishing the most recent baseline and excess rate from the latest tariff as a reference point (November 2023), and then using the normalized curve to estimate the cost for the remaining months relative to the reference point rate.

<sup>22</sup> <https://www.cpuc.ca.gov/industries-and-topics/natural-gas/greenhouse-gas-cap-and-trade-program/california-climate-credit>

### 7.2.1 Pacific Gas & Electric

The following pages provide details on the PG&E electricity and natural gas tariffs applied in this study. Table 29 describes the baseline territories that were assumed for each climate zone. A net surplus compensation rate of \$0.07051/ kWh was applied to any net annual electricity generation based on a one-year average of the rates between December 2022 and November 2023.

**Table 29: PG&E Baseline Territory by Climate Zone**

Climate Zone	Baseline Territory
CZ01	V
CZ02	X
CZ03	T
CZ04	X
CZ05	T
CZ11	R
CZ12	S
CZ13	R
CZ16	Y

The PG&E monthly gas rate for G-1 in \$/therm was applied on a monthly basis according to the rates shown in Table 30. These rates are based on applying a normalization curve to the November 2023 tariff based on ten years of historical gas data. Corresponding CARE rates reflect the 20 percent discount per the GL-1 tariff.

**Table 30: PG&E Monthly Gas Rate (\$/therm)**

Month	Total Charge	
	Baseline	Excess
January	\$2.05	\$2.43
February	\$2.08	\$2.46
March	\$1.92	\$2.31
April	\$1.80	\$2.20
May	\$1.77	\$2.18
June	\$1.78	\$2.18
July	\$1.80	\$2.20
August	\$1.85	\$2.26
September	\$1.92	\$2.33
October	\$1.99	\$2.40
November	\$2.06	\$2.46
December	\$2.05	\$2.44

## Residential GAS Baseline Territories and Quantities <sup>1/</sup>

**Effective April 1, 2022 - Present**

BASELINE QUANTITIES (Therms Per Day Per Dwelling Unit)

Individually Metered			
Baseline Territories	Summer (April-October) <u>Effective Apr. 1, 2022</u>	Winter Off-Peak (Nov, Feb, Mar) <u>Effective Nov. 1, 2022</u>	Winter On-Peak (Dec, Jan) <u>Effective Dec. 1, 2022</u>
P	0.39	1.88	2.19
Q	0.56	1.48	2.00
R	0.36	1.24	1.81
S	0.39	1.38	1.94
T	0.56	1.31	1.68
V	0.59	1.51	1.71
W	0.39	1.14	1.68
X	0.49	1.48	2.00
Y	0.72	2.22	2.58

Master Metered			
Baseline Territories	Summer (April-October) <u>Effective Apr. 1, 2022</u>	Winter Off-Peak (Nov, Feb, Mar) <u>Effective Nov. 1, 2022</u>	Winter On-Peak (Dec, Jan) <u>Effective Dec. 1, 2022</u>
P	0.29	1.01	1.13
Q	0.56	0.67	0.77
R	0.33	0.87	1.16
S	0.29	0.61	0.65
T	0.56	1.01	1.10
V	0.59	1.28	1.32
W	0.26	0.71	0.87
X	0.33	0.67	0.77
Y	0.52	1.01	1.13

Summer Season: Apr-Oct  
 Winter Off-Peak: Nov, Feb, Mar  
 Winter On-Peak: Dec, Jan

Advice Letter: 4589-G  
 Decision 21-11-016  
 GRC 2020 Ph II [Application 19-11-019]  
 Filed: Nov 22, 2019



**Pacific Gas and Electric Company**

Oakland, California

Cancelling Revised

Revised Revised

Cal. P.U.C. Sheet No.

56550-E

Cal. P.U.C. Sheet No.

56229-E

**ELECTRIC SCHEDULE E-TOU-C**  
RESIDENTIAL TIME-OF-USE (PEAK PRICING 4 - 9 p.m. EVERY DAY)

Sheet 2

RATES:  
(Cont'd.)

**E-TOU-C TOTAL BUNDLED RATES**

Total Energy Rates (\$ per kWh)	PEAK		OFF-PEAK	
<i>Summer</i>				
Total Usage	\$0.53933	(I)	\$0.45589	(I)
Baseline Credit (Applied to Baseline Usage Only)	(\$0.08851)	(R)	(\$0.08851)	(R)
<i>Winter</i>				
Total Usage	\$0.43862	(I)	\$0.40827	(I)
Baseline Credit (Applied to Baseline Usage Only)	(\$0.08851)	(R)	(\$0.08851)	(R)
Delivery Minimum Bill Amount (\$ per meter per day)	\$0.37612			
California Climate Credit (per household, per semi-annual payment occurring in the March* and October bill cycles)	(\$38.39)			

Total bundled service charges shown on customer's bills are unbundled according to the component rates shown below. Where the delivery minimum bill amount applies, the customer's bill will equal the sum of (1) the delivery minimum bill amount plus (2) for bundled service, the generation rate times the number of kWh used. For revenue accounting purposes, the revenues from the delivery minimum bill amount will be assigned to the Transmission, Transmission Rate Adjustments, Reliability Services, Public Purpose Programs, Nuclear Decommissioning, Competition Transition Charges, Energy Cost Recovery Amount, Wildfire Fund Charge, and New System Generation Charges based on kWh usage times the corresponding unbundled rate component per kWh, with any residual revenue assigned to Distribution.

\* Pursuant to D.23-02-014, disbursement of the April 2023 residential Climate Credit shall begin by March 1, 2023.

(Continued)

Advice Decision	7009-E	Issued by <b>Meredith Allen</b> Vice President, Regulatory Affairs	Submitted Effective Resolution	August 25, 2023 September 1, 2023
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**Pacific Gas and Electric Company**  
Oakland, California

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Cancelling Revised

Cal. P.U.C. Sheet No. 56551-E  
Cal. P.U.C. Sheet No. 56230-E

**ELECTRIC SCHEDULE E-TOU-C** Sheet 3  
RESIDENTIAL TIME-OF-USE (PEAK PRICING 4 - 9 p.m. EVERY DAY)

RATES:  
(Cont d.)

**UNBUNDLING OF E-TOU-C TOTAL RATES**

Energy Rates by Component (\$ per kWh)	PEAK		OFF-PEAK	
<b>Generation:</b>				
Summer (all usage)	\$0.19776		\$0.13432	
Winter (all usage)	\$0.14916		\$0.12413	
<b>Distribution**:</b>				
Summer (all usage)	\$0.17029	(I)	\$0.15029	(I)
Winter (all usage)	\$0.11618	(I)	\$0.11286	(I)
<b>Conservation Incentive Adjustment (Baseline Usage)</b>			(\$0.02216)	(I)
<b>Conservation Incentive Adjustment (Over Baseline Usage)</b>			\$0.06635	(I)
<b>Transmission* (all usage)</b>			\$0.05254	
<b>Transmission Rate Adjustments* (all usage)</b>			\$0.00059	
<b>Reliability Services* (all usage)</b>			\$0.00069	
<b>Public Purpose Programs (all usage)</b>			\$0.02578	
<b>Nuclear Decommissioning (all usage)</b>			\$0.00135	
<b>Competition Transition Charges (all usage)</b>			\$0.00030	
<b>Energy Cost Recovery Amount (all usage)</b>			(\$0.00071)	
<b>Wildfire Fund Charge (all usage)</b>			\$0.00530	
<b>New System Generation Charge (all usage)**</b>			\$0.00346	
<b>Wildfire Hardening Charge (all usage)</b>			\$0.00254	
<b>Recovery Bond Charge (all usage)</b>			\$0.00528	(R)
<b>Recovery Bond Credit (all usage)</b>			(\$0.00528)	(I)
<b>Bundled Power Charge Indifference Adjustment (all usage)***</b>			\$0.01309	

\* Transmission, Transmission Rate Adjustments and Reliability Service charges are combined for presentation on customer bills.  
 \*\* Distribution and New System Generation Charges are combined for presentation on customer bills.  
 \*\*\* Direct Access, Community Choice Aggregation and Transitional Bundled Service Customers pay the applicable Vintaged Power Charge Indifference Adjustment. Generation and Bundled PCIA are combined for presentation on bundled customer bills.

(Continued)

Advice	7009-E	Issued by	Submitted	August 25, 2023
Decision		Meredith Allen	Effective	September 1, 2023
		Vice President, Regulatory Affairs	Resolution	



**Pacific Gas and Electric Company**

Oakland, California

Revised  
Cancelling Revised

Cal. P.U.C. Sheet No. 56547-E  
Cal. P.U.C. Sheet No. 56226-E

**ELECTRIC SCHEDULE E-ELEC**  
RESIDENTIAL TIME-OF-USE (ELECTRIC HOME)  
SERVICE FOR CUSTOMERS WITH QUALIFYING ELECTRIC TECHNOLOGIES

Sheet 2

RATES:(Cont'd.)

**TOTAL BUNDLED RATES**

Base Services Charge (\$ per meter per day)	\$0.49281			
Total Energy Rates (\$ per kWh)		<u>PEAK</u>	<u>PART-PEAK</u>	<u>OFF-PEAK</u>
Summer Usage		\$0.56589 (I)	\$0.40401 (I)	\$0.34733 (I)
Winter Usage		\$0.33438 (I)	\$0.31229 (I)	\$0.29843 (I)
California Climate Credit (per household, per semi-annual payment occurring in the March† and October bill cycles)	(\$38.39)			

Total bundled service charges shown on a customer's bills are unbundled according to the component rates shown below.

**UNBUNDLING OF TOTAL RATES**

Energy Rates by Component (\$ per kWh)	<u>PEAK</u>	<u>PART-PEAK</u>	<u>OFF-PEAK</u>
<b>Generation:</b>			
Summer Usage	\$0.28164	\$0.18253	\$0.13743
Winter Usage	\$0.11951	\$0.09954	\$0.08619
<b>Distribution**:</b>			
Summer Usage	\$0.17932 (I)	\$0.11655 (I)	\$0.10497 (I)
Winter Usage	\$0.10994 (I)	\$0.10782 (I)	\$0.10731 (I)
<b>Transmission* (all usage)</b>	\$0.05254	\$0.05254	\$0.05254
<b>Transmission Rate Adjustments* (all usage)</b>	\$0.00059	\$0.00059	\$0.00059
<b>Reliability Services* (all usage)</b>	\$0.00069	\$0.00069	\$0.00069
<b>Public Purpose Programs (all usage)</b>	\$0.02578	\$0.02578	\$0.02578
<b>Nuclear Decommissioning (all usage)</b>	\$0.00135	\$0.00135	\$0.00135
<b>Competition Transition Charges (all usage)</b>	\$0.00030	\$0.00030	\$0.00030
<b>Energy Cost Recovery Amount (all usage)</b>	(\$0.00071)	(\$0.00071)	(\$0.00071)
<b>Wildfire Fund Charge (all usage)</b>	\$0.00530	\$0.00530	\$0.00530
<b>New System Generation Charge (all usage)**</b>	\$0.00346	\$0.00346	\$0.00346
<b>Wildfire Hardening Charge (all usage)</b>	\$0.00254	\$0.00254	\$0.00254
<b>Recovery Bond Charge (all usage)</b>	\$0.00528 (R)	\$0.00528 (R)	\$0.00528 (R)
<b>Recovery Bond Credit (all usage)</b>	(\$0.00528) (I)	(\$0.00528) (I)	(\$0.00528) (I)
<b>Bundled Power Charge Indifference Adjustment (all usage)***</b>	\$0.01309	\$0.01309	\$0.01309

\* Transmission, Transmission Rate Adjustments and Reliability Service charges are combined for presentation on customer bills.  
 \*\* Distribution and New System Generation Charges are combined for presentation on customer bills.  
 \*\*\* Direct Access, Community Choice Aggregation and Transitional Bundled Service Customers pay the applicable Vintaged Power Charge Indifference Adjustment. Generation and Bundled PCIA are combined for presentation on bundled customer bills.  
 † Pursuant to D.23-02-014, disbursement of the April 2023 residential Climate Credit shall begin by March 1, 2023.

(Continued)

Advice	7009-E	Issued by	Submitted	August 25, 2023
Decision		<b>Meredith Allen</b>	Effective	September 1, 2023
		Vice President, Regulatory Affairs	Resolution	



**Pacific Gas and Electric Company**  
San Francisco, California

Cancelling Revised

Revised Revised

Cal. P.U.C. Sheet No. 54734-E  
Cal. P.U.C. Sheet No. 53424-E

54734-E  
53424-E

**ELECTRIC SCHEDULE D-CARE** Sheet 1  
**LINE-ITEM DISCOUNT FOR CALIFORNIA ALTERNATE RATES FOR ENERGY (CARE)**  
**CUSTOMERS**

**APPLICABILITY:** This schedule is applicable to single-phase and polyphase residential service in single-family dwellings and in flats and apartments separately metered by PG&E and domestic submetered tenants residing in multifamily accommodations, mobilehome parks and to qualifying recreational vehicle parks and marinas and to farm service on the premises operated by the person whose residence is supplied through the same meter, where the applicant qualifies for California Alternate Rates for Energy (CARE) under the eligibility and certification criteria set forth in Electric Rule 19.1. CARE service is available on Schedules E-1, E-6, E-TOU-B, E-TOU-C, E-TOU-D, EV2, E-ELEC, EM, ES, ESR, ET and EM-TOU. (T)

**TERRITORY:** This rate schedule applies everywhere PG&E provides electric service.

**RATES:** Customers taking service on this rate schedule whose otherwise applicable rate schedule has no Delivery Minimum Bill Amount (Schedule E-ELEC) will receive a CARE percentage discount of 35.000% on their total bundled charges (except for the California Climate Credit, which will not be discounted). Customers taking service on this rate schedule whose otherwise applicable rate schedule has a Delivery Minimum Bill Amount (all other schedules) will receive a CARE percentage discount ("A" or "C" below) on their total bundled charges on their otherwise applicable rate schedule (except for the California Climate Credit, which will not be discounted) and also will receive a percentage discount ("B" or "D" below) on the delivery minimum bill amount, if applicable. The CARE discount will be calculated for direct access and community choice aggregation customers based on the total charges as if they were subject to bundled service rates. Discounts will be applied as a residual reduction to distribution charges, after D-CARE customers are exempted from the Wildfire Fund Charge, Recovery Bond Charge, Recovery Bond Credit, and the CARE surcharge portion of the public purpose program charge used to fund the CARE discount. These conditions also apply to master-metered customers and to qualified sub-metered tenants where the master-meter customer is jointly served under PG&E's Rate Schedule D-CARE and either Schedule EM, ES, ESR, ET, or EM-TOU. (N)  
|  
|  
(N)  
(T)  
|  
(T)  
(T)

For master-metered customers where one or more of the submetered tenants qualifies for CARE rates under the eligibility and certification criteria set forth in Rule 19.1, 19.2, or 19.3, the CARE discount is equal to a percentage ("C" below) of the total bundled charges, multiplied by the number of CARE units divided by the total number of units. In addition, master-metered customers eligible for D-CARE will receive a percentage discount ("D" below) on the delivery minimum bill amount, if applicable.

It is the responsibility of the master-metered customer to advise PG&E within 15 days following any change in the number of dwelling units and/or any decrease in the number of qualifying CARE applicants that results when such applicants move out of their submetered or non-submetered dwelling unit, or submetered permanent-residence RV or permanent-residence boat. (L)  
|  
(L)

(Continued)



Cancelling Revised Cal. P.U.C. Sheet No. 56208-E  
 Revised Cal. P.U.C. Sheet No. 56020-E

**ELECTRIC SCHEDULE D-CARE** Sheet 2  
 LINE-ITEM DISCOUNT FOR CALIFORNIA ALTERNATE RATES FOR ENERGY (CARE)  
 CUSTOMERS

RATES: (Cont'd)	A. D-CARE Discount:	34.965	% (Percent)	(I)
	B. Delivery Minimum Bill Discount:	50.000	% (Percent)	
	C. Master-Meter D-CARE Discount:	34.965	% (Percent)	(I)
	D. Master-Meter Delivery Minimum Bill Discount:	50.000	% (Percent)	

**SPECIAL CONDITIONS:**

1. OTHERWISE APPLICABLE SCHEDULE: The Special Conditions of the Customer's otherwise applicable rate schedule will apply to this schedule.
2. ELIGIBILITY: To be eligible to receive D-CARE the applicant must qualify under the criteria set forth in PG&E's Electric Rules 19.1, 19.2, and 19.3 and meet the certification requirements thereof to the satisfaction of PG&E. Qualifying Direct Access, Community Choice Aggregation Service, and Transitional Bundled Service customers are also eligible to take service on Schedule D-CARE. Applicants may qualify for D-CARE at their primary residence only. Customers or sub-metered tenants participating in the Family Electric Rate Assistance (FERA) program cannot concurrently participate in the CARE program.

Advice	6968-E	Issued by	Submitted
Decision		<b>Meredith Allen</b>	<u>June 23, 2023</u>
		Vice President, Regulatory Affairs	Effective <u>July 1, 2023</u>
			Resolution _____

### 7.2.2 Southern California Edison

The following pages provide details on the SCE electricity tariffs applied in this study. Table 31 describes the baseline territories that were assumed for each climate zone. A net surplus compensation rate of \$ 0.06030/ kWh was applied to any net annual electricity generation based on a one-year average of the rates between December 2022 and November 2023.

**Table 31: SCE Baseline Territory by Climate Zone**

Climate Zone	Baseline Territory
CZ06	6
CZ08	8
CZ09	9
CZ10	10
CZ14	14
CZ15	15

Summer Daily Allocations (June through September)

Baseline Region Number	Daily kWh Allocation	All-Electric Allocation
5	17.2	17.9
6	11.4	8.8
8	12.6	9.8
9	16.5	12.4
10	18.9	15.8
13	22.0	24.6
14	18.7	18.3
15	46.4	24.1
16	14.4	13.5

Winter Daily Allocations (October through May)

Baseline Region Number	Daily kWh Allocation	All-Electric Allocation
5	18.7	29.1
6	11.3	13.0
8	10.6	12.7
9	12.3	14.3
10	12.5	17.0
13	12.6	24.3
14	12.0	21.3
15	9.9	18.2
16	12.6	23.1

Schedule TOU-D  
 TIME-OF-USE  
 DOMESTIC  
 (Continued)

Sheet 12 (T)

SPECIAL CONDITIONS

- Applicable rate time periods are defined as follows:

Option 4-9 PM, Option 4-9 PM-CPP, Option PRIME, Option PRIME-CPP :

(T)

TOU Period	Weekdays		Weekends and Holidays	
	Summer	Winter	Summer	Winter
On-Peak	4 p.m. - 9 p.m.	N/A	N/A	N/A
Mid-Peak	N/A	4 p.m. - 9 p.m.	4 p.m. - 9 p.m.	4 p.m. - 9 p.m.
Off-Peak	All other hours	9 p.m. - 8 a.m.	All other hours	9 p.m. - 8 a.m.
Super-Off-Peak	N/A	8 a.m. - 4 p.m.	N/A	8 a.m. - 4 p.m.
CPP Event Period	4 p.m. - 9 p.m.	4 p.m. - 9 p.m.	N/A	N/A



Southern California Edison  
 Rosemead, California (U 338-E)

Revised Cal. PUC Sheet No. 85111-E  
 Revised Cal. PUC Sheet No. 74502-E

**Schedule TOU-D**  
**TIME-OF-USE**  
**DOMESTIC**  
 (Continued)

Sheet 2

**RATES**

Customers receiving service under this Schedule will be charged the applicable rates under Option 4-9 PM, Option 4-9 PM-CPP, Option 5-8 PM, Option 5-8 PM-CPP, Option PRIME, Option PRIME-CPP Option A, Option A-CPP, Option B, or Option B-CPP, as listed below. CPP Event Charges will apply to all energy usage during CPP Event Energy Charge periods and CPP Non-Event Energy Credits will apply as a reduction on CPP Non-Event Energy Credit Periods during Summer Season days, 4:00 p.m. to 9:00 p.m., as described in Special Conditions 1 and 3, below:

	Delivery Service Total <sup>1</sup>	Generation <sup>2</sup>	
		UG <sup>3</sup>	DWREC <sup>3</sup>
<b>Option 4-9 PM / Option 4-9 PM-CPP</b>			
Energy Charge - \$/kWh			
Summer Season - On-Peak	0.28829 (R)	0.28543 (I)	0.00000
Mid-Peak	0.28829 (R)	0.17707 (I)	0.00000
Off-Peak	0.24482 (R)	0.11382 (I)	0.00000
Winter Season - Mid-Peak	0.28829 (R)	0.21752 (I)	0.00000
Off-Peak	0.24482 (R)	0.13851 (I)	0.00000
Super-Off-Peak	0.22919 (R)	0.11890 (I)	0.00000
Baseline Credit <sup>4</sup> - \$/kWh	(0.09759) (I)	0.00000	
Fixed Recovery Charge - \$/kWh	0.00090 (R)		
Basic Charge - \$/day			
Single-Family Residence	0.031		
Multi-Family Residence	0.024		
Minimum Charge <sup>**</sup> - \$/day			
Single Family Residence	0.348		
Multi-Family Residence	0.348		
Minimum Charge (Medical Baseline) <sup>**</sup> - \$/day			
Single Family Residence	0.173		
Multi-Family Residence	0.173		
California Climate Credit <sup>10</sup>	(71.00) (I)		
California Alternate Rates for			
Energy Discount - %	100.00 <sup>*</sup>		
Family Electric Rate Assistance Discou	100.00		
<b>Option 4-9 PM-CPP</b>			
CPP Event Energy Charge - \$/kWh		0.80000	
Summer CPP Non-Event Credit			
On-Peak Energy Credit - \$/kWh		(0.15170)	
Maximum Available Credit - \$/kWh <sup>****</sup>			
Summer Season		(0.87183) (R)	

\* Represents 100% of the discount percentage as shown in the applicable Special Condition of this Schedule.  
 \*\* The Minimum Charge is applicable when the Delivery Service Energy Charge, plus the applicable Basic Charge is less than the Minimum Charge.  
 \*\*\* The ongoing Competition Transition Charge CTC of (\$0.00003) per kWh is recovered in the UG component of Generation. (I)  
 \*\*\*\* The Baseline Credit applies up to 100% of the Baseline Allocation, regardless of Time-of-Use time period. Additional Baseline Allocations apply for Customers with Heat Pump Water Heaters served under this Option. The Baseline Allocations are set forth in Preliminary Statement, Part H.  
 \*\*\*\*\*The Maximum Available Credit is the capped credit amount for CPP Customers dual participating in other demand response programs.  
 1 Total = Total Delivery Service rates are applicable to Bundled Service, Direct Access (DA) and Community Choice Aggregation Service (CCA Service) Customers, except DA and CCA Service Customers are not subject to the DWRBC rate component of this Schedule but instead pay the DWRBC as provided by Schedule DA-CRS or Schedule CCA-CRS.  
 2 Generation = The Gen rates are applicable only to Bundled Service Customers. See Special Condition below for PCIA recovery.  
 3 DWREC = Department of Water Resources (DWR) Energy Credit - For more information on the DWR Energy Credit, see the Billing Calculation Special Condition of this Schedule.  
 4 Applied on an equal basis, per household, semi-annually. See the Special Conditions of this Schedule for more information.

(Continued)

(To be inserted by utility)  
 Advice 4929-E  
 Decision \_\_\_\_\_

Issued by  
Michael Backstrom  
 Vice President

(To be inserted by Cal. PUC)  
 Date Submitted Dec 28, 2022  
 Effective Jan 1, 2023  
 Resolution E-5217

2/13



Southern California Edison  
Rosemead, California (U 338-E)

Revised Cal. PUC Sheet No. 86132-E  
Cancelling Revised Cal. PUC Sheet No. 85624-E

Schedule TOU-D  
TIME-OF-USE  
DOMESTIC  
(Continued)

Sheet 6

RATES (Continued)

Option PRIME / Option PRIME-CPP	Delivery Service Total <sup>1</sup>	Generation <sup>2</sup>	
		UG <sup>**</sup>	DWREC <sup>3</sup>
Energy Charge - \$/kWh/Meter/Day			
Summer Season			
On-Peak	0.22789 (I)	0.42769 (I)	0.00000
Mid-Peak	0.22789 (I)	0.15221 (I)	0.00000
Off-Peak	0.15191 (I)	0.10162 (I)	0.00000
Winter Season			
Mid-Peak	0.23353 (I)	0.36028 (I)	0.00000
Off-Peak	0.14530 (I)	0.08830 (I)	0.00000
Super-Off-Peak	0.14530 (I)	0.08830 (I)	0.00000
Fixed Recovery Charge - \$/kWh	0.00260 (I)		
Basic Charge - \$/Meter/Day	0.427 (I)		
EV Meter Credit (Separately Metered E	(0.323) (N)		
EV Submeter Credit - \$/Meter/Day	(0.111) (R)		
California Climate Credit <sup>10</sup>	(71.00)		
California Alternate Rates for Energy Discount - %	100.00*		
Family Electric Rate Assistance Discou	100.00		
Medical Line Item Discount - %	100.000		
Option PRIME-CPP			
CPP Event Energy Charge - \$/kWh		0.80000	
Summer CPP Non-Event Credit			
On-Peak Energy Credit - \$/kWh		(0.15170)	
Maximum Available Credit - \$/kWh****			
Summer Season		(0.71812) (R)	

\* Represents 100% of the discount percentage as shown in the applicable Special Condition of this Schedule.  
 \*\* The ongoing Competition Transition Charge (CTC) of (\$0.00003) per kWh is recovered in the UG component of Generation.  
 \*\*\*\* The Maximum Available Credit is the capped credit amount for CPP Customers dual participating in other demand response programs.  
 1 Total = Total Delivery. Service rates are applicable to Bundled Service, Direct Access (DA) and Community Choice Aggregation Service (CCA Service) Customers, except DA and CCA Service Customers are not subject to the DWRC rate component of this Schedule but instead pay the DWRC as provided by Schedule DA-CRS or Schedule CCA-CRS.  
 2 Generation = The Gen rates are applicable only to Bundled Service Customers. See Special Condition below for PCIA recovery.  
 3 DWREC = Department of Water Resources (DWR) Energy Credit - For more information on the DWR Energy Credit, see the Billing Calculation Special Condition of this Schedule.  
 4 Applied on an equal basis, per household, semi-annually. See the Special Conditions of this Schedule for more information.

(Continued)

(To be inserted by utility)  
 Advice 5041-E  
 Decision \_\_\_\_\_

Issued by  
Michael Backstrom  
 Vice President

(To be inserted by Cal. PUC)  
 Date Submitted May 30, 2023  
 Effective Jun 1, 2023  
 Resolution \_\_\_\_\_

6/19



Southern California Edison  
Rosemead, California (U 338-E)

Revised Cal. PUC Sheet No. 85618-E  
Cancelling Revised Cal. PUC Sheet No. 85109-E

Schedule D-CARE Sheet 1  
CALIFORNIA ALTERNATE RATES FOR ENERGY  
DOMESTIC SERVICE

APPLICABILITY

Applicable to domestic service to CARE households residing in a permanent Single-Family Accommodation or Multifamily Accommodation where the customer meets all the Special Conditions of this Schedule. Customers enrolled in the CARE program are not eligible for the Family Electric Rate Assistance (FERA) program.

Pursuant to Special Condition 12 herein, customers receiving service under this Schedule are eligible to receive the California Climate Credit as shown in the Rates section below.

TERRITORY

Within the entire territory served.

RATES

The applicable charges set forth in Schedule D shall apply to Customers served under this Schedule.

CARE Discount:

A 29.8 percent discount is applied to a CARE Customer's bill prior to the application of the Public Utilities Commission Reimbursement Fee (PUCRF) and any applicable user fees, taxes, and late payment charges. CARE Customers are required to pay the PUCRF and any applicable user fees, taxes, and late payment charges in full. In addition, CARE Customers are exempt from paying the CARE Surcharge of \$0.00888 per kWh and the Wildfire Fund Non-Bypassable Charge of \$0.00530 per kWh. (R)  
The 29.8 percent discount, in addition to these exemptions result in an average effective CARE Discount of 32.5 percent.

(Continued)

(To be inserted by utility)

Advice 4977-E  
Decision 23-01-002  
1H12 22-12-031

Issued by  
Michael Backstrom  
Vice President

(To be inserted by Cal. PUC)  
Date Submitted Feb 27, 2023  
Effective Mar 1, 2023  
Resolution \_\_\_\_\_

### 7.2.3 Southern California Gas

Following are the SoCalGas natural gas tariffs applied in this study. Table 32 describes the baseline territories that were assumed for each climate zone.

**Table 32: SoCalGas Baseline Territory by Climate Zone**

Climate Zone	Baseline Territory
CZ05	2
CZ06	1
CZ08	1
CZ09	1
CZ10	1
CZ14	2
CZ15	1

The SoCalGas monthly gas rate in \$/therm was applied on a monthly basis according to the rates shown in Table 33. These rates are based on applying a normalization curve to the November 2023 tariff based on ten years of historical gas data. Long-term historical natural gas rate data was only available for SoCalGas' procurement charges.<sup>23</sup> The baseline and excess transmission charges were found to be consistent over the course of a year and applied for the entire year based on 2023 rates. CARE rates reflect the 20 percent discount per the GR tariff.

**Table 33: SoCalGas Monthly Gas Rate (\$/therm)**

Month	Procurement Charge	Transportation Charge		Total Charge	
		Baseline	Excess	Baseline	Excess
January	\$0.72	\$0.86	\$1.31	\$1.92	\$2.36
February	\$0.50	\$0.86	\$1.31	\$1.57	\$2.02
March	\$0.44	\$0.86	\$1.31	\$1.48	\$1.93
April	\$0.39	\$0.86	\$1.31	\$1.39	\$1.84
May	\$0.41	\$0.86	\$1.31	\$1.43	\$1.87
June	\$0.46	\$0.86	\$1.31	\$1.49	\$1.93
July	\$0.47	\$0.86	\$1.31	\$1.51	\$1.96
August	\$0.51	\$0.86	\$1.31	\$1.58	\$2.03
September	\$0.46	\$0.86	\$1.31	\$1.52	\$1.96
October	\$0.45	\$0.86	\$1.31	\$1.48	\$1.92
November	\$0.48	\$0.86	\$1.31	\$1.54	\$1.99
December	\$0.57	\$0.86	\$1.31	\$1.63	\$2.08

Southern California Gas Company									
Residential Rates									
Nov-23									
Customer Type	Commodity	Rate	Procurement Charge	Transportation Charge	New Rate Effective	New Rate Effective	Absolute Rate	% Change	
	Rate Schedule	Charge	Type	¢/therm	¢/therm	11/1/2023	10/1/2023	Change	Change
Residential Individually Metered									
	Schedule No. GR	GR	Baseline	67.806	86.490	154.296	125.096	29.200	23.3%
	Res. Service	GR	Non Baseline	67.806	131.037	198.843	169.726	29.117	17.2%
		GT-R	Baseline	00.000	86.490	86.490	87.038	-00.548	-0.6%
		GT-R	Non Baseline	00.000	131.037	131.037	131.668	-00.631	-0.5%

<sup>23</sup> The SoCalGas procurement and transmission charges were obtained from the following site: <https://www.socalgas.com/for-your-business/energy-market-services/gas-prices RES2023.xlsx> (live.com)

### 7.2.4 San Diego Gas & Electric

Following are the SDG&E electricity and natural gas tariffs applied in this study. Table 34 describes the baseline territories that were assumed for each climate zone. A net surplus compensation rate of \$0.04542/ kWh was applied to any net annual electricity generation based on a one-year average of the rates between December 2022 and November 2023.

**Table 34: SDG&E Baseline Territory by Climate Zone**

Climate Zone	Baseline Territory
CZ07	Coastal
CZ10	Inland
CZ14	Mountain

The SDG&E monthly gas rate in \$/therm was applied on a monthly basis according to the rates shown in Table 35. These rates are based on applying a normalization curve to the November 2023 tariff based on ten years of historical gas data. CARE rates reflect the 20 percent discount per the G-CARE tariff.

**Table 35: SDG&E Monthly Gas Rate (\$/therm)**

Month	Total Charge	
	Baseline	Excess
January	\$2.34	\$2.63
February	\$2.28	\$2.57
March	\$2.21	\$2.51
April	\$2.14	\$2.45
May	\$2.18	\$2.48
June	\$2.23	\$2.55
July	\$2.26	\$2.57
August	\$2.32	\$2.62
September	\$2.26	\$2.59
October	\$2.21	\$2.55
November	\$2.24	\$2.57
December	\$2.38	\$2.70

**Baseline Usage:** The following quantities of gas used in individually metered residences are to be billed at the baseline rates:

<u>All Customers:</u>	<u>Daily Therm Allowance</u>
Summer (May to Oct)	0.359
Winter On-Peak (Dec, Jan & Feb)	1.233
Winter Off-Peak (Nov, Mar, & Apr)	0.692



San Diego Gas & Electric Company  
 San Diego, California

Revised Cal. P.U.C. Sheet No. 37022-E  
 Canceling Revised Cal. P.U.C. Sheet No. 36337-E

**SCHEDULE TOU-DR1**  
**RESIDENTIAL TIME-OF-USE**

Sheet 2

**RATES**

**Total Rates:**

Description – TOU DR1	UDC Total Rate	DWR BC + WF-NBC	EECC Rate + DWR Credit	Total Rate
<b>Summer:</b>				
On-Peak	0.25752	R 0.00530	I 0.57043	I 0.83325
Off-Peak	0.25752	R 0.00530	I 0.25697	I 0.51979
Super Off-Peak	0.25752	R 0.00530	I 0.09233	I 0.35515
<b>Winter:</b>				
On-Peak	0.43809	I 0.00530	I 0.19307	I 0.63646
Off-Peak	0.43809	I 0.00530	I 0.10855	I 0.55194
Super Off-Peak	0.43809	I 0.00530	I 0.08402	I 0.52741
Summer Baseline Adjustment Credit up to 130% of Baseline	(0.11724)	R		(0.11724) R
Winter Baseline Adjustment Credit up to 130% of Baseline	(0.11724)	R		(0.11724) R
Minimum Bill (\$/day)	0.380	I		0.380 I

Description – TOU DR1-CARE	UDC Total Rate	DWR BC + WF-NBC	EECC Rate + DWR Credit	Total Rate	Total Effective Care Rate
<b>Summer – CARE Rates:</b>					
On-Peak	0.25682	R 0.00000	I 0.57043	I 0.82725	I 0.55368
Off-Peak	0.25682	R 0.00000	I 0.25697	I 0.51379	I 0.33965
Super Off-Peak	0.25682	R 0.00000	I 0.09233	I 0.34915	I 0.22725
<b>Winter – CARE Rates:</b>					
On-Peak	0.43739	I 0.00000	I 0.19307	I 0.63048	I 0.41930
Off-Peak	0.43739	I 0.00000	I 0.10855	I 0.54594	I 0.36160
Super Off-Peak	0.43739	I 0.00000	I 0.08402	I 0.52141	I 0.34485
Summer Baseline Adjustment Credit up to 130% of Baseline	(0.11724)	R		(0.11724) R	(0.08004) R
Winter Baseline Adjustment Credit up to 130% of Baseline	(0.11724)	R		(0.11724) R	(0.08004) R
Minimum Bill (\$/day)	0.190	I		0.190 I	0.190 I

**Note:**

- (1) Total Rates consist of UDC, Schedule DWR-BC (Department of Water Resources Bond Charge), Schedule WF-NBC (CA Wildfire Fund charge) and Schedule EECC (Electric Energy Commodity Cost) rates, with the EECC rates reflecting a DWR Credit. EECC rates are applicable to bundled customers only. See Special Condition 16 for PCIA (Power Charge Indifference Adjustment) recovery.
- (2) Total Rates presented are for customers that receive commodity supply and delivery service from Utility.
- (3) DWR-BC and WF-NBC charges do not apply to CARE customers.
- (4) As identified in the rates tables, customer bills will also include line-item summer and winter credits for usage up to 130% of baseline to provide the rate capping benefits adopted by Assembly Bill 1X and Senate Bill 695.
- (5) WF-NBC rate is 0.00530 + DWR-BC Bond Charge is 0.00000.

R, I

(Continued)

2C8  
 Advice Ltr. No. 4129-E  
 Decision No. \_\_\_\_\_

Issued by  
**Dan Skopec**  
 Senior Vice President  
 Regulatory Affairs

Submitted Dec 30, 2022  
 Effective Jan 1, 2023  
 Resolution No. E-5217

Time Periods

All time periods listed are applicable to local time. The definition of time will be based upon the date service is rendered.

TOU Periods – Weekdays	Summer	Winter
On-Peak	4:00 p.m. – 9:00 p.m.	4:00 p.m. – 9:00 p.m.
Off-Peak	6:00 a.m. – 4:00 p.m.; 9:00 p.m. - midnight	6:00 a.m. – 4:00 p.m. Excluding 10:00 a.m. – 2:00 p.m. in March and April; 9:00 p.m. - midnight
Super Off-Peak	Midnight – 6:00 a.m.	Midnight – 6:00 a.m. 10:00 a.m. – 2:00 p.m. in March and April
TOU Period – Weekends and Holidays	Summer	Winter
On-Peak	4:00 p.m. – 9:00 p.m.	4:00 p.m. – 9:00 p.m.
Off-Peak	2:00 p.m. – 4:00 p.m.; 9:00 p.m. - midnight	2:00 p.m. – 4:00 p.m.; 9:00 p.m. - midnight
Super Off-Peak	Midnight – 2:00 p.m.	Midnight – 2:00 p.m.

Seasons: Summer June 1 – October 31  
 Winter November 1 – May 31

15. Baseline Usage: The following quantities of electricity are used to calculate the baseline adjustment credit.

	Baseline Allowance For Climatic Zones*			
	Coastal	Inland	Mountain	Desert
<b>Basic Allowance</b>				
Summer (June 1 to October 31)	9.0	10.4	13.6	15.9
Winter (November 1 to May 31)	9.2	9.6	12.9	10.9
<b>All Electric**</b>				
Summer (June 1 to October 31)	6.0	8.7	15.2	17.0
Winter (November 1 to May 31)	8.8	12.2	22.1	17.1

\* Climatic Zones are shown on the Territory Served, Map No. 1.

\*\* All Electric allowances are available upon application to those customers who have permanently installed space heating or who have electric water heating and receive no energy from another source.



San Diego Gas & Electric Company  
San Diego, California

Revised Cal. P.U.C. Sheet No. 37217-E

Canceling Revised Cal. P.U.C. Sheet No. 37016-E

**SCHEDULE EV-TOU-5**

Sheet 1

COST-BASED DOMESTIC TIME-OF-USE FOR HOUSEHOLDS WITH ELECTRIC VEHICLES

APPLICABILITY

Service under this schedule is specifically limited to customers who require service for charging of a currently registered Motor Vehicle, as defined by the California Motor Vehicle Code, which is: 1) a battery electric vehicle (BEV) or plug-in hybrid electric vehicle (PHEV) recharged via a recharging outlet at the customer's premises; or 2) a natural gas vehicle (NGV) refueled via a home refueling appliance (HRA) at the customer's premises. This schedule is not available to customers with a conventional charge sustaining (battery recharged solely from the vehicle's on-board generator) hybrid electric vehicle (HEV).

Residential customers taking service on Schedule NBT, who are required to utilize EV-TOU-5 as their otherwise applicable schedule (OAS) for electric service, do not require a qualifying motor vehicle, as described above to participate on Schedule EV-TOU-5.

N  
N  
N

Customers on this schedule may also qualify for a semi-annual California Climate Credit \$(60.70) per Schedule GHG-ARR.

TERRITORY

Within the entire territory served by the utility.

RATES

**Total Rates:**

Description – EV-TOU-5 Rates	UDC Total Rate	DWR BC + WF-NBC	EECC Rate + DWR Credit	Total Rate
Basic Service Fee	16.00			16.00
<b>Summer</b>				
On-Peak	0.28032	I 0.00530	I 0.53067	I 0.81629
Off-Peak	0.28032	I 0.00530	I 0.19567	I 0.48129
Super Off-Peak	0.05588	I 0.00530	I 0.09233	I 0.15351
<b>Winter</b>				
On-Peak	0.28032	I 0.00530	I 0.22587	I 0.51149
Off-Peak	0.28032	I 0.00530	I 0.16213	I 0.44775
Super Off-Peak	0.05588	I 0.00530	I 0.08402	I 0.14520

(Continued)

1C5

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San Diego Gas & Electric Company  
San Diego, California

Revised Cal. P.U.C. Sheet No. 37019-E

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**SCHEDULE EV-TOU-5**

Sheet 4

COST-BASED DOMESTIC TIME-OF-USE FOR HOUSEHOLDS WITH ELECTRIC VEHICLES

Notes: Transmission Energy charges include the Transmission Revenue Balancing Account Adjustment (TRBAA) of \$(0.00242) per kWh and the Transmission Access Charge Balancing Account Adjustment (TACBAA) of \$(0.01631) per kWh. PPP Energy charges includes Low Income PPP rate (LI-PPP) \$0.01669/kWh, Non-low Income PPP rate (Non-LI-PPP) \$0.00333/kWh (pursuant to PU Code Section 399.8, the Non-LI-PPP rate may not exceed January 1, 2000 levels), Procurement Energy Efficiency Surcharge Rate of \$0.00422 /kWh, California Solar Initiative rate (CSI) of \$0.00000/kWh and Self-Generation Incentive Program rate (SGIP) \$0.00122/kWh. The basic service fee of \$16 per month is applied to a customer's bill and a 50% discount is applied for CARE, Medical Baseline, or Family Electric Rate Assistance Program (FERA) customers resulting in their basic service fees to be \$8 per month.

R, R  
I  
R  
I  
I

Rate Components

The Utility Distribution Company Total Rates (UDC Total) shown above are comprised of the following components (if applicable): (1) Transmission (Trans) Charges, (2) Distribution (Distr) Charges, (3) Public Purpose Program (PPP) Charges, (4) Nuclear Decommissioning (ND) Charge, (5) Ongoing Competition Transition Charges (CTC), (6) Local Generation Charge (LGC), (7) Reliability Services (RS), and (8) the Total Rate Adjustment Component (TRAC).

Certain Direct Access customers are exempt from the TRAC, as defined in Rule 1 – Definitions.

Franchise Fee Differential

A Franchise Fee Differential of 5.78% will be applied to the monthly billings calculated under this schedule for all customers within the corporate limits of the City of San Diego. Such Franchise Fee Differential shall be so indicated and added as a separate item to bills rendered to such customers.

Time Periods:

All time periods listed are applicable to actual "clock" time)

TOU Period – Weekdays	Summer	Winter
On-Peak	4:00 p.m. – 9:00 p.m.	4:00 p.m. – 9:00 p.m.
Off-Peak	6:00 a.m. – 4:00 p.m.; 9:00 p.m. – midnight	6:00 a.m. – 4:00 p.m. Excluding 10:00 a.m.–2:00 p.m.in March and April; 9:00 p.m. - midnight
Super-Off-Peak	Midnight – 6:00 a.m.	Midnight – 6:00 a.m. 10:00 a.m. – 2:00 p.m. in March and April

TOU Period – Weekends and Holidays	Summer	Winter
On-Peak	4:00 p.m. – 9:00 p.m.	4:00 p.m. – 9:00 p.m.
Off-Peak	2:00 p.m. – 4:00 p.m.; 9:00 p.m. – midnight	2:00 p.m. – 4:00 p.m. 9:00 p.m. - midnight
Super-Off-Peak	Midnight – 2:00 p.m.	Midnight – 2:00 p.m.

Seasons:

Summer June 1 – October 31  
Winter November 1 – May 31

(Continued)

4C8  
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Issued by  
**Dan Skopec**  
Senior Vice President  
Regulatory Affairs

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San Diego Gas & Electric Company  
San Diego, California

Revised Cal. P.U.C. Sheet No. 35718-E  
Canceling Revised Cal. P.U.C. Sheet No. 32576-E

**SCHEDULE E-CARE**

Sheet 1

CALIFORNIA ALTERNATE RATES FOR ENERGY

APPLICABILITY

This schedule provides a California Alternate Rates for Energy (CARE) discount to each of the following types of customers listed below that meet the requirements for CARE eligibility as defined in Rule 1, Definitions, and herein, and is taken in conjunction with the customer's otherwise applicable service schedule.

- 1) Customers residing in a permanent single-family accommodation, separately metered by the Utility.
- 2) Multi-family dwelling units and mobile home parks supplied through one meter on a single premises where the individual unit is submetered.
- 3) Non-profit group living facilities.
- 4) Agricultural employee housing facilities.

TERRITORY

Within the entire territory served by the Utility.

DISCOUNT

- 1) **Residential CARE:** Qualified residential CARE customers will receive a total effective discount according to the following:

	2015	2016	2017	2018	2019	2020 and beyond
<b>Effective Discount</b>	<b>40%</b>	<b>39%</b>	<b>38%</b>	<b>38%</b>	<b>36% R</b>	<b>35%</b>

Pursuant to Commission Decision (D.) 15-07-001, the average effective CARE discount for residential customers will decrease 1% each year until an average effective discount of 35% is reached in 2020.

The average effective CARE discount consists of: (a) exemptions from paying the CARE Surcharge, Department of Water Resources Bond Charge (DWR-BC), Vehicle-Grid Integration (VGI) costs, and California Solar Initiative (CSI); (b) a 50% minimum bill relative to Non-CARE; (c) the California Wildfire Fund Charge (WF-NBC) and (d) a separate line-item bill discount for all qualified residential CARE customers with the exclusion of CARE Medical Baseline customers taking service on tiered rates schedules. D.15-07-001 retained the rate subsidies in Non-CARE Medical Baseline tiered rates and thereby a separate line-item discount is provided for these CARE Medical Baseline customers

(Continued)

1C5  
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**Dan Skopec**  
Vice President

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### 7.2.5 City of Palo Alto Utilities

Following are the CPAU electricity and natural gas tariffs applied in this study. The CPAU monthly gas rate in \$/therm was applied on a monthly basis according to the rates shown in Table 36. These rates are based on applying a normalization curve to the October 2023 tariff based on seven years of historical gas data. The monthly service charge applied was \$14.01 per month per the November 2023 G-1 tariff.

**Table 36: CPAU Monthly Gas Rate (\$/therm)**

Month	G1 Volumetric Total Baseline	G1 Volumetric Total Excess
January	\$1.83532	\$3.35639
February	\$1.38055	\$2.59947
March	\$1.32506	\$2.47695
April	\$1.29680	\$2.44038
May	\$1.29511	\$2.43804
June	\$1.32034	\$2.45406
July	\$1.35688	\$2.61519
August	\$1.40696	\$2.67944
September	\$1.42130	\$2.70301
October	\$1.42310	\$2.48300
November	\$1.46286	\$2.45547
December	\$1.62415	\$2.62128

**RESIDENTIAL ELECTRIC SERVICE**

UTILITY RATE SCHEDULE E-1

**A. APPLICABILITY:**

This Rate Schedule applies to separately metered single-family residential dwellings receiving Electric Service from the City of Palo Alto Utilities.

**B. TERRITORY:**

This rate schedule applies everywhere the City of Palo Alto provides Electric Service.

**C. UNBUNDLED RATES:**

<u>Per kilowatt-hour (kWh)</u>	<u>Commodity</u>	<u>Distribution</u>	<u>Public Benefits</u>	<u>Total</u>
Tier 1 usage	\$ 0.09999	\$ 0.06954	\$ 0.00568	\$ 0.17521
Tier 2 usage Any usage over Tier 1	0.13873	0.10225	0.00568	0.24666
<u>Minimum Bill (\$/day)</u>				0.4181

**D. SPECIAL NOTES:**

**1. Calculation of Cost Components**

The actual bill amount is calculated based on the applicable rates in Section C above and adjusted for any applicable discounts, surcharges and/or taxes. On a Customer's bill statement, the bill amount may be broken down into appropriate components as calculated under Section C.

**2. Calculation of Usage Tiers**

Tier 1 Electricity usage shall be calculated and billed based upon a level of 11 kWh per day, prorated by Meter reading days of Service. As an example, for a 30-day bill, the Tier 1 level would be 330 kWh. For further discussion of bill calculation and proration, refer to Rule and Regulation 11.

*{End}*

**CITY OF PALO ALTO UTILITIES**

Issued by the City Council



CITY OF  
**PALO ALTO**  
 UTILITIES

Supersedes Sheet No E-1-1  
 dated 7-1-2022

Sheet No **E-1-1**  
 Effective 7-1-2023

## 7.2.6 Sacramento Municipal Utilities District (Electric Only)

Following are the SMUD electricity tariffs applied in this study. The rates effective January 2023 were used.

### Residential Time-of-Day Service Rate Schedule R-TOD

#### II. Firm Service Rates

##### A. Time-of-Day (5-8 p.m.) Rate

	Effective as of January 1, 2023	Effective as of January 1, 2024	Effective as of May 1, 2024	Effective as of January 1, 2025	Effective as of May 1, 2025
<b>Time-of-Day (5-8 p.m.) Rate (RT02)</b>					
<b>Non-Summer Season (October - May)</b>					
System Infrastructure Fixed Charge <i>per month per meter</i>	\$23.50	\$24.15	\$24.80	\$25.50	\$26.20
Electricity Usage Charge					
Peak \$/kWh	\$0.1547	\$0.1590	\$0.1633	\$0.1678	\$0.1724
Off-Peak \$/kWh	\$0.1120	\$0.1151	\$0.1183	\$0.1215	\$0.1248
<b>Summer Season (June - September)</b>					
System Infrastructure Fixed Charge <i>per month per meter</i>	\$23.50	\$24.15	\$24.80	\$25.50	\$26.20
Electricity Usage Charge					
Peak \$/kWh	\$0.3279	\$0.3369	\$0.3462	\$0.3557	\$0.3655
Mid-Peak \$/kWh	\$0.1864	\$0.1914	\$0.1967	\$0.2021	\$0.2077
Off-Peak \$/kWh	\$0.1350	\$0.1387	\$0.1425	\$0.1464	\$0.1505

##### B. Optional Critical Peak Pricing Rate

- The CPP Rate base prices per time-of-day period are the same as the prices per time-of-day period for TOD (5-8 p.m.).
- The CPP Rate provides a discount per kWh on the Mid-Peak and Off-Peak prices during summer months.
- During CPP Events, customers will be charged for energy used at the applicable time-of-day period rate plus the CPP Rate Event Price per kWh as shown on [www.smud.org](http://www.smud.org).
- During CPP Events, energy exported to the grid will be compensated at the CPP Rate Event Price per kWh as shown on [www.smud.org](http://www.smud.org).
- The CPP Rate Event Price and discount will be updated annually at SMUD's discretion and posted on [www.smud.org](http://www.smud.org).

##### C. Plug-In Electric Vehicle Credit (rate categories RT02 and RTC1)

This credit is for residential customers who have a licensed passenger battery electric plug-in or plug-in hybrid electric vehicle.

Credit applies to all electricity usage charges from midnight to 6:00 a.m. daily.

Electric Vehicle Credit..... **-\$0.0150/kWh**

#### III. Electricity Usage Surcharges

Refer to the following rate schedules for details on these surcharges.

- A. **Hydro Generation Adjustment (HGA).** Refer to Rate Schedule HGA.

#### IV. Rate Option Menu

- A. **Energy Assistance Program Rate.** Refer to Rate Schedule EAPR.
- B. **Medical Equipment Discount Program.** Refer to Rate Schedule MED.
- C. **Joint Participation in Medical Equipment Discount and Energy Assistance Program Rate.** Refer to Rate Schedule MED.

**A. Time-of-Day (5-8 p.m.) Rate (rate category RT02)**

1. The TOD (5-8 p.m.) Rate is the standard rate for SMUD’s residential customers. Eligible customers can elect the Fixed Rate under Rate Schedule R as an alternative rate.
2. The TOD (5-8 p.m.) Rate is an optional rate for customers who have an eligible renewable electrical generation facility under Rate Schedule NEMI that was approved for installation by SMUD prior to January 1, 2018.
3. This rate has five kilowatt-hour (kWh) prices, depending on the time-of-day and season as shown below. Holidays are detailed in Section V. Conditions of Service.

<b>Summer (Jun 1 - Sept 30)</b>	<b>Peak</b>	Weekdays between 5:00 p.m. and 8:00 p.m.
	<b>Mid-Peak</b>	Weekdays between noon and midnight except during the Peak hours.
	<b>Off-Peak</b>	All other hours, including weekends and holidays <sup>1</sup> .
<b>Non-Summer (Oct 1 - May 31)</b>	<b>Peak</b>	Weekdays between 5:00 p.m. and 8:00 p.m.
	<b>Off-Peak</b>	All other hours, including weekends and holidays <sup>1</sup> .

<sup>1</sup> See Section V. Conditions of Service

### 7.2.7 Fuel Escalation Assumptions

The average annual escalation rates in Table 37 were used in this study. These are based on assumptions from the CPUC 2021 En Banc hearings on utility costs through 2030 (California Public Utilities Commission, 2021a). Escalation rates through the remainder of the 30-year evaluation period are based on the escalation rate assumptions within the 2022 TDV factors. No data was available to estimate electricity escalation rates for CPAU and SMUD, therefore electricity escalation rates for PG&E and statewide natural gas escalation rates were applied. Table 38 presents the average annual escalation rates used in the utility rate escalation sensitivity analysis shown in Section 4.6.3. Rates were applied for the same 30-year period and are based on the escalation rate assumptions within the 2025 LSC factors from 2027 through 2053.<sup>24</sup> These rates were developed for electricity use statewide (not utility-specific) and assume steep increases in gas rates in the latter half of the analysis period. Data was not available for years 2024, 2025, and 2026 and so the CPUC En Banc assumptions were applied for those years using the average rate across the three IOUs for statewide electricity escalation.

**Table 37: Real Utility Rate Escalation Rate Assumptions, CPUC En Banc and 2022 TDV Basis**

Year	Statewide Natural Gas Residential Average Rate (%/year, real)	Electric Residential Average Rate (%/year, real)		
		PG&E	SCE	SDG&E
2024	4.6%	1.8%	1.6%	2.8%
2025	4.6%	1.8%	1.6%	2.8%
2026	4.6%	1.8%	1.6%	2.8%
2027	4.6%	1.8%	1.6%	2.8%
2028	4.6%	1.8%	1.6%	2.8%
2029	4.6%	1.8%	1.6%	2.8%
2030	4.6%	1.8%	1.6%	2.8%
2031	2.0%	0.6%	0.6%	0.6%
2032	2.4%	0.6%	0.6%	0.6%
2033	2.1%	0.6%	0.6%	0.6%
2034	1.9%	0.6%	0.6%	0.6%
2035	1.9%	0.6%	0.6%	0.6%
2036	1.8%	0.6%	0.6%	0.6%
2037	1.7%	0.6%	0.6%	0.6%
2038	1.6%	0.6%	0.6%	0.6%
2039	2.1%	0.6%	0.6%	0.6%
2040	1.6%	0.6%	0.6%	0.6%
2041	2.2%	0.6%	0.6%	0.6%
2042	2.2%	0.6%	0.6%	0.6%
2043	2.3%	0.6%	0.6%	0.6%
2044	2.4%	0.6%	0.6%	0.6%
2045	2.5%	0.6%	0.6%	0.6%
2046	1.5%	0.6%	0.6%	0.6%
2047	1.3%	0.6%	0.6%	0.6%
2048	1.6%	0.6%	0.6%	0.6%
2049	1.3%	0.6%	0.6%	0.6%
2050	1.5%	0.6%	0.6%	0.6%
2051	1.8%	0.6%	0.6%	0.6%
2052	1.8%	0.6%	0.6%	0.6%
2053	1.8%	0.6%	0.6%	0.6%

<sup>24</sup> <https://www.energy.ca.gov/files/2025-energy-code-hourly-factors>. Actual escalation factors were provided by consultants E3.

**Table 38: Real Utility Rate Escalation Rate Assumptions, 2025 LSC Basis**

Year	Statewide Natural Gas Residential Average Rate (%/year, real)	Statewide Electricity Residential Average Rate (%/year, real)
2024	4.6%	2.1%
2025	4.6%	2.1%
2026	4.6%	2.1%
2027	4.2%	0.6%
2028	3.2%	1.9%
2029	3.6%	1.6%
2030	6.6%	1.3%
2031	6.7%	1.0%
2032	7.7%	1.2%
2033	8.2%	1.1%
2034	8.2%	1.1%
2035	8.2%	0.9%
2036	8.2%	1.1%
2037	8.2%	1.1%
2038	8.2%	1.0%
2039	8.2%	1.1%
2040	8.2%	1.1%
2041	8.2%	1.1%
2042	8.2%	1.1%
2043	8.2%	1.1%
2044	8.2%	1.1%
2045	8.2%	1.1%
2046	8.2%	1.1%
2047	3.1%	1.1%
2048	-0.5%	1.1%
2049	-0.6%	1.1%
2050	-0.5%	1.1%
2051	-0.6%	1.1%
2052	-0.6%	1.1%
2053	-0.6%	1.1%

### 7.3 Summary of Efficiency Measures

Table 39 provides the details of the efficiency (non-preempted) measures, by climate zone, included in the following all-electric packages for the single family prototype:

- Efficiency Only
- Efficiency + High Efficiency (Preempted) Equipment
- Efficiency + PV
- Efficiency + PV + Battery

The efficiency measures for the single family mixed fuel packages are presented in Table 40, and Table 41 presents the efficiency measures for all the ADU packages. In all tables, the lack of an “X” indicates that the prescriptive values for that climate zone were not changed. See Appendix 7.4 for a list of prescriptive values by climate zone. Efficiency measures are described in Section 3.3.1.

**Table 39: All-Electric Single Family Efficiency Measures, Various Packages**

Climate Zone	3 ACH50	R-10 Slab	Attic Ceiling Insulation	0.25 Roof Solar Reflectance	0.24 U-Factor / 0.50 SHGC Windows	0.35 W/cfm	Buried Ducts	Basic Compact Hot Water Credit
1		X	R-60				X	
2		X	R-60			X	X	X
3			R-60			X	X	X
4		X	R-60			X	X	X
5		X <sup>1</sup>	R-49			X	X	X
6			R-60			X	X	X
7			R-49				X	X
8			R-60			X	X	X
9			R-60			X	X	X
10			R-60	X		X	X	X
11		X	R-60	X		X	X	X
12		X	R-60	X		X	X	X
13		X	R-60	X		X	X	X
14	X	X	R-60	X		X	X	X
15		X	R-60	X		X	X	X
16			R-60		X	X	X	

<sup>1</sup> This measure in Climate Zone 5 was only evaluated for the Efficiency + PV + Battery package.

**Table 40: Mixed Fuel Single Family Measures, Efficiency Only & Efficiency + PV + Battery Packages**

Climate Zone	3 ACH50	R-10 Slab	Attic: EE Only	Attic: EE + PV + Bat	0.25 Roof Solar Reflectance	0.24 U-Factor / 0.50 SHGC Windows	0.30 U-Factor / 0.50 SHGC Windows	0.35 W/cfm	Buried Ducts	CDHW <sup>1</sup> : EE Only	CDHW: EE + PV + Bat
1		X	R-60 vs R-38				X		X		
2		X	R-60 vs R-38	R-49				X	X	X	X
3			R-60 vs R-30	R-38			X	EE Only	X		X
4		X	R-60 vs R-38	R-49				X	X		X
5			R-60 vs R-38	R-49				X	X	X	X
6			R-49 vs R-30	R-49				X	X	X	X
7			R-49 vs R-30	R-49					X	X	X
8			R-60 vs R-30	R-49				X	X	X	X
9			R-49 vs R-30	R-49				X	X	X	X
10			R-60 vs R-38		X			X	X	X	X
11		X	R-60 vs R-38	R-49	X			X	X	X	X
12		X	R-60 vs R-38	R-49	X			X	X	X	X
13		X	R-60 vs R-38	R-49	X			X	X		X
14	X	X	R-60 vs R-38	R-49	X			X	X		X
15		X	R-60 vs R-38	R-49	X			X	X	X	X
16			R-60 vs R-38	R-49		X		X	X		

<sup>1</sup> CDHW stands for basic Compact Domestic Hot Water credit

**Table 41: Efficiency Measures for All ADU Packages**

Climate Zone	3 ACH50	R-10 Slab	Attic <sup>1</sup>	0.25 Roof Solar Reflectance	0.24 U-Factor / 0.50 SHGC Windows	Ductless VCHP <sup>2</sup>	Basic Compact Hot Water Credit <sup>3</sup>
1		X	R-60 vs R-38			X	
2		X	R-60 vs R-38			X	X
3			R-60 vs R-30			X	X
4		X	R-60 vs R-38			X	X
5			R-60 vs R-38			X	X
6			R-60 vs R-30			X	X
7			R-60 vs R-30			X	X
8			R-60 vs R-30			X	X
9			R-60 vs R-30			X	X
10			R-60 vs R-38	X		X	X
11		X	R-60 vs R-38	X		X	X
12		X	R-60 vs R-38	X		X	X
13		X	R-60 vs R-38	X		X	X
14	X	X	R-60 vs R-38	X		X	X
15		X	R-60 vs R-38	X		X	X
16			R-60 vs R-38		X	X	

<sup>1</sup> This measure was added to all ADU packages except the Mixed Fuel Efficiency + High Efficiency Equipment package.

<sup>2</sup> The ductless VCHP measure was only applied to the all-electric packages; the mixed fuel packages instead applied 0.35 W/cfm fans in Climate Zones 2, 4-6, and 8-15.

<sup>3</sup> The compact hot water measure was only applied to the all-electric packages.

## 7.4 Summary of Applicable Prescriptive Base Case Measures

This appendix lists the prescriptive values, by climate zone, of building components relevant to the measures included in this analysis. Table 42 outlines envelope, PV, and battery values; Table 43 outlines space conditioning values, and Table 44 outlines domestic water heating (DHW) values.

**Table 42: Prescriptive Envelope, PV, and Battery Measures by Climate Zone**

CZ	Air Infiltration <sup>1</sup>	Foundation	Wall Insulation <sup>2</sup>	Attic Insulation <sup>3</sup>	Roof Aged Solar Reflectivity	Window U-Factor / SHGC	PV <sup>4</sup>	Battery
1	5 ACH50	Uninsulated slab	R-21 + R-5	R-38	0.1	0.30 / 0.35	code min.	none
2	5 ACH50	Uninsulated slab	R-21 + R-5	R-38	0.1	0.30 / 0.23	code min.	none
3	5 ACH50	Uninsulated slab	R-21 + R-5	R-30	0.1	0.30 / 0.35	code min.	none
4	5 ACH50	Uninsulated slab	R-21 + R-5	R-38 + R-19	0.1	0.30 / 0.23	code min.	none
5	5 ACH50	Uninsulated slab	R-21 + R-5	R-30	0.1	0.30 / 0.35	code min.	none
6	5 ACH50	Uninsulated slab	R-15 + R-4	R-30	0.1	0.30 / 0.23	code min.	none
7	5 ACH50	Uninsulated slab	R-15 + R-4	R-30	0.1	0.30 / 0.23	code min.	none
8	5 ACH50	Uninsulated slab	R-21 + R-5	R-38 + R-19	0.1	0.30 / 0.23	code min.	none
9	5 ACH50	Uninsulated slab	R-21 + R-5	R-38 + R-19	0.1	0.30 / 0.23	code min.	none
10	5 ACH50	Uninsulated slab	R-21 + R-5	R-38 + R-19	0.2	0.30 / 0.23	code min.	none
11	5 ACH50	Uninsulated slab	R-21 + R-5	R-38 + R-19	0.2	0.30 / 0.23	code min.	none
12	5 ACH50	Uninsulated slab	R-21 + R-5	R-38 + R-19	0.2	0.30 / 0.23	code min.	none
13	5 ACH50	Uninsulated slab	R-21 + R-5	R-38 + R-19	0.2	0.30 / 0.23	code min.	none
14	5 ACH50	Uninsulated slab	R-21 + R-5	R-38 + R-19	0.2	0.30 / 0.23	code min.	none
15	5 ACH50	Uninsulated slab	R-21 + R-5	R-38 + R-19	0.2	0.30 / 0.23	code min.	none
16	5 ACH50	R-7, 16" slab insulation	R-21 + R-5	R-38 + R-19	0.1	0.30 / 0.35	code min.	none

<sup>1</sup> 5 ACH50 is prescriptively required however verification is not required.

<sup>2</sup> Cavity wall insulation + continuous rigid insulation.

<sup>3</sup> Ceiling/attic insulation R-value. R-38 + R-19 reflect High Performance Attics (HPAs) as defined by Option B in Table 150.1-A.

<sup>4</sup> Prescriptive PV capacities (kW-DC) by climate zone are summarized in Table 4.

**Table 43: Prescriptive HVAC Measures by Climate Zone**

CZ	Heating Type	AC Type	Heating Efficiency <sup>1</sup>	HVAC Efficiency (SEER2/EER2)	HVAC Fan Efficacy (W/cfm)	Ducts <sup>2</sup>
1	Gas Furnace	AC	80%	14.3 / 11.7	0.45	R-8, 5%, in attic (not buried)
2	Gas Furnace	AC	80%	14.3 / 11.7	0.45	R-8, 5%, in attic (not buried)
3	Heat pump	Heat pump	7.5	14.3 / 11.7	0.45	R-6, 5%, in attic (not buried)
4	Heat pump	Heat pump	7.5	14.3 / 11.7	0.45	R-8, 5%, in attic (not buried)
5	Gas Furnace	AC	80%	14.3 / 11.7	0.45	R-6, 5%, in attic (not buried)
6	Gas Furnace	AC	80%	14.3 / 11.7	0.45	R-6, 5%, in attic (not buried)
7	Gas Furnace	AC	80%	14.3 / 11.7	0.45	R-6, 5%, in attic (not buried)
8	Gas Furnace	AC	80%	14.3 / 11.7	0.45	R-8, 5%, in attic (not buried)
9	Gas Furnace	AC	80%	14.3 / 11.7	0.45	R-8, 5%, in attic (not buried)
10	Gas Furnace	AC	80%	14.3 / 11.7	0.45	R-8, 5%, in attic (not buried)
11	Gas Furnace	AC	80%	14.3 / 11.7	0.45	R-8, 5%, in attic (not buried)
12	Gas Furnace	AC	80%	14.3 / 11.7	0.45	R-8, 5%, in attic (not buried)
13	Heat pump	Heat pump	7.5	14.3 / 11.7	0.45	R-8, 5%, in attic (not buried)
14	Heat pump	Heat pump	7.5	14.3 / 11.7	0.45	R-8, 5%, in attic (not buried)
15	Gas Furnace	AC	80%	14.3 / 11.7	0.45	R-8, 5%, in attic (not buried)
16	Gas Furnace	AC	80%	14.3 / 11.7	0.45	R-8, 5%, in attic (not buried)

<sup>1</sup> AFUE for gas furnaces, HSPF2 for heat pumps.

<sup>2</sup> Duct insulation R-value, duct leakage, duct location.

**Table 44: Prescriptive Water Heating Measures by Climate Zone**

CZ	DHW Type	Location: Single Family	Location: ADU	Basic Compact Distribution Credit
1	Heat pump	Garage	In conditioned space, ducted to/from outside	Yes
2	Heat pump	Garage	In conditioned space, ducted to/from outside	No
3	Gas tankless	Garage	In conditioned space, ducted to/from outside	No
4	Gas tankless	Garage	In conditioned space, ducted to/from outside	No
5	Heat pump	Garage	In conditioned space, ducted to/from outside	No
6	Heat pump	Garage	In conditioned space, ducted to/from outside	No
7	Heat pump	Garage	In conditioned space, ducted to/from outside	No
8	Heat pump	Garage	In conditioned space, ducted to/from outside	No
9	Heat pump	Garage	In conditioned space, ducted to/from outside	No
10	Heat pump	Garage	In conditioned space, ducted to/from outside	No
11	Heat pump	Garage	In conditioned space, ducted to/from outside	No
12	Heat pump	Garage	In conditioned space, ducted to/from outside	No
13	Gas tankless	Garage	In conditioned space, ducted to/from outside	No
14	Gas tankless	Garage	In conditioned space, ducted to/from outside	No
15	Heat pump	Garage	In conditioned space, ducted to/from outside	No
16	Heat pump	Garage	In conditioned space, ducted to/from outside	Yes

## Get In Touch

The adoption of reach codes can differentiate jurisdictions as efficiency leaders and help accelerate the adoption of new equipment, technologies, code compliance, and energy savings strategies.

As part of the Statewide Codes & Standards Program, the Reach Codes Subprogram is a resource available to any local jurisdiction located throughout the state of California.

Our experts develop robust toolkits as well as provide specific technical assistance to local jurisdictions (cities and counties) considering adopting energy reach codes. These include cost-effectiveness research and analysis, model ordinance language and other code development and implementation tools, and specific technical assistance throughout the code adoption process.

If you are interested in finding out more about local energy reach codes, the Reach Codes Team stands ready to assist jurisdictions at any stage of a reach code project.



Visit [LocalEnergyCodes.com](https://www.localenergycodes.com) to access our resources and sign up for newsletters.



Contact [info@localenergycodes.com](mailto:info@localenergycodes.com) for no-charge assistance from expert Reach Code advisors.



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# 2022 Cost-Effectiveness Study: Multifamily New Construction

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## Acronym List

2023 PV\$ – Present value costs in 2023

ACH50 – Air Changes per Hour at 50 pascals pressure differential

ACM – Alternative Calculation Method

ADU – Accessory Dwelling Unit

AFUE – Annual Fuel Utilization Efficiency

B/C – Lifecycle Benefit-to-Cost Ratio

BEopt – Building Energy Optimization Tool

BSC – Building Standards Commission

CA IOUs – California Investor-Owned Utilities

CASE – Codes and Standards Enhancement

CBEEC-Res – Computer program developed by the California Energy Commission for use in demonstrating compliance with the California Residential Building Energy Efficiency Standards

CFI – California Flexible Installation

CFM – Cubic Feet per Minute

CO<sub>2</sub> – Carbon Dioxide

CPAU – City of Palo Alto Utilities

CPUC – California Public Utilities Commission

CZ – California Climate Zone

DHW – Domestic Hot Water

DOE – Department of Energy

DWHR – Drain Water Heat Recovery

EDR – Energy Design Rating

EER – Energy Efficiency Ratio

EF – Energy Factor

GHG – Greenhouse Gas



## Cost Effectiveness Analysis: Multifamily New Construction

HERS Rater – Home Energy Rating System Rater

HPA – High Performance Attic

HPWH – Heat Pump Water Heater

HSPF – Heating Seasonal Performance Factor

HVAC – Heating, Ventilation, and Air Conditioning

IECC – International Energy Conservation Code

IOU – Investor Owned Utility

kBtu – kilo-British thermal unit

kWh – Kilowatt Hour

LBNL – *Lawrence Berkeley National Laboratory*

LCC – Lifecycle Cost

LLAHU – Low Leakage Air Handler Unit

VLLDCS – Verified Low Leakage Ducts in Conditioned Space

MF – Multifamily

NEEA – Northwest Energy Efficiency Alliance

NEM – Net Energy Metering

NPV – Net Present Value

NREL – *National Renewable Energy Laboratory*

PG&E – Pacific Gas and Electric Company

POU – Publicly-Owned-Utilities

PV – Photovoltaic

SCE – Southern California Edison

SDG&E – San Diego Gas and Electric

SEER – Seasonal Energy Efficiency Ratio

SF – Single Family

SMUD – Sacramento Municipal Utility District

SoCalGas – Southern California Gas Company

TDV – Time Dependent Valuation

Therm – Unit for quantity of heat that equals 100,000 British thermal units

Title 24 – Title 24, Part 6

TOU – Time-Of-Use

UEF – Uniform Energy Factor

ZNE – Zero-net Energy

### Summary Of Revisions

Date	Description	Reference (page or section)
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6/20/2023	Minor revisions to content; no change to results	2, 3, 32, 33

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## Executive Summary

The California Codes and Standards (C&S) Reach Codes program provides technical support to local governments considering adopting a local ordinance (reach code) intended to support meeting local and/or statewide energy efficiency and greenhouse gas (GHG) reduction goals. The program facilitates adoption and implementation of the code when requested by local jurisdictions by providing resources such as cost-effectiveness studies, model language, sample findings, and other supporting documentation.

This report documents cost-effective combinations of measures that exceed the minimum state requirements, the 2022 Building Energy Efficiency Standards (Title 24, Part 6 or Energy Code), effective January 1, 2023, for newly constructed multifamily buildings. The analysis considers low-rise and mid-rise multifamily building types and evaluates mixed fuel and all-electric package options in all sixteen California climate zones (CZs). Packages include a code compliant electrification package and a mixed fuel efficiency package, as well as the addition of above-code on-site solar photovoltaic (PV) capacity and battery energy storage. The 2022 Energy Code established electric heat pumps as the prescriptive baseline for space heating in most climate zones. As a result, this analysis primarily focuses on the electrification of central water heating. Space heating electrification was also evaluated where the prescriptive heat pump baseline didn't apply: In Climate Zone 16 for multifamily buildings three habitable stories or fewer, and Climate Zones 1 and 16 for multifamily buildings greater than three habitable stories.

This analysis used two different metrics to assess the cost-effectiveness of the proposed upgrades. Both methodologies require estimating and quantifying the incremental costs and energy savings associated with each energy efficiency measure over a 30-year analysis period. On-Bill cost-effectiveness is a customer-based lifecycle cost (LCC) approach that values energy based upon estimated site energy usage and customer utility bill savings using today's electricity and natural gas utility tariffs. Time Dependent Valuation (TDV) is the California Energy Commission's LCC methodology, which is intended to capture the long-term projected cost of energy including costs for providing energy during peak periods of demand, carbon emissions, grid transmission and distribution impacts. This is the methodology used by the Energy Commission in evaluating cost-effectiveness for efficiency measures in Title 24, Part 6.

Two multifamily prototypes were evaluated in this study. A 3-story loaded corridor and a 5-story mixed use prototype, which combined are estimated to represent 91 percent of new multifamily construction in California.

The following summarizes key results from the study:

- The Reach Codes Team found all-electric new construction to be feasible and cost-effective based on the California Energy Commission's Time Dependent Valuation (TDV) metric in all cases. In many cases all-electric prescriptive code construction results in an increase in utility costs and is not cost-effective On-Bill. Some exceptions include the SMUD and CPAU territories where lower electricity rates relative to gas rates result in lower overall utility bills.
- All-electric packages have lower GHG emissions than mixed fuel packages in all cases, due to the clean power sources currently available from California's power providers.
- The 2022 Energy Code's new source energy metric combined with the heat pump space heating baseline in most climate zones encourages all-electric construction. While the code does not include an electric baseline for water heating, the penalty for central electric water heating observed in the performance approach in past code cycles has been removed and a credit is provided for well-designed central heat pump water heaters in most cases.
- Electrification combined with increased PV capacity results in utility cost savings and was found to be On-Bill cost-effective in all cases.
- The results in this study are based on today's net energy metering (NEM 2.0) rules and do not account for recently approved changes to the NEM tariff (referred to as the net billing tariff). The net billing tariff decreases the value of PV to the consumer as compared to NEM 2.0. As a result, the cost-effectiveness of the packages that include above-code PV capacity is expected to be less under the net billing tariff. Conversely, the net

billing tariff is expected to increase On-Bill cost-effectiveness of the all-electric prescriptive code scenario. An all-electric home has better on-site utilization of generated electricity from PV than a mixed fuel home with a similar sized PV system, and as a result exports less electricity to the grid. Since the net-billing tariff values exports less than under NEM 2.0, the relative impact on annual utility costs to the mixed fuel baseline is greater.

- This analysis does justify a modest reach based on either efficiency TDV or source energy for all-electric buildings. However, this may be challenging for some projects given the recent changes to which the industry must adapt, including the efficiency updates and multifamily restructuring in the 2022 Title 24, Part 6 code. While project compliance margins using a CO<sub>2</sub> refrigerant heat pump water heating system are high, the Reach Code Team found lower compliance margins using other heat pump water heater system designs. Focusing on supporting projects to electrify water heating is expected to support the market shift towards more central heat pump water heaters.
- For jurisdictions interested in a reach code that allows for mixed fuel buildings, a mixed fuel efficiency and PV package (and battery for the 3-story prototype) was found to be cost-effective based on TDV in all cases and cost-effective On-Bill in most climate zones. This path, referred to as “Electric-Preferred”, allows for mixed fuel buildings but requires a higher building performance than for all-electric buildings. The efficiency measures evaluated in this study did not provide significant compliance benefit. As a result, the Reach Codes Team recommends establishing a compliance margin target based on source energy or total TDV. This would allow for PV and battery above minimum code requirements to be used to meet the target.
- Jurisdictions interested in increasing affordable multifamily housing should know that applying the CARE rates has the overall impact of increasing utility cost savings for an all-electric building in most climate zones compared to a code compliant mixed fuel building, improving On-Bill cost-effectiveness.

Table ES-1 summarizes results for each prototype and depicts the efficiency TDV compliance margins achieved for each climate zone and package. All results presented in the table have a positive compliance margin (greater than zero percent). Cells highlighted in **green** depict cases with a positive compliance margin and cost-effective results using both On-Bill and TDV approaches. Cells highlighted in **yellow** depict cases with a positive compliance margin and cost-effective results using either the On-Bill or TDV approach. Cells **not highlighted** depict cases with a positive compliance margin but that were not cost-effective using either the On-Bill or TDV approach.

**Table ES-1. Summary of Efficiency TDV Compliance Margins and Cost-Effectiveness**

Climate Zone	Electric /Gas Utility	3-Story				5-Story			
		All-Electric Prescriptive Code	All-Electric + PV	Mixed Fuel Efficiency	Mixed Fuel Efficiency + PV + Battery	All-Electric Prescriptive Code	All-Electric + PV	Mixed Fuel Efficiency	Mixed Fuel Efficiency + PV
CZ01	PGE	26%	26%	1%	1%	14%	14%	0%	0%
CZ02	PGE	20%	20%	1%	1%	9%	9%	1%	1%
CZ03	PGE	21%	21%	1%	1%	11%	11%	0%	0%
CZ04	PGE	18%	18%	1%	1%	9%	9%	1%	1%
CZ04	CPAU	18%	18%	1%	1%	9%	9%	1%	1%
CZ05	PGE	23%	23%	1%	1%	12%	12%	0%	0%
CZ05	PGE/SCG	23%	23%	1%	1%	12%	12%	0%	0%
CZ06	SCE/SCG	18%	18%	1%	1%	9%	9%	0%	0%
CZ07	SDGE	20%	20%	0%	0%	11%	11%	0%	0%
CZ08	SCE/SCG	13%	13%	1%	1%	8%	8%	1%	1%
CZ09	SCE	13%	13%	1%	1%	7%	7%	1%	1%
CZ10	SCE/SCG	14%	14%	3%	3%	7%	7%	2%	2%
CZ10	SDGE	14%	14%	3%	3%	7%	7%	2%	2%
CZ11	PGE	14%	14%	3%	3%	8%	8%	2%	2%
CZ12	PGE	17%	17%	2%	2%	9%	9%	2%	2%
CZ12	SMUD/PGE	17%	17%	2%	2%	9%	9%	2%	2%
CZ13	PGE	13%	13%	4%	4%	7%	7%	2%	2%
CZ14	SCE/SCG	13%	13%	3%	3%	6%	6%	2%	2%
CZ14	SDGE	13%	13%	3%	3%	6%	6%	2%	2%
CZ15	SCE/SCG	5%	5%	5%	5%	3%	3%	3%	3%
CZ16	PG&E	24%	24%	5%	5%	9%	9%	2%	2%

Local jurisdictions may also adopt ordinances that amend different Parts of the California Building Standards Code or may elect to amend other state or municipal codes. The decision regarding which code to amend will determine the specific requirements that must be followed for an ordinance to be legally enforceable. Reach codes that amend Part 6 of the CA Building Code and require energy performance (including PV and storage) beyond state code minimums must demonstrate that the proposed changes are cost-effective and obtain approval from the Energy Commission prior to filing with the BSC.

Model ordinance language and other resources are posted on the C&S Reach Codes Program website at [LocalEnergyCodes.com](http://LocalEnergyCodes.com). Local jurisdictions that are considering adopting an ordinance may contact the program for further technical support at [info@localenergycodes.com](mailto:info@localenergycodes.com).

## 1 Introduction

This report documents cost-effective combinations of measures that exceed the minimum state requirements, the 2022 Building Energy Efficiency Standards, effective January 1, 2023, for newly constructed multifamily buildings. This report was developed in coordination with the California Statewide Investor-Owned Utilities (CA IOUs) Codes and Standards Program, key consultants, and engaged cities—collectively known as the Reach Codes Team. The CA IOU Codes and Standards Program is comprised of IOUs representatives from Pacific Gas and Electric (PG&E), Southern California Edison (SCE) and San Diego Gas and Electric (SDG&E) and two Publicly-Owned-Utilities (POUs) – Sacramento Municipal Utility District (SMUD) and City of Palo Alto Utilities (CPAU),

The analysis considers low-rise and mid-rise multifamily building types and evaluates mixed fuel and all-electric package options in all sixteen California climate zones (CZs)<sup>1</sup> Packages include combinations of efficiency measures, on-site renewable energy, and battery energy storage.

The California Building Energy Efficiency Standards Title 24, Part 6 (Energy Code) (California Energy Commission, 2022a) is maintained and updated every three years by two state agencies: the California Energy Commission (Energy Commission) and the Building Standards Commission (BSC). In addition to enforcing the code, local jurisdictions have the authority to adopt local energy efficiency ordinances—or reach codes—that exceed the minimum standards defined by Title 24 (as established by Public Resources Code Section 25402.1(h)2 and Section 10-106 of the Building Energy Efficiency Standards (California Energy Commission, 2022a)). Local jurisdictions must demonstrate that the requirements of the proposed ordinance are cost-effective and do not result in buildings consuming more energy than is permitted by Title 24. In addition, the jurisdiction must obtain approval from the Energy Commission and file the ordinance with the BSC for the ordinance to be legally enforceable.

The Department of Energy (DOE) sets minimum efficiency standards for equipment and appliances that are federally regulated under the National Appliance Energy Conservation Act, including heating, cooling, and water heating equipment (E-CFR, 2020). Since state and local governments are prohibited from adopting higher minimum efficiencies than the federal standards require, the focus of this study is to identify and evaluate cost-effective packages that do not include high efficiency heating, cooling, and water heating equipment. High efficiency appliances are often the easiest and most affordable measures to increase energy performance. While federal preemption limits reach code mandatory requirements for covered appliances, in practice, builders may install any package of compliant measures to achieve the performance requirements.

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<sup>1</sup> See Appendix 7.1 Map of California Climate Zones for a graphical depiction of climate zone locations.

## 2 Methodology and Assumptions

### 2.1 Analysis for Reach Codes

This section describes the approach to calculating cost-effectiveness including benefits, costs, metrics, and utility rate selection.

#### 2.1.1 Modeling

The Reach Codes Team performed energy simulations using software approved for 2022 Title 24 Code compliance analysis, CBECC 2022.2.0.

Using the 2022 baseline as the starting point, prospective energy efficiency measures were identified and modeled to determine the projected site energy (therm and kWh) and compliance impacts. Annual utility costs were calculated using hourly data output from CBECC, and electricity and natural gas tariffs for each of the investor-owned utilities (IOUs).

This analysis focused on residential apartments only (a prior study and report analyzed the cost-effectiveness of above code packages for nonresidential buildings (Statewide Reach Codes Team, 2022b). The Statewide Reach Codes Team selected measures for evaluation based on the single family 2022 reach code analysis (Statewide Reach Codes Team, 2022a) and the multifamily 2019 reach code analysis [ (Statewide Reach Codes Team, 2020), (Statewide Reach Codes Team, 2021)] as well as experience with and outreach to architects, builders, and engineers.

#### 2.1.2 Cost-Effectiveness

##### 2.1.2.1 Benefits

This analysis used two different metrics to assess the cost-effectiveness of the proposed upgrades. Both methodologies require estimating and quantifying the incremental costs and energy savings associated with each energy efficiency measure. The main difference between the methodologies is the manner in which they value energy and thus the cost savings of reduced or avoided energy use:

**Utility Bill Impacts (On-Bill):** This customer-based lifecycle cost (LCC) approach values energy based upon estimated site energy usage and customer utility bill savings using the latest electricity and natural gas utility tariffs available at the time of writing this report. Total savings are estimated over a 30-year duration and include discounting of future utility costs and energy cost inflation.

**Time Dependent Valuation (TDV):** This reflects the Energy Commission's current LCC methodology, which is intended to capture the total value or cost of energy use over 30 years. This method accounts for long-term projected costs, such as the cost of providing energy during peak periods of demand, costs for carbon emissions, and grid transmission and distribution impacts. This metric values energy use differently depending on the fuel source (natural gas, electricity, and propane), time of day, and season. Electricity used (or saved) during peak periods has a much higher value than electricity used (or saved) during off-peak periods due to the less inefficient energy generation sources providing peak electricity (Horii, Cutter, Kapur, Arent, & Conotyannis, 2014). This is the methodology used by the Energy Commission in evaluating cost-effectiveness for efficiency measures in the 2022 Energy Code.

##### 2.1.2.2 Costs

The Reach Codes Team assessed the incremental costs of the measures and packages over a 30-year lifecycle. Incremental costs represent the equipment, installation, replacements, and maintenance costs of the proposed measure relative to the 2022 Energy Code minimum requirements or standard industry practices. Present value of replacement cost is included for measures with lifetimes less than the evaluation period.

##### 2.1.2.3 Metrics

Cost-effectiveness is presented using net present value (NPV) and benefit-to-cost (B/C) ratio metrics.

**NPV:** The lifetime NPV is reported as a cost-effectiveness metric, Equation 1 demonstrates how this is calculated. If the NPV of a measure or package is positive, it is considered cost-effective. A negative values represent net costs.

**B/C Ratio:** This is the ratio of the present value (PV) of all benefits to the present value of all costs over 30 years (PV benefits divided by PV costs). The criteria benchmark for cost-effectiveness is a B/C ratio greater than one. A value of one indicates the NPV of the savings over the life of the measure is equivalent to the NPV of the lifetime incremental cost of that measure. A value greater than one represents a positive return on investment. The B/C ratio is calculated according to Equation 2.

### Equation 1

$$NPV_{Benefits} = \sum_{t=0}^n \frac{B_t}{(1+r)^t} - \sum_{t=0}^n \frac{C_t}{(1+r)^t}$$

### Equation 2

$$B/C = \frac{\sum_{t=0}^n \frac{B_t}{(1+r)^t}}{\sum_{t=0}^n \frac{C_t}{(1+r)^t}}$$

Improving the efficiency of a project often requires an initial incremental investment. In most cases the benefit is represented by annual On-Bill utility or TDV savings, and the cost is represented by incremental first cost and replacement costs. Some packages result in initial construction cost savings (negative incremental cost), and either energy cost savings (positive benefits), or increased energy costs (negative benefits). In cases where both construction costs and energy-related savings are negative, the construction cost savings are treated as the ‘benefit’ while the increased energy costs are the ‘cost.’ In cases where a measure or package is cost-effective immediately (i.e., upfront construction cost savings and lifetime energy cost savings), B/C ratio cost-effectiveness is represented by “>1”.

The lifetime costs or benefits are calculated according to Equation 3.

### Equation 3

$$PV = \sum_{t=0}^n \frac{C_t}{(1+r)^t}$$

Where:

- $n$  = analysis term in years
- $r$  = discount rate

The following summarizes the assumptions applied in this analysis to both methodologies.

- Analysis term of 30 years
- Real discount rate of three percent

TDV is a normalized monetary format and there is a unique procedure for calculating the present value benefit of TDV energy savings. The present value of the energy cost savings in dollars is calculated by multiplying the TDV savings (reported by the CBECC simulation software) by a NPV factor developed by the Energy Commission (see E3’s 2022 TDV report for details (Energy + Environmental Economics, 2020)). The 30-year residential NPV factor is \$0.173/kTDV for the 2022 Energy Code.

### Equation 4

$$NPV_{TDV} = \sum_{t=0}^n \frac{TDV_t}{(1+r)^t}$$

## 2.1.3 Utility Rates

In coordination with the CA IOU rate team (comprised of representatives from PG&E, SCE, SDG&E, SMUD, and CPAU), the Reach Codes Team determined appropriate utility rates for each climate zone in order to calculate utility

costs and determine On-Bill cost-effectiveness for the proposed measures and packages. The utility tariffs, summarized in Table 1, were determined based on the most prevalent active rate in each territory. Utility rates were applied to each climate zone based on the predominant IOU serving the population of each zone, with a few climate zones evaluated multiple times under different utility scenarios. Climate Zones 10 and 14 were evaluated with both SCE for electricity and Southern California Gas Company (SoCalGas) for gas and SDG&E tariffs for both electricity and gas since each utility has customers within these climate zones. Climate Zone 5 is evaluated under both PG&E and SoCalGas natural gas rates. Two POU or municipal utility rates were also evaluated: SMUD in Climate Zone 12 and CPAU in Climate Zone 4.

For the IOUs in-unit gas was evaluated under the G1 rate and central gas for water heating was evaluated under the relevant master metered gas tariff, GM. Electricity use for central water heating was evaluated using the residential TOU rates. The water heating utility bill was calculated separately from the in-unit electricity bill. Photovoltaic (PV) and battery energy storage benefits were applied according to virtual net energy metering (VNEM) rules.<sup>2</sup> PV was first assigned to the central water heating meter to offset 100 percent of the electricity use. The remaining PV and all of the battery impacts were then split evenly across the apartment meters. The same approach was applied for CPAU and SMUD using the rates described in Table 1.

The multifamily prototypes used in this analysis include common area spaces that serve the residents (lobby, leasing office, corridors, etc.). Most of the energy use for these spaces could not be separated from that for the dwelling units within the CBECC model. As a result, average per dwelling unit hourly energy use was calculated to include both the dwelling unit and common space energy use.

First-year utility costs were calculated using hourly electricity and natural gas output from CBECC and applying the utility tariffs summarized in Table 1. Annual costs were also estimated for customers eligible for the CARE tariff discounts on both electricity and natural gas bills. The CARE tariff was only applied to the in-unit apartment meters. Appendix 7.2 Utility Rate Schedules includes details of each utility tariff.

For cases with PV generation, the approved NEM 2.0 tariffs were applied along with minimum daily use billing and mandatory non-bypassable charges. In December the California Public Utilities Commission (CPUC) issued a decision adopting a net billing tariff (NBT) as a successor to NEM 2.0 that will go into effect April of 2023<sup>3</sup> Given the recent timing of this decision there was not time to incorporate these changes into this analysis. The Reach Codes Team conducted a limited sensitivity analysis on the impacts of NBT relative to NEM 2.0 on utility bills. It was found that utility costs will increase for all homes with PV systems; however, the increase was less for an all-electric building compared to a mixed fuel building with a similarly sized PV system. As a result of better onsite utilization of PV generation and thus fewer exports to the grid, the Reach Codes Team expects the cost-effectiveness for the electrification scenarios for the all-electric home evaluated in this report to improve under NBT. Conversely, cost-effectiveness of increasing PV capacity is expected to be reduced under NBT.

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<sup>2</sup> PG&E: [https://www.pge.com/tariffs/assets/pdf/tariffbook/ELEC\\_SCHEDS\\_NEM2V.pdf](https://www.pge.com/tariffs/assets/pdf/tariffbook/ELEC_SCHEDS_NEM2V.pdf)

SDG&E: [https://tariff.sdge.com/tm2/pdf/tariffs/ELEC\\_ELEC-SCHEDS\\_NEM-V-ST.pdf](https://tariff.sdge.com/tm2/pdf/tariffs/ELEC_ELEC-SCHEDS_NEM-V-ST.pdf)

SCE:

<https://edisonintl.sharepoint.com/teams/Public/TM2/Shared%20Documents/Forms/AllItems.aspx?ga=1&id=%2Fteams%2FPublic%2FTM2%2FShared%20Documents%2FPublic%2FRegulatory%2FTariff%2DSCE%20Tariff%20Books%2FElectric%2FSchedules%2FOther%20Rates%2FELECTRIC%5FSCHEDULES%5FNEM%2DV%2DST%2Epdf&parent=%2Fteams%2FPublic%2FTM2%2FShared%20Documents%2FPublic%2FRegulatory%2FTariff%2DSCE%20Tariff%20Books%2FElectric%2FSchedules%2FOther%20Rates>

<sup>3</sup> <https://www.cpuc.ca.gov/nemrevisit>

**Table 1. Utility Tariffs Used Based on Climate Zone**

**IOUs**

Climate Zones	Electric / Gas Utility	Electricity	Natural Gas
1-5,11-13,16	PG&E / PG&E	E-TOU Option C	G1 (in-unit) & GM (central water heating) <sup>1</sup>
5	PG&E / SoCalGas	E-TOU Option C	GM
6, 8-10, 14, 15	SCE / SoCalGas	TOU-D Option 4-9	GM
7, 10, 14	SDG&E / SDG&E	TOU-DR-1	GM

**POUs**

Climate Zones	Electric / Gas Utility	Electricity	Natural Gas
4	CPAU / CPAU	E-1 (in-unit) & E-2 (central water heating)	G-2
12	SMUD / PG&E	R-TOD, RT02 (in-unit) & RSMM (central water heating)	GM

<sup>1</sup>G1 rate applied to gas use within the apartment units, which only occurs in Climate Zones 1 and 16, see Section 3 for details. GM rate applied to gas use for central water heating.

Utility rates are assumed to escalate over time according to the assumptions from the CPUC 2021 En Banc hearings on utility costs through 2030 (California Public Utilities Commission, 2021a). Escalation rates through the remainder of the 30-year evaluation period are based on the escalation rate assumptions within the 2022 TDV factors. See Appendix 7.2.7 Fuel Escalation Assumptions for details.

## 2.2 2022 T24 Compliance Metrics

2022 Title 24, Part 6 Section 170.1 defines the energy budget of the building based on source energy and TDV energy for space-conditioning, indoor lighting, mechanical ventilation, PV and battery storage systems, service water heating and covered process loads. In 2022, the Energy Commission introduced the new compliance metric of source energy, which differs by fuel source (as does TDV) and is a reasonable proxy for greenhouse gas emissions. Additionally, for multifamily buildings four habitable stories and higher prescriptive requirements for PV and battery systems were also introduced. This led to the need to differentiate an efficiency compliance metric, which ensured that the building met minimum efficiency standards, and a total energy compliance metric which incorporated the PV and battery standards. In order to be compliant with the building code a building needs to comply with all three compliance metrics described below:

- **Efficiency TDV.** Efficiency TDV accounts for all regulated end-uses but does not include the impacts of PV and battery storage.
- **Total TDV.** Total TDV includes regulated end-uses and accounts for PV and battery storage contributions.
- **Source Energy.** Source energy is based on fuel used for power generation and distribution.

## 2.3 Greenhouse Gas Emissions

The analysis reports the greenhouse gas (GHG) emission estimates based on assumptions within CBECC. There are 8,760 hourly multipliers accounting for time dependent energy use and carbon based on source emissions, including renewable portfolio standard projections. There are two series of multipliers—one for Northern California climate

zones, and another for Southern California climate zones.<sup>4</sup> GHG emissions are reported as average annual metric tons of CO<sub>2</sub> equivalent over the 30-year building lifetime.

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<sup>4</sup> CBECC multipliers are the same for CZs 1-5 and 11-13 (Northern California), while there is another set of multipliers for CZs 6-10 and 14-16 (Southern California).

### 3 Prototypes, Measure Packages, and Costs

This section describes the prototypes, measures, costs, and the scope of analysis drawing from previous reach code research where appropriate.

#### 3.1 Prototype Characteristics

The Energy Commission defines building prototypes which it uses to evaluate the cost-effectiveness of proposed changes to Title 24 requirements. There are 4 multifamily prototypes used in code development: a 2-story garden style, a 3-story loaded corridor, a 5-story mixed use and a 10-story mixed use. Based on work completed for the 2022 Title 24 code development, the 3-story and the 5-story represent 33 percent and 58 percent, respectively, of new multifamily construction in California. As a result, these two prototypes are used in this analysis. Additional details on all four prototypes can be found in the Multifamily Prototypes Report (TRC, 2019).

Table 2 describes the basic characteristics of each prototype.

**Table 2. Prototype Characteristics**

Characteristic	3-Story Loaded Corridor	5-Story Mixed Use
Conditioned Floor Area	39,372 ft <sup>2</sup>	113,100 ft <sup>2</sup> total: 33,660 ft <sup>2</sup> nonresidential 79,440 ft <sup>2</sup> residential
Num. of Stories	3	6 Stories total: 1 story parking garage (below grade) 1 story of nonresidential space 4 stories of residential space
Num. of Bedrooms	(6) Studio (12) 1-bed (12) 2-bed (6) 3-bed	(8) studios (40) 1-bed units (32) 2-bed units (8) 3-bed units
Window-to-Wall Area Ratio	25%	25%
Wall Type	Wood framed	Wood frame over a first-floor concrete podium
Roof Type	Flat roof	Flat roof
Foundation	Slab-on-grade	Concrete podium with underground parking

The methodology used in the analyses for each of the prototypical building types begins with a design that precisely meets the minimum 2022 prescriptive requirements.<sup>5</sup> Table 170.2-A and 170.2-B in the 2022 Standards (California Energy Commission, 2022a) list the prescriptive measures that determine the baseline design in each climate zone. Other features are designed to meet, but not exceed, the minimum requirements and are consistent with the Standard Design in the ACM Reference Manual (California Energy Commission, 2022c). The analysis also assumed electric resistance cooking in the apartment units to reflect current market data. The 3-story building prototype includes a central laundry facility, and the 5-story assumes laundry in the units. Laundry equipment was assumed to be electric in all cases; electrification of laundry equipment was not addressed in this study. The nonresidential 2022 reach code analysis (Statewide Reach Codes Team, 2022b) did consider electrification of central laundry facilities within the small hotel prototype.

Table 3 describes characteristics as they were applied to the base case energy model in this analysis. In a shift from the 2019 Standards, the 2022 Standards define a prescriptive fuel source for space heating establishing an electric

<sup>5</sup>Due to planned software updates to how the prescriptive requirements are applied in the Standard Design and challenges for certain space types with sizing heating and cooling equipment the same in the Proposed Design as in the Standards, the results compliance margins for the base case models were not exactly zero percent..

heat pump baseline in all climate zones except 16 for multifamily buildings three habitable stories and fewer and 1 and 16 for multifamily buildings four habitable stories and greater.

**Table 3. Base Case Characteristics of the Prototypes**

Characteristic	3-Story Loaded Corridor	5-story Mixed Use
Space Heating/Cooling <sup>1</sup>	Individual split systems with ducts in conditioned space CZ 1-15: Heat pump CZ 16: Natural gas furnace with air conditioner	Individual split systems with ducts in conditioned space CZ2-15: Heat pump CZ1, 16: Dual-fuel heat pump with natural gas backup
Ventilation	Individual balanced fans, continuously operating	Individual balanced fans, continuously operating
Water Heater <sup>1</sup>	Natural gas central boiler with solar thermal sized to meet the prescriptive requirements by climate zone.	Natural gas central boiler with solar thermal sized to meet the prescriptive requirements by climate zone.
Hot Water Distribution	Central recirculation	Central recirculation
Cooking	Electric	Electric
Clothes Drying	Electric (central)	Electric (in-unit)
PV System	Sized according to the prescriptive requirements in Equation 170.2-C of the 2022 Title 24 Standards. Size differs by climate zone ranging from 1.60 kW to 2.90 kW per dwelling unit, see Table 4.	Sized according to the prescriptive requirements in Equation 170.2-D of the 2022 Title 24 Standards. Size differs by climate zone ranging from 2.26 kW to 3.34 kW per dwelling unit, see Table 4.
Battery System	None	None

<sup>1</sup> Equipment efficiencies are equal to minimum federal appliance efficiency standards.

Table 4 summarizes the PV capacities for the base case packages.

**Table 4. Base Package PV Capacities (kW-DC)**

Climate Zone	Base Package	
	3-Story	5-Story
CZ01	2.00	2.26
CZ02	1.79	2.68
CZ03	1.70	2.26
CZ04	1.75	2.68
CZ05	1.60	2.26
CZ06	1.77	2.68
CZ07	1.67	2.68
CZ08	1.91	2.68
CZ09	1.92	2.68
CZ10	1.98	2.68
CZ11	2.21	2.68
CZ12	1.96	2.68
CZ13	2.33	2.68
CZ14	1.94	2.68
CZ15	2.90	3.34
CZ16	1.76	2.26

## 3.2 Measure Definitions and Costs

Measures evaluated in this study fall into two categories: those associated with general efficiency, onsite generation, and demand flexibility and those associated with building electrification. The Reach Codes Team selected measures based on cost-effectiveness as well as decades of experience with residential architects, builders, and engineers along with general knowledge of the relative consumer acceptance of many measures. This analysis focused on measures that impacted the residential dwelling units only.

The following sections describe the details and incremental cost assumptions for each of the measures. Incremental costs represent the equipment, installation, replacement, and maintenance costs of the proposed measures relative to the base case. Replacement costs are applied for roofs, mechanical equipment, PV inverters and battery systems over the 30-year evaluation period. Incremental maintenance costs are estimated for PV systems, but not any other measures. Costs were estimated to reflect costs to the building owner. All costs are provided as present value in 2023 (2023 PV\$).

The Reach Codes Team obtained measure costs from distributors, contractors, literature review, and online sources such as Home Depot and RS Means. Contractor markups are incorporated. These are the Reach Codes Team best estimate of average costs statewide. Regional variation in costs is not accounted for, although it's recognized that local costs may differ. Cost increases due to recent high inflation rates and supply chain delays are not included.

### 3.2.1 Efficiency, Solar PV, and Batteries

The following are descriptions of each of the efficiency, PV, and battery measures evaluated under this analysis and applied in at least one of the packages presented in this report. Table 5 summarizes the incremental cost assumptions for each of these measures. These measures were evaluated for all climate zones but were ultimately adopted in a subset of climate zones based on cost-effectiveness outcomes.

**Lower U-Factor Fenestration:** Reduce window U-factor to 0.24. The prescriptive U-factor is 0.30 in all climate zones except Climate Zones 7 and 8 where it is 0.34. This measure is included in Climate Zone 16 only.

**Cool Roof:** Install a roofing product that's rated by the Cool Roof Rating Council to have an aged solar reflectance (ASR) equal to or greater than 0.70. Low-sloped roofs were assumed in all cases. The 2022 Title 24 specifies a prescriptive ASR of 0.63 for Climate Zones 9 through 11 and 13 through 15. This measure is included in Climate Zones 9 through 15.

**Low Pressure Drop Ducts:** Upgrade the duct distribution system to reduce external static pressure and meet a maximum fan efficacy of 0.35 Watts per cfm. This may involve upsizing ductwork, reducing the total effective length of ducts, and/or selecting low pressure drop components such as filters. Fan watt draw must be verified by a HERS rater according to the procedures outlined in the 2022 Reference Appendices RA3.3 (California Energy Commission, 2022b). This measure is included in Climate Zones 1 and 10 through 16.

**Verified Low Leakage Ducts in Conditioned Space:** Seal the ducts to achieve a measured leakage no greater than 25 cfm leakage to outside. This may be verified using a guarded blower door test to isolate leakage to outside. Alternatively, this can also be satisfied by demonstrating that total leakage is not greater than 25 cfm. Ducts are assumed to already be located in conditioned space in the baseline. This measure is included in all climate zones.

**Solar PV:** Installation of on-site PV is required in the 2022 residential code unless an exception is met. The PV sizing methodology in each package was developed to offset annual building electricity use and avoid oversizing which would violate net energy metering (NEM) rules.<sup>6</sup> In all cases, PV is evaluated in CBECC according to the California Flexible Installation (CFI) assumptions. This measure is included in all climate zones.

**Battery Energy Storage:** A battery system was evaluated in CBECC-Res with control type set to "Time-of-Use" and with default efficiencies of 95% for both charging and discharging. This control option assumes the battery system will

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<sup>6</sup> NEM rules apply to the IOU territories only.

charge or discharge based on a utility tariff time-of use signal. To qualify, the battery system must meet the requirements outlined in the 2022 Reference Appendices JA12.2.3.2 (California Energy Commission, 2022b). This measure is included in all climate zones but only for the 3-story prototype. A 100kWh battery was applied following the battery sizing requirements for multifamily buildings more than three habitable stories per Equation 170.2-E of the 2022 Energy Code.

**Table 5. Incremental Cost Assumptions**

Measure	Performance Level	Incremental Cost per Dwelling Unit (2023 PV\$)		Source & Notes
		3-Story	5-Story	
<b>Non-Preempted Measures</b>				
Window U-factor	0.24 vs 0.30	\$536	\$489	\$4.23/ft <sup>2</sup> of window area based on analysis conducted for the 2019 and 2022 Title 24 cycles (Statewide CASE Team, 2018).
Low-Sloped Cool Roof Aged Solar Reflectance	0.63 vs 0.10	\$314	\$222	\$0.525/ft <sup>2</sup> of roof area first incremental cost based on the 2022 Residential Additions and Alterations CASE Report (Statewide CASE Team, 2020b). Total costs assume present value of replacement at year 15.
	0.70 vs 0.63	\$24	\$17	\$0.04/ft <sup>2</sup> of roof area first incremental cost based on the 2022 Nonresidential High Performance Envelope CASE Report (Statewide CASE Team, 2020a). Costs assume a blended average across roofing product types. Total costs assume present value of replacement at year 15.
Low Pressure Drop Ducts	0.35 vs 0.45 W/cfm	\$44	\$44	Costs assume half-hour labor per multifamily dwelling unit. Labor rate of \$88 per hour is from 2022 RS Means for sheet metal workers and includes a weighted average City Cost Index for labor for California.
Verified Low Leakage Ducts in Conditioned Space	≤25 cfm leakage to outside	\$132	\$132	Costs assume half-hour labor per multifamily dwelling unit and a \$100 HERS Rater fee. Labor rate of \$88 per hour is from 2022 RS Means for sheet metal workers and includes a weighted average City Cost Index for labor for California. Ducts are already assumed to be located in conditioned space and the incremental costs reflect additional sealing and testing only.
<b>PV + Battery</b>				
PV System	First Cost	\$1.47/W	\$1.47/W	First costs from LBNL’s Tracking the Sun 2022 costs (Barbose, Darghouth, O’Shaughnessy, & Forrester, 2022) and represent median costs in California in 2021 of \$2.10/WDC for nonresidential greater than 100kWDC systems. The first cost was reduced by the solar energy Investment Tax Credit (ITC) of 30%. <sup>1</sup> Costs are presented as the average of 2023, 2024, and 2025. Inverter replacement cost of \$0.14/WDC present value includes replacements at year 11 at \$0.15/WDC (nominal) and at year 21 at \$0.12/WDC (nominal) per the 2019 PV CASE Report (California Energy Commission, 2017). System maintenance costs of \$0.31/WDC present value assume \$0.02/WDC (nominal) annually per the 2019 PV CASE Report (California Energy Commission, 2017).
	Inverter replacement	\$0.14/W	\$0.14/W	
	Maintenance	\$0.31/W	\$0.31/W	

Measure	Performance Level	Incremental Cost per Dwelling Unit (2023 PV\$)		Source & Notes
		3-Story	5-Story	
Battery	First cost	\$700/kWh	n/a	First cost of \$1,000/kWh from LBNL’s Tracking the Sun 2022 costs (Barbose, Darghouth, O’Shaughnessy, & Forrester, 2022) for residential systems > 30kWh. The report derived costs from California’s Self-Generation Incentive Program (SGIP) residential participant cost data. First cost is reduced by the solar energy ITC of 30%. <sup>1</sup> No SGIP incentives are included. Costs are assumed to remain consistent at \$1,000/kWh through 2025 and then reduced by 7% annually based on SDG&E’s Behind-the-Meter Battery Market Study (E-Source companies, 2020) over a 10 year period. Replacement is assumed at years 10 and 20. At year 10 the replacement cost is based on the average of expected 2033, 2034, and 2035 costs after applying the ITC for a future value cost of \$435. Replacement cost at year 20 is based on a future value cost of \$484 and does not include any ITC reduction.
	Replacement cost	\$564/kWh	n/a	

<sup>1</sup>As part of the Inflation Reduction Act in August 2022 the Section 25D Investment Tax Credit was extended and raised to 30% through 2032 with a step-down to 26% in 2033 and 22% in 2034. It’s assumed that the ITC is not renewed and is 0% starting in 2035. <https://www.irs.gov/pub/taxpros/fs-2022-40.pdf>.

## 3.2.2 All-Electric

This analysis compared a code compliant mixed fuel prototype, which uses natural gas for water heating only in most climate zones, with a code compliant all-electric prototype. In these cases, the relative costs between natural gas and electric appliances and natural gas infrastructure and the associated infrastructure costs for not providing natural gas to the building were included.

To estimate costs the Reach Codes Team leveraged costs from the 2022 Multifamily All-Electric CASE Report (Statewide CASE Team, 2020c) and the 2019 reach code multifamily cost-effectiveness studies (Statewide Reach Codes Team, 2020), (Statewide Reach Codes Team, 2021)), and online equipment research. Present value replacement costs are included in the total lifetime incremental costs.

### 3.2.2.1 Water Heating

Federal regulations establish minimum efficiency requirements for heat pump water heaters with rated storage volume less than 120 gallons. While some heat pump water heaters falling into this regulated category can be used in a central water heater design, they are not required and therefore this measure does not trigger federal preemption and heat pump equipment of any efficiency level may be used for this analysis to justify the basis of a reach code.

For the central heat pump water heating system in the 3-story prototype the system design was based on the 2022 All-Electric Multifamily CASE Report (Statewide CASE Team, 2020c) and used CO<sub>2</sub> refrigerant based heat pump water heaters (four Sanden GS3-45HPA-US units), 525 gallons of storage, and a 250 gallon electric resistance swing tank. The 2022 CASE work based the 5-story system design on Colmac R-134a refrigerant heat pump water heaters. While this is an acceptable design, R-134a or R-410a refrigerant heat pump water heaters were found to be less cost-effective for the prototypes evaluated in this analysis due to higher incremental costs and lower overall performance relative to CO<sub>2</sub> refrigerant products. As such, the Reach Codes Team evaluated a CO<sub>2</sub> refrigerant system for the 5-story prototype for this analysis. As part of the 2025 Energy Code update cycle, designs for both multifamily prototypes are being reexamined using CO<sub>2</sub> refrigerant heat pump water heaters. While full design and cost information was not yet available for this analysis, preliminary design data was used to inform sizing of a Sanden system for this prototype. The system used 10 heat pump water heaters (Sanden GS3-45HPA-US units), 800 gallons of storage, and a 200 gallon electric resistance swing tank.

Table 6 reports costs for the central heat pump water heating systems relative to a gas boiler system with solar thermal that meets the prescriptive requirements of 20% solar fraction in Climate Zones 1 through 9 and 35% solar fraction in Climate Zones 10 through 16. Costs include equipment and labor, gas piping within the building for the boiler system, and additional electrical service necessary for the heat pump system. Replacement costs are based on an effective useful life of 15 years for the water heaters and tanks, and 20 years for the solar thermal collectors. For the solar thermal systems, it's also assumed that the glycol is replaced at years 9, 18 and 27. Additional details on cost assumptions are presented in Appendix 7.3 Cost Details.

**Table 6. Heat Pump Water Heater Incremental System Costs (Present Value (2023\$))**

Item		3-Story		5-Story		Source & Notes
		Central Gas Boiler	Central Heat Pump	Central Gas Boiler	Central Heat Pump	
First Cost	CZs 1-9	\$173,772	\$211,531	\$279,163	\$343,920	3-story costs directly from 2022 Multifamily All-Electric CASE Report. 5-story costs estimated based on component costs for the 3-story from the CASE report.
	CZs 10-16	\$182,810		\$300,883		
Replacement Cost	CZs 1-9	\$32,297	\$44,263	\$59,930	\$110,659	
	CZs 10-16	\$36,943		\$69,361		
<b>Total Incremental Cost</b>	<b>CZs 1-9</b>		<b>\$49,725</b>		<b>\$115,486</b>	
	<b>CZs 10-16</b>	n/a	<b>\$36,041</b>	n/a	<b>\$84,335</b>	
<b>Incremental Cost per Dwelling Unit</b>	<b>CZs 1-9</b>		<b>\$1,381</b>		<b>\$1,312</b>	
	<b>CZs 10-16</b>		<b>\$1,001</b>		<b>\$958</b>	

### 3.2.2.2 Space Heating

Table 7 presents the costs for heat pump space heater conversion from gas equipment. In most climate zones the baseline per the 2022 Energy Code is a heat pump space heater, so these costs are only applied in a couple of instances. For the 3-story prototype the baseline in Climate Zone 16 is a gas furnace and air conditioner. For the 5-story prototype the baseline in Climate Zones 1 and 16 is a dual fuel heat pump with a gas furnace as backup. Costs include equipment and labor, gas piping within the building for the boiler system, and additional electrical service necessary for the heat pump system. Most of the cost difference between the two systems is attributed to higher labor costs to install the gas system as a result of gas piping and venting. Additional details on cost assumptions are presented in Appendix 7.3 Cost Details.

**Table 7. Heat Pump Space Heater Costs per Dwelling Unit (Present Value (2023\$))**

Item	3-Story		5-Story		Source & Notes
	Furnace + Split AC	Heat Pump	Furnace + Split HP	Heat Pump	
First Cost	\$20,667	\$16,776	\$21,245	\$16,597	Costs largely based on the 2022 Multifamily All-Electric CASE Report with some updates to reflect online equipment cost research and labor cost alignments.
Replacement Cost	\$8,059	\$7,326	\$9,052	\$7,326	See lifetimes referenced in Table 8.
Residual Value	(\$1,591)	\$0	\$0	\$0	Residual value at the end of the 30-year analysis period was accounted for to represent the remaining life of any equipment.
<b>Total</b>	<b>\$27,135</b>	<b>\$24,102</b>	<b>\$30,296</b>	<b>\$23,924</b>	
<b>Incremental Cost</b>		<b>(\$3,032)</b>		<b>(\$6,373)</b>	

Equipment lifetimes applied in this analysis for the space conditioning measures are summarized in Table 8. The lifetime for the heat pump, furnace, and air conditioner are based on the Database for Energy Efficient Resources (DEER) (California Public Utilities Commission, 2021b). In DEER, heat pump and air conditioner measures are assigned an effective useful lifetime (EUL) of 15 years and a furnace an EUL of 20 years. The heating and cooling system components are typically replaced at the same time when one reaches the end of its life and the other is near

it. Therefore, it is assumed that both the furnace and air conditioner are replaced at the same time at year 17.5, halfway between 15 and 20 years. For HVAC system costing, air-conditioning is included in all cases in both the base case and proposed models.

**Table 8. Lifetime of Water Heating & Space Conditioning Equipment Measures**

Measure	Lifetime
Gas Furnace	17.5
Air Conditioner	17.5
Heat Pump	15
Dual Fuel Heat Pump	15

### 3.2.2.3 Natural Gas Infrastructure

Eliminating natural gas to a building saves costs associated with connecting a service line from the street main to the building, piping distribution within the building, and monthly meter customer charges from the utility. This section focuses on the first item, not connecting gas service to the building. The latter two are captured in the appliance costs and the utility bill analysis. Cost savings for removing natural gas infrastructure to a multifamily building in IOU territory are presented in Table 9 and Table 10. These costs are applied as cost savings for the all-electric case when compared to the mixed fuel baseline.

These costs are project dependent and may be significantly impacted by such factors as utility territory, site characteristics, distance to the nearest natural gas main and main location, joint trenching, whether work is conducted by the utility or a private contractor, and number of dwelling units per development. All gas utilities participating in this study were solicited for cost information.

**Service Extension:** Service extension costs to the building were taken from a PG&E memo dated December 5, 2019 to Energy Commission staff (see Appendix 7.4 PG&E Gas Infrastructure Cost Memo for a copy of the memo). The estimated cost of \$6,750 excludes costs for trenching and assumes nonresidential new construction within a developed area. For the 5-story building the cost is apportioned between the residential and nonresidential spaces in the building based on associated conditioned floor areas where 84 percent is residential. All of the spaces in the 3-story building are residential based.

Today, total costs are reduced to account for deductions per the Utility Gas Main Extensions rules.<sup>7</sup> These rules categorize distribution line extensions as “refundable” costs, which are offset or subsidized by all other ratepayers. The CPUC issued a Decision in September 2022 that eliminates the subsidies effective July 1, 2023 (California Public Utilities Commission, 2022). Since most of the development that will occur during the three-year 2022 code cycle (2023-2025) will not be subject to these deduction allowances they are not included in this analysis.

**Meter:** Cost per meter provided by PG&E of \$3,600 for a commercial meter to serve the central water heating and \$600 per multifamily dwelling unit. The \$600 dwelling unit meter is only applied in Climate Zone 16 for the 3-story prototype and Climate Zones 1 and 16 for the 5-story prototypes where gas is used either for primary or backup space heating. Two scenarios are presented in the tables. One is the case with electric space heating, no in-unit gas and the only residential gas use is to serve the central water heating system. The other case represents the scenario where there is in-unit gas to service space heating.

<sup>7</sup> PG&E Rule 15: [https://www.pge.com/tariffs/assets/pdf/tariffbook/GAS\\_RULES\\_15.pdf](https://www.pge.com/tariffs/assets/pdf/tariffbook/GAS_RULES_15.pdf).  
 SoCalGas Rule 20: <https://www.socalgas.com/regulatory/tariffs/tm2/pdf/20.pdf>.  
 SDG&E Rule 15: [https://tariff.sdge.com/tm2/pdf/GAS\\_GAS-RULES\\_GRULE15.pdf](https://tariff.sdge.com/tm2/pdf/GAS_GAS-RULES_GRULE15.pdf).

**Natural Gas Plan Review:** Total costs are based on TRC’s 2019 reach code analysis for Palo Alto (TRC, 2018 ). The cost for the 5-story prototype is apportioned between the residential and nonresidential spaces in the building in the same way as was done for the service extension costs.

**Table 9. IOU Natural Gas Infrastructure Cost Savings for All-Electric Building**

Item		3-Story	5-Story
Service Extension		\$6,750	\$5,695
Meter	No In-Unit Gas (Gas DHW only)	\$3,600	\$3,600
	In-Unit Gas	\$25,200	\$56,400
Plan Review		\$2,316	\$1,954

**Table 10. Multifamily IOU Total Natural Gas Infrastructure Costs**

Prototype	Scenario	Total Building	Per Dwelling Unit
3-Story	No In-Unit Gas	\$12,666	\$352
	In-Unit Gas	\$34,266	\$952
5-Story	No In-Unit Gas	\$11,248	\$128
	In-Unit Gas	\$64,048	\$728

CPAU provides gas service to its customers and therefore separate costs were evaluated based on CPAU gas service connection fees.<sup>8</sup> Table 11 presents the breakdown of gas infrastructure costs used in this analysis for CPAU. The same approach to apportioning the total building costs to the residential spaces as described in the IOU section was applied here for the service extension and plan review costs for the 5-story prototype. Meter costs were based on \$1,772 for an 800 cubic foot per hour commercial meter for the central water heating system.

**Table 11. Multifamily CPAU Total Natural Gas Infrastructure Costs**

Item	3-Story	5-Story
Service Extension	\$5,892	\$4,971
Meter	\$1,772	\$1,772
Plan Review	\$2,557	\$2,157

### 3.3 Measure Packages

The Reach Codes Team evaluated three packages for mixed fuel homes and five packages for all-electric homes for each prototype and climate zone, as described below.

1. All-Electric Prescriptive Code: This package meets all the prescriptive requirements of the 2022 Energy Code.
2. All-Electric Prescriptive Code + PV: Using the code minimum package as a starting point, PV capacity was added to offset 100 percent of the estimated annual electricity use.
3. Mixed Fuel Efficiency Only: This package uses only efficiency measures that do not trigger federal preemption including envelope and duct distribution efficiency measures.

<sup>8</sup> CPAU Schedule G-5 effective 09-01-2019: <https://www.cityofpaloalto.org/files/assets/public/utilities/utilities-engineering/general-specifications/gas-service-connection-fees.pdf>

4. Mixed Fuel Efficiency + PV + Battery: Using the Efficiency Package as a starting point, PV capacity was added to offset 100 percent of the estimated annual electricity use. A battery system was also added. This package only applies to the 3-story prototype. The 5-story prototype includes a battery system in the baseline per the 2022 prescriptive requirements.
5. Mixed Fuel Efficiency + PV: Using the Efficiency Package as a starting point, PV capacity was added to offset 100 percent of the estimated annual electricity use. This package only applies to the 5-story prototype.

## 4 Results

Cost-effectiveness results are presented per prototype and measure packages described in Section 3.3. The TDV and On-Bill based cost-effectiveness results are presented in terms of B/C ratio and NPV. Energy savings, compliance margin, utility bill savings, and incremental costs are also shown.

In the following figures, **green** highlighting indicates that the case is cost-effective with a B/C ratio greater than or equal to 1 and a NPV greater than or equal to 0. **Red** highlighting indicates the case is not cost-effective.

Compliance margins are presented as percentages both for the efficiency TDV and the source energy metrics. A compliance margin that is equal to or greater than 0 indicates the case is code compliant.

### 4.1 All-Electric Prescriptive Code

Table 12 and Table 13 shows results for the multifamily all-electric prescriptive code case compared to the 2022 baseline. For both prototypes this scenario is cost-effective based on TDV in all climate zones. This scenario is only On-Bill cost-effective in a few climate zones. The 3-story all-electric case is cost-effective On-Bill in Climate Zones 1 through 3, 4 in CPAU territory, 12 in SMUD territory, and 16. The 5-story all-electric case is cost-effective On-Bill in Climate Zones 1, 4, 12 in SMUD territory, and 16.

In most cases there is a small net increase in utility cost in the first year.

There is an incremental cost for the central heat pump water heater ranging from \$361 to \$697 per dwelling unit.

The all-electric packages applied to the 3-story prototype in Climate Zone 16 and the 5-story prototype in Climate Zones 1 and 16 incorporate both gas to electric water heating and gas to electric space heating measures. In these cases, there are significant cost savings due to the avoided first costs of installing a gas furnace as compared to a heat pump. As a result, these cases are On-Bill cost-effective.

These results reflect a CO<sub>2</sub> refrigerant based central heat pump water heating system. The 5-story prototype was also evaluated with a R-134a refrigerant based central heat pump water heater and these results are shown in Appendix 7.5 Central Heat Pump Water Heater Comparison.

Table 12. 3-Story Cost-Effectiveness Results per Dwelling Unit: All-Electric Prescriptive Code

Climate Zone	Electric /Gas Utility	Efficiency TDV Comp Margin	Source Comp Margin	Annual Elec Savings (kWh)	Annual Gas Savings (therms)	Utility Cost Savings		Incremental Cost		On-Bill		TDV	
						First Year	Lifecycle (2022\$)	First Year	Lifecycle (2022\$)	B/C Ratio	NPV	B/C Ratio	NPV
CZ01	PGE	26%	15%	-904	135	(\$19)	\$1,676	\$97	\$429	3.9	\$1,247	>1	\$4,158
CZ02	PGE	20%	11%	-801	115	(\$30)	\$1,061	\$697	\$1,029	1.0	\$32	9.9	\$2,998
CZ03	PGE	21%	10%	-789	115	(\$26)	\$1,148	\$697	\$1,029	1.1	\$119	9.9	\$2,990
CZ04	PGE	18%	9%	-759	109	(\$31)	\$922	\$697	\$1,029	0.9	(\$108)	9.2	\$2,767
CZ04	CPAU	18%	9%	-759	109	\$233	\$8,191	\$765	\$1,097	7.5	\$7,094	7.7	\$2,700
CZ05	PGE	23%	9%	-789	112	(\$30)	\$1,009	\$697	\$1,029	0.98	(\$21)	9.3	\$2,782
CZ05	PGE/SCG	23%	9%	-789	112	(\$79)	(\$515)	\$697	\$1,029	0.0	(\$1,545)	9.3	\$2,782
CZ06	SCE/SCG	18%	7%	-709	100	(\$61)	(\$226)	\$697	\$1,029	0.0	(\$1,255)	8.6	\$2,551
CZ07	SDGE	20%	8%	-704	102	(\$69)	(\$427)	\$697	\$1,029	0.0	(\$1,456)	9.1	\$2,712
CZ08	SCE/SCG	13%	6%	-689	96	(\$61)	(\$302)	\$697	\$1,029	0.0	(\$1,331)	8.2	\$2,432
CZ09	SCE	13%	5%	-698	96	(\$64)	(\$351)	\$697	\$1,029	0.0	(\$1,380)	8.0	\$2,363
CZ10	SCE/SCG	14%	7%	-701	83	(\$88)	(\$1,109)	\$446	\$649	0.0	(\$1,758)	>1	\$1,959
CZ10	SDGE	14%	7%	-701	83	(\$112)	(\$1,803)	\$446	\$649	0.0	(\$2,452)	>1	\$1,959
CZ11	PGE	14%	10%	-740	91	(\$64)	(\$177)	\$446	\$649	0.0	(\$826)	>1	\$2,212
CZ12	PGE	17%	11%	-755	94	(\$62)	(\$70)	\$446	\$649	0.0	(\$719)	>1	\$2,297
CZ12	SMUD/PGE	17%	11%	-755	94	\$68	\$2,942	\$446	\$649	4.5	\$2,293	>1	\$2,297
CZ13	PGE	13%	9%	-717	86	(\$65)	(\$291)	\$446	\$649	0.0	(\$940)	>1	\$2,050
CZ14	SCE/SCG	13%	7%	-748	83	(\$102)	(\$1,413)	\$446	\$649	0.0	(\$2,063)	>1	\$1,759
CZ14	SDGE	13%	7%	-748	83	(\$128)	(\$2,191)	\$446	\$649	0.0	(\$2,841)	>1	\$1,759
CZ15	SCE/SCG	5%	2%	-607	64	(\$89)	(\$1,403)	\$446	\$649	0.0	(\$2,053)	>1	\$1,305
CZ16	PG&E	24%	29%	-1,928	185	(\$178)	(\$1,066)	(\$4,045)	(\$2,983)	2.8	\$1,917	>1	\$4,352

Table 13. 5-Story Cost-Effectiveness Results per Dwelling Unit: All-Electric Prescriptive Code

Climate Zone	Electric /Gas Utility	Efficiency TDV Comp Margin	Source Comp Margin	Annual Elec Savings (kWh)	Annual Gas Savings (therms)	Utility Cost Savings		Incremental Cost		On-Bill		TDV	
						First Year	Lifecycle (2022\$)	First Year	Lifecycle (2022\$)	B/C Ratio	NPV	B/C Ratio	NPV
CZ01	PGE	14%	9%	-1,146	147	(\$49)	\$1,209	(\$4,639)	(\$5,788)	>1	\$6,998	>1	\$9,816
CZ02	PGE	9%	6%	-888	120	(\$45)	\$809	\$608	\$1,185	0.7	(\$375)	3.0	\$2,270
CZ03	PGE	11%	7%	-874	120	(\$46)	\$778	\$608	\$1,185	0.7	(\$407)	3.1	\$2,421
CZ04	PGE	9%	6%	-824	113	\$18	\$2,130	\$608	\$1,185	1.8	\$945	3.1	\$2,393
CZ04	CPAU	9%	6%	-824	113	\$230	\$8,205	\$635	\$1,211	6.8	\$6,994	3.0	\$2,367
CZ05	PGE	12%	6%	-871	117	(\$47)	\$706	\$608	\$1,185	0.6	(\$479)	2.8	\$2,065
CZ05	PGE/SCG	12%	6%	-871	117	(\$99)	(\$919)	\$608	\$1,185	0.0	(\$2,103)	2.8	\$2,065
CZ06	SCE/SCG	9%	5%	-739	104	(\$10)	\$986	\$608	\$1,185	0.8	(\$199)	2.9	\$2,183
CZ07	SDGE	11%	6%	-735	106	(\$74)	(\$500)	\$608	\$1,185	0.0	(\$1,685)	2.9	\$2,215
CZ08	SCE/SCG	8%	4%	-710	100	(\$79)	(\$644)	\$608	\$1,185	0.0	(\$1,829)	3.0	\$2,259
CZ09	SCE	7%	4%	-725	100	(\$53)	(\$51)	\$608	\$1,185	0.0	(\$1,236)	3.0	\$2,274
CZ10	SCE/SCG	7%	4%	-729	84	(\$111)	(\$1,615)	\$361	\$831	0.0	(\$2,445)	2.7	\$1,374
CZ10	SDGE	7%	4%	-729	84	(\$137)	(\$2,404)	\$361	\$831	0.0	(\$3,234)	2.7	\$1,374
CZ11	PGE	8%	5%	-790	92	(\$86)	(\$663)	\$361	\$831	0.0	(\$1,494)	3.1	\$1,656
CZ12	PGE	9%	6%	-809	96	(\$83)	(\$527)	\$361	\$831	0.0	(\$1,358)	3.0	\$1,620
CZ12	SMUD/PGE	9%	6%	-809	96	\$62	\$2,831	\$361	\$831	3.4	\$2,000	3.0	\$1,620
CZ13	PGE	7%	5%	-754	88	(\$83)	(\$686)	\$361	\$831	0.0	(\$1,517)	3.0	\$1,570
CZ14	SCE/SCG	6%	3%	-803	84	(\$131)	(\$2,085)	\$361	\$831	0.0	(\$2,916)	2.2	\$928
CZ14	SDGE	6%	3%	-803	84	(\$165)	(\$3,106)	\$361	\$831	0.0	(\$3,937)	2.2	\$928
CZ15	SCE/SCG	3%	1%	-602	65	(\$105)	(\$1,775)	\$361	\$831	0.0	(\$2,606)	1.9	\$695
CZ16	PG&E	9%	11%	-1,388	142	(\$127)	(\$675)	(\$4,886)	(\$6,142)	9.1	\$5,467	>1	\$6,704

## 4.2 All-Electric Plus PV

Table 14 and Table 15 present cost-effectiveness results for the all-electric plus PV packages for the 3-story and 5-story prototypes, respectively. All cases are cost-effective both On-Bill and based on TDV.

**Table 14. 3-Story Cost-Effectiveness Results per Dwelling Unit: All-Electric 100% PV**

Climate Zone	Electric /Gas Utility	Efficiency TDV Comp Margin	Source Comp Margin	Annual Elec Savings (kWh)	Annual Gas Savings (therms)	Utility Cost Savings		Incremental Cost		On-Bill		TDV	
						First Year	Lifecycle (2022\$)	First Year	Lifecycle (2022\$)	B/C Ratio	NPV	B/C Ratio	NPV
CZ01	PGE	26%	24%	2,127	135	\$782	\$20,242	\$3,638	\$5,034	4.0	\$15,208	3.2	\$9,448
CZ02	PGE	20%	20%	1,835	115	\$653	\$16,910	\$3,294	\$4,406	3.8	\$12,504	3.3	\$8,632
CZ03	PGE	21%	20%	1,711	115	\$614	\$15,998	\$3,076	\$4,123	3.9	\$11,875	3.4	\$8,209
CZ04	PGE	18%	18%	1,558	109	\$559	\$14,587	\$2,841	\$3,818	3.8	\$10,770	3.6	\$8,230
CZ04	CPAU	18%	18%	1,558	109	\$489	\$14,138	\$2,909	\$3,886	3.6	\$10,253	3.6	\$8,162
CZ05	PGE	23%	20%	1,604	112	\$579	\$15,137	\$2,826	\$3,798	4.0	\$11,338	3.6	\$8,026
CZ05	PGE/SCG	23%	20%	1,604	112	\$531	\$13,613	\$2,826	\$3,798	3.6	\$9,814	3.6	\$8,026
CZ06	SCE/SCG	18%	17%	1,207	100	\$378	\$9,795	\$2,364	\$3,197	3.1	\$6,598	3.8	\$7,092
CZ07	SDGE	20%	21%	1,528	102	\$723	\$19,318	\$2,777	\$3,734	5.2	\$15,584	3.5	\$7,623
CZ08	SCE/SCG	13%	17%	1,393	96	\$426	\$10,842	\$2,569	\$3,464	3.1	\$7,378	3.9	\$7,908
CZ09	SCE	13%	15%	1,204	96	\$379	\$9,756	\$2,335	\$3,160	3.1	\$6,596	3.9	\$7,158
CZ10	SCE/SCG	14%	18%	1,381	83	\$404	\$10,130	\$2,237	\$2,978	3.4	\$7,152	4.1	\$7,031
CZ10	SDGE	14%	18%	1,381	83	\$621	\$16,493	\$2,237	\$2,978	5.5	\$13,514	4.1	\$7,031
CZ11	PGE	14%	19%	1,843	91	\$625	\$15,782	\$2,940	\$3,893	4.1	\$11,889	3.4	\$7,748
CZ12	PGE	17%	19%	1,704	94	\$579	\$14,777	\$2,756	\$3,654	4.0	\$11,124	3.6	\$7,607
CZ12	SMUD/PGE	17%	19%	1,704	94	\$399	\$10,615	\$2,756	\$3,654	2.9	\$6,961	3.6	\$7,607
CZ13	PGE	13%	17%	1,572	86	\$544	\$13,822	\$2,567	\$3,408	4.1	\$10,415	3.6	\$7,148
CZ14	SCE/SCG	13%	18%	1,572	83	\$449	\$11,152	\$2,300	\$3,060	3.6	\$8,092	4.2	\$7,668
CZ14	SDGE	13%	18%	1,572	83	\$688	\$18,158	\$2,300	\$3,060	5.9	\$15,098	4.2	\$7,668
CZ15	SCE/SCG	5%	11%	1,163	64	\$330	\$8,164	\$1,966	\$2,626	3.1	\$5,539	3.9	\$5,567
CZ16	PG&E	24%	38%	1,371	185	\$700	\$19,307	(\$1,064)	\$894	21.6	\$18,412	58.9	\$11,596

Table 15. 5-Story Cost-Effectiveness Results per Dwelling Unit: All-Electric 100% PV

Climate Zone	Electric /Gas Utility	Efficiency TDV Comp Margin	Source Comp Margin	Annual Elec Savings (kWh)	Annual Gas Savings (therms)	Utility Cost Savings		Incremental Cost		On-Bill		TDV	
						First Year	Lifecycle (2022\$)	First Year	Lifecycle (2022\$)	B/C Ratio	NPV	B/C Ratio	NPV
CZ01	PGE	14%	21%	1,437	147	\$629	\$16,919	(\$1,574)	(\$1,803)	>1	\$18,721	>1	\$18,222
CZ02	PGE	9%	14%	428	120	\$262	\$7,918	\$1,930	\$2,904	2.7	\$5,015	4.0	\$8,679
CZ03	PGE	11%	16%	682	120	\$327	\$9,417	\$2,121	\$3,152	3.0	\$6,265	4.0	\$9,285
CZ04	PGE	9%	13%	92	113	\$207	\$6,524	\$1,476	\$2,313	2.8	\$4,211	4.1	\$7,054
CZ04	CPAU	9%	13%	92	113	\$337	\$10,667	\$1,502	\$2,340	4.6	\$8,327	4.0	\$7,027
CZ05	PGE	12%	16%	451	117	\$259	\$7,806	\$1,815	\$2,754	2.8	\$5,052	4.0	\$8,096
CZ05	PGE/SCG	12%	16%	451	117	\$207	\$6,182	\$1,815	\$2,754	2.2	\$3,427	4.0	\$8,096
CZ06	SCE/SCG	9%	12%	-163	104	\$98	\$3,449	\$1,127	\$1,859	1.9	\$1,590	3.8	\$5,035
CZ07	SDGE	11%	15%	74	106	\$192	\$6,131	\$1,387	\$2,198	2.8	\$3,934	3.9	\$6,204
CZ08	SCE/SCG	8%	14%	265	100	\$154	\$4,666	\$1,516	\$2,365	2.0	\$2,301	4.0	\$7,053
CZ09	SCE	7%	12%	60	100	\$122	\$3,930	\$1,307	\$2,093	1.9	\$1,837	3.7	\$5,636
CZ10	SCE/SCG	7%	13%	289	84	\$131	\$3,912	\$1,266	\$2,007	1.9	\$1,905	3.9	\$5,749
CZ10	SDGE	7%	13%	289	84	\$238	\$6,951	\$1,266	\$2,007	3.5	\$4,945	3.9	\$5,749
CZ11	PGE	8%	17%	1,091	92	\$417	\$10,990	\$2,226	\$3,256	3.4	\$7,734	4.2	\$10,472
CZ12	PGE	9%	16%	594	96	\$263	\$7,487	\$1,712	\$2,587	2.9	\$4,901	4.3	\$8,544
CZ12	SMUD/PGE	9%	16%	594	96	\$260	\$7,419	\$1,712	\$2,587	2.9	\$4,889	4.3	\$8,544
CZ13	PGE	7%	17%	1,036	88	\$398	\$10,479	\$2,064	\$3,045	3.4	\$7,434	4.2	\$9,715
CZ14	SCE/SCG	6%	11%	182	84	\$102	\$3,250	\$1,170	\$1,883	1.7	\$1,368	4.0	\$5,515
CZ14	SDGE	6%	11%	182	84	\$194	\$5,858	\$1,170	\$1,883	3.1	\$3,975	4.0	\$5,515
CZ15	SCE/SCG	3%	10%	387	65	\$153	\$4,119	\$1,238	\$1,971	2.1	\$2,148	3.6	\$4,998
CZ16	PG&E	9%	23%	1,007	142	\$501	\$13,864	(\$2,682)	(\$3,275)	>1	\$17,139	>1	\$16,140

### 4.3 Mixed Fuel Efficiency

Table 16 and Table 17 show results for the Mixed Fuel Efficiency packages. The packages are cost-effective based on at least one of the two metrics in Climate Zones 1, 2, 4, and 8 through 16 for the 3-story prototype and in Climate Zones 2, 4, 6, and 8 through 15 for the 5-story prototype. In all cases the NPV values, whether negative or positive, are small. The compliance impacts are also small.

A summary of measures included in each package is provided in Appendix 7.6 Summary of Measures by Package.

**Table 16. 3-Story Cost-Effectiveness Results per Dwelling Unit: Mixed Fuel Efficiency**

Climate Zone	Electric /Gas Utility	Efficiency TDV Comp Margin	Source Comp Margin	Annual Elec Savings (kWh)	Annual Gas Savings (therms)	Utility Cost Savings		Incremental Cost		On-Bill		TDV	
						First Year	Lifecycle (2022\$)	First Year	Lifecycle (2022\$)	B/C Ratio	NPV	B/C Ratio	NPV
CZ01	PGE	1%	1%	41	0	\$12	\$273	\$176	\$176	1.6	\$98	1.2	\$38
CZ02	PGE	1%	0%	24	0	\$7	\$162	\$132	\$132	1.2	\$30	1.5	\$62
CZ03	PGE	1%	0%	17	0	\$5	\$111	\$132	\$132	0.8	(\$21)	0.8	(\$27)
CZ04	PGE	1%	0%	21	0	\$6	\$141	\$132	\$132	1.1	\$9	1.3	\$46
CZ04	CPAU	1%	0%	21	0	\$3	\$74	\$132	\$132	0.6	(\$58)	1.3	\$46
CZ05	PGE	1%	0%	19	0	\$5	\$123	\$132	\$132	0.9	(\$9)	0.8	(\$32)
CZ05	PGE/SCG	1%	0%	19	0	\$5	\$123	\$132	\$132	0.9	(\$9)	0.8	(\$32)
CZ06	SCE/SCG	1%	0%	9	0	\$2	\$56	\$132	\$132	0.4	(\$75)	0.7	(\$44)
CZ07	SDGE	0%	0%	7	0	\$3	\$72	\$132	\$132	0.5	(\$60)	0.4	(\$81)
CZ08	SCE/SCG	1%	0%	20	0	\$6	\$140	\$132	\$132	1.1	\$9	1.5	\$59
CZ09	SCE	1%	0%	28	0	\$8	\$192	\$146	\$156	1.2	\$36	1.6	\$88
CZ10	SCE/SCG	3%	1%	65	0	\$20	\$447	\$190	\$199	2.2	\$247	2.4	\$277
CZ10	SDGE	3%	1%	65	0	\$27	\$683	\$190	\$199	3.4	\$484	2.4	\$277
CZ11	PGE	3%	1%	91	0	\$30	\$699	\$190	\$199	3.5	\$499	3.5	\$489
CZ12	PGE	2%	0%	98	0	\$33	\$766	\$381	\$514	1.5	\$252	1.5	\$273
CZ12	SMUD/PGE	2%	0%	98	0	\$17	\$396	\$381	\$514	0.8	(\$118)	1.5	\$273
CZ13	PGE	4%	1%	99	0	\$33	\$765	\$190	\$199	3.8	\$566	3.9	\$574
CZ14	SCE/SCG	3%	1%	88	0	\$26	\$585	\$190	\$199	2.9	\$385	3.1	\$427
CZ14	SDGE	3%	1%	88	0	\$36	\$886	\$190	\$199	4.4	\$686	3.1	\$427
CZ15	SCE/SCG	5%	2%	182	0	\$54	\$1,226	\$190	\$199	6.1	\$1,026	5.8	\$957
CZ16	PG&E	5%	4%	16	12	\$34	\$1,012	\$712	\$712	1.4	\$300	1.3	\$184

**Table 17. 5-Story Cost-Effectiveness Results per Dwelling Unit: Mixed Fuel Efficiency**

Climate Zone	Electric /Gas Utility	Efficiency TDV Comp Margin	Source Comp Margin	Annual Elec Savings (kWh)	Annual Gas Savings (therms)	Utility Cost Savings		Incremental Cost		On-Bill		TDV	
						First Year	Lifecycle (2022\$)	First Year	Lifecycle (2022\$)	B/C Ratio	NPV	B/C Ratio	NPV
CZ01	PGE	0%	0%	5	0	\$2	\$39	\$176	\$176	0.2	(\$137)	0.2	(\$136)
CZ02	PGE	1%	0%	11	0	\$2	\$38	\$132	\$132	0.3	(\$94)	1.9	\$118
CZ03	PGE	0%	0%	7	0	\$2	\$46	\$132	\$132	0.3	(\$86)	0.8	(\$23)
CZ04	PGE	1%	0%	12	0	\$2	\$40	\$132	\$132	0.3	(\$92)	1.9	\$114
CZ04	CPAU	1%	0%	12	0	\$2	\$39	\$132	\$132	0.3	(\$93)	1.9	\$114
CZ05	PGE	0%	0%	6	0	\$1	\$17	\$132	\$132	0.1	(\$114)	0.4	(\$73)
CZ05	PGE/SCG	0%	0%	6	0	\$1	\$17	\$132	\$132	0.1	(\$114)	0.4	(\$73)
CZ06	SCE/SCG	0%	0%	12	0	\$2	\$51	\$132	\$132	0.4	(\$81)	1.4	\$49
CZ07	SDGE	0%	0%	10	0	\$0	\$0	\$132	\$132	0.0	(\$132)	0.9	(\$7)
CZ08	SCE/SCG	1%	0%	24	0	\$8	\$184	\$132	\$132	1.4	\$53	2.2	\$152
CZ09	SCE	1%	0%	28	0	\$4	\$96	\$142	\$149	0.6	(\$52)	2.1	\$163
CZ10	SCE/SCG	2%	1%	66	0	\$21	\$491	\$186	\$192	2.6	\$298	3.2	\$425
CZ10	SDGE	2%	1%	66	0	\$30	\$751	\$186	\$192	3.9	\$558	3.2	\$425
CZ11	PGE	2%	1%	83	0	\$29	\$665	\$186	\$192	3.5	\$473	4.2	\$621
CZ12	PGE	2%	0%	84	0	\$29	\$681	\$321	\$414	1.6	\$267	2.3	\$546
CZ12	SMUD/PGE	2%	0%	84	0	\$16	\$372	\$321	\$414	0.9	(\$42)	2.3	\$546
CZ13	PGE	2%	1%	95	0	\$33	\$765	\$186	\$192	4.0	\$573	4.9	\$742
CZ14	SCE/SCG	2%	1%	75	0	\$11	\$246	\$186	\$192	1.3	\$54	3.9	\$561
CZ14	SDGE	2%	1%	75	0	\$34	\$847	\$186	\$192	4.4	\$654	3.9	\$561
CZ15	SCE/SCG	3%	2%	172	0	\$55	\$1,257	\$186	\$192	6.5	\$1,065	7.3	\$1,212
CZ16	PG&E	2%	2%	40	4	\$23	\$616	\$665	\$665	0.9	(\$49)	0.999	(\$0)

#### 4.4 Mixed Fuel Plus PV (Plus Battery for the 3-Story Prototype)

Table 18 presents the Mixed Fuel Efficiency + PV + Battery package for the 3-story prototype. The battery system is a 100kWh battery. This scenario is cost-effective for all climate zones and under both metrics except for On-Bill in Climate Zone 4 in CPAU territory. Table 19 presents the Mixed Fuel Efficiency + PV package for the 5-story prototype. This package is cost-effective under TDV in all climate zones and cost-effective On-Bill everywhere except in Climate Zones 6 and 7. In the cases where it is not cost-effective, it is very close to being so with small negative NPV. In Climate Zone 6 in the 5-story prototype there is no upgrade to the PV system capacity as the prescriptive PV system already offset all of the estimated electricity use.

Table 18. 3-Story Cost-Effectiveness Results per Dwelling Unit: Mixed Fuel Efficiency + PV + Battery

Climate Zone	Electric /Gas Utility	Efficiency TDV Comp Margin	Source Comp Margin	Annual Elec Savings (kWh)	Annual Gas Savings (therms)	Utility Cost Savings		Incremental Cost		On-Bill		TDV	
						First Year	Lifecycle (2022\$)	First Year	Lifecycle (2022\$)	B/C Ratio	NPV	B/C Ratio	NPV
CZ01	PGE	1%	16%	2,068	0	\$543	\$12,588	\$4,603	\$6,917	1.8	\$5,671	1.5	\$3,724
CZ02	PGE	1%	16%	1,757	0	\$462	\$10,718	\$3,881	\$5,990	1.8	\$4,728	1.6	\$3,820
CZ03	PGE	1%	17%	1,624	0	\$423	\$9,797	\$3,700	\$5,754	1.7	\$4,043	1.5	\$3,157
CZ04	PGE	1%	17%	1,476	0	\$383	\$8,878	\$3,518	\$5,518	1.6	\$3,360	1.6	\$3,067
CZ04	CPAU	1%	17%	1,476	0	\$171	\$3,967	\$3,518	\$5,518	0.7	(\$1,551)	1.6	\$3,067
CZ05	PGE	1%	18%	1,520	0	\$393	\$9,107	\$3,503	\$5,498	1.7	\$3,609	1.6	\$3,526
CZ05	PGE/SCG	1%	18%	1,520	0	\$393	\$9,107	\$3,503	\$5,498	1.7	\$3,609	1.6	\$3,526
CZ06	SCE/SCG	1%	18%	1,112	0	\$336	\$7,677	\$3,127	\$5,009	1.5	\$2,668	1.4	\$1,917
CZ07	SDGE	0%	20%	1,431	0	\$550	\$13,713	\$3,498	\$5,493	2.5	\$8,220	1.6	\$3,159
CZ08	SCE/SCG	1%	18%	1,311	0	\$413	\$9,427	\$3,328	\$5,270	1.8	\$4,156	1.4	\$2,277
CZ09	SCE	1%	17%	1,129	0	\$367	\$8,375	\$3,129	\$5,017	1.7	\$3,359	1.4	\$1,937
CZ10	SCE/SCG	3%	19%	1,342	0	\$420	\$9,584	\$3,321	\$5,254	1.8	\$4,331	1.5	\$2,588
CZ10	SDGE	3%	19%	1,342	0	\$533	\$13,303	\$3,321	\$5,254	2.5	\$8,049	1.5	\$2,588
CZ11	PGE	3%	17%	1,833	0	\$500	\$11,587	\$3,914	\$6,025	1.9	\$5,562	1.6	\$3,852
CZ12	PGE	2%	17%	1,701	0	\$442	\$10,239	\$3,926	\$6,105	1.7	\$4,133	1.6	\$3,583
CZ12	SMUD/PGE	2%	17%	1,701	0	\$285	\$6,609	\$3,926	\$6,105	1.1	\$503	1.6	\$3,583
CZ13	PGE	4%	17%	1,568	0	\$431	\$9,983	\$3,594	\$5,609	1.8	\$4,374	1.7	\$3,944
CZ14	SCE/SCG	3%	19%	1,556	0	\$477	\$10,886	\$3,388	\$5,341	2.0	\$5,545	1.6	\$3,434
CZ14	SDGE	3%	19%	1,556	0	\$607	\$15,155	\$3,388	\$5,341	2.8	\$9,815	1.6	\$3,434
CZ15	SCE/SCG	5%	19%	1,241	0	\$421	\$9,616	\$3,136	\$5,013	1.9	\$4,603	1.6	\$3,076
CZ16	PG&E	5%	17%	1,286	12	\$357	\$8,508	\$3,894	\$5,833	1.5	\$2,674	1.6	\$3,219

Table 19. 5-Story Cost-Effectiveness Results per Dwelling Unit: Mixed Fuel Efficiency + PV

Climate Zone	Electric /Gas Utility	Efficiency TDV Comp Margin	Source Comp Margin	Annual Elec Savings (kWh)	Annual Gas Savings (therms)	Utility Cost Savings		Incremental Cost		On-Bill		TDV	
						First Year	Lifecycle (2022\$)	First Year	Lifecycle (2022\$)	B/C Ratio	NPV	B/C Ratio	NPV
CZ01	PGE	0%	5%	1,446	0	\$341	\$7,917	\$1,889	\$2,403	3.3	\$5,514	3.0	\$4,757
CZ02	PGE	1%	2%	444	0	\$55	\$1,275	\$567	\$697	1.8	\$578	4.4	\$2,365
CZ03	PGE	0%	4%	693	0	\$119	\$2,766	\$801	\$1,002	2.8	\$1,764	4.4	\$3,423
CZ04	PGE	1%	1%	112	0	\$14	\$324	\$226	\$254	1.3	\$69	3.5	\$632
CZ04	CPAU	1%	1%	112	0	\$13	\$307	\$226	\$254	1.2	\$53	3.5	\$632
CZ05	PGE	0%	3%	464	0	\$56	\$1,310	\$550	\$676	1.9	\$634	4.2	\$2,165
CZ05	PGE/SCG	0%	3%	464	0	\$56	\$1,310	\$550	\$676	1.9	\$634	4.2	\$2,165
CZ06	SCE/SCG	0%	0%	12	0	\$2	\$51	\$132	\$132	0.4	(\$81)	1.4	\$49
CZ07	SDGE	0%	1%	95	0	\$0	\$0	\$212	\$237	0.0	(\$237)	2.8	\$423
CZ08	SCE/SCG	1%	3%	299	0	\$42	\$968	\$388	\$465	2.1	\$504	4.3	\$1,527
CZ09	SCE	1%	1%	99	0	\$12	\$284	\$204	\$230	1.2	\$54	3.0	\$465
CZ10	SCE/SCG	2%	3%	364	0	\$57	\$1,296	\$450	\$536	2.4	\$759	4.2	\$1,720
CZ10	SDGE	2%	3%	364	0	\$103	\$2,566	\$450	\$536	4.8	\$2,030	4.2	\$1,720
CZ11	PGE	2%	7%	1,178	0	\$281	\$6,521	\$1,276	\$1,610	4.1	\$4,911	4.8	\$6,162
CZ12	PGE	2%	4%	683	0	\$120	\$2,791	\$898	\$1,164	2.4	\$1,627	4.2	\$3,716
CZ12	SMUD/PGE	2%	4%	683	0	\$102	\$2,362	\$898	\$1,164	2.0	\$1,198	4.2	\$3,716
CZ13	PGE	2%	7%	1,137	0	\$274	\$6,347	\$1,179	\$1,484	4.3	\$4,863	4.8	\$5,599
CZ14	SCE/SCG	2%	2%	266	0	\$33	\$748	\$342	\$395	1.9	\$353	4.7	\$1,447
CZ14	SDGE	2%	2%	266	0	\$62	\$1,554	\$342	\$395	3.9	\$1,158	4.7	\$1,447
CZ15	SCE/SCG	3%	5%	567	0	\$125	\$2,851	\$535	\$646	4.4	\$2,204	5.6	\$2,994
CZ16	PG&E	2%	6%	1,051	4	\$237	\$5,569	\$1,601	\$1,883	3.0	\$3,686	3.1	\$4,011

### 4.5 CARE Rate Comparison

Table 20 presents a comparison of On-Bill cost-effectiveness results for CARE tariffs relative to standard tariffs for the all-electric prescriptive code case. The CARE rates apply to the apartment meters only and don't impact the central water heating utility costs. Applying the CARE rates lowers both electric and gas utility bills for the consumer and the net impact for an all-electric building in most climate zones is lower overall bills and improved cost-effectiveness relative to the standard tariffs. Although not presented here, the all-electric + PV packages are all still On-Bill cost-effective using the CARE tariffs.

**Table 20. On-Bill IOU Cost-Effectiveness Comparison with CARE Tariffs, Results per Dwelling Unit: All-Electric Prescriptive Code**

Climate Zone	Electric /Gas Utility	3-Story				5-Story			
		Standard		CARE		Standard		CARE	
		B/C Ratio	NPV						
CZ01	PGE	3.9	\$1,247	9.5	\$3,637	>1	\$6,998	>1	\$10,045
CZ02	PGE	1.0	\$32	3.1	\$2,139	0.7	(\$375)	2.5	\$1,831
CZ03	PGE	1.1	\$119	3.1	\$2,187	0.7	(\$407)	2.6	\$1,901
CZ04	PGE	0.9	(\$108)	2.8	\$1,884	1.8	\$945	2.9	\$2,218
CZ05	PGE	0.98	(\$21)	3.0	\$2,041	0.6	(\$479)	2.5	\$1,773
CZ05	PGE/SCG	0.0	(\$1,545)	1.5	\$517	0.0	(\$2,103)	1.1	\$148
CZ06	SCE/SCG	0.0	(\$1,255)	0.9	(\$57)	0.8	(\$199)	2.1	\$1,349
CZ07	SDGE	0.0	(\$1,456)	1.8	\$856	0.0	(\$1,685)	1.3	\$343
CZ08	SCE/SCG	0.0	(\$1,331)	0.8	(\$165)	0.0	(\$1,829)	1.2	\$271
CZ09	SCE	0.0	(\$1,380)	0.8	(\$204)	0.0	(\$1,236)	1.6	\$750
CZ10	SCE/SCG	0.0	(\$1,758)	0.1	(\$574)	0.0	(\$2,445)	0.5	(\$447)
CZ10	SDGE	0.0	(\$2,452)	0.8	(\$162)	0.0	(\$3,234)	0.0	(\$1,590)
CZ11	PGE	0.0	(\$826)	2.7	\$1,119	0.0	(\$1,494)	1.7	\$616
CZ12	PGE	0.0	(\$719)	2.9	\$1,263	0.0	(\$1,358)	2.0	\$793
CZ13	PGE	0.0	(\$940)	2.4	\$936	0.0	(\$1,517)	1.6	\$491
CZ14	SCE/SCG	0.0	(\$2,063)	0.0	(\$803)	0.0	(\$2,916)	0.3	(\$613)
CZ14	SDGE	0.0	(\$2,841)	0.0	(\$3,407)	0.0	(\$3,937)	1.1	\$61
CZ15	SCE/SCG	0.0	(\$2,053)	0.0	(\$1,036)	0.0	(\$2,606)	0.0	(\$1,452)
CZ16	PG&E	2.8	\$1,917	>1	\$5,527	9.1	\$5,467	>1	\$8,557

**Error! Not a valid bookmark self-reference.** presents the comparison for the mixed fuel efficiency and PV packages. Generally, the opposite trend occurs here for the mixed fuel packages where the CARE rate lowers utility cost savings and the benefit-to-cost ratios decline.

**Table 21. On-Bill IOU Cost-Effectiveness Comparison with CARE Tariffs, Results per Dwelling Unit: Mixed Fuel Packages**

Climate Zone	Electric /Gas Utility	3-Story (Efficiency + PV + Battery)				5-Story (Efficiency + PV)			
		Standard		CARE		Standard		CARE	
		B/C Ratio	NPV	B/C Ratio	NPV	B/C Ratio	NPV	B/C Ratio	NPV
CZ01	PGE	1.8	\$5,671	1.2	\$1,113	3.3	\$5,514	2.2	\$2,765
CZ02	PGE	1.8	\$4,728	1.2	\$907	1.8	\$578	1.5	\$337
CZ03	PGE	1.7	\$4,043	1.1	\$579	2.8	\$1,764	2.0	\$1,028
CZ04	PGE	1.6	\$3,360	1.0	\$259	1.3	\$69	0.8	(\$44)
CZ05	PGE	1.7	\$3,609	1.1	\$414	1.9	\$634	1.7	\$442
CZ05	PGE/SCG	1.7	\$3,609	1.1	\$414	1.9	\$634	1.7	\$442
CZ06	SCE/SCG	1.5	\$2,668	0.9	(\$515)	0.4	(\$81)	0.3	(\$92)
CZ07	SDGE	2.5	\$8,220	1.7	\$4,106	0.0	(\$237)	0.0	(\$237)
CZ08	SCE/SCG	1.8	\$4,156	1.1	\$446	2.1	\$504	1.3	\$137
CZ09	SCE	1.7	\$3,359	0.99	(\$26)	1.2	\$54	0.9	(\$28)
CZ10	SCE/SCG	1.8	\$4,331	1.1	\$577	2.4	\$759	1.3	\$180
CZ10	SDGE	2.5	\$8,049	1.8	\$4,180	4.8	\$2,030	0.0	(\$536)
CZ11	PGE	1.9	\$5,562	1.2	\$1,435	4.1	\$4,911	2.7	\$2,744
CZ12	PGE	1.7	\$4,133	1.1	\$517	2.4	\$1,627	1.8	\$905
CZ13	PGE	1.8	\$4,374	1.2	\$883	4.3	\$4,863	2.9	\$2,777
CZ14	SCE/SCG	2.0	\$5,545	1.3	\$1,395	1.9	\$353	1.3	\$136
CZ14	SDGE	2.8	\$9,815	1.4	\$2,292	3.9	\$1,158	0.0	(\$395)
CZ15	SCE/SCG	1.9	\$4,603	1.2	\$887	4.4	\$2,204	1.9	\$586
CZ16	PG&E	1.5	\$2,674	0.97	(\$162)	3.0	\$3,686	2.0	\$1,908

#### 4.6 Greenhouse Gas Reductions

Figure 1 and Figure 2 compare greenhouse gas reductions across all the packages for the multifamily 3-story and 5-story prototypes, respectively. Savings represent average annual savings per dwelling unit over the 30-year lifetime of the analysis. Electrification of gas uses represents the greatest greenhouse gas reductions, followed by PV. Greenhouse gas reductions are greatest for the all-electric + PV package.

Figure 1. 3-Story greenhouse gas reductions (metric tons) per dwelling unit

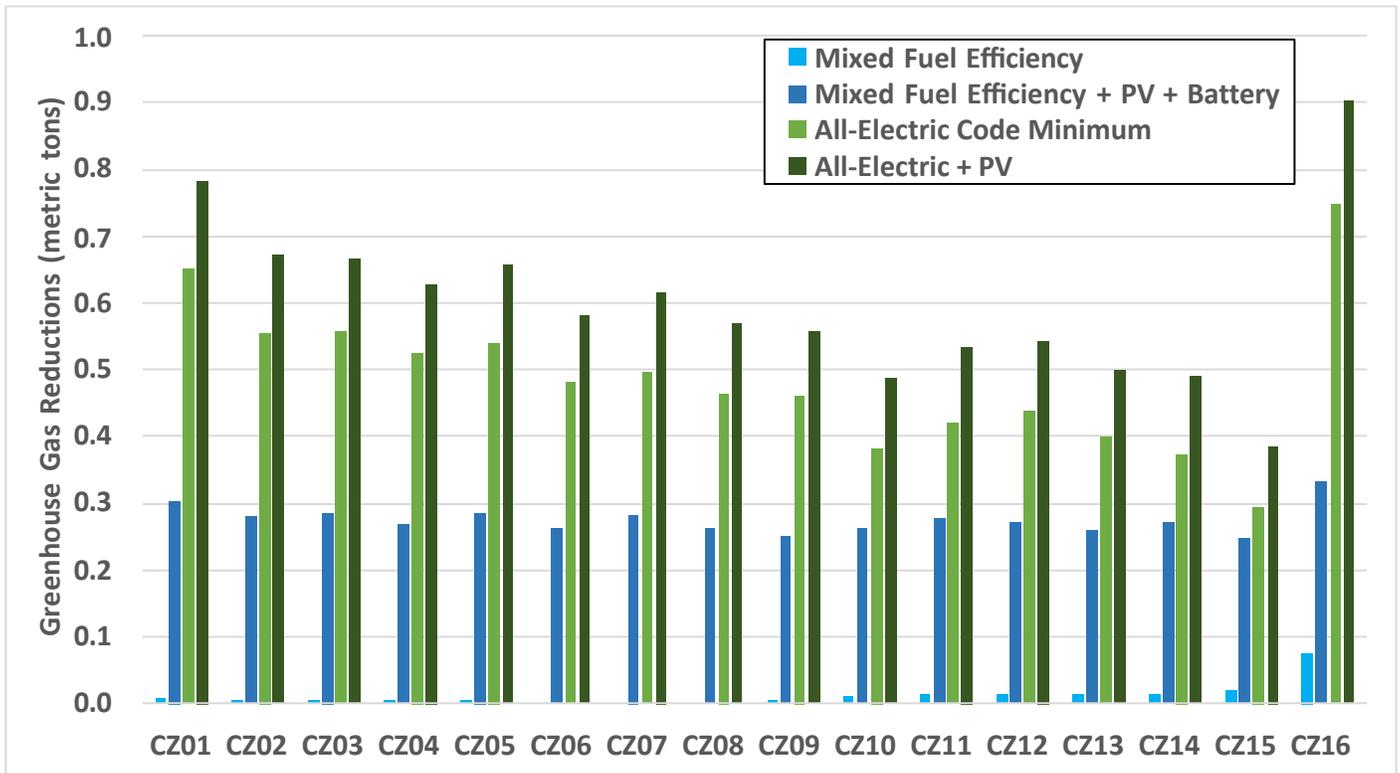
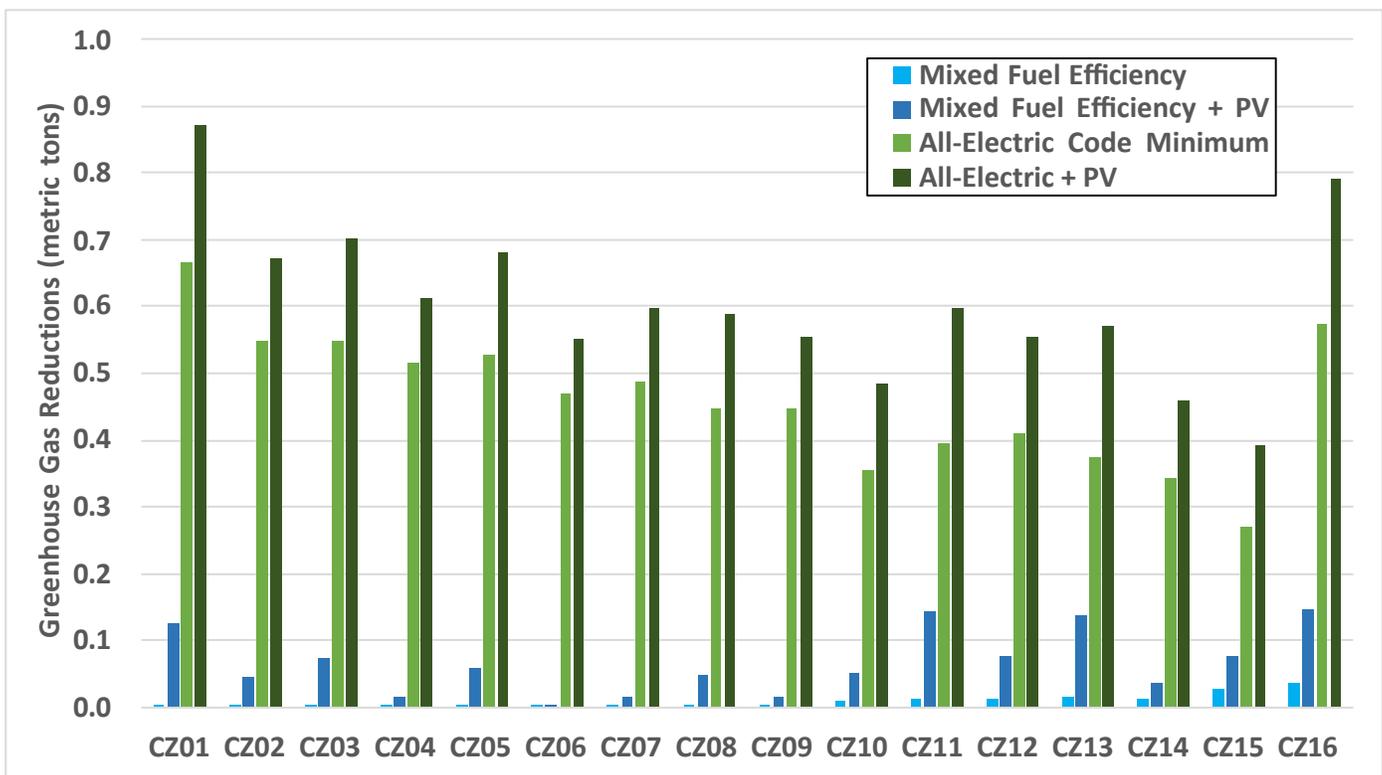


Figure 2. 5-Story greenhouse gas savings (metric tons) per dwelling unit



## 5 Summary

The Reach Codes Team identified packages of electrification and energy efficiency measures as well as packages combining these measures with solar PV generation and battery storage, simulated them using building modeling software, and gathered costs to determine the cost-effectiveness of multiple scenarios. The Reach Codes Team coordinated with multiple utilities, cities, and building community experts to develop a set of assumptions considered reasonable in the current market. Changing assumptions, such as the period of analysis, measure selection, cost assumptions, energy escalation rates, or utility tariffs are likely to change results.

Table 22 summarizes results for each prototype and depicts the efficiency TDV compliance margins achieved for each climate zone and package. Because local reach codes must both exceed the Energy Commission performance budget (i.e., have a positive compliance margin) and be cost-effective, the Reach Codes Team highlighted cells meeting these two requirements to help clarify the upper boundary for potential reach code policies. All results presented in this study have a positive compliance margin.

- Cells highlighted in **green** depict cases with a positive compliance margin and cost-effective results using both On-Bill and TDV approaches.
- Cells highlighted in **yellow** depict cases with a positive compliance margin and cost-effective results using either the On-Bill or TDV approach.
- Cells **not highlighted** depict cases with a positive compliance margin but that were not cost-effective using either the On-Bill or TDV approach.

Following are key takeaways and recommendations from the analysis.

- The Reach Codes Team found all-electric new construction to be feasible and cost-effective based on the California Energy Commission's Time Dependent Valuation (TDV) metric in all cases. In many cases all-electric prescriptive code construction results in an increase in utility costs and is not cost-effective On-Bill. Some exceptions include the SMUD and CPAU territories where lower electricity rates relative to gas rates result in lower overall utility bills.
- All-electric packages have lower GHG emissions than mixed fuel packages in all cases, due to the clean power sources currently available from California's power providers.
- The 2022 Energy Code's new source energy metric combined with the heat pump space heating baseline in most climate zones encourages all-electric construction. While the code does not include an electric baseline for water heating, the penalty for central electric water heating observed in the performance approach in past code cycles has been removed and a credit is provided for well-designed central heat pump water heaters in most cases.
- Electrification combined with increased PV capacity results in utility cost savings and was found to be On-Bill cost-effective in all cases.
- The results in this study are based on today's net energy metering (NEM 2.0) rules and do not account for recently approved changes to the NEM tariff (referred to as the net billing tariff). The net billing tariff decreases the value of PV to the consumer as compared to NEM 2.0. As a result, the cost-effectiveness of the packages that include above-code PV capacity is expected to be less under the net billing tariff. Conversely, the net billing tariff is expected to increase On-Bill cost-effectiveness of the all-electric prescriptive code scenario. An all-electric home has better on-site utilization of generated electricity from PV than a mixed fuel home with a similar sized PV system, and as a result exports less electricity to the grid. Since the net-billing tariff values exports less than under NEM 2.0, the relative impact on annual utility costs to the mixed fuel baseline is greater.
- This analysis does justify requiring a modest reach based on either efficiency TDV or source energy for all-electric buildings. However, this may be challenging for some projects given the recent changes to which the industry must adapt, including the efficiency updates and multifamily restructuring in the 2022 Title 24, Part 6 code. While project compliance margins using a CO<sub>2</sub> refrigerant heat pump water heating system are high, the Reach Code Team found lower compliance margins using other heat pump water heater system designs.

Focusing on supporting projects to electrify water heating is expected to support the market shift towards more central heat pump water heaters.

- For jurisdictions interested in a reach code that allows for mixed fuel buildings, a mixed fuel efficiency and PV package (and battery for the 3-story prototype) was found to be cost-effective based on TDV in all cases and cost-effective On-Bill in most climate zones. This path, referred to as “Electric-Preferred”, allows for mixed fuel buildings but requires a higher building performance than for all-electric buildings. The efficiency measures evaluated in this study did not provide significant compliance benefit. As a result, the Reach Codes Team recommends establishing a compliance margin target based on source energy or total TDV. This would allow for PV and battery above minimum code requirements to be used to meet the target.
- Jurisdictions interested in increasing affordable multifamily housing should know that applying the CARE rates has the overall impact of increasing utility cost savings for an all-electric building in most climate zones compared to a code compliant mixed fuel building, improving On-Bill cost-effectiveness.

Local jurisdictions may also adopt ordinances that amend different parts of the California Building Standards Code or may elect to amend other state or municipal codes. The decision regarding which code to amend will determine the specific requirements that must be followed for an ordinance to be legally enforceable. Reach codes that amend Part 6 of the California Building Code and require energy performance beyond state code minimums must demonstrate the proposed changes are cost-effective and obtain approval from the Energy Commission.

**Table 22. Summary of Efficiency TDV Compliance Margins and Cost-Effectiveness**

Climate Zone	Electric /Gas Utility	3-Story				5-Story			
		All-Electric Prescriptive Code	All-Electric + PV	Mixed Fuel Efficiency	Mixed Fuel Efficiency + PV + Battery	All-Electric Prescriptive Code	All-Electric + PV	Mixed Fuel Efficiency	Mixed Fuel Efficiency + PV
CZ01	PGE	26%	26%	1%	1%	14%	14%	0%	0%
CZ02	PGE	20%	20%	1%	1%	9%	9%	1%	1%
CZ03	PGE	21%	21%	1%	1%	11%	11%	0%	0%
CZ04	PGE	18%	18%	1%	1%	9%	9%	1%	1%
CZ04	CPAU	18%	18%	1%	1%	9%	9%	1%	1%
CZ05	PGE	23%	23%	1%	1%	12%	12%	0%	0%
CZ05	PGE/SCG	23%	23%	1%	1%	12%	12%	0%	0%
CZ06	SCE/SCG	18%	18%	1%	1%	9%	9%	0%	0%
CZ07	SDGE	20%	20%	0%	0%	11%	11%	0%	0%
CZ08	SCE/SCG	13%	13%	1%	1%	8%	8%	1%	1%
CZ09	SCE	13%	13%	1%	1%	7%	7%	1%	1%
CZ10	SCE/SCG	14%	14%	3%	3%	7%	7%	2%	2%
CZ10	SDGE	14%	14%	3%	3%	7%	7%	2%	2%
CZ11	PGE	14%	14%	3%	3%	8%	8%	2%	2%
CZ12	PGE	17%	17%	2%	2%	9%	9%	2%	2%
CZ12	SMUD/PGE	17%	17%	2%	2%	9%	9%	2%	2%
CZ13	PGE	13%	13%	4%	4%	7%	7%	2%	2%
CZ14	SCE/SCG	13%	13%	3%	3%	6%	6%	2%	2%
CZ14	SDGE	13%	13%	3%	3%	6%	6%	2%	2%
CZ15	SCE/SCG	5%	5%	5%	5%	3%	3%	3%	3%
CZ16	PG&E	24%	24%	5%	5%	9%	9%	2%	2%

## 6 References

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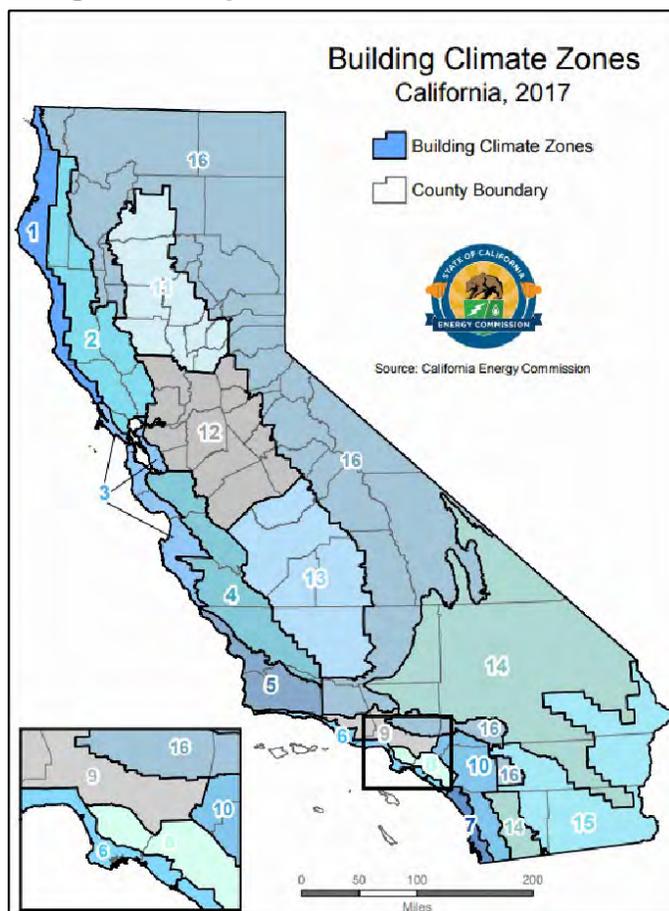
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## 7 Appendices

### 7.1 Map of California Climate Zones

Climate zone geographical boundaries are depicted in Figure 3. The map in Figure 3 along with a zip-code search directory is available at: [https://ww2.energy.ca.gov/maps/renewable/building\\_climate\\_zones.html](https://ww2.energy.ca.gov/maps/renewable/building_climate_zones.html)

Figure 3. Map of California climate zones.



## 7.2 Utility Rate Schedules

The Reach Codes Team used the CA IOU and POU rate tariffs detailed below to determine the On-Bill savings for each package. The California Climate Credit was applied for both electricity and natural gas service for the IOUs using the 2022 credits shows below.<sup>9</sup> The credits were applied to reduce the total calculated annual bill, including any fixed fees or minimum bill amounts.

### 2022 Electric California Climate Credit Schedule

	April	May	June	July	Aug	Sept	Oct
<b>PG&amp;E</b>	\$39.30						\$39.30
<b>SCE</b>	\$59.00						\$59.00
<b>SDG&amp;E</b>					\$64.17	\$64.17	

## Residential Natural Gas California Climate Credit

The 2022 Natural Gas California Climate Credit is distributed in April.

	2018 <sup>†</sup>	2019	2020	2021	2022	Total Value Received Per Household 2018-2022
<b>PG&amp;E</b>	\$30	\$25	\$27	\$25	\$47.83	<b>\$154</b>
<b>SDG&amp;E</b>	*	\$34	\$21	\$18	\$43.06	<b>\$116</b>
<b>Southwest Gas</b>	\$22	\$25	\$27	\$28	\$49.44	<b>\$150</b>
<b>SoCalGas</b>	*	\$50	\$26	\$22	\$44.17	<b>\$142</b>

Electricity rates reflect the most recent approved tariffs. Monthly gas rates were estimated based on the latest available gas rate (December 2022) and a curve to reflect how natural gas prices fluctuate with seasonal supply and demand. The seasonal curve was estimated from monthly residential tariffs between 2012 and 2022 (between 2020 and 2022 for CPAU). 12-month curves were created from monthly gas rates for each of the eleven years (three years for CPAU). These annual curves were then averaged to arrive at an average normalized annual curve. This was conducted separately for baseline and excess energy rates. Costs used in this analysis were then derived by establishing the most recent baseline and excess rate from the latest tariff as a reference point (December 2022), and then using the normalized curve to estimate the cost for the remaining months relative to the reference point rate.

<sup>9</sup> <https://www.cpuc.ca.gov/industries-and-topics/natural-gas/greenhouse-gas-cap-and-trade-program/california-climate-credit>

### 7.2.1 Pacific Gas & Electric

The following pages provide details on the PG&E electricity and natural gas tariffs applied in this study. **Error! Reference source not found.** describes the baseline territories that were assumed for each climate zone. A net surplus compensation rate of \$0.0474/ kWh was applied to any net annual electricity generation based on a one-year average of the rates between November 2021 and October 2022.

**Table 23. PG&E Baseline Territory by Climate Zone**

Climate Zone	Baseline Territory
CZ01	V
CZ02	X
CZ03	T
CZ04	X
CZ05	T
CZ11	R
CZ12	S
CZ13	R
CZ16	Y

The PG&E monthly gas rate in \$/therm was applied on a monthly basis according to the rates shown in **Error! Reference source not found.** These are applied to both the G-1 and GM rates. These rates are based on applying a normalization curve to the December 2022 tariff based on eleven years of historical gas data. See the beginning of Section **Error! Reference source not found. Error! Reference source not found.** for further details. The corresponding CARE rates are shown in **Error! Reference source not found.** and reflect the 20 percent discount per the GL-1 tariff. The GM master metered wather heating baseline quantity of 0.43 therms per dwelling unit per day in all baseline territories and in both seasons was applied to the centrally metered gas water heating.

**Table 24. PG&E Monthly Gas Rate (\$/therm)**

Month	Total Charge	
	Baseline	Excess
January	\$2.20579	\$2.66008
February	\$2.24291	\$2.69637
March	\$2.11750	\$2.58278
April	\$2.08101	\$2.55500
May	\$2.08062	\$2.55844
June	\$2.09104	\$2.56928
July	\$2.10404	\$2.58189
August	\$2.15162	\$2.63251
September	\$2.18718	\$2.67910
October	\$2.23153	\$2.71934
November	\$2.32121	\$2.79158
December	\$2.34123	\$2.80922

**Table 25. PG&E Monthly CARE (GL-1) Gas Rate (\$/therm)**

Month	Total CARE Charge	
	Baseline	Excess
January	\$1.76463	\$2.12806
February	\$1.79433	\$2.15710
March	\$1.69400	\$2.06622
April	\$1.66480	\$2.04400
May	\$1.66449	\$2.04675
June	\$1.67283	\$2.05543
July	\$1.68323	\$2.06551
August	\$1.72129	\$2.10601
September	\$1.74974	\$2.14328
October	\$1.78523	\$2.17547
November	\$1.85697	\$2.23327
December	\$1.87298	\$2.24738

## Residential GAS

### Baseline Territories and Quantities <sup>1/</sup>

**Effective April 1, 2022 - Present**

BASELINE QUANTITIES (Therms Per Day Per Dwelling Unit)

Individually Metered			
Baseline Territories	Summer (April-October) Effective Apr. 1, 2022	Winter Off-Peak (Nov, Feb, Mar) Effective Nov. 1, 2022	Winter On-Peak (Dec, Jan) Effective Dec. 1, 2022
P	0.39	1.88	2.19
Q	0.56	1.48	2.00
R	0.36	1.24	1.81
S	0.39	1.38	1.94
T	0.56	1.31	1.68
V	0.59	1.51	1.71
W	0.39	1.14	1.68
X	0.49	1.48	2.00
Y	0.72	2.22	2.58

Master Metered			
Baseline Territories	Summer (April-October) Effective Apr. 1, 2022	Winter Off-Peak (Nov, Feb, Mar) Effective Nov. 1, 2022	Winter On-Peak (Dec, Jan) Effective Dec. 1, 2022
P	0.29	1.01	1.13
Q	0.56	0.67	0.77
R	0.33	0.87	1.16
S	0.29	0.61	0.65
T	0.56	1.01	1.10
V	0.59	1.28	1.32
W	0.26	0.71	0.87
X	0.33	0.67	0.77
Y	0.52	1.01	1.13

Summer Season: Apr-Oct  
 Winter Off-Peak: Nov, Feb, Mar  
 Winter On-Peak: Dec, Jan

Advice Letter: 4589-G  
 Decision 21-11-016  
 GRC 2020 Ph II [Application 19-11-019]  
 Filed: Nov 22, 2019



**Pacific Gas and Electric Company**

U 39 San Francisco, California

Cancelling Revised Cal. P.U.C. Sheet No. 53472-E  
 Revised Cal. P.U.C. Sheet No. 52702-E

**ELECTRIC SCHEDULE E-TOU-C** Sheet 2  
 RESIDENTIAL TIME-OF-USE (PEAK PRICING 4 - 9 p.m. EVERY DAY)

RATES: (Cont'd.) **E-TOU-C TOTAL BUNDLED RATES** (T)

Total Energy Rates (\$ per kWh)	PEAK		OFF-PEAK	
<i>Summer</i>				
Total Usage	\$0.48902	(I)	\$0.42558	(I)
Baseline Credit (Applied to Baseline Usage Only)	(\$0.09054)	(R)	(\$0.09054)	(R)
<i>Winter</i>				
Total Usage	\$0.39193	(I)	\$0.37460	(I)
Baseline Credit (Applied to Baseline Usage Only)	(\$0.09054)	(R)	(\$0.09054)	(R)
Delivery Minimum Bill Amount (\$ per meter per day)	\$0.34810			
California Climate Credit (per household, per semi-annual payment occurring in the April and October bill cycles)	(\$39.30)			

Total bundled service charges shown on customer's bills are unbundled according to the component rates shown below. Where the delivery minimum bill amount applies, the customer's bill will equal the sum of (1) the delivery minimum bill amount plus (2) for bundled service, the generation rate times the number of kWh used. For revenue accounting purposes, the revenues from the delivery minimum bill amount will be assigned to the Transmission, Transmission Rate Adjustments, Reliability Services, Public Purpose Programs, Nuclear Decommissioning, Competition Transition Charges, Energy Cost Recovery Amount, Wildfire Fund Charge, and New System Generation Charges based on kWh usage times the corresponding unbundled rate component per kWh, with any residual revenue assigned to Distribution.

(Continued)

Advice	6803-E-A	Issued by	Submitted	May 31, 2022
Decision		<b>Robert S. Kenney</b>	Effective	June 1, 2022
		Vice President, Regulatory Affairs	Resolution	



**Pacific Gas and Electric Company**  
 U 39 San Francisco, California

Revised Revised Cal. P.U.C. Sheet No. 53474-E  
 Cancelling Revised Cal. P.U.C. Sheet No. 50175-E

**ELECTRIC SCHEDULE E-TOU-C** Sheet 4  
 RESIDENTIAL TIME-OF-USE (PEAK PRICING 4 - 9 p.m. EVERY DAY)

SPECIAL CONDITIONS: 1. BASELINE (TIER 1) QUANTITIES: The following quantities of electricity are to be used to define usage eligible for the baseline credit:

**BASELINE QUANTITIES (kWh PER DAY)**

Baseline Territory*	Code B - Basic Quantities				Code H - All-Electric Quantities			
	Summer		Winter		Summer		Winter	
	Tier 1		Tier 1		Tier 1		Tier 1	
P	13.5	(R)	11.0	(R)	15.2	(R)	26.0	(R)
Q	9.8	(R)	11.0	(R)	8.5	(R)	26.0	(R)
R	17.7	(R)	10.4	(R)	19.9	(R)	26.7	(R)
S	15.0	(R)	10.2	(R)	17.8	(R)	23.7	(R)
T	6.5	(R)	7.5	(R)	7.1	(R)	12.9	(R)
V	7.1	(R)	8.1	(R)	10.4	(R)	19.1	(I)
W	19.2	(R)	9.8	(R)	22.4	(R)	19.0	(R)
X	9.8	(R)	9.7	(R)	8.5	(R)	14.6	(R)
Y	10.5	(R)	11.1	(R)	12.0	(R)	24.0	(R)
Z	5.9	(R)	7.8	(R)	6.7	(R)	15.7	(R)

2. TIME PERIODS FOR E-TOU-C: Times of the year and times of the day are defined as follows:

Summer (service from June 1 through September 30):

Peak: 4:00 p.m. to 9:00 p.m. All days

Off-Peak: All other times

Winter (service from October 1 through May 31):

Peak: 4:00 p.m. to 9:00 p.m. All days

Off-Peak: All other times

\* The applicable baseline territory is described in Part A of the Preliminary Statement

(Continued)

Advice Decision	6603-E-A	Issued by	Robert S. Kenney	Submitted	May 31, 2022
		Vice President, Regulatory Affairs		Effective	June 1, 2022
				Resolution	



**Pacific Gas and Electric Company**  
 U 39 San Francisco, California

Revised Cal. P.U.C. Sheet No. 53424-E  
 Cancelling Revised Cal. P.U.C. Sheet No. 52653-E

**ELECTRIC SCHEDULE D-CARE** Sheet 1  
 LINE-ITEM DISCOUNT FOR CALIFORNIA ALTERNATE RATES FOR ENERGY (CARE)  
 CUSTOMERS

**APPLICABILITY:** This schedule is applicable to single-phase and polyphase residential service in single-family dwellings and in flats and apartments separately metered by PG&E and domestic submetered tenants residing in multifamily accommodations, mobilehome parks and to qualifying recreational vehicle parks and marinas and to farm service on the premises operated by the person whose residence is supplied through the same meter, where the applicant qualifies for California Alternate Rates for Energy (CARE) under the eligibility and certification criteria set forth in Electric Rule 19.1. CARE service is available on Schedules E-1, E-6, E-TOU-B, E-TOU-C, E-TOU-D, EV2, EM, ES, ESR, ET and EM-TOU.

**TERRITORY:** This rate schedule applies everywhere PG&E provides electric service.

**RATES:** Customers taking service on this rate schedule will receive a percentage discount ("A" below) on their total bundled charges on their otherwise applicable rate schedule (except for the California Climate Credit, which will not be discounted). In addition, customers will receive a percentage discount ("B" below) on the delivery minimum bill amount, if applicable. The CARE discount will be calculated for direct access and community choice aggregation customers based on the total charges as if they were subject to bundled service rates. Discounts will be applied as a residual reduction to distribution charges, after D-CARE customers are exempted from the Wildfire Fund Charge, Recovery Bond Charge, Recovery Bond Credit, and the CARE surcharge portion of the public purpose program charge used to fund the CARE discount. These conditions also apply to master-metered customers and to qualified sub-metered tenants where the master-meter customer is jointly served under PG&E's Rate Schedule D-CARE and either Schedule EM, ES, ESR, ET, or EM-TOU.

(T)  
(T)

For master-metered customers where one or more of the submetered tenants qualifies for CARE rates under the eligibility and certification criteria set forth in Rule 19.1, 19.2, or 19.3, the CARE discount is equal to a percentage ("C" below) of the total bundled charges, multiplied by the number of CARE units divided by the total number of units. In addition, master-metered customers eligible for D-CARE will receive a percentage discount ("D" below) on the delivery minimum bill amount, if applicable.

It is the responsibility of the master-metered customer to advise PG&E within 15 days following any change in the number of dwelling units and/or any decrease in the number of qualifying CARE applicants that results when such applicants move out of their submetered or non-submetered dwelling unit, or submetered permanent-residence RV or permanent-residence boat.

- A. D-CARE Discount: 34.947 % (Percent) (I)
- B. Delivery Minimum Bill Discount: 50.000 % (Percent)
- C. Master-Meter D-CARE Discount: 34.947 % (Percent) (I)
- D. Master-Meter Delivery Minimum Bill Discount: 50.000 % (Percent)

**SPECIAL CONDITIONS:** 1. OTHERWISE APPLICABLE SCHEDULE: The Special Conditions of the Customer's otherwise applicable rate schedule will apply to this schedule.

(Continued)

Advice	6603-E-A	Issued by	Submitted	May 31, 2022
Decision		<b>Robert S. Kenney</b>	Effective	June 1, 2022
		Vice President, Regulatory Affairs	Resolution	

## 7.2.2 Southern California Edison

The following pages provide details on are the SCE electricity tariffs applied in this study. **Error! Reference source not found.** describes the baseline territories that were assumed for each climate zone. A net surplus compensation rate of \$ 0.04361/ kWh was applied to any net annual electricity generation based on a one-year average of the rates between November 2021 and October 2022

**Table 26: SCE Baseline Territory by Climate Zone**

Climate Zone	Baseline Territory
CZ06	6
CZ08	8
CZ09	9
CZ10	10
CZ14	14
CZ15	15

Summer Daily Allocations (June through September)

Baseline Region Number	Daily kWh Allocation	All-Electric Allocation
5	17.2	17.9
6	11.4	8.8
8	12.6	9.8
9	16.5	12.4
10	18.9	15.8
13	22.0	24.6
14	18.7	18.3
15	46.4	24.1
16	14.4	13.5

Winter Daily Allocations (October through May)

Baseline Region Number	Daily kWh Allocation	All-Electric Allocation
5	18.7	29.1
6	11.3	13.0
8	10.6	12.7
9	12.3	14.3
10	12.5	17.0
13	12.6	24.3
14	12.0	21.3
15	9.9	18.2
16	12.6	23.1

Schedule TOU-D  
 TIME-OF-USE  
 DOMESTIC  
 (Continued)

Sheet 12 (T)

**SPECIAL CONDITIONS**

- Applicable rate time periods are defined as follows:

Option 4-9 PM, Option 4-9 PM-CPP, Option PRIME, Option PRIME-CPP :

TOU Period	Weekdays		Weekends and Holidays	
	Summer	Winter	Summer	Winter
On-Peak	4 p.m. - 9 p.m.	N/A	N/A	N/A
Mid-Peak	N/A	4 p.m. - 9 p.m.	4 p.m. - 9 p.m.	4 p.m. - 9 p.m.
Off-Peak	All other hours	9 p.m. - 8 a.m.	All other hours	9 p.m. - 8 a.m.
Super-Off-Peak	N/A	8 a.m. - 4 p.m.	N/A	8 a.m. - 4 p.m.
CPP Event Period	4 p.m. - 9 p.m.	4 p.m. - 9 p.m.	N/A	N/A

(T)



Southern California Edison  
Rosemead, California (U 338-E)

Canceling

Revised  
Revised

Cal. PUC Sheet No. 74502-E  
Cal. PUC Sheet No. 73968-E

**Schedule TOU-D**  
**TIME-OF-USE**  
**DOMESTIC**  
(Continued)

Sheet 2

**RATES**

Customers receiving service under this Schedule will be charged the applicable rates under Option 4-9 PM, Option 4-9 PM-CPP, Option 5-8 PM, Option 5-8 PM-CPP, Option PRIME, Option PRIME-CPP Option A, Option A-CPP, Option B, or Option B-CPP, as listed below. CPP Event Charges will apply to all energy usage during CPP Event Energy Charge periods and CPP Non-Event Energy Credits will apply as a reduction on CPP Non-Event Energy Credit Periods during Summer Season days, 4:00 p.m. to 9:00 p.m., as described in Special Conditions 1 and 3, below:

	Delivery Service Total <sup>1</sup>	Generation <sup>2</sup>	
		UG <sup>3</sup>	DWREC <sup>4</sup>
<b>Option 4-9 PM / Option 4-9 PM-CPP</b>			
Energy Charge - \$/kWh			
Summer Season - On-Peak	0.29820 (R)	0.23706 (I)	0.00000
Mid-Peak	0.29820 (R)	0.13648 (I)	0.00000
Off-Peak	0.25471 (I)	0.07939 (R)	0.00000
Winter Season - Mid-Peak	0.29820 (R)	0.17235 (I)	0.00000
Off-Peak	0.25471 (I)	0.10198 (R)	0.00000
Super-Off-Peak	0.23907 (I)	0.08508 (I)	0.00000
Baseline Credit <sup>4</sup> - \$/kWh	(0.09086) (I)	0.00000	
Fixed Recovery Charge - \$/kWh	0.00117 (I)		
Basic Charge - \$/day			
Single-Family Residence	0.031		
Multi-Family Residence	0.024		
Minimum Charge <sup>5</sup> - \$/day			
Single Family Residence	0.346		
Multi-Family Residence	0.346		
Minimum Charge (Medical Baseline) <sup>6</sup> - \$/day			
Single Family Residence	0.173		
Multi-Family Residence	0.173		
California Climate Credit <sup>7</sup>	(59.00)		
California Alternate Rates for Energy Discount - %	100.00 <sup>8</sup>		
Family Electric Rate Assistance Discount -	100.00		
Option 4-9 PM-CPP			
CPP Event Energy Charge - \$/kWh		0.80000	
Summer CPP Non-Event Credit			
On-Peak Energy Credit - \$/kWh		(0.15170)	
Maximum Available Credit - \$/kWh <sup>9</sup>			
Summer Season		(0.50662) (I)	

<sup>1</sup> Represents 100% of the discount percentage as shown in the applicable Special Condition of this Schedule.  
<sup>2</sup> The Minimum Charge is applicable when the Delivery Service Energy Charge, plus the applicable Basic Charge is less than the Minimum Charge.  
<sup>3</sup> The ongoing Competition Transition Charge (CTC) of (\$0.00019) per kWh is recovered in the UG component of Generation. (R)  
<sup>4</sup> The Baseline Credit applies up to 100% of the Baseline Allocation, regardless of Time-of-Use time period. Additional Baseline Allocations apply for Customers with Heat Pump Water Heaters served under this Option. The Baseline Allocations are set forth in Preliminary Statement, Part H. (T)  
<sup>5</sup> The Maximum Available Credit is the capped credit amount for CPP Customers dual participating in other demand response programs. (T)  
<sup>6</sup> Total = Total Delivery Service rates are applicable to Bundled Service, Direct Access (DA) and Community Choice Aggregation Service (CCA Service) Customers, except DA and CCA Service Customers are not subject to the DWRBC rate component of this Schedule but instead pay the DWRBC as provided by Schedule DA-CRB or Schedule CCA-CRB.  
<sup>7</sup> Generation = The Gen rates are applicable only to Bundled Service Customers. See Special Condition below for PCIA recovery.  
<sup>8</sup> DWREC = Department of Water Resources (DWR) Energy Credit - For more information on the DWR Energy Credit, see the Billing Calculation Special Condition of this Schedule.  
<sup>9</sup> Applied on an equal basis, per household, semi-annually. See the Special Conditions of this Schedule for more information.

(Continued)

(To be inserted by utility)  
 Advice 4864-E  
 Decision 22-08-001

Issued by  
**Michael Backstrom**  
 Vice President

(To be inserted by Cal. PUC)  
 Date Submitted Sep 15, 2022  
 Effective Oct 1, 2022  
 Resolution \_\_\_\_\_

2017



Southern California Edison  
Rosemead, California (U 338-E)

Revised Cal. PUC Sheet No. 74493-E  
Cancelling Revised Cal. PUC Sheet No. 73964-E

Schedule D-CARE  
CALIFORNIA ALTERNATE RATES FOR ENERGY  
DOMESTIC SERVICE

Sheet 1

APPLICABILITY

Applicable to domestic service to CARE households residing in a permanent Single-Family Accommodation or Multifamily Accommodation where the customer meets all the Special Conditions of this Schedule. Customers enrolled in the CARE program are not eligible for the Family Electric Rate Assistance (FERA) program.

Pursuant to Special Condition 12 herein, customers receiving service under this Schedule are eligible to receive the California Climate Credit as shown in the Rates section below.

TERRITORY

Within the entire territory served.

RATES

The applicable charges set forth in Schedule D shall apply to Customers served under this Schedule.

CARE Discount:

A 28.9 percent discount is applied to a CARE Customer's bill prior to the application of the Public Utilities Commission Reimbursement Fee (PUCRF) and any applicable user fees, taxes, and late payment charges. CARE Customers are required to pay the PUCRF and any applicable user fees, taxes, and late payment charges in full. In addition, CARE Customers are exempt from paying the CARE Surcharge of \$0.00931 per kWh and the Wildfire Fund Non-Bypassable Charge of \$0.00652 per kWh. The 28.9 percent discount, in addition to these exemptions result in an average effective CARE Discount of 32.5 percent.

(Continued)

(To be inserted by utility)  
Advice 4864-E  
Decision 22-08-001

Issued by  
Michael Backstrom  
Vice President

(To be inserted by Cal. PUC)  
Date Submitted Sep 15, 2022  
Effective Oct 1, 2022  
Resolution \_\_\_\_\_

10/10

### 7.2.3 Southern California Gas

Following are the SoCalGas natural gas tariffs applied in this study. **Error! Reference source not found.** describes the baseline territories that were assumed for each climate zone.

**Table 27. SoCalGas Baseline Territory by Climate Zone**

Climate Zone	Baseline Territory
CZ05	2
CZ06	1
CZ08	1
CZ09	1
CZ10	1
CZ14	2
CZ15	1

The SoCalGas monthly gas rate in \$/therm was applied on a monthly basis according to the rates shown in **Error! Reference source not found.** These rates are based on applying a normalization curve to the December 2022 tariff based on eleven years of historical gas data. See the beginning of Section **Error! Reference source not found.** **Error! Reference source not found.** for further details. Long-term historical natural gas rate data was only available for SoCalGas’ procurement charges.<sup>10</sup> The baseline and excess transmission charges were found to be consistent over the course of a year and applied for the entire year based on 2022 rates. CARE rates reflect the 20 percent discount per the GR tariff.

**Table 28. SoCalGas Monthly Gas Rate (\$/therm)**

Month	Procurement Charge	Transportation Charge		Total Charge	
		Baseline	Excess	Baseline	Excess
January	\$0.90581	\$0.82487	\$1.23877	\$1.73068	\$2.14458
February	\$0.83669	\$0.82487	\$1.23877	\$1.66156	\$1.84967
March	\$0.80596	\$0.82487	\$1.23877	\$1.63083	\$1.82938
April	\$0.71941	\$0.82487	\$1.23877	\$1.54428	\$1.75890
May	\$0.77049	\$0.82487	\$1.23877	\$1.59536	\$1.78548
June	\$0.86253	\$0.82487	\$1.23877	\$1.68740	\$1.83337
July	\$0.87687	\$0.82487	\$1.23877	\$1.70174	\$1.86833
August	\$0.95391	\$0.82487	\$1.23877	\$1.77878	\$1.91089
September	\$0.85896	\$0.82487	\$1.23877	\$1.68383	\$1.83611
October	\$0.84147	\$0.82487	\$1.23877	\$1.66634	\$1.84936
November	\$0.89018	\$0.82487	\$1.23877	\$1.71505	\$1.88836
December	\$1.05329	\$0.82487	\$1.23877	\$1.87816	\$1.98294

<sup>10</sup> The SoCalGas procurement and transmission charges were obtained from the following site: <https://www.socalgas.com/for-your-business/energy-market-services/gas-prices>

Schedule No. GM		Sheet 2	
<b>MULTI-FAMILY SERVICE</b>			
(Includes GM-E, GM-C, GM-EC, GM-CC, GT-ME, GT-MC and all GMB Rates)			
(Continued)			
<b>APPLICABILITY</b> (Continued)			
Multi-family Accommodations built prior to December 15, 1981 and currently served under this schedule may also be eligible for service under Schedule No. GS. If an eligible Multi-family Accommodation served under this schedule converts to an applicable submetered tariff, the tenant rental charges shall be revised for the duration of the lease to reflect removal of the energy related charges.			
Eligibility for service hereunder is subject to verification by the Utility.			
<b>TERRITORY</b>			
Applicable throughout the service territory.			
<b>RATES</b>			
Customer Charge, per meter, per day: .....	<u>GM/GT-M</u> 16.438¢	<u>GMB/GT-MB</u> \$19.792	
For "Space Heating Only" customers, a daily Customer Charge applies during the winter period from November 1 through April 30 <sup>1/2</sup> : .....			
	33.149¢		
<b>GM</b>			
<b>Baseline Rate, per therm (baseline usage defined per Special Conditions 3 and 4):</b>	<u>GM-E</u>	<u>GM-EC<sup>3/</sup></u>	<u>GT-ME</u>
Procurement Charge: <sup>2/</sup> .....	110.870¢	110.870¢	N/A
Transmission Charge: .....	90.256¢	90.256¢	90.256¢
Total Baseline Charge (all usage): .....	201.126¢	201.126¢	90.256¢
<b>Non-Baseline Rate, per therm (usage in excess of baseline usage):</b>			
Procurement Charge: <sup>2/</sup> .....	110.870¢	110.870¢	N/A
Transmission Charge: .....	135.367¢	135.367¢	135.367¢
Total Non Baseline Charge (all usage): .....	246.237¢	246.237¢	135.367¢

3. **Baseline Usage:** The following usage is to be billed at the Baseline rate for Multi-family Accommodation units. Usage in excess of applicable Baseline allowances will be billed at the Non-Baseline rate.

<u>Per Residence</u>	<u>Daily Therm Allowance for Climate Zones*</u>		
	<u>1</u>	<u>2</u>	<u>3</u>
Summer (May 1- Oct.31)	0.424	0.424	0.424
Winter On-Peak (Dec., Jan., and Feb.)	1.600	1.867	2.600
Winter Off-Peak (Nov., Mar., and Apr.)	0.874	0.923	1.714

### 7.2.4 San Diego Gas & Electric

Following are the SDG&E electricity and natural gas tariffs applied in this study. **Error! Reference source not found.** describes the baseline territories that were assumed for each climate zone. A net surplus compensation rate of \$0.04174 / kWh was applied to any net annual electricity generation based on a one-year average of the rates between January 2022 and December 2022.

**Table 29. SDG&E Baseline Territory by Climate Zone**

Climate Zone	Baseline Territory
CZ07	Coastal
CZ10	Inland
CZ14	Mountain

The SDG&E monthly gas rate in \$/therm was applied on a monthly basis according to the rates shown in **Error! Reference source not found.** These rates are based on applying a normalization curve to the December 2022 tariff based on eleven years of historical gas data. See the beginning of Section **Error! Reference source not found.** **Error! Reference source not found.** for further details. CARE rates reflect the 20 percent discount per the G-CARE tariff.

**Table 30. SDG&E Monthly Gas Rate (\$/therm)**

Month	Total Charge	
	Baseline	Excess
January	\$2.33762	\$2.34748
February	\$2.26751	\$2.28440
March	\$2.25119	\$2.27016
April	\$2.20192	\$2.22744
May	\$2.24252	\$2.26403
June	\$2.31819	\$2.33060
July	\$2.32406	\$2.33630
August	\$2.37527	\$2.38090
September	\$2.33542	\$2.34971
October	\$2.30366	\$2.32151
November	\$2.31722	\$2.33381
December	\$2.45653	\$2.73517

**Baseline Usage:** The following quantities of gas used in individually metered residences are to be billed at the baseline rates:

<u>All Customers:</u>	<u>Daily Therm Allowance</u>
Summer (May to Oct)	0.359
Winter On-Peak (Dec, Jan & Feb)	1.233
Winter Off-Peak (Nov, Mar, & Apr)	0.692

**SCHEDULE GM**

Sheet 2

**MULTI-FAMILY NATURAL GAS SERVICE**  
 (Includes Rates for GM, GM-C and GTC/GTCA)

**RATES**

	GM	GM-C	GTC/GTCA <sup>1</sup>
Baseline Rate, per therm (baseline usage defined in Special Condition 4)			
Procurement Charge <sup>2</sup> .....	\$1.05454	\$1.42421	I N/A
Transmission Charge.....	\$1.40199	\$1.40199	\$1.40201
Total Baseline Charge.....	\$2.45653	\$2.82620	I \$1.40201
<b>Non-Baseline Rate (usage in excess of baseline usage)</b>			
Procurement Charge <sup>2</sup> .....	\$1.05454	\$1.42421	I N/A
Transmission Charge.....	\$1.68063	\$1.68063	\$1.68065
Total Non-Baseline Charge.....	\$2.73517	\$3.10484	I \$1.68065
<b>Minimum Bill, per day<sup>3</sup></b>			
Non-CARE customers.....	\$0.13151	\$0.13151	\$0.13151
CARE customers.....	\$0.10521	\$0.10521	\$0.10521

**Franchise Fee Differential:**

A Franchise Fee Differential of 1.03% will be applied to the monthly billings calculated under this schedule for all customers within the corporate limits of the City of San Diego. Such Franchise Fee Differential shall be so indicated and added as a separate item to bills rendered to such customers.

**Additional Charges**

Rates may be adjusted to reflect any applicable taxes, franchise fees or other fees, regulatory surcharges, and interstate or intrastate pipeline charges that may occur.

**SPECIAL CONDITIONS**

- Definitions.** The definitions of principal terms used in this schedule are found either herein or in Rule 1, Definitions.
- Number of Therms.** The number of therms to be billed shall be determined in accordance with Rule 2. The daily therm allowance in the Baseline Usage, shown in Special Condition 4, shall be multiplied by the number of qualified residential units. It is the responsibility of the customer to advise the Utility within 15 days following any change in the submetering arrangements or the number of dwelling units or Mobilehome Park spaces provided gas service. The number of qualifying units is subject to verification by the Utility.
- Exclusions.** Gas service for non-domestic enterprises such as rooming houses, boarding houses, dormitories, rest homes, military barracks, transient trailer parks, stores, restaurants, service stations, and other similar establishments will be separately metered and billed under the applicable schedules.

<sup>1</sup> The rates for core transportation-only customers, with the exception of customers taking service under Schedule GT-NGV, include any FERC Settlement Proceeds Memorandum Account (FSPMA) credit adjustments.  
<sup>2</sup> This charge is applicable to Utility Procurement Customers and includes the GPC and GPC-A Procurement Charges shown in Schedule GPC which are subject to change monthly as set forth in Special Condition 7.  
<sup>3</sup> Effective starting May 1, 2020, the minimum bill is calculated as the minimum bill charge of \$0.13151 per day times the number of days in the billing cycle (approximately \$4 per month) with a 20% discount applied for CARE customer resulting in a minimum bill charge of \$0.10521 per day (approximately \$3.20 per month).

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2H7 Issued by Submitted Dec 9, 2022  
 Advice Ltr. No. 3145-G Effective Dec 10, 2022



San Diego Gas & Electric Company  
 San Diego, California

Revised Cal. P.U.C. Sheet No. 36337-E

Canceling Revised Cal. P.U.C. Sheet No. 35747-E

**SCHEDULE TOU-DR1**  
**RESIDENTIAL TIME-OF-USE**

Sheet 2

RATES

Total Rates:

Description – TOU DR1	UDC Total Rate	DWR BC + WF-NBC	EECC Rate + DWR Credit	Total Rate
<b>Summer:</b>				
On-Peak	0.26467	I 0.00309 R	0.42232 R	0.69008 R
Off-Peak	0.26467	I 0.00309 R	0.19003 R	0.45779 I
Super Off-Peak	0.26467	I 0.00309 R	0.06802 R	0.33578 I
<b>Winter:</b>				
On-Peak	0.39848	I 0.00309 R	0.14268 R	0.54425 R
Off-Peak	0.39848	I 0.00309 R	0.08004 R	0.48161 I
Super Off-Peak	0.39848	I 0.00309 R	0.06187 R	0.46344 I
Summer Baseline Adjustment Credit up to 130% of Baseline	(0.10182)	R		(0.10182) R
Winter Baseline Adjustment Credit up to 130% of Baseline	(0.10182)	R		(0.10182) R
Minimum Bill (\$/day)	0.350			0.350

Note:

- (1) Total Rates consist of UDC, Schedule DWR-BC (Department of Water Resources Bond Charge), Schedule WF-NBC (CA Wildfire Fund charge) and Schedule EECC (Electric Energy Commodity Cost) rates, with the EECC rates reflecting a DWR Credit. EECC rates are applicable to bundled customers only. See Special Condition 16 for PCIA (Power Charge Indifference Adjustment) recovery.
- (2) Total Rates presented are for customers that receive commodity supply and delivery service from Utility.
- (3) DWR-BC and WF-NBC charges do not apply to CARE customers.
- (4) As identified in the rates tables, customer bills will also include line-item summer and winter credits for usage up to 130% of baseline to provide the rate capping benefits adopted by Assembly Bill 1X and Senate Bill 695.
- (5) WF-NBC rate is 0.00652 + DWR-BC Bond Charge is (0.00343).

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(Continued)

2C10

Advice Ltr. No. 4004-E

Decision No. 22-03-003

Issued by  
**Dan Skopec**  
 Vice President  
 Regulatory Affairs

Submitted May 16, 2022

Effective Jun 1, 2022

Resolution No. \_\_\_\_\_

Time Periods

All time periods listed are applicable to local time. The definition of time will be based upon the date service is rendered.

TOU Periods – Weekdays	Summer	Winter
On-Peak	4:00 p.m. – 9:00 p.m.	4:00 p.m. – 9:00 p.m.
Off-Peak	6:00 a.m. – 4:00 p.m.; 9:00 p.m. - midnight	6:00 a.m. – 4:00 p.m. Excluding 10:00 a.m. – 2:00 p.m. in March and April; 9:00 p.m. - midnight
Super Off-Peak	Midnight – 6:00 a.m.	Midnight – 6:00 a.m. 10:00 a.m. – 2:00 p.m. in March and April
TOU Period – Weekends and Holidays	Summer	Winter
On-Peak	4:00 p.m. – 9:00 p.m.	4:00 p.m. – 9:00 p.m.
Off-Peak	2:00 p.m. – 4:00 p.m.; 9:00 p.m. - midnight	2:00 p.m. – 4:00 p.m.; 9:00 p.m. - midnight
Super Off-Peak	Midnight – 2:00 p.m.	Midnight – 2:00 p.m.

Seasons:        Summer        June 1 – October 31  
                   Winter         November 1 – May 31

15. **Baseline Usage:** The following quantities of electricity are used to calculate the baseline adjustment credit.

	Baseline Allowance For Climatic Zones*			
	Coastal	Inland	Mountain	Desert
<b>Basic Allowance</b>				
Summer (June 1 to October 31)	9.0	10.4	13.6	15.9
Winter (November 1 to May 31)	9.2	9.6	12.9	10.9
<b>All Electric**</b>				
Summer (June 1 to October 31)	6.0	8.7	15.2	17.0
Winter (November 1 to May 31)	8.8	12.2	22.1	17.1

\* Climatic Zones are shown on the Territory Served, Map No. 1.

\*\* All Electric allowances are available upon application to those customers who have permanently installed space heating or who have electric water heating and receive no energy from another source.

- (1) Total Rates consist of UDC, Schedule DWR-BC (Department of Water Resources Bond Charge), and Schedule EECC (Electric Energy Commodity Cost) rates, with the EECC rates reflecting a DWR Credit of \$0.00000 that customers receive on their monthly bills.
- (2) Total Rates presented are for customers that receive commodity supply and delivery service from Utility. Differences in total rates paid by Direct Access (DA) and Community Choice Aggregation (CCA) customers are identified in Schedule DA-CRS and CCA-CRS, respectively.
- (3) DWR-BC charges do not apply to CARE or Medical Baseline customers.
- (4) Total Effective CARE Rate is presented for illustrative purposes only, and reflects the average effective CARE discount CARE customers receive which consists of (a) exemptions from paying the CARE Surcharge, DWR-BC, California Solar Initiative (CSI) and Vehicle-Grid Integration (VGI) Costs; (b) a 50% minimum bill relative to Non-CARE; and (c) a separate line-item bill discount for all qualified residential CARE customers.
- (5) Current DWR-BC as presented is now used for collecting the California Wildfire Fund Charge effective Oct 1, 2020 (See Schedule WF – NBC). DWR BC will be renamed at implementation of SDG&E’s new customer information system.



San Diego Gas & Electric Company  
San Diego, California

Revised Cal. P.U.C. Sheet No. 35718-E

Canceling Revised Cal. P.U.C. Sheet No. 32576-E

**SCHEDULE E-CARE**

Sheet 1

CALIFORNIA ALTERNATE RATES FOR ENERGY

APPLICABILITY

This schedule provides a California Alternate Rates for Energy (CARE) discount to each of the following types of customers listed below that meet the requirements for CARE eligibility as defined in Rule 1, Definitions, and herein, and is taken in conjunction with the customer's otherwise applicable service schedule.

- 1) Customers residing in a permanent single-family accommodation, separately metered by the Utility.
- 2) Multi-family dwelling units and mobile home parks supplied through one meter on a single premises where the individual unit is submetered.
- 3) Non-profit group living facilities.
- 4) Agricultural employee housing facilities.

TERRITORY

Within the entire territory served by the Utility.

DISCOUNT

- 1) **Residential CARE:** Qualified residential CARE customers will receive a total effective discount according to the following:

	2015	2016	2017	2018	2019	2020 and beyond
<b>Effective Discount</b>	40%	39%	38%	38%	36% R	35%

Pursuant to Commission Decision (D.) 15-07-001, the average effective CARE discount for residential customers will decrease 1% each year until an average effective discount of 35% is reached in 2020.

The average effective CARE discount consists of: (a) exemptions from paying the CARE Surcharge, Department of Water Resources Bond Charge (DWR-BC), Vehicle-Grid Integration (VGI) costs, and California Solar Initiative (CSI); (b) a 50% minimum bill relative to Non-CARE; (c) the California Wildfire Fund Charge (WF-NBC) and (d) a separate line-item bill discount for all qualified residential CARE customers with the exclusion of CARE Medical Baseline customers taking service on tiered rates schedules. D.15-07-001 retained the rate subsidies in Non-CARE Medical Baseline tiered rates and thereby a separate line-item discount is provided for these CARE Medical Baseline customers

(Continued)

1C5

Advice Ltr. No. 3928-E

Issued by  
**Dan Skopec**  
Vice President

Submitted Dec 30, 2021  
Effective Jan 1, 2022

### 7.2.5 City of Palo Alto Utilities

Following are the CPAU electricity and natural gas tariffs applied in this study. The CPAU monthly gas rate in \$/therm was applied on a monthly basis according to the rates shown in **Error! Reference source not found.**. These rates are based on applying a normalization curve to the December 2022 tariff based on three years of historical gas data. See the beginning of Section **Error! Reference source not found. Error! Reference source not found.** for further details. The monthly service charge applied was \$106.90 per month per the December 2022 G-2 tariff.

**Table 31. CPAU Monthly Gas Rate (\$/therm)**

Month	G2 Volumetric Totals
January	\$1.80964
February	\$1.67009
March	\$1.68480
April	\$1.68698
May	\$1.78478
June	\$1.88288
July	\$1.88355
August	\$2.06943
September	\$2.06798
October	\$2.08553
November	\$2.09681
December	\$2.45700

**RESIDENTIAL ELECTRIC SERVICE**

UTILITY RATE SCHEDULE E-1

**A. APPLICABILITY:**

This Rate Schedule applies to separately metered single-family residential dwellings receiving Electric Service from the City of Palo Alto Utilities.

**B. TERRITORY:**

This rate schedule applies everywhere the City of Palo Alto provides Electric Service.

**C. UNBUNDLED RATES:**

<u>Per kilowatt-hour (kWh)</u>	<u>Commodity</u>	<u>Distribution</u>	<u>Public Benefits</u>	<u>Total</u>
Tier 1 usage	\$0.08547	\$0.05429	\$0.00469	\$0.14445
Tier 2 usage Any usage over Tier 1	0.11858	0.08008	0.00469	0.20335
<u>Minimum Bill (\$/day)</u>				0.3447

**RESIDENTIAL MASTER-METERED AND SMALL NON-RESIDENTIAL ELECTRIC SERVICE**

UTILITY RATE SCHEDULE E-2

**A. APPLICABILITY:**

This Rate Schedule applies to the following Customers receiving Electric Service from the City of Palo Alto Utilities:

1. Small non-residential Customers receiving Non-Demand Metered Electric Service; and
2. Customers with Accounts at Master-Metered multi-family facilities.

**B. TERRITORY:**

This rate schedule applies everywhere the City of Palo Alto provides Electric Service.

**C. UNBUNDLED RATES:**

<u>Per kilowatt-hour (kWh)</u>	<u>Commodity</u>	<u>Distribution</u>	<u>Public Benefits</u>	<u>Total</u>
Summer Period	\$0.12151	\$0.09276	\$0.00469	\$0.21896
Winter Period	0.08715	0.06171	0.00469	0.15355
<u>Minimum Bill (\$/day)</u>				0.8777

**EXPORT ELECTRICITY COMPENSATION**

UTILITY RATE SCHEDULE E-EEC-1

**A. APPLICABILITY:**

This Rate Schedule applies in conjunction with the otherwise applicable Rate Schedules for each Customer class. This Rate Schedule may not apply in conjunction with any time-of-use Rate Schedule. This Rate Schedule applies to Customer-Generators as defined in Rule and Regulation 2 who are either not eligible for Net Energy Metering or who are eligible for Net Energy metering but elect to take Service under this Rate Schedule.

**B. TERRITORY:**

Applies to locations within the service area of the City of Palo Alto.

**C. RATE:**

The following buyback rate shall apply to all electricity exported to the grid.

	<u>Per kWh</u>
Export electricity compensation rate	\$0.1045

## 7.2.6 Sacramento Municipal Utilities District (Electric Only)

Following are the SMUD electricity tariffs applied in this study. The rates effective January 2023 were used.

### Residential Time-of-Day Service Rate Schedule R-TOD

#### II. Firm Service Rates

##### A. Time-of-Day (5-8 p.m.) Rate

	Effective as of October 1, 2021	Effective as of March 1, 2022	Effective as of January 1, 2023
<b>Time-of-Day (5-8 p.m.) Rate (RT02)</b>			
<b>Non-Summer Season (October - May)</b>			
System Infrastructure Fixed Charge <i>per month per meter</i>	\$22.70	\$23.05	\$23.50
Electricity Usage Charge			
Peak <i>\$/kWh</i>	\$0.1494	\$0.1516	\$0.1547
Off-Peak <i>\$/kWh</i>	\$0.1082	\$0.1098	\$0.1120
<b>Summer Season (June - September)</b>			
System Infrastructure Fixed Charge <i>per month per meter</i>	n/a	\$23.05	\$23.50
Electricity Usage Charge			
Peak <i>\$/kWh</i>	n/a	\$0.3215	\$0.3279
Mid-Peak <i>\$/kWh</i>	n/a	\$0.1827	\$0.1864
Off-Peak <i>\$/kWh</i>	n/a	\$0.1323	\$0.1350

##### A. Time-of-Day (5-8 p.m.) Rate (rate category RT02)

- The TOD (5-8 p.m.) Rate is the standard rate for SMUD’s residential customers. Eligible customers can elect the Fixed Rate under Rate Schedule R as an alternative rate.
- The TOD (5-8 p.m.) Rate is an optional rate for customers who have an eligible renewable electrical generation facility under Rate Schedule NEMI that was approved for installation by SMUD prior to January 1, 2018.
- This rate has five kilowatt-hour (kWh) prices, depending on the time-of-day and season as shown below. Holidays are detailed in Section V. Conditions of Service.

<b>Summer (Jun 1 - Sept 30)</b>	<b>Peak</b>	Weekdays between 5:00 p.m. and 8:00 p.m.
	<b>Mid-Peak</b>	Weekdays between noon and midnight except during the Peak hours.
	<b>Off-Peak</b>	All other hours, including weekends and holidays <sup>1</sup> .
<b>Non-Summer (Oct 1 - May 31)</b>	<b>Peak</b>	Weekdays between 5:00 p.m. and 8:00 p.m.
	<b>Off-Peak</b>	All other hours, including weekends and holidays <sup>1</sup> .

<sup>1</sup> See Section V. Conditions of Service

**C. Master-Metered Multifamily Accommodation and Mobile Home Park Billing (Rate Category RSMM) Closed**

	Effective as of October 1, 2021	Effective as of March 1, 2022	Effective as of January 1, 2023
<b>Master Metered Multifamily and Mobile Home Park Billing (Closed)</b>			
<b>Non-Summer Season (October - May)</b>			
<b>System Infrastructure Fixed Charge</b> <i>per month per meter</i>	\$22.70	\$23.05	\$23.50
<b>Electricity Usage Charge</b>			
All kWh usage per month <i>\$/kWh</i>	\$0.1279	\$0.1298	\$0.1324
<b>Summer Season (June - September)</b>			
<b>System Infrastructure Fixed Charge</b> <i>per month per meter</i>	n/a	\$23.05	\$23.50
<b>Electricity Usage Charge</b>			
All kWh usage per month <i>\$/kWh</i>	n/a	\$0.1486	\$0.1516

### 7.2.7 Fuel Escalation Assumptions

The average annual escalation rates in **Error! Reference source not found.** were used in this study. These are based on assumptions from the CPUC 2021 En Banc hearings on utility costs through 2030 (California Public Utilities Commission, 2021a). Escalation rates through the remainder of the 30-year evaluation period are based on the escalation rate assumptions within the 2022 TDV factors. No data was available to estimate electricity escalation rates for CPAU and SMUD, therefore electricity escalation rates for PG&E and statewide natural gas escalation rates were applied.

**Table 32: Real Utility Rate Escalation Rate Assumptions**

	Statewide Natural Gas Residential Average Rate (%/year, real)	Electric Residential Average Rate (%/year, real)		
		PG&E	SCE	SDG&E
2023	4.6%	1.8%	1.6%	2.8%
2024	4.6%	1.8%	1.6%	2.8%
2025	4.6%	1.8%	1.6%	2.8%
2026	4.6%	1.8%	1.6%	2.8%
2027	4.6%	1.8%	1.6%	2.8%
2028	4.6%	1.8%	1.6%	2.8%
2029	4.6%	1.8%	1.6%	2.8%
2030	4.6%	1.8%	1.6%	2.8%
2031	2.0%	0.6%	0.6%	0.6%
2032	2.4%	0.6%	0.6%	0.6%
2033	2.1%	0.6%	0.6%	0.6%
2034	1.9%	0.6%	0.6%	0.6%
2035	1.9%	0.6%	0.6%	0.6%
2036	1.8%	0.6%	0.6%	0.6%
2037	1.7%	0.6%	0.6%	0.6%
2038	1.6%	0.6%	0.6%	0.6%
2039	2.1%	0.6%	0.6%	0.6%
2040	1.6%	0.6%	0.6%	0.6%
2041	2.2%	0.6%	0.6%	0.6%
2042	2.2%	0.6%	0.6%	0.6%
2043	2.3%	0.6%	0.6%	0.6%
2044	2.4%	0.6%	0.6%	0.6%
2045	2.5%	0.6%	0.6%	0.6%
2046	1.5%	0.6%	0.6%	0.6%
2047	1.3%	0.6%	0.6%	0.6%
2048	1.6%	0.6%	0.6%	0.6%
2049	1.3%	0.6%	0.6%	0.6%
2050	1.5%	0.6%	0.6%	0.6%
2051	1.8%	0.6%	0.6%	0.6%
2052	1.8%	0.6%	0.6%	0.6%

### 7.3 Cost Details

Table 33 presents additional detail on the first cost assumptions for the central water heating systems. For the 5-story prototype costs are provided both for a CO<sub>2</sub> refrigerant Sanden-based and R-134a refrigerant Colmac-based heat pump water heater designs. The results presented in the main body of this report are based on the Sanden design. A sensitivity analysis was also conducted for a Colmac design (see Appendix 7.5 Central Heat Pump Water Heater Comparison) and the cost comparison is presented here. All costs are based on data from the 2022 Multifamily All-Electric CASE Report (Statewide CASE Team, 2020c).

**Table 33. Heat Pump Water Heater First Costs per Building (Present Value (2023\$))**

Item	3-Story (36-units)			5-Story (88-units)			
	Gas Boiler (CZs 1-9)	Gas Boiler (CZs 10-16)	Heat Pump	Gas Boiler (CZs 1-9)	Gas Boiler (CZs 10-16)	Heat Pump (Sanden)	Heat Pump (Colmac)
Water Heating Equipment	\$87,602	\$87,602	\$140,907	\$135,146	\$135,146	\$244,742	\$319,485
Solar Thermal Collector	\$39,800	\$46,888	n/a	\$74,740	\$91,776	n/a	n/a
Gas Piping	\$8,890	\$8,890	n/a	\$9,065	\$9,065	n/a	n/a
Electrical Circuits	n/a	n/a	\$25,000	n/a	n/a	\$25,000	\$25,000
Overhead & Markup	\$37,480	\$39,430	\$45,624	\$60,212	\$64,896	\$74,179	\$94,733
<b>Total</b>	<b>\$173,772</b>	<b>\$182,810</b>	<b>\$211,531</b>	<b>\$279,163</b>	<b>\$300,883</b>	<b>\$343,920</b>	<b>\$439,218</b>

Table 34 presents additional detail on the first cost assumptions for the space heating systems.

**Table 34. Heat Pump Space Heater First Costs per Dwelling Unit (Present Value (2023\$))**

Item	3-Story		5-Story		Source & Notes
	Furnace + Split AC	Heat Pump	Furnace + Split HP	Heat Pump	
Dwelling Unit HVAC	\$5,651	\$5,460	\$6,109	\$5,460	Gas system costs based on 2022 Multifamily All-Electric CASE Report. Heat pump costs based on online equipment research indicating a 2-ton HP is \$191 less than a furnace/AC of the same size.
Refrigerant Piping	\$563	\$563	\$423	\$423	2022 Multifamily All-Electric CASE Report.
Gas Piping	\$92	\$0	\$227	\$0	
Electrical Circuits	\$0	\$150	\$0	\$150	
Labor	\$9,904	\$6,985	\$9,904	\$6,985	Based on the 2022 Multifamily All-Electric CASE Report with adjustments to align with updated equipment costs.
Overhead & Markup	\$4,457	\$3,618	\$4,582	\$3,579	Based on a 27% markup
<b>Total</b>	<b>\$20,667</b>	<b>\$16,776</b>	<b>\$21,245</b>	<b>\$16,597</b>	
<b>Incremental Cost</b>		<b>(\$3,891)</b>		<b>(\$4,647)</b>	

## 7.4 PG&E Gas Infrastructure Cost Memo



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December 5, 2019

Energy Commission Staff:

On March 2, 2018, PG&E provided gas extension cost estimates for residential existing and new subdivisions (see attached memo). We have recently updated our estimates and are therefore providing an updated memo.

In addition to mainline and service extension costs, we are also providing estimates of the cost of gas meters for different building types including both residential and commercial customers. These estimates are based on PG&E historical jobs.

Developing gas extension cost estimates is complex and the actual costs are project dependent. Costs vary widely with location, terrain, distance to the nearest main, joint trenching, materials, number of dwellings per development, and several other site and job-specific conditions. For these reasons, it is not practical to come up with estimates that represent every case. Instead we are including estimates based on historical averages taken from projects within PG&E's territory. It is not recommended to compare specific project costs to these estimates as any number of factors could lead to higher or lower costs than these averages are representing.

We are also including estimates for in-house gas infrastructure costs and specific plan review costs. These estimates are from external sources, and are not based on PG&E data, but have been provided for the sake of completeness and for use in energy efficiency analysis.

To further anchor the estimates, several assumptions have been made:

1. It is assumed that during new construction, gas infrastructure will likely be joint trenched with electric infrastructure. As a result, the incremental cost of trenching associated with the gas infrastructure alone is minimal. Therefore, all mainline cost estimates exclude trench costs. Service extension cost estimates include both estimates with and without trench costs. In the case where new construction would require overhead electric and underground gas infrastructure, the estimates with trench costs included for service extensions should be utilized.
2. It is assumed that new construction in an existing subdivision would not generally require a mainline extension. In cases where a mainline extension would be required to an existing subdivision, the costs are highly dependent on the location, terrain, and distance to the nearest main.



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- These estimates are for total costs. The cost estimates have not been reduced to account for the portion of the costs paid by all customers due to application of Rule 15<sup>1</sup> and Rule 16<sup>2</sup> allowances. Hence, costs to the specific customer may be lower than the estimates below, as the specific customer benefits from the Rule 15 and Rule 16 allowances.

Table 1: PG&E Gas Infrastructure Cost Estimates

	Existing Subdivision/Development	New Greenfield Subdivision/Development
Mainline Extension	N/A <sup>3</sup>	<u>Single-Family</u> \$17/ft <sup>4</sup>  <u>Multi-Family</u> \$11/ft <sup>4</sup>
Service Extension (Typically 1" pipe from mainline to the meter)	\$6750 per service/building <sup>4</sup> (excludes trench costs)  \$9200 per service/building <sup>4</sup> (includes trench costs)	\$1300 per service/building <sup>4</sup> (includes mainline extension costs within the subdivision; excludes trench costs)  \$1850 per service/building <sup>4</sup> (includes mainline extension costs within the subdivision; includes trench costs)
Meter	<u>Residential Single Family</u> \$300 per meter <sup>5</sup>  <u>Residential Multi-Family</u> \$300 per meter + \$300 per meter manifold outlet <sup>5</sup>  <u>Small/Medium Commercial</u> \$3600 per meter <sup>6</sup>	<u>Residential Single Family</u> \$300 per meter <sup>5</sup>  <u>Residential Multi-Family</u> \$300 per meter + \$300 per meter manifold outlet <sup>5</sup>  <u>Small/Medium Commercial</u> \$3600 per meter <sup>6</sup>

<sup>1</sup> [https://www.pge.com/tariffs/tm2/pdf/ELEC\\_RULES\\_15.pdf](https://www.pge.com/tariffs/tm2/pdf/ELEC_RULES_15.pdf)

<sup>2</sup> [https://www.pge.com/tariffs/tm2/pdf/ELEC\\_RULES\\_16.pdf](https://www.pge.com/tariffs/tm2/pdf/ELEC_RULES_16.pdf)

<sup>3</sup> It is assumed that new construction in an existing subdivision would not require a main extension.

<sup>4</sup> Estimates based on PG&E jobs from Jan 2016 - Dec 2017 from PG&E's Service Planning team.

<sup>5</sup> Estimates from PG&E's Dedicated Estimating Team. For Multi-Family units, the costs of \$300 per meter and \$300 per meter manifold outlet should be combined for a total of \$600 per meter.

<sup>6</sup> PG&E Marginal Customer Access Cost Estimates presented in the 2019 Gas Cost Allocation Proceedings (GCAP), A.17-09-006, Exhibit PG&E-2, Appendix A, Section A, Table A-1. The Average Connection Cost per Customer values were included in the MCAC worksheet that accompanied the GCAP testimony.



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	<u>Large Commercial</u> \$32,000 per meter <sup>5</sup>	<u>Large Commercial</u> \$32,000 per meter <sup>5</sup>
--	--	--

Note: Service extension cost estimates for New Greenfield Subdivisions include mainline extension costs as well. Therefore, mainline cost estimates can be ignored for the purpose of estimating total project costs.

Table 2: Gas Infrastructure Cost Estimates from Other Sources

	Existing Subdivision/Development	New Greenfield Subdivision/Development
In-House Infrastructure	<u>Single-Family</u> \$800 <sup>7</sup>	<u>Single-Family</u> \$800 <sup>7</sup>
	<u>Multi-Family</u> \$600 per unit <sup>7</sup>	<u>Multi-Family</u> \$600 per unit <sup>7</sup>
	<u>Medium Office</u> \$600-4500 <sup>7,k</sup>	<u>Medium Office</u> \$600-4500 <sup>7,k</sup>
	<u>Medium Retail</u> \$10,000 <sup>8</sup>	<u>Medium Retail</u> \$10,000 <sup>8</sup>
Plan Review (Will vary by city and often not a fixed fee)	<u>Residential</u> Palo Alto - \$850 <sup>9</sup>	<u>Residential</u> Palo Alto - \$850 <sup>9</sup>
	<u>Nonresidential</u> Palo Alto - \$2316 <sup>9</sup>	<u>Nonresidential</u> Palo Alto - \$2316 <sup>9</sup>

Please let us know if there are any follow-up questions or clarifications.

Best regards,

<sup>7</sup> Frontier Energy, Inc., Misti Bruneri & Associates, LLC. 2019. "2019 Cost-effectiveness Study: Low Rise Residential New Construction." Available at: <https://localenergycodes.com/content/performance-ordinances>

<sup>8</sup> TRC, EnergySuff. 2019. "2019 Nonresidential New Construction Reach Code Cost Effectiveness Study." Available at: <https://localenergycodes.com/content/performance-ordinances>

<sup>9</sup> TRC. 2018. "City of Palo Alto 2019 Title 24 Energy Reach Code Cost Effectiveness Analysis Draft." Available at: <http://cityofpaloalto.org/civicax/filebank/documents/66742>

## 7.5 Central Heat Pump Water Heater Comparison

Table 35 presents energy and cost-effectiveness results for a R-134a refrigerant based system design using a Colmac central heat pump water heater in the 5-story prototype. This was only found to be cost-effective based on at least one of the two metrics in Climate Zones 1, 4 in CPAU territory, and 16.

**Table 35. 5-Story Cost-Effectiveness: All-Electric Prescriptive Code with R-134a Heat Pump Water Heater**

Climate Zone	Electric /Gas Utility	Efficiency TDV Comp Margin	Source Comp Margin	Annual Elec Savings (kWh)	Annual Gas Savings (therms)	Utility Cost Savings		Incremental Cost		On-Bill		TDV	
						First Year	Lifecycle (2022\$)	First Year	Lifecycle (2022\$)	B/C Ratio	NPV	B/C Ratio	NPV
CZ01	PGE	6%	6%	-1,496	147	(\$155)	(\$1,240)	(\$3,556)	(\$4,223)	3.4	\$2,984	>1	\$5,870
CZ02	PGE	4%	2%	-1,197	120	(\$145)	(\$1,513)	\$1,691	\$2,749	0.0	(\$4,262)	0.5	(\$1,287)
CZ03	PGE	6%	3%	-1,166	120	(\$138)	(\$1,360)	\$1,691	\$2,749	0.0	(\$4,109)	0.8	(\$523)
CZ04	PGE	4%	2%	-1,116	113	(\$76)	(\$49)	\$1,691	\$2,749	0.0	(\$2,798)	0.7	(\$949)
CZ04	CPAU	4%	2%	-1,116	113	\$185	\$7,144	\$1,718	\$2,776	2.6	\$4,368	0.6	(\$976)
CZ05	PGE	5%	2%	-1,161	117	(\$137)	(\$1,391)	\$1,691	\$2,749	0.0	(\$4,140)	0.5	(\$1,412)
CZ05	PGE/SCG	5%	2%	-1,161	117	(\$189)	(\$3,016)	\$1,691	\$2,749	0.0	(\$5,765)	0.5	(\$1,412)
CZ06	SCE/SCG	4%	1%	-1,000	104	(\$92)	(\$879)	\$1,691	\$2,749	0.0	(\$3,628)	0.6	(\$1,013)
CZ07	SDGE	5%	2%	-996	106	(\$183)	(\$3,216)	\$1,691	\$2,749	0.0	(\$5,965)	0.7	(\$936)
CZ08	SCE/SCG	3%	1%	-948	100	(\$156)	(\$2,413)	\$1,691	\$2,749	0.0	(\$5,162)	0.7	(\$695)
CZ09	SCE	3%	0%	-966	100	(\$132)	(\$1,863)	\$1,691	\$2,749	0.0	(\$4,612)	0.7	(\$738)
CZ10	SCE/SCG	3%	1%	-962	84	(\$188)	(\$3,375)	\$1,444	\$2,395	0.0	(\$5,770)	0.3	(\$1,596)
CZ10	SDGE	3%	1%	-962	84	(\$239)	(\$4,959)	\$1,444	\$2,395	0.0	(\$7,354)	0.3	(\$1,596)
CZ11	PGE	4%	3%	-1,029	92	(\$165)	(\$2,487)	\$1,444	\$2,395	0.0	(\$4,882)	0.4	(\$1,367)
CZ12	PGE	4%	3%	-1,081	96	(\$172)	(\$2,591)	\$1,444	\$2,395	0.0	(\$4,986)	0.3	(\$1,667)
CZ12	SMUD/PGE	4%	3%	-1,081	96	\$26	\$1,988	\$1,444	\$2,395	0.8	(\$407)	0.3	(\$1,667)
CZ13	PGE	3%	2%	-976	88	(\$156)	(\$2,361)	\$1,444	\$2,395	0.0	(\$4,756)	0.4	(\$1,452)
CZ14	SCE/SCG	2%	-1%	-1,045	84	(\$210)	(\$3,880)	\$1,444	\$2,395	0.0	(\$6,275)	0.1	(\$2,056)
CZ14	SDGE	2%	-1%	-1,045	84	(\$270)	(\$5,725)	\$1,444	\$2,395	0.0	(\$8,120)	0.1	(\$2,056)
CZ15	SCE/SCG	2%	-1%	-718	65	(\$146)	(\$2,713)	\$1,444	\$2,395	0.0	(\$5,108)	0.3	(\$1,564)
CZ16	PG&E	-5%	6%	-1,913	142	(\$276)	(\$4,142)	(\$3,803)	(\$4,577)	1.1	\$435	1.2	\$746

## 7.6 Summary of Measures by Package

Table 36 provides the details of the measures in each of the efficiency package by climate zone. The measures are the same for the 3-story and 5-story prototypes. Table 37 presents the PV capacities per dwelling unit in the upgrade packages. In Climate Zone 6 for the mixed fuel case in the 5-story prototype there is no upgrade to the PV system capacity as the prescriptive PV system already offset all of the estimated electricity use.

**Table 36. Mixed Fuel Efficiency Package Measures**

Climate Zone	0.70 Roof Solar Reflectance	0.24 U-Factor Windows	0.35 W/cfm	Verified Low Leakage Ducts in Conditioned Space
1			X	X
2				X
3				X
4				X
5				X
6				X
7				X
8				X
9	X			X
10	X		X	X
11	X		X	X
12	X		X	X
13	X		X	X
14	X		X	X
15	X		X	X
16		X	X	X

**Table 37. Upgrade Package PV Capacities (kW-DC)**

Climate Zone	All-Electric + PV		Mixed Fuel + PV	
	3-Story	5-Story	3-Story	5-Story
<b>CZ01</b>	4.41	4.35	3.69	3.43
<b>CZ02</b>	3.56	3.58	3.02	2.98
<b>CZ03</b>	3.31	3.29	2.80	2.72
<b>CZ04</b>	3.21	3.27	2.73	2.75
<b>CZ05</b>	3.04	3.08	2.57	2.55
<b>CZ06</b>	2.91	3.04	2.49	2.68
<b>CZ07</b>	3.09	3.21	2.64	2.74
<b>CZ08</b>	3.18	3.30	2.76	2.86
<b>CZ09</b>	3.04	3.16	2.63	2.73
<b>CZ10</b>	3.20	3.30	2.79	2.86
<b>CZ11</b>	3.90	3.95	3.42	3.43
<b>CZ12</b>	3.53	3.60	3.05	3.08
<b>CZ13</b>	3.77	3.84	3.32	3.36
<b>CZ14</b>	3.20	3.23	2.79	2.79
<b>CZ15</b>	3.93	3.94	3.58	3.58
<b>CZ16</b>	3.79	3.76	2.60	2.90

## Get In Touch

The adoption of reach codes can differentiate jurisdictions as efficiency leaders and help accelerate the adoption of new equipment, technologies, code compliance, and energy savings strategies.

As part of the Statewide Codes & Standards Program, the Reach Codes Subprogram is a resource available to any local jurisdiction located throughout the state of California.

Our experts develop robust toolkits as well as provide specific technical assistance to local jurisdictions (cities and counties) considering adopting energy reach codes. These include cost-effectiveness research and analysis, model ordinance language and other code development and implementation tools, and specific technical assistance throughout the code adoption process.

If you are interested in finding out more about local energy reach codes, the Reach Codes Team stands ready to assist jurisdictions at any stage of a reach code project.



Visit [LocalEnergyCodes.com](https://www.localenergycodes.com) to access our resources and sign up for newsletters.



Contact [info@localenergycodes.com](mailto:info@localenergycodes.com) for no-charge assistance from expert Reach Code advisors



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## 2022 CODE CYCLE: **Cost Effectiveness Analysis: 5-Story Multifamily New Construction Update**



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TRC Companies, Inc

**Prepared for:**

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## Acronym List

B/C – Benefit-to-Cost Ratio

CASE – Codes and Standards Enhancement

CBECC - California Building Energy Code Compliance

CBSC - California Building Standards Commission

CEC - California Energy Commission

CPAU – City of Palo Alto Utilities

CZ – Climate Zone

GHG - Greenhouse Gas

IOU – Investor-Owned Utility

POU – Publicly Owned Utility

PG&E – Pacific Gas & Electric (utility)

SCE – Southern California Edison (utility)

SCG – Southern California Gas (utility)

SDG&E – San Diego Gas & Electric (utility)

SSF – Solar Savings Fraction

LADWP – Los Angeles Department of Water and Power

kWh – Kilowatt Hour

NPV – Net Present Value

PV - Solar Photovoltaic

TDV - Time Dependent Valuation

Title 24 – California Code of Regulations Title 24, Part 6



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### Summary of Revisions

Date	Description	Reference (page or section)
6/20/2023	Original Release	-
10/24/24	Abbreviated report with updated 5-story packages, DHW costs, HPWH system design, increased solar thermal package, and software update to CBECC 2022.3.1	-

## 1 Introduction

This abbreviated report is an addendum to the statewide 2022 Cost-Effectiveness Study for Multifamily New Construction report that documents cost-effective combinations of measures that exceed the minimum state requirements, the 2022 Building Energy Efficiency Standards, effective January 1, 2023, for newly constructed multifamily buildings. This report was developed in coordination with the California Statewide Investor-Owned Utilities (CA IOUs) Codes and Standards Program, key consultants, and engaged cities, which are collectively known as the Reach Codes Team. The CA IOU Codes and Standards Program is comprised of IOUs representatives from Pacific Gas and Electric (PG&E), Southern California Edison (SCE), and San Diego Gas and Electric (SDG&E).

The focus of this update is to provide an additional package for the 5-story mixed use multifamily building type in the most recent CBECC software version in support of the single source margin reach code strategy. The package includes a combination of efficiency measures and an increase in the capacity of the solar thermal water heating system. In addition, this study uses updated water heater costs and heat pump water heater (HPWH) system design from the 2025 Multifamily Domestic Hot Water CASE study (Statewide CASE Team, 2023).

## 2 Methodology and Assumptions

The focus of this update is to provide additional packages for the 5-story multifamily building type in the most recent CBECC software version in support of the single source margin reach code strategy. The general methodology is consistent with the statewide study with the following updates:

1. Updated analysis focused on the 5-story prototype only.
2. Energy models were updated using CBECC 2022.3.1.
3. An additional mixed fuel package with an increased solar thermal system capacity resulting in 0.35 solar savings fraction (SSF) in climate zones (CZ) 1-9 and 0.50 SSF in CZ 10-16.
4. Updated water heater costs and HPWH system design consistent with the 2025 Multifamily Domestic Hot Water CASE study (Statewide CASE Team, 2023).

### 2.1 Reach Codes

This section describes the approach to calculate cost-effectiveness including benefits, costs, and metrics.

#### 2.1.1 Benefits

This analysis used a time dependent valuation (TDV) of energy-based approach to evaluate cost-effectiveness. TDV requires estimating and quantifying energy savings and costs associated with energy measures.

TDV was developed by the Energy Commission to reflect the time dependent value of energy including long-term projected costs of energy such as the cost of providing energy during peak periods of demand and other societal costs including projected costs for carbon emissions and grid transmission impacts. This metric values energy use differently depending on the fuel source (gas, electricity, and propane), time of day, and season. Electricity used (or saved) during peak periods has a much higher value than electricity used (or saved) during off-peak periods.

Utility costs and On-Bill cost-effectiveness were not evaluated for this update.

### 2.1.2 Costs

The Reach Codes Team assessed the incremental costs and savings of the energy packages over the lifecycle of 30 years for the multifamily buildings. Incremental costs represent the equipment, installation, replacement, and maintenance costs of the proposed measure relative to the 2022 Title 24 Standards minimum requirements or standard industry practices. The Reach Codes Team obtained measure costs from manufacturer distributors, contractors, literature review, and online sources such as Home Depot and RS Means. Taxes and contractor markups were added as appropriate. Maintenance and replacement costs are included where appropriate.

Table 1 includes the costs for the updated measures including the updated HPWH system to align with the 2025 Multifamily DHW CASE study and the upsized solar thermal system to 0.35 SSF and 0.50 SSF for CZ 1-9 and CZ 10-16 respectively.

**Table 1: Measure Costs**

Measure	Climate Zones	Performance Level	Incremental Cost per Dwelling Unit	Source & Notes
HPWH	1-9	2 Large-capacity CO <sub>2</sub> refrigerant Mitsubishi Heat2O	\$809	2025 Multifamily Domestic Hot Water CASE study (Statewide CASE Team, 2023)
	10-16		\$421	
Solar Thermal System	1-9	0.35 SSF	\$774	Storage tank size design aligns with the 2022 Multifamily Domestic Hot Water CASE study (Statewide CASE Team, 2020). Solar thermal system cost methodology aligns with the original 2022 Multifamily Reach Code Report but is scaled up for the upsized solar thermal system (Statewide Reach Codes Team, 2023).
	10-16	0.50 SSF	\$942	

### 2.1.3 Metrics

Cost-effectiveness is presented using net present value (NPV) and benefit-to-cost (B/C) ratio metrics.

- NPV: The Reach Codes Team uses net savings (NPV benefits minus NPV costs) as the cost-effectiveness metric. If the net savings of a measure or package is positive, it is considered cost effective. Negative net savings represent net costs to the consumer. A measure that has negative energy cost benefits (energy cost increase) can still be cost effective if the costs to implement the measure are even more negative (i.e., construction and maintenance cost savings).
- B/C Ratio: Ratio of the present value of all benefits to the present value of all costs over 30 years (NPV benefits divided by NPV costs). The criterion for cost-effectiveness is a B/C greater than 1.0. A value of one indicates the savings over the life of the measure are equivalent to the incremental cost of that measure. A value greater than one represents a positive return on investment.

Improving the energy performance of a building often requires an initial investment. In most cases the benefit is represented by TDV savings, and the cost by incremental first cost and replacement costs. However, some packages result in initial construction cost savings (negative incremental cost), and either energy cost savings (positive benefits), or increased energy costs (negative benefits). In cases where both construction costs and energy-related savings are negative, the construction cost savings are treated as the benefit while the increased energy costs are the cost. In cases where a measure or package is cost-effective immediately (i.e., upfront construction cost savings and lifetime energy cost savings), B/C ratio cost-effectiveness is represented by “>1”. Because of these situations, NPV savings are also reported, which, in these cases, are positive values.

### 3 Prototype Designs and Measure Packages

#### 3.1 Multifamily Prototype Buildings

The focus of this update is on the 5-story mixed use prototype described in Table 2 below. For more details on the building prototype selection methodology, please refer to the 2022 Multifamily New Construction Cost-Effectiveness Study (Statewide Reach Codes Team, 2023).

**Table 2: Prototype Characteristics**

Characteristic	5-Story Mixed Use
Conditioned Floor Area	113,100 ft <sup>2</sup> total: 33,660 ft <sup>2</sup> nonresidential 79,440 ft <sup>2</sup> residential
Num. of Stories	6 Stories total: 1 story parking garage (below grade) 1 story of nonresidential space 4 stories of residential space
Num. of Bedrooms	(8) studios (40) 1-bed units (32) 2-bed units (8) 3-bed units
Window-to-Wall Area Ratio	25%
Wall Type	Wood frame over a first-floor concrete podium
Roof Type	Flat roof
Foundation	Concrete podium with underground parking

#### 3.2 Measure Packages

The Reach Codes Team evaluated an updated all-electric and mixed fuel package for the 5-story prototype, as described below.

1. All-Electric Prescriptive Code: This package meets all the prescriptive requirements of the 2022 Energy Code. In this update, 2 large-capacity CO<sub>2</sub> refrigerant Mitsubishi Heat2O HPWHs were used instead of the Sanden HPWH used in the initial report.
2. Mixed Fuel Efficiency + Solar Thermal: Using the Efficiency Package from the main study as a starting point, an upsized solar thermal system was added with efficiencies of 0.35 SSF for CZ1-9 and 0.50 SSF for CZ 10-16. This is an increase from the prescriptive solar thermal requirements of 0.20 SSF in CZ 1-9 and 0.35 SSF in CZ 10-16.

## 4 Results

Cost-effectiveness results are presented for measure packages described in Section 3.2. The TDV based cost-effectiveness results are presented in terms of B/C ratio and NPV. Energy savings, compliance margin, and incremental costs are also shown.

In the following figures, green highlighting indicates that the case is cost-effective with a B/C ratio greater than or equal to 1 and an NPV greater than or equal to 0. Red highlighting indicates the case is not cost-effective.

Compliance margins are presented as percentages both for the efficiency TDV and the source energy metrics. A compliance margin that is equal to or greater than 0 indicates the case is code compliant.

Table 3 and Table 4 show results for the all-electric package and the mixed fuel package respectively. In the all-electric package for CZ 1 and 16, there are significant cost savings. This is because the base case for CZ 1 and 16 is an electric heat pump with natural gas backup, so the large negative cost reflects the avoided first costs of installing a gas furnace as compared to a heat pump.

**Table 3: All-Electric 5-Story Multifamily Cost-Effectiveness Results per Dwelling Unit**

Climate Zone	Electric/ Gas Utility	Efficiency TDV Comp Margin	Source Comp Margin	Annual Elec Savings (kWh)	Annual Gas Savings (therms)	Incremental Cost		TDV	
						First Year	Lifecycle (2022\$)	B/C Ratio	NPV
CZ01	PGE	15%	21%	-1,024	139	(\$5,820)	(\$6,292)	>1	\$9,525
CZ02	PGE	10%	14%	-799	112	(\$573)	\$681	4.0	\$1,917
CZ03	PGE	11%	16%	-787	111	(\$573)	\$681	3.9	\$1,903
CZ04	PGE	9%	15%	-754	105	(\$573)	\$681	3.6	\$1,678
CZ04	CPAU	9%	15%	-754	105	(\$546)	\$707	3.4	\$1,651
CZ05	PGE	11%	15%	-785	109	(\$573)	\$681	3.7	\$1,759
CZ05	PGE/SCG	11%	15%	-785	109	(\$573)	\$681	3.7	\$1,759
CZ06	SCE/SCG	8%	17%	-695	96	(\$573)	\$681	2.8	\$1,155
CZ07	SDGE	10%	23%	-689	99	(\$573)	\$681	3.1	\$1,392
CZ08	SCE/SCG	7%	12%	-672	92	(\$573)	\$681	2.7	\$1,115
CZ09	SCE/SCG	6%	10%	-683	92	(\$573)	\$681	2.7	\$1,117
CZ10	SCE/SCG	6%	10%	-683	77	(\$843)	\$293	6.5	\$1,440
CZ10	SDGE	6%	10%	-683	77	(\$843)	\$293	6.5	\$1,440
CZ11	PGE	7%	12%	-723	85	(\$843)	\$293	7.9	\$1,793
CZ12	PGE	8%	16%	-743	89	(\$843)	\$293	8.8	\$2,030
CZ12	SMUD/PGE	8%	16%	-743	89	(\$843)	\$293	8.8	\$2,030
CZ13	PGE	6%	11%	-697	81	(\$843)	\$293	7.2	\$1,623
CZ14	SCE/SCG	5%	7%	-735	77	(\$843)	\$293	5.6	\$1,192
CZ14	SDGE	5%	7%	-735	77	(\$843)	\$293	5.6	\$1,192
CZ15	SCE/SCG	2%	1%	-576	59	(\$843)	\$293	3.3	\$601
CZ16	PGE	9%	25%	-1,322	141	(\$6,090)	(\$6,679)	>1	\$8,886

Table 4: Mixed Fuel + Efficiency + Solar Thermal 5-Story Multifamily Cost-Effectiveness Results per Dwelling Unit

Climate Zone	Electric/ Gas Utility	Efficiency TDV Comp Margin	Source Comp Margin	Annual Elec Savings (kWh)	Annual Gas Savings (therms)	Incremental Cost		TDV	
						First Year	Lifecycle (2022\$)	B/C Ratio	NPV
CZ01	PGE	4%	8%	2	16	\$712	\$899	1.0	\$13
CZ02	PGE	4%	8%	10	14	\$669	\$855	1.2	\$159
CZ03	PGE	5%	10%	4	16	\$669	\$855	1.2	\$142
CZ04	PGE	4%	11%	10	16	\$669	\$855	1.3	\$263
CZ04	CPAU	4%	11%	10	16	\$669	\$855	1.3	\$263
CZ05	PGE	5%	11%	3	17	\$669	\$855	1.2	\$164
CZ05	PGE/SCG	5%	11%	3	17	\$669	\$855	1.2	\$164
CZ06	SCE/SCG	4%	13%	9	15	\$669	\$855	1.2	\$138
CZ07	SDGE	5%	13%	6	16	\$669	\$855	1.1	\$135
CZ08	SCE/SCG	4%	11%	21	14	\$669	\$855	1.2	\$156
CZ09	SCE/SCG	4%	12%	25	14	\$679	\$872	1.2	\$196
CZ10	SCE/SCG	6%	16%	81	18	\$839	\$1,073	1.5	\$598
CZ10	SDGE	6%	16%	81	18	\$839	\$1,073	1.5	\$598
CZ11	PGE	6%	12%	103	16	\$839	\$1,073	1.6	\$716
CZ12	PGE	6%	13%	97	16	\$974	\$1,294	1.5	\$681
CZ12	SMUD/PGE	6%	13%	97	16	\$974	\$1,294	1.5	\$681
CZ13	PGE	6%	13%	117	16	\$839	\$1,073	1.7	\$822
CZ14	SCE/SCG	7%	17%	94	18	\$839	\$1,073	1.7	\$763
CZ14	SDGE	7%	17%	94	18	\$839	\$1,073	1.7	\$763
CZ15	SCE/SCG	7%	20%	211	17	\$839	\$1,073	2.1	\$1,292
CZ16	PGE	7%	11%	72	21	\$1,318	\$1,545	1.1	\$135

## 5 Summary

The Reach Codes Team developed packages of energy efficiency measures as well as packages combining energy efficiency with solar thermal systems, simulated them in building modeling software, and gathered costs to determine the cost-effectiveness of multiple scenarios. The Reach Codes Team coordinated with multiple utilities, cities, and building community experts to develop a set of assumptions considered reasonable in the current market. Changing assumptions, such as the period of analysis, measure selection, cost assumptions, or energy escalation rates are likely to change results.

Table 5 summarizes results and depicts the source energy compliance margins achieved for each package. Because local reach codes must both exceed the Energy Commission performance budget (i.e., have a positive compliance margin) and be cost-effective, the Reach Codes Team highlighted cells meeting these two requirements to help clarify the upper boundary for potential reach code policies. All results presented in this study have a positive compliance margin.

- Cells highlighted in **green** depict a positive compliance margin and TDV cost-effective.
- Cells **not highlighted** depict a package that was not TDV cost effective.

The Reach Codes Team concluded the following from the results of this study.

- All-electric package continues to be cost-effective with TDV in the updated 2022.3.1 CBECC software.
- The mixed fuel package with efficiency measures and increased solar thermal systems are cost-effective in all climate zones and demonstrates comparable compliance margins to the all-electric case.

**Table 5: Summary of Source Energy Compliance Margins and Cost-Effectiveness for the 5-Story Prototype**

Climate Zone	Electric/ Gas Utility	All-Electric	Mixed Fuel + Efficiency + Solar Thermal
CZ01	PGE	21%	8%
CZ02	PGE	14%	8%
CZ03	PGE	16%	10%
CZ04	PGE	15%	11%
CZ04	CPAU	15%	11%
CZ05	PGE	15%	11%
CZ05	PGE/SCG	15%	11%
CZ06	SCE/SCG	17%	13%
CZ07	SDGE	23%	13%
CZ08	SCE/SCG	12%	11%
CZ09	SCE/SCG	10%	12%
CZ10	SCE/SCG	10%	16%
CZ10	SDGE	10%	16%
CZ11	PGE	12%	12%
CZ12	PGE	16%	13%
CZ12	SMUD/PGE	16%	13%
CZ13	PGE	11%	13%
CZ14	SCE/SCG	7%	17%
CZ14	SDGE	7%	17%
CZ15	SCE/SCG	1%	20%
CZ16	PGE	25%	11%

## 6 References

Statewide CASE Team. (2020). *2022 Multifamily Domestic Hot Water*. Codes and Standards Enhancement (CASE) Initiative.

Statewide CASE Team. (2023). *2025 Multifamily Domestic Hot Water*. Codes and Standards Enhancement (CASE) Initiative.

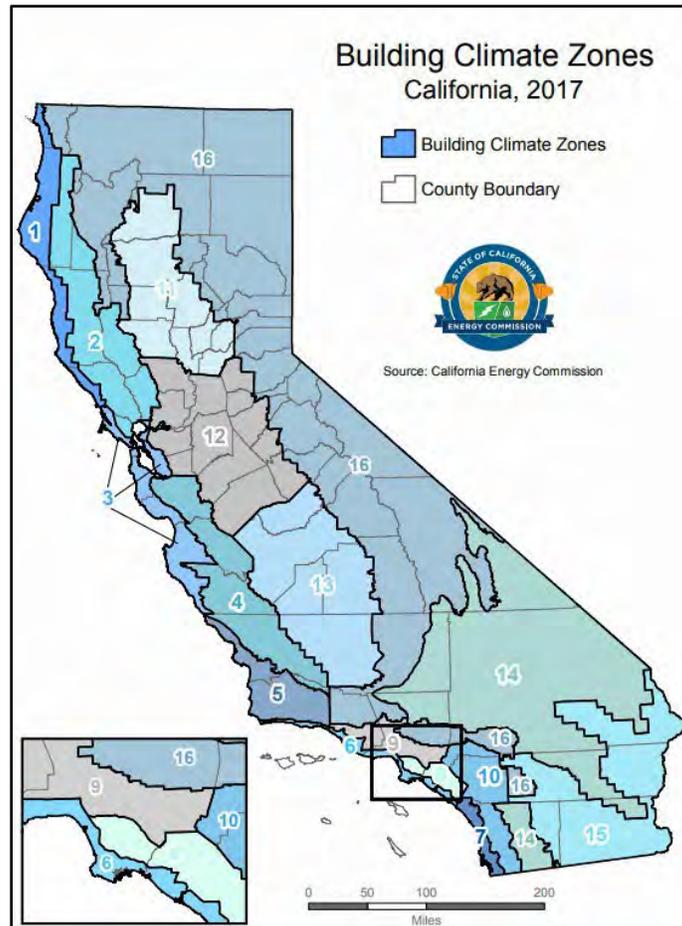
Statewide Reach Codes Team. (2023). *2022 Cost-Effectiveness Study: Multifamily New Construction*.

## 7 Appendices

### 7.1 Map of California Climate Zones

Climate zone geographical boundaries are depicted in Figure 1. The map in Figure 1 along with a zip-code search directory is available at: [https://ww2.energy.ca.gov/maps/renewable/building\\_climate\\_zones.html](https://ww2.energy.ca.gov/maps/renewable/building_climate_zones.html)

**Figure 1. Map of California climate zones.**



## Get In Touch

The adoption of reach codes can differentiate jurisdictions as efficiency leaders and help accelerate the adoption of new equipment, technologies, code compliance, and energy savings strategies.

As part of the Statewide Codes & Standards Program, the Reach Codes Subprogram is a resource available to any local jurisdiction located throughout the state of California.

Our experts develop robust toolkits as well as provide specific technical assistance to local jurisdictions (cities and counties) considering adopting energy reach codes. These include cost-effectiveness research and analysis, model ordinance language and other code development and implementation tools, and specific technical assistance throughout the code adoption process.

If you are interested in finding out more about local energy reach codes, the Reach Codes Team stands ready to assist jurisdictions at any stage of a reach code project.



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# 2019 Reach Code Cost-Effectiveness Analysis

## Full-Service and Quick-Service Restaurants

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## Acronym/Abbreviation List

AC – Air-Conditioning (unit)

ASHRAE – Society of Heating, Refrigerating and Air-Conditioning Engineers

B/C – Benefit-to-Cost (ratio)

CBCEC - California Building Energy Code Compliance

BSC - California Building Standards Commission

CEC - California Energy Commission

CHP – Commercial Heat Pump

CPAU – City of Palo Alto Utilities (utility)

CZ – Climate Zone

DEER - Database for Energy Efficiency Resources

DOE – United States Department of Energy

DX – Direct Expansion

E3 - Energy and Environmental Economics

ft<sup>2</sup> – Square Foot

ft<sup>3</sup> – Cubic Feet Per Minute

FSR – Full-Service Restaurant

gal – Gallon

gph – Gallons Per Hour

GHG - Greenhouse Gas

HVAC - Heating, Ventilation, and Air-Conditioning (equipment)

IOU – Investor-Owned Utility

kBtu – kilo British Thermal Unit

kBtu/hr – kilo British Thermal Unit Per Hour

kW – Kilowatt

kWh – Kilowatt-Hour



LADWP – Los Angeles Department of Water and Power (utility)

mtons – Metric Tons

NPV – Net Present Value

POU – Publicly-Owned Utility

PG&E – Pacific Gas & Electric (utility)

PV – Photovoltaic (solar)

QSR – Quick-Service Restaurant

SCE – Southern California Edison (utility)

SHW – Service hot water

SoCalGas – Southern California Gas (utility)

SDG&E – San Diego Gas & Electric (utility)

SMUD – Sacramento Municipal Utility District (utility)

TDV – Time Dependent Valuation

Title 24 – California Code of Regulations Title 24, Part 6

W – Watt(s)

Wdc – Direct Current Watt(s)

VAV – Variable Air Volume

Summary of Revisions		
Date	Description	Reference (page or section)
X/2022	Original Release	NA

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## 1 Introduction

The California Building Energy Efficiency Standards Title 24, Part 6 (Title 24) (CEC California Energy Commission 2019) is maintained and updated every three years by two state agencies: the California Energy Commission (CEC) and the Building Standards Commission (BSC). In addition to enforcing the code, local jurisdictions have the authority to adopt local energy efficiency ordinances—or reach codes—that exceed the minimum standards defined by Title 24 (as established by Public Resources Code Section 25402.1(h)2 and Section 10-106 of Title 24, Part 6). Local jurisdictions must demonstrate that the requirements of the proposed ordinance are cost effective and do not result in buildings consuming more energy than is permitted by Title 24. In addition, the jurisdiction must obtain approval from the CEC and file the ordinance with the BSC for the ordinance to be legally enforceable.

This report documents cost-effective combinations of measures that exceed the minimum state requirements, the 2019 Building Energy Efficiency Standards, effective January 1, 2020, for design in newly constructed buildings. This report was developed in coordination with the California Statewide Investor-Owned Utilities (IOUs) Codes and Standards Program, key consultants, and engaged cities—collectively known as the Reach Code Team.

The Reach Code Team published nonresidential new construction studies in 2019 that documented the cost effectiveness of energy measure packages of Medium Office, Medium Retail, and Small Hotel prototypes. (Statewide Utility Team 2020) Based on stakeholder requests, this report extends that analysis to two other new construction prototypes: quick-service and full-service restaurants (QSR and FSR, respectively). Measures include energy efficiency, electrification, solar photovoltaics (PV), and battery storage.

The United States Department of Energy (DOE) sets minimum efficiency standards for equipment and appliances that are federally regulated under the National Appliance Energy Conservation Act, including heating, cooling, and water heating equipment. (E-CFR 2020) Since state and local governments are prohibited from adopting higher minimum efficiencies than the federal standards require, the focus of this study is to identify and evaluate cost-effective packages that do not include high-efficiency (HE) heating, cooling, and water heating equipment. However, because federal appliance standards do not cover some of the appliances in the quick-service restaurant (QSR) and full-service restaurant (FSR) models, HE models are not preempted and are included in the study. HE appliances are often the easiest and most affordable measures to increase energy performance. While federal preemption limits reach code mandatory requirements for covered appliances, in practice, builders may install any package of compliant measures to achieve the performance requirements.

## 2 Methodology and Assumptions

The Reach Code Team analyzed the two prototypes using the methodology described in this section.

### 2.1 Cost Effectiveness

This section describes the approach to calculating cost effectiveness including benefits, costs, metrics, and utility rate selection.

#### 2.1.1 Benefits

Across all prototypes, this analysis used both *on-bill* and *time dependent valuation* (TDV) of energy-based approaches to evaluate cost effectiveness. Both approaches involve quantifying the energy savings and costs associated with energy measures, with the primary difference being how energy is valued:

- **On-bill:** Customer-based lifecycle cost approach that values energy based upon estimated customer on-bill impacts over a 15-year duration using electricity and natural gas utility rates, accounting for a three percent discount rate and energy cost inflation per Appendix 7.2.
- **TDV:** TDV was developed by the CEC to reflect the time dependent value of energy including long-term projected costs of energy. This includes costs of electricity supply during periods of peak demand, as well as projected costs for carbon emissions. Electricity used (or saved) during peak periods has a much higher value than electricity used (or saved) during off-peak periods. This metric values energy usage differently depending on the fuel source (electricity, natural gas, and propane), time of day, and time of year.

The Reach Code Team performed energy simulations using the most recent software available for 2019 Title 24 code compliance analysis, California Building Energy Code Compliance for Commercial Buildings (CBECC-Com) 2019.1.3. The Reach Code Team also tested the 2022 weather files and 2022 TDV multipliers using a research version of CBECC-Com 2022 software for most results to understand potential impacts on cost effectiveness, with results located in Section 7.5. This study will be updated when the compliance version of CBECC-Com 2022 becomes available in the first half of 2022.

#### 2.1.2 Costs

The Reach Code Team assessed the incremental costs and savings of the energy packages over 15 years for each restaurant prototype. Incremental costs represent the equipment, installation, replacements, and maintenance costs of the proposed measure relative to the 2019 Title 24 Standards minimum requirements or standard industry practices. The Reach Code Team obtained measure costs from manufacturer distributors, contractors, literature review, and online sources, such as Home Depot and RS Means. Taxes and contractor markups were added as appropriate. Maintenance and replacement costs are included.

The Reach Code Team leveraged cost data from 2022 Title 24 Codes and Standards Enhancement (CASE) work<sup>1</sup> and received additional cost estimates from a San Francisco Bay Area mechanical

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<sup>1</sup> CASE efforts include detailed itemized costs for a wide range of HVAC and SHW systems, and from a variety of resources. Visit <https://title24stakeholders.com/> for more information.

contractor for the heating, ventilation, and air conditioning (HVAC) and service water heating (SWH) systems for all packages. The Reach Code Team determined cost estimates for kitchen appliances from online retailers, using the average costs from three different appliance retailers for the analysis. The Reach Code Team adjusted material and labor costs for each climate zone (CZ) based on weighting factors from RSMeans.

### 2.1.3 Metrics

Cost effectiveness is presented using net present value (NPV) and benefit-to-cost (B/C) ratio metrics.

- **NPV:** The Reach Code Team uses net savings (NPV benefits minus NPV costs) as the cost-effectiveness metric. If the net savings of a measure or package is positive, it is considered cost effective. Negative savings represent net costs. A measure that has negative energy cost benefits (i.e., the energy cost increases) can still be cost effective if the costs to implement the measure are even more negative (i.e., construction and maintenance cost savings).
- **B/C ratio:** The ratio of the present value of all benefits to the present value of all costs over 15 years (NPV benefits divided by NPV costs). The criterion for cost effectiveness is a B/C ratio greater than 1.0. A value of 1.0 indicates the savings over the life of the measure are equivalent to the incremental cost of that measure. A value greater than one represents a positive return on investment.

Improving the energy performance of a building often requires an initial investment. In most cases the benefit is represented by annual on-bill utility or TDV savings and the cost by incremental first cost and replacement costs. However, some packages result in initial construction cost savings (negative incremental cost) and either energy cost savings (positive benefits) or increased energy costs (negative benefits). In cases where both incremental construction cost and energy-related savings are negative, the construction cost savings are treated as the benefit while the increased energy costs are the cost. In cases where a measure or package is cost effective immediately (i.e., upfront construction cost savings and lifetime energy cost savings), B/C ratio cost effectiveness is represented by “>1”. Because of these situations, NPV savings are also reported, which in these cases are positive values.

### 2.1.4 Utility Rates

In coordination with the rate specialists at each IOU, and the publicly available information for several publicly-owned utilities (POUs), the Reach Code Team determined appropriate utility rates for each prototype and package (see Appendix 7.2 for details). The utility tariffs were determined based on the annual load profile of each prototype and the corresponding package, the most prevalent rate in each territory, and information that the rate offering was not planned to be phased out. For some prototypes there are multiple options for rates because of the varying load profiles of mixed-fuel buildings versus all-electric (AE) buildings. If more than one rate schedule is applicable for a particular load profile, the Reach Code Team did not attempt to compare or test a variety of tariffs to determine their impact on cost effectiveness. Utility rates were applied to each CZ based on the predominant IOU serving the population of each zone according to Figure 1.

A time-of-use (TOU) rate was applied to all cases. In addition to energy consumption charges, there are kW demand charges for monthly peak loads. Utilities calculate the peak load by the highest kW of the 15-minute interval readings in the month. However, the energy modeling software produces results on hourly intervals; therefore, the Reach Code Team calculated the demand charges by multiplying the highest load of all hourly loads in a month with the corresponding demand charge per kW. For cases with PV

generation, the approved NEM2 (Net Energy Metering) tariffs were applied along with minimum daily use billing and mandatory non-bypassable charges. For the PV cases, annual electric production was always less than annual electricity consumption; therefore, no credits for surplus generation were necessary.

**Figure 1. Utility Tariffs used based on CZ**

CZ	Electric/Gas Utility	Electricity (TOU)	Natural Gas
<b>IOUs</b>			
1-5,11-13,16	Pacific Gas and Electric Company (PG&E)	B-1 / B-10	G-NR1
5	PG&E/Southern California Gas Company (SoCalGas)	B-1 / B-10	G-10 (GN-10)
6, 8-10, 14, 15	Southern California Edison (SCE)/SoCalGas	TOU-GS-1 / TOU-GS-2/ TOU-GS-3	G-10 (GN-10)
7, 10, 14	San Diego Gas & Electric Company (SDG&E)	TOU-A+EECC / AL-TOU+EECC	GN-3
<b>POUs</b>			
4	City of Palo Alto (CPAU)	E-2/E-4 TOU	G-2
12	Sacramento Municipal Utility District (SMUD)/PG&E	GSN/GSS	G-NR1
6, 8, 9, 16	Los Angeles Department of Water and Power (LADWP)/SoCalGas	A-1 / A-2	G-10 (GN-10)

Utility rates are assumed to escalate over time using assumptions from research conducted by Energy and Environmental Economics (E3) in the 2019 study *Residential Building Electrification in California* (Energy & Environmental Economics 2019) and escalation rates used in the development of the 2022 TDV multipliers for the 2022 Building Energy Efficiency Standards (Energy & Environmental Economics 2021). See Appendix 7.2 Utility Rate Schedules for additional details.

## 2.2 Greenhouse Gas Emissions

The analysis uses the greenhouse gas (GHG) emission multipliers developed by E3 (E3 2021) to support development of compliance metrics for use in the 2022 California energy code. There are 8,760 hourly multipliers accounting for time dependent energy use and carbon emissions based on source emissions, including renewable portfolio standard projections. For the 2022 code cycle, the multipliers also incorporate GHG from methane and refrigerant leakage, which are two significant sources of GHG emissions. (NORESO 2020) There are 32 strings of multipliers, with a different string for each California CZ and each fuel type (metric tons of CO<sub>2</sub> per kWh for electricity and metric tons of CO<sub>2</sub> per therm for natural gas). The Reach Code Team used the 2022 multipliers to calculate emissions from both the 2019 and 2022 results.

### 3 Prototypes, Measure Packages, and Costs

This section describes the prototypes and analysis method. The Reach Code Team used modified versions of DOE building prototypes to evaluate cost effectiveness of measure packages after initializing the prototypes to comply with 2019 Title 24 new construction requirements. The Reach Code Team performed analyses beginning with DOE prototypes FSR and QSR. TRC designed all baseline prototypes to be mixed-fuel and have compliance margins as close to zero percent as possible to reflect a prescriptively compliant new construction building in each CZ.

The Reach Code Team analyzed two restaurant prototypes to discern the variance in analysis results depending on the type of restaurant: an FSR, representing fine dining serving American cuisine, and a QSR, representing a quick-service burger diner. Section 7.3 includes more details on restaurant types.

#### 3.1 Prototype Characteristics

The Reach Code Team utilized DOE prototypes for the basic geometry of the FSR and QSR buildings, and applied prescriptive Title 24 new construction requirements, as summarized in Figure 2.

**Figure 2. Restaurant Baseline Prototype Characteristics**

		FSR	QSR
Conditioned floor area (ft <sup>2</sup> )	Total	5,500	2,500
	Dining	4,000	1,250
	Kitchen	1,500	1,250
Number of stories		1	1
Wall assembly U-factor		0.069 (CZ1), 0.062 (CZ2, 4, 5, 8-16), 0.082 (CZ3)	
Roof assembly U-factor		0.034 (CZ1-5, 9-16), 0.049 (CZ6-8)	
Window-to-wall area ratio		0.17	0.14

#### 3.2 Measure Definition and Costs

The Reach Code Team developed basis-of-designs (BODs) for kitchen process, HVAC (heating, ventilation, and air-conditioning), and SWH equipment for mixed-fuel and AE restaurants. The BODs served as the foundation for modeling inputs and cost assumptions for the cost-effectiveness analysis and is further detailed in Appendix 7.3, including details such as energy efficient appliance selection and kitchen exhaust hood design. None of the cooking appliances examined in this study are subject to federal energy efficiency requirements.

##### 3.2.1 Cooking Appliances

For cooking appliances, the Reach Code Team focused on gas cooking appliances that require a Type I exhaust hood.<sup>2</sup> Compared to appliances needing a Type II exhaust hood, Type I appliances present

<sup>2</sup> Type I hoods are installed over cooking appliances, and they include listed grease filters, baffles, and a fire suppression system. Type II hood may or may not have grease filters or baffles and is not designed to have a fire-suppression system. Compared to Type II hoods, Type I hoods have higher exhaust rate requirements and thus have a larger energy impact. Thus, Type I hoods require more design optimization and control.

challenges for electrification, and have large impacts on HVAC loads. Most appliances requiring Type II hoods, such as dishwashers, are already AE and require a smaller amount of exhaust air. The Reach Code Team determined the type and number of cooking appliances appropriate for the QSR and FSR based on data collected from more than 100 restaurants by PG&E and Frontier Energy (formerly Fisher-Nickel). (PG&E and Fisher-Nickel 2014) We selected specific models of cooking appliances and developed typical hourly energy load profiles for each appliance based on information collected through:

- Literature review, including Database for Energy Efficiency Resources (DEER) workpapers (DEER 2020), American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) RP 1362 (ASHRAE 2008), the IOU rebate product list (California Energy Wise 2020), Gas Technology Institute (GTI) and Fisher-Nickel (GTI and Fisher-Nickel 2013), and Energy Star® commercial kitchen product criteria;
- Interviews and BOD reviews with food service technology subject matter experts, including SCE, SoCalGas, SDG&E, and Frontier Energy (formerly Fisher-Nickel); and
- Market research, including product specification review.

The Reach Code Team developed two BODs for the QSR, a burger diner and a taqueria. The Reach Code Team verified that both are technically feasible, and the selected appliances in each package can achieve equivalent cooking capacity and cooking needs (see Appendix 7.3.1.3). Ultimately, the Reach Code Team tested only the burger diner for cost effectiveness analysis due to scope limitations, though cost-effectiveness results are not expected to be significantly different for the taqueria. The FSR BOD represents a fine dining restaurant serving American cuisine.

### 3.2.2 Exhaust and Ventilation

Both the QSR and FSR have wall-mounted canopy exhaust hoods that overhang appliances by six inches (in.) on each side, per ASHRAE 154. (ASHRAE 2020) The total exhaust rate is the maximum airflow allowed by 2019 Title 24 Table 140.9 for the appropriate equipment duty level. The larger system in the FSR includes demand-controlled kitchen ventilation (DCKV) per 2019 Title 24 prescriptive requirements.

For kitchen ventilation design, the Reach Code Team assumed makeup air was supplied via an outdoor air-makeup unit in the baseline (code minimum) packages. HVAC systems are sized to maintain space cooling and heating setpoints specified by the 2019 Title 24 Alternative Calculation Method Reference Manual.

### 3.2.3 Service Water Heating

For SWH design, the Reach Code Team reviewed a 2010 PG&E and Fisher-Nickel report and California Energy Wise design guide to determine the SWH design parameters and load profiles for both the QSR and FSR, and worked with commercial heat pump (CHP) water heater manufacturers to develop system designs. (Fisher-Nickel and PG&E 2010, California Energy Wise 2020)

### 3.2.4 All-Electric Design

The Reach Code Team compared the incremental differences in equipment selection, and associated costs, from a mixed-fuel baseline to AE restaurants for HVAC, SWH, kitchen process equipment, and

gas/electrical infrastructure. Figure 3 and Figure 4 show the costs for FSR and QSR, respectively, in CZ 12 as an example.

This analysis assumes that in an AE new construction scenario fuel gas would not be supplied to the site. Eliminating fuel gas in new construction saves costs associated with connecting a service line from the street main to the building, a gas meter, piping distribution within the building, plan review, and monthly connection charges by the utility. The Reach Code Team assumed 1.5-inch and 2-inch fuel gas pipes sized using Schedule 40 of the International Fuel Gas Code for QSR and FSR, respectively, for the plumbing distribution. Pipes were costed using an average of material and labor costs for steel and corrugated stainless-steel tubing material. The natural gas plan review cost is based on information received from CPAU. Meter costs are from PG&E and include both material and labor. The service extension costs are based on guidance from PG&E, who noted that the cost range is highly varied and that there is no *typical* cost, with costs being highly dependent on length of extension, terrain, whether the building is in a developed or undeveloped area, and number of buildings to be served. While an actual service extension cost is uncertain, the Reach Code Team believes the costs assumed in this analysis are within a reasonable range based on a sample range of costs provided by PG&E. These costs assume new construction in a previously developed area.

For replacement and maintenance costs, the Reach Code Team assumed the replacement of all cooking appliances at year ten. Based on interviews with subject matter experts, a typical mixed-fuel kitchen needs regular maintenance ten times a year, whereas an AE kitchen would require maintenance five times a year without the need for plumbing maintenance. We assumed each visit would cost \$150.

Figure 3. New Construction FSR All-Electric Construction Costs, CZ12 Example

Mixed-Fuel Measure	Mixed-Fuel Cost	All-Electric measure	All-Electric Cost	All-Electric Incremental Cost
<b>Mechanical Equipment</b>				
HVAC: Packaged furnace, DX AC	\$164,951	HVAC: Packaged heat pump	\$161,040	\$(3,911)
SWH: Gas storage water heater with recirculation loop - 400 kBtu/hr heater (2) - 200-gallon (gal) tank (1)	\$38,088	SWH: Heat pump water heaters with storage tank with recirculation loop - Four Colmac CxV-5 (4) - 500 gal of primary storage (1) - 5 kW 120-gal electric resistance loop heater (1)	\$146,864	\$108,776
<b>Kitchen Appliances</b>				
Gas cooking appliances: - Underfired broiler (1) - French fryer (2) - Griddle, single sided (1) - Broiler, salamander (1) - Oven, convection double deck (1) - Oven, range (2) - Range, six open burners (2) - Range, stock pot (2)	\$53,263	Electric cooking appliances: - Chain broiler (1) - French fryer (2) - Griddle, single sided (1) - Broiler, salamander (1) - Oven, convection double deck (1) - Oven, induction range (2) - Range, six burner induction cooktop (2) - Range, induction stock pot (2)	\$101,638	\$48,375
<b>Infrastructure</b>				
In-house gas plumbing	\$7,873	In-house electrical upgrades for branch circuits	\$2,626	\$(5,247)
400 ampere (A) panel	\$7,669	800 A panel	\$15,338	\$7,669
Natural gas plan review	\$2,316	<i>Not applicable</i>	\$0	\$(2,316)
Gas service extension	\$13,000	<i>Not applicable</i>	\$0	\$(13,000)
Gas meter	\$3,000	<i>Not applicable</i>	\$0	\$(3,000)
<b>Total</b>	<b>\$290,160</b>		<b>\$427,506</b>	<b>\$137,346</b>

Figure 4. New Construction QSR All-Electric Construction Costs, CZ12 Example

Mixed-fuel measure	Mixed-fuel cost	All-electric measure	All-electric cost	All-electric incremental cost
<b>Mechanical Equipment</b>				
HVAC: Packaged furnace, DX AC	\$105,102	HVAC: Packaged heat pump	\$115,127	\$10,025
SWH: Gas storage water heater - 150,000 Btu/hr heater (1) - 100-gal tank (1)	\$17,383	SWH: Heat pump water heaters with storage tank - AO Smith CHP 120 - Transfer fan + louvered door	\$21,940	\$4,557
<b>Kitchen Appliances</b>				
Gas cooking appliances: - French Fryer (4) - Griddle, single sided (2) - Half-size electric convection oven (1)	\$21,649	Electric cooking appliances: - French fryer (4) - Griddle, single sided (2) - Half-size electric convection oven (1)	\$43,534	\$21,886
<b>Infrastructure</b>				
In-house gas plumbing	\$2,998	In-house electrical upgrades for branch circuits	\$1,919	\$(1,080)
400 A panel	\$7,669	800 A panel	\$15,338	\$7,669
Natural gas plan review	\$2,316	<i>Not applicable</i>	\$0	\$(2,316)
Gas service extension	\$13,000	<i>Not applicable</i>	\$0	\$(13,000)
Gas meter	\$3,000	<i>Not applicable</i>	\$0	\$(3,000)
<b>Total</b>	<b>\$173,117</b>		<b>\$197,858</b>	<b>\$24,741</b>

### 3.2.5 Efficiency

The Reach Code Team identified potential efficiency measures above the 2019 Title 24 code baseline to test for cost effectiveness. The measures were developed based on the Team’s review of proposed 2022 Title 24 CASE nonresidential measures, as well as ASHRAE 90.1 and 189.1 Standards. The Reach Code Team developed the final measure list based on iterative modeling and discussions with designers and contractors.

#### 3.2.5.1 Kitchen appliances

- **Energy efficient cooking appliances:** Specifies cooking appliances that meet ENERGY STAR specifications<sup>3</sup> or are qualified for IOU rebates<sup>4</sup>, compared to mixed-fuel baseline appliances that are not ENERGY STAR or rebate-qualified. All-electric packages only contain ENERGY STAR or rebate-qualified cooking appliances, as these measures are not federally regulated and avoid preemption.
- **Kitchen of the Future (KOF)<sup>5</sup>:** Specifies a HE AE cooking appliance package to reduce space requirements, improve energy efficiency and reduce cooking time. The KOF involves careful design and selection of more advanced electric appliances that combine cooking processes. For example, combination and rapid cook ovens are used to replace broilers, convection ovens, range oven, and stock pot. Due to the appliances selected in BODs for each respective prototype, KOF principles are only applied to the FSR.

#### 3.2.5.2 Envelope

- **Cool roof:** Specifies solar reflectance exceeding 2019 Title 24 roof solar reflectance requirements, representing the 2022 code requirements. The restaurant prototypes have steep-sloped roof.
  - CZs 2 and 4 through 16: The minimum aged solar reflectance is increased from 0.20 to 0.25, the minimum thermal emittance increased from 0.75 to 0.80, and the aged solar reflective index from 16 to 23.
  - CZs 1 and 3: No proposed steep-sloped roof measure.

The 2022 High Performance Envelope CASE Report demonstrates similar cool roof opportunities available for low-sloped roofs (Title 24 Stakeholders 2020).

- **Modify fenestration solar heat gain coefficient (SHGC) and U-factor:** In all CZs, reduces the window SHGC from the prescriptive value of 0.25 to 0.20, and reduces the window U-factor from 0.36 to 0.31. No change to visible transmittance requirements.

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<sup>3</sup> EnergyStar commercial food service equipment. [https://www.energystar.gov/products/commercial\\_food\\_service\\_equipment](https://www.energystar.gov/products/commercial_food_service_equipment)

<sup>4</sup> California Energy Wise summary of product qualified for IOU rebates. <https://caenergywise.com/instant-rebates/#qualifying-products>. Check the utility’s website for more details.

<sup>5</sup> Kitchen of Future (KOF) concept was presented by Food Service Technology Center (FSTC) at Frontier Energy Inc. Presentation by Richard Young at ASHRAE Golden Gate Chapter Seminar on Building Decarbonization. The reach code team consulted FSTC for KOF equipment selection for this study. <https://ggashrae.org/meetinginfo.php?id=165&ts=1598039593>

### 3.2.5.3 Lighting

- **Reduced interior lighting power density (LPD):** Specifies the maximum allowable LPD values based on the 2022 Nonresidential Indoor Lighting CASE Report ((CEC) California Energy Commission 2021). Reduces the LPD requirement in the dining area from 0.55 watts (W) per ft<sup>2</sup> (W/ft<sup>2</sup>) to 0.35 W/ft<sup>2</sup>. This measure only applies to dining and bar areas, which are only in the FSR and not the QSR.

### 3.2.5.4 HVAC

- **Efficiency in lower capacity HVAC units:** Increases operating efficiency of lower capacity HVAC units with cooling capacity greater than 33,000 Btu/hr in the QSR by applying the following:
  - Add an economizer.
  - Require a minimum of two stages of mechanical cooling capacity for direct expansion (DX) air-conditioning (AC) units.
  - Require a minimum fan speed ratio of 0.5.  
The 2019 Title 24 prescriptive requirements already specify economizer usage for units with a cooling capacity greater than 54,000 Btu/hr, and both two-stage cooling and a minimum fan speed ratio of 0.5 for units with a cooling capacity greater than 65,000 Btu/hr. This measure only applies to QSR because the HVAC units in FSR are too large for this measure to be applicable.
- **Transfer air for kitchens:** Decrease kitchen makeup air supply by adding the following:
  - Require at least 15 percent or 25 percent of replacement air come from transfer air in the dining space, for QSR and FSR respectively, that would otherwise be exhausted.
  - For QSR, implement a demand ventilation system for the kitchen.
- **Fan power budget:** Reduces supply and exhaust fan motor horsepower based on the proposed requirements of the 2022 CASE Report Air Distribution: High Performance Ducts and Fan Systems, which expands current requirements of 2019 Title 24 Section 140.4(c)1 (Energy Solutions 2020). Power budgets of each fan are dependent on the type of fan (supply or exhaust) and airflow.

### 3.2.5.5 Service hot water

- **Low-flow hot water dishwashing:** Specifies commercial dishwashers that use 20 percent less water than ENERGY STAR specifications and uses pre-rinse spray valves (PRSV) qualified for IOU rebates. In addition, the dishwasher includes heat recovery function such that it only needs connection to cold water and reduces hot water demand and sizes of the central service hot water (SHW) system. For QSRs, which typically specify a three-compartment sink for dishwashing, this measure would replace or add a dishwasher to reduce total hot water load. FSRs specify dishwashers as standard practice.
- **Reduce supply water temperature:** Reduces hot water demand and supply hot water temperature for the FSR, from 140°F to 125°F. These features are critical to enable AE heat pump water heater (HPWH) design to reduce upfront equipment cost and operational cost. This is a no-cost measure that is enabled by the use of the above-specified dishwasher. See details in Appendix 7.3.3 for details.

- **Low-flow water fixtures:** Specifies adding a 1.0 gallon per minute (gpm) faucet aerators to hand-washing sinks in the kitchen to reduce water usage. Title 20 requires kitchen sinks to have a flow rate of at most 1.8 gpm.
- **Low-demand electric SHW plant:** When all the measures above are applied to the FSR, the SHW equipment can be down-sized from four (4) Colmac CxV 5 to two (2) AO Smith CHP-120 due to a 27 percent reduction in daily hot water demand (see Figure 47 in Appendix 7.3.3). This results in upfront and operational cost savings and improved cost effectiveness for AE packages that include efficiency measures.

The incremental measure costs for these measures are in Figure 5.

**Figure 5. Restaurant Efficiency Measure Incremental Costs**

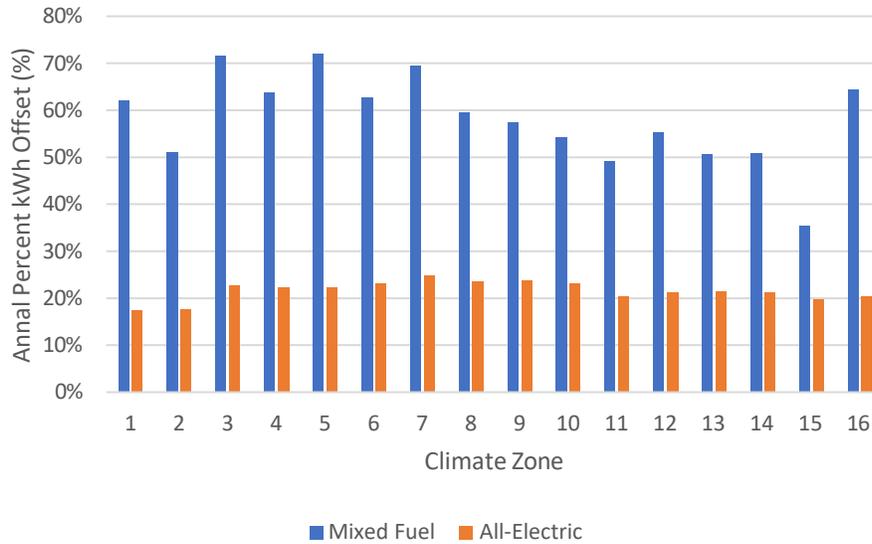
Measure Name	Incremental Cost Description	FSR	QSR
Energy efficient gas cooking appliances	Varies by appliance; only applicable in comparison to a mixed-fuel baseline	\$48,376	\$21,886
KOF electric cooking appliances	Only applicable for electric kitchen packages, and incremental cost in comparison to a mixed-fuel baseline	\$71,018	n/a
Cool roof	\$0.02/ft <sup>2</sup> of roof (Title 24 Stakeholders 2020)	\$0 - \$141 depending on CZ	\$0 - \$64 depending on CZ
Modify fenestration SHGC and U-factor	\$4.24/ft <sup>2</sup> of window	\$2,153	\$1,188
Reduced LPD	-\$1.36/ft <sup>2</sup> of floor area (Title 24 Stakeholders 2020)	\$(5,420)	n/a
Efficiency in lower capacity HVAC units	\$2,606/unit (Statewide Utility Team 2020, DMG n.d.).	n/a	\$0 - \$2,606 depending on CZ
Transfer air for kitchens	Cost is negligible as it only requires modification to control programming	\$0	\$0
Fan power budget	For constant volume HVAC units, \$0.27/ft <sup>2</sup> of building floor area For variable volume HVAC units, \$0.31/ft <sup>2</sup> of building floor area	\$2,170	\$1,112
Low-flow hot water dishwashing	<u>For FSR:</u> - HE door-type high temperature dishwasher: \$5,056/unit - HE undercounter-type high temperature dishwasher: \$4,460/unit - PRSV: \$22 /unit <u>For QSR:</u> - HE door-type high temperature dishwasher: \$7,633/unit - PRSV: \$22/unit	\$9,539	\$7,656
Low flow fixtures	- Faucet Aerator: \$8/unit - Five (5) kitchen hand-washing sinks in FSR and two (2) in QSR	\$40	\$16
Low-demand electric SHW plant (FSR only)	Reduced service hot water equipment cost, see Section 7.3.3 for details. - Two A.O. Smith HPWH and recirculation tank - Plumbing for central HPWH - Total \$73,969, result in an incremental cost of \$35,881 in comparison to a mixed-fuel baseline	\$35,881	N/A

### 3.2.6 Solar PV

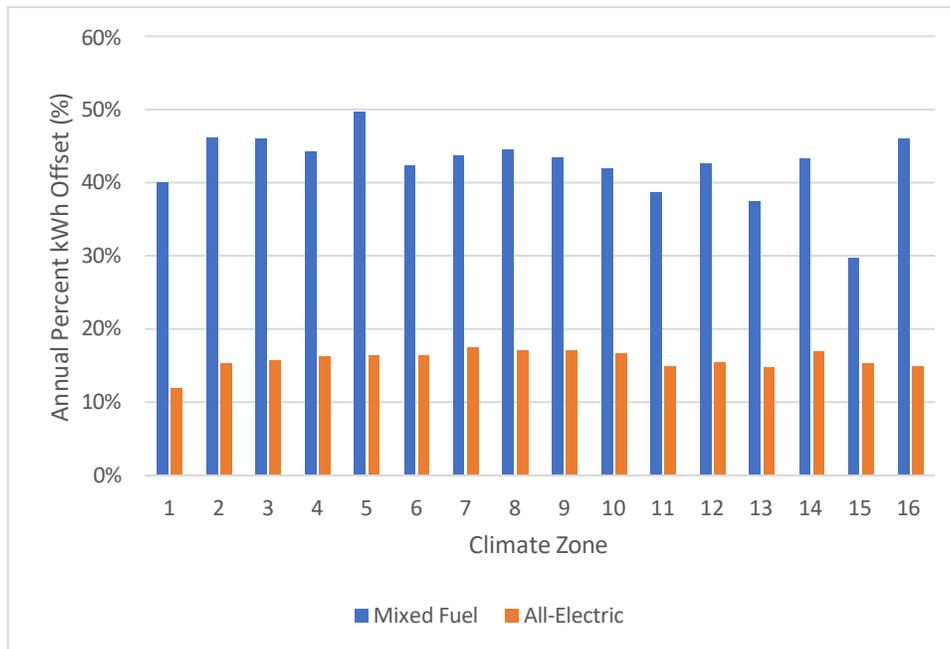
The Reach Code Team estimated 50% of the roof area is available to install PV and has solar access, with a capacity of 15 W/ft<sup>2</sup>. This approach assumes that the other 50% of the roof is for skylights, mechanical equipment, and walking paths. Figure 6 and Figure 7 depict the portion of annual electricity consumption that is offset by PV for both mixed-fuel and AE buildings in the FSR and QSR, respectively. PV energy output is built into CBECC-Com and is based on the

National Renewable Energy Laboratory’s (NREL) PVWatts calculator, which includes long-term performance degradation estimates.<sup>6</sup>

**Figure 6. FSR - Annual Percent kWh Offset with 41.3 kW Array**



**Figure 7. QSR: Annual Percent kWh Offset with 18.8 kW Array**



<sup>6</sup> More information available at: <https://pvwatts.nrel.gov/downloads/pvwattsv5.pdf>

The PV costs include first cost to purchase and install the system, inverter replacement costs, and annual maintenance costs, summarized in Figure 8. Upfront solar PV system costs are reduced by the federal income tax credit (ITC) of approximately 26% due to a phased reduction in the credit through the year 2022.<sup>7</sup>

**Figure 8. Restaurant Solar PV Costs**

	Unit Cost	FSR	QSR	Useful Life (years)	Source
Solar PV system installation	\$1.86/direct current W (Wdc)	\$76,560	\$34,880	30	NREL Q1 ((NREL) National Renewable Energy Laboratory 2018)
Inverter replacement	\$0.15/Wdc	\$6,190	\$2,820	10	E3 Rooftop Solar PV System Report (E3 2020)
Annual maintenance costs	\$0.02/Wdc	\$826	\$376	1	
<b>Total</b>	<b>\$2.03/Wdc</b>	<b>\$83,576</b>	<b>\$38,076</b>		

### 3.2.7 Battery Storage

This measure includes installation of batteries to allow energy generated through PV to be stored and used later, providing utility cost benefits. The Reach Code Team assessed the impact of battery sizes and control algorithms on TDV savings. The battery size is optimized for each prototype to offset the majority of the peak period load (i.e., 4:00 PM – 9:00 PM). The Reach Code Team used the *ranked day demand response* control method, which assumes batteries are charged anytime PV generation is greater than the building load but discharges to the electric grid beginning on the highest priced hour of the day. This control algorithm uses the relative ranking of the highest TDV for a day to determine its rank instead of a specific TDV value as threshold.

This control option is *not* reflective of the current products on the market and represents an ideally controlled condition where there is real-time electricity pricing, and was selected because it would optimize cost-effectiveness. While the analysis uses this control strategy, the proposed requirement would not mandate the control strategy used in practice. CBECC-Com has approximations of performance characteristics changes due to environmental conditions, charge/discharge rates, and degradation with age and use.

The Reach Code Team used costs of \$1,000 per kWh based on preliminary findings from concurrent research by the Statewide Utilities Codes and Standards Program, using data from the Self Generation Incentive Program. (Self Generation Incentive Program 2020) Batteries are eligible for the ITC if they are installed at the same time as the renewable generation source and

<sup>7</sup> The federal credit drops to 22% in 2023 before dropping permanently to 10% for commercial projects in 2024. More information on federal Investment Tax Credits available at: <https://www.seia.org/initiatives/solar-investment-tax-credit-itc>; <https://www.seia.org/sites/default/files/2021-01/SEIA-ITC-Factsheet-2021-Jan.pdf>

at least 75% of the energy used to charge the battery comes from a renewable source. Thus, the Reach Code Team also applied a 26% cost reduction to battery costs to reflect the ITC.

### 3.3 Measure Packages

For restaurants, the Reach Code Team analyzed the packages outlined below. As part of an effort to improve cost effectiveness, the Reach Code Team modeled a hybrid package that is AE except for a gas water heater, because an AE water heating system represented a significant portion of the incremental cost of the AE design (reference Figure 3 and Figure 4).

The Reach Code Team examined the following building packages:

- Restaurant Baseline Package (MF Code): Mixed-fuel prescriptively built building.
- Mixed Fuel Packages
  - Mixed-Fuel + Efficiency (MF Eff): Mixed-fuel appliances, including only efficiency measures.
  - Mixed-Fuel + Efficiency + HE Cooking (MF Eff HE): Mixed-fuel appliances, including efficiency measures and high efficiency (HE) gas cooking appliances.
  - Mixed-Fuel + Efficiency + HE Cooking + Solar PV and Battery (MF Eff HE PVB): Mixed-fuel appliances, including efficiency measures, HE gas cooking appliances, solar PV array and battery.
- Electrification Packages
  - All-Electric HVAC + Efficiency (AE Eff HVAC): All-electric HVAC only, including efficiency measures and baseline gas water heater and gas cooking.
  - All-Electric HVAC and SHW + Efficiency (AE Eff HVAC SHW): All-electric HVAC and SHW only, including efficiency measures and baseline gas cooking
  - All-Electric (AE HE): All-electric prescriptively built HVAC and SHW, including electric appliances that meet federal minimum efficiency criteria, as well as electrical upgrades. HE electric cooking appliances, such as induction cooktops are included in the package.
  - All-Electric + Efficiency (AE Eff HE): All-electric HVAC and SHW, including efficiency measures and HE electric cooking.
  - All-Electric + KOF + Efficiency (AE Eff KOF): All-electric HVAC and SHW, including efficiency measures and Kitchen of Future electric cooking. KOF only applies to FSR.
  - All-Electric + Efficiency + Solar PV and Battery (AE Eff HE PVB): All-electric HVAC and SHW, including efficiency measures, HE electric cooking (KOF in FSR), and a solar PV array and battery.
  - Hybrid + Efficiency + HE Cooking + Solar PV and Battery (HB Eff HE PVB): All-electric HVAC, baseline gas storage water heater, efficiency measures, HE electric cooking (KOF in FSR), and a solar PV array and battery.

## 4 Results

Results for the prototype-specific measure packages described in Section 3 are presented below.

The TDV and on-bill based cost-effectiveness results are presented in terms of B/C ratio and NPV savings. What constitutes a *benefit* or a *cost* varies with the scenarios because both energy savings and incremental construction costs may be negative depending on the package. Typically, on-bill savings are categorized as a benefit while incremental construction costs are treated as costs. In cases where both construction costs and on-bill savings are negative, the construction cost savings are treated as the benefit while the on-bill negative savings are the cost.

For CZs with cost-effectiveness analyses reviewed for two utility rate structures, the Reach Code Team added a “-2” to indicate the second utility. For example, Climate Zone 4 cost-effectiveness analysis was performed for both PG&E and CPAU rate structures, so the CZs are indicated as “CZ04” and “CZ04-2” respectively in the following tables.

Overarching factors to keep in mind when reviewing the results include:

- **All-electric packages will have lower GHG emissions** than mixed-fuel packages in all cases, due to the clean power sources currently available from California’s power providers.
- To pass the CEC’s application process, local reach codes that amend the energy code must both be cost effective compared to the mixed-fuel baseline package and exceed the energy performance budget using TDV (i.e., have a positive compliance margin) compared to the standard design in the compliance software. To emphasize these two important factors, **the figures in this section highlight in green the modeling results that have either a positive compliance margin or are cost effective.** This will allow readers to identify whether a scenario is fully or partially supportive of a reach code. When a modeling result is not cost effective, it is highlighted in red. Conversely, Section 5 highlights only results that have both a positive compliance margin and are cost effective, to allow readers to identify reach code-ready scenarios.
- Title 24 does not specify electric or gas HVAC and SHW equipment in a prescriptive section, and a designer is allowed to specify either equipment type as long as it meets mandatory efficiency requirements. However, when using the performance approach to comply with code, HVAC and SHW equipment is compared to a mixed-fuel standard design for restaurants. This typically results in **TDV-related penalties and associated negative compliance margins for electric equipment.** These negative compliance margins are reflected in the baseline AE packages, listed below for each prototype, and they must be overcome with the addition of building energy efficiency measures.
- Process loads, including cooking, are non-regulated loads and are not included in the compliance TDV calculation, thus there is no credit or penalty associated with equipment selection. Heat transfer to the space associated with process loads is equal in both the standard and proposed design and have the same impact on HVAC energy consumption in the model. **While using electric cooking appliances can reduce HVAC energy use, this benefit is not reflected in the compliance margin** as the compliance software reduces the HVAC load for both models equally. Nonetheless, for cost-effectiveness analysis, the Reach Code Team compares the total TDV of the proposed package to a

fixed mixed-fuel package (not the standard design) and captures the interactive impacts of process loads, including reduced HVAC loads.

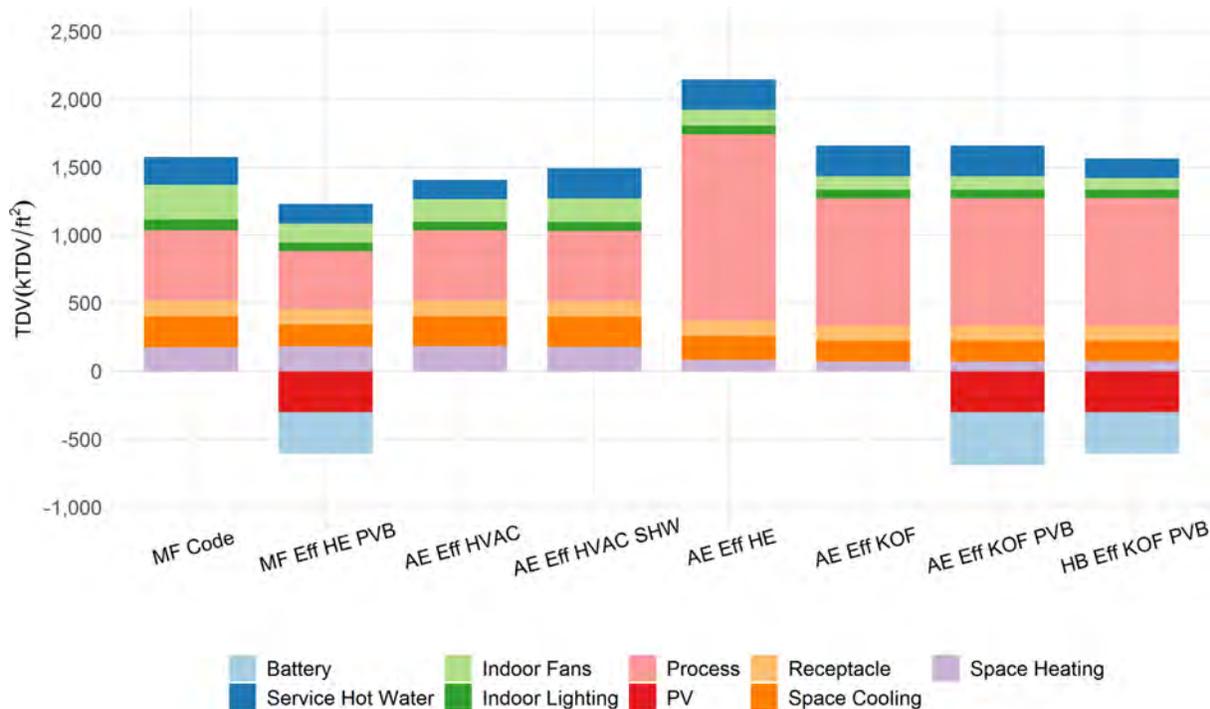
- Under the 2019 energy code, the **CEC does not currently allow compliance credit for either solar PV or battery storage in nonresidential buildings**. Thus, compliance margins for nonresidential packages containing these technologies are the same as packages without. However, the Reach Code Team did include the impact of solar PV and battery when calculating overall TDV cost effectiveness.
- The cost-effectiveness results for 2022 analysis differs from 2019 mainly in \$TDV savings, but they also differ slightly in energy consumption, which translates in minor difference in on-bill energy savings. The Reach Code Team has not reported the software outputs for 2022 compliance margins, as the 2022 Title 24 compliance software is still being developed.

As a point of comparison, mixed-fuel baseline energy figures are provided in Section 7.4 Mixed-Fuel Baseline Energy Figures.

### 4.1 FSR

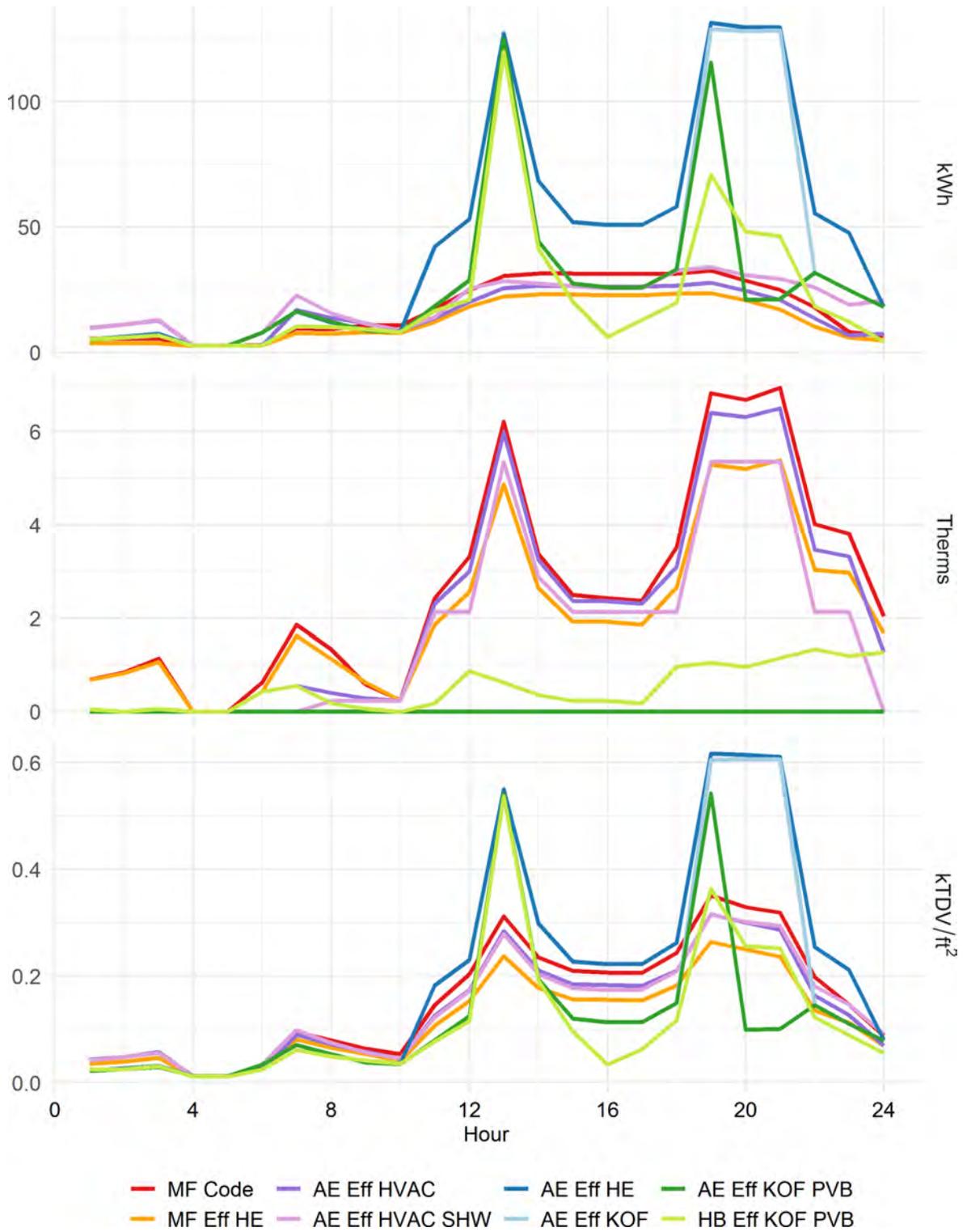
Figure 9 shows the TDV end-use breakdown for the FSR in CZ 12. The AE packages with electric cooking have a higher TDV energy usage than the mixed-fuel baseline. Thus, the primary opportunity to reduce the TDV energy consumption of an AE restaurant is to offset the process (i.e., cooking) energy use with solar PV generation and battery storage.

**Figure 9. TDV of FSR Packages: CZ12**



To attempt to optimize size and operation of the battery storage system, the Reach Code Team analyzed the cooking appliance load profiles developed through research described in Section 7.3. Figure 10 shows the 24-hour load profiles of the FSR in CZ 12 on June 15, 2021. As expected, the AE packages have substantially higher lunchtime and dinnertime peak kWh loads than the mixed-fuel baselines, which are steady throughout the day.

Figure 10. Hourly Load Profile of FSR Packages - CZ12 (June 15, 2021)



#### 4.1.1 Mixed-Fuel

Figure 11 shows results of the mixed-fuel energy efficiency measure packages compared to a mixed-fuel baseline. These measure packages are highly cost effective and could integrate more costly efficiency measures to further enhance energy performance.

Figure 12 shows integrating HE gas cooking products with the energy efficiency packages remains cost effective in all CZs. In some CZs, the compliance margin increases as compared to Mixed-Fuel + Eff, and conversely, the compliance margin decreases in other CZs.<sup>8</sup> The cost effectiveness of adding HE cooking appliances is slightly lower than the prior package containing only building efficiency measures.

The solar PV and battery measure package is TDV cost effective in all CZs (Figure 13).

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<sup>8</sup> The software modeling of restaurant energy use is highly sensitive to kitchen HVAC unit design flowrate, even though the fan is variable speed. This sensitivity results in a climate-zone dependent tradeoff between fan energy and space heating energy. In some CZs, the electricity savings increases more due to the smaller fan design flowrate in the proposed design than for the baseline condition, which also results in larger gas savings. Unexpectedly, in some other CZs, an increased fan design flowrate also results in electricity savings, but gas usage increases. This study does not examine the software algorithms that determine these results, nor attempt to optimize fan air flow selections for each CZ.

Figure 11. Cost Effectiveness for FSR: Mixed-Fuel + Eff

CZ	Utility	Annual Elec Savings (kWh)	Annual Gas Savings (therms)	Annual GHG Reductions (mtons)	Compliance Margin	Upfront Incremental Package Cost	Lifecycle Utility Cost Savings	Lifecycle \$TDV Savings	B/C Ratio (On-bill)	B/C Ratio (TDV)	NPV (On-bill)	NPV (TDV)
CZ01	PG&E	21,349	3,707	24.3	8.5%	\$8,483	\$139,880	\$114,022	16.5	13.4	\$131,397	\$105,540
CZ02	PG&E	25,985	3,070	21.3	13.4%	\$8,624	\$146,313	\$125,049	17.0	14.5	\$137,688	\$116,425
CZ03	PG&E	21,355	2,924	19.8	11.7%	\$8,483	\$126,255	\$106,741	14.9	12.6	\$117,772	\$98,258
CZ03-2	PCE	21,355	2,924	19.8	11.7%	\$8,483	\$124,708	\$106,741	14.7	12.6	\$116,225	\$98,258
CZ04	PG&E	25,391	2,711	19.3	16.0%	\$8,624	\$137,370	\$122,087	15.9	14.2	\$128,745	\$113,462
CZ04-2	CPAU	25,391	2,711	19.3	16.0%	\$8,624	\$111,831	\$122,087	13.0	14.2	\$103,207	\$113,462
CZ05	PG&E	21,408	3,051	20.5	12.1%	\$8,624	\$128,230	\$106,358	14.9	12.3	\$119,606	\$97,734
CZ05-2	SCG	21,408	3,051	20.5	12.1%	\$8,624	\$108,816	\$106,358	12.6	12.3	\$100,192	\$97,734
CZ06	SCE	25,911	2,325	17.1	17.2%	\$8,624	\$71,411	\$112,342	8.3	13.0	\$62,787	\$103,717
CZ06-2	LA	25,911	2,325	17.1	17.2%	\$8,624	\$61,650	\$112,342	7.1	13.0	\$53,026	\$103,717
CZ07	SDG&E	22,958	2,131	15.7	16.1%	\$8,624	\$100,336	\$100,629	11.6	11.7	\$91,712	\$92,005
CZ08	SCE	28,487	2,182	16.8	17.7%	\$8,624	\$74,098	\$119,144	8.6	13.8	\$65,474	\$110,520
CZ08-2	LA	28,487	2,182	16.8	17.7%	\$8,624	\$61,604	\$119,144	7.1	13.8	\$52,980	\$110,520
CZ09	SCE	28,834	2,302	17.6	15.5%	\$8,624	\$76,456	\$120,498	8.9	14.0	\$67,832	\$111,874
CZ09-2	LA	28,834	2,302	17.6	15.5%	\$8,624	\$63,443	\$120,498	7.4	14.0	\$54,818	\$111,874
CZ10	SDG&E	31,867	2,374	18.3	17.4%	\$8,624	\$140,704	\$135,811	16.3	15.7	\$132,080	\$127,187
CZ10-2	SCE	31,867	2,374	18.3	17.4%	\$8,624	\$83,624	\$135,811	9.7	15.7	\$75,000	\$127,187
CZ11	PG&E	32,576	2,765	20.8	15.2%	\$8,624	\$165,048	\$138,095	19.1	16.0	\$156,424	\$129,471
CZ12	PG&E	29,935	2,795	20.5	14.4%	\$8,624	\$155,764	\$130,042	18.1	15.1	\$147,140	\$121,418
CZ12-2	SMUD	29,935	2,795	20.5	14.4%	\$8,624	\$105,267	\$130,042	12.2	15.1	\$96,643	\$121,418
CZ13	PG&E	33,782	2,684	20.6	16.6%	\$8,624	\$167,570	\$141,575	19.4	16.4	\$158,946	\$132,951
CZ14	SDG&E	34,597	2,751	20.9	18.0%	\$8,624	\$131,584	\$144,361	15.3	16.7	\$122,960	\$135,736
CZ14-2	SCE	34,597	2,751	20.9	18.0%	\$8,624	\$85,580	\$144,361	9.9	16.7	\$76,956	\$135,736
CZ15	SCE	42,495	1,805	16.8	18.8%	\$8,624	\$86,440	\$146,095	10.0	16.9	\$77,816	\$137,470
CZ16	PG&E	24,049	3,659	24.4	10.7%	\$8,624	\$151,408	\$128,636	17.6	14.9	\$142,783	\$120,012
CZ16-2	LA	24,049	3,659	24.4	10.7%	\$8,624	\$59,985	\$128,636	7.0	14.9	\$51,361	\$120,012

Figure 12. Cost Effectiveness for FSR: Mixed-Fuel + Eff + HE Cooking

CZ	Utility	Annual Elec Savings (kWh)	Annual Gas Savings (therms)	Annual GHG Reductions (mtons)	Compliance Margin	Upfront Incremental Package Cost	Lifecycle Utility Cost Savings	Lifecycle \$TDV Savings	B/C Ratio (On-bill)	B/C Ratio (TDV)	NPV (On-bill)	NPV (TDV)
CZ01	PG&E	19,996	4,302	27.4	13.5%	\$49,533	\$146,438	\$120,287	3.0	2.4	\$96,905	\$70,754
CZ02	PG&E	27,512	4,476	29.5	13.6%	\$49,674	\$177,531	\$154,779	3.6	3.1	\$127,857	\$105,104
CZ03	PG&E	22,714	4,091	26.6	16.2%	\$49,533	\$152,538	\$131,325	3.1	2.7	\$103,005	\$81,792
CZ03-2	PCE	22,714	4,091	26.6	16.2%	\$49,533	\$150,862	\$131,325	3.0	2.7	\$101,329	\$81,792
CZ04	PG&E	27,402	4,189	27.9	15.6%	\$49,674	\$171,770	\$149,195	3.5	3.0	\$122,096	\$99,521
CZ04-2	CPAU	27,402	4,189	27.9	15.6%	\$49,674	\$145,862	\$149,195	2.9	3.0	\$96,188	\$99,521
CZ05	PG&E	22,672	4,211	27.1	16.4%	\$49,674	\$153,843	\$130,467	3.1	2.6	\$104,168	\$80,793
CZ05-2	SCG	22,672	4,211	27.1	16.4%	\$49,674	\$127,612	\$130,467	2.6	2.6	\$77,937	\$80,793
CZ06	SCE	29,196	4,098	27.7	18.0%	\$49,674	\$99,448	\$151,415	2.0	3.0	\$49,774	\$101,741
CZ06-2	LA	29,196	4,098	27.7	18.0%	\$49,674	\$87,205	\$151,415	1.8	3.0	\$37,530	\$101,741
CZ07	SDG&E	27,676	3,914	26.6	21.1%	\$49,674	\$142,496	\$145,434	2.9	2.9	\$92,822	\$95,760
CZ08	SCE	30,220	4,122	28.1	16.2%	\$49,674	\$100,540	\$153,233	2.0	3.1	\$50,866	\$103,558
CZ08-2	LA	30,220	4,122	28.1	16.2%	\$49,674	\$87,357	\$153,233	1.8	3.1	\$37,683	\$103,558
CZ09	SCE	32,355	4,219	29.0	12.9%	\$49,674	\$107,875	\$163,970	2.2	3.3	\$58,201	\$114,296
CZ09-2	LA	32,355	4,219	29.0	12.9%	\$49,674	\$95,371	\$163,970	1.9	3.3	\$45,696	\$114,296
CZ10	SDG&E	35,052	4,299	29.7	13.5%	\$49,674	\$177,333	\$175,162	3.6	3.5	\$127,659	\$125,487
CZ10-2	SCE	35,052	4,299	29.7	13.5%	\$49,674	\$113,132	\$175,162	2.3	3.5	\$63,457	\$125,487
CZ11	PG&E	32,348	4,508	30.6	11.0%	\$49,674	\$196,023	\$168,737	3.9	3.4	\$146,349	\$119,063
CZ12	PG&E	32,101	4,409	30.0	13.7%	\$49,674	\$192,962	\$168,764	3.9	3.4	\$143,288	\$119,089
CZ12-2	SMUD	32,101	4,409	30.0	13.7%	\$49,674	\$139,420	\$168,764	2.8	3.4	\$89,746	\$119,089
CZ13	PG&E	32,667	4,474	30.5	10.8%	\$49,674	\$196,086	\$169,596	3.9	3.4	\$146,411	\$119,922
CZ14	SDG&E	34,755	4,570	31.2	11.7%	\$49,674	\$168,066	\$176,983	3.4	3.6	\$118,391	\$127,309
CZ14-2	SCE	34,755	4,570	31.2	11.7%	\$49,674	\$112,294	\$176,983	2.3	3.6	\$62,619	\$127,309
CZ15	SCE	52,022	4,184	32.0	11.1%	\$49,674	\$135,412	\$217,652	2.7	4.4	\$85,738	\$167,977
CZ16	PG&E	27,262	5,080	33.1	15.1%	\$49,674	\$188,253	\$158,946	3.8	3.2	\$138,579	\$109,271
CZ16-2	LA	27,262	5,080	33.1	15.1%	\$49,674	\$81,321	\$158,946	1.6	3.2	\$31,647	\$109,271

Figure 13. Cost Effectiveness for FSR: Mixed-Fuel + Eff + HE Cooking + PV + B

CZ	Utility	Annual Elec Savings (kWh)	Annual Gas Savings (therms)	Annual GHG Reductions (mtons)	Compliance Margin	Upfront Incremental Package Cost	Lifecycle Utility Cost Savings	Lifecycle \$TDV Savings	B/C Ratio (On-bill)	B/C Ratio (TDV)	NPV (On-bill)	NPV (TDV)
CZ01	PG&E	71,211	4,302	35.8	13.5%	\$285,975	\$317,667	\$356,736	1.1	1.2	\$31,693	\$70,762
CZ02	PG&E	88,669	4,476	40.4	13.6%	\$286,116	\$392,809	\$436,959	1.4	1.5	\$106,693	\$150,842
CZ03	PG&E	84,088	4,091	37.1	16.2%	\$285,975	\$349,110	\$406,777	1.2	1.4	\$63,135	\$120,803
CZ03-2	PCE	84,088	4,091	37.1	16.2%	\$285,975	\$343,158	\$406,777	1.2	1.4	\$57,183	\$120,803
CZ04	PG&E	90,887	4,189	39.3	15.6%	\$286,116	\$389,912	\$450,394	1.4	1.6	\$103,796	\$164,278
CZ04-2	CPAU	90,887	4,189	39.3	15.6%	\$286,116	\$285,981	\$450,394	1.0	1.6	(\$135)	\$164,278
CZ05	PG&E	88,890	4,211	38.4	16.4%	\$286,116	\$362,600	\$422,422	1.3	1.5	\$76,484	\$136,306
CZ05-2	SCG	88,890	4,211	38.4	16.4%	\$286,116	\$354,983	\$422,422	1.2	1.5	\$68,867	\$136,306
CZ06	SCE	91,437	4,098	38.7	18.0%	\$286,116	\$182,874	\$411,731	0.6	1.4	(\$103,242)	\$125,615
CZ06-2	LA	91,437	4,098	38.7	18.0%	\$286,116	\$151,356	\$411,731	0.5	1.4	(\$134,760)	\$125,615
CZ07	SDG&E	92,597	3,914	38.4	21.1%	\$286,116	\$244,655	\$407,237	0.9	1.4	(\$41,461)	\$121,120
CZ08	SCE	93,046	4,122	39.5	16.2%	\$286,116	\$181,883	\$429,192	0.6	1.5	(\$104,233)	\$143,076
CZ08-2	LA	93,046	4,122	39.5	16.2%	\$286,116	\$130,347	\$429,192	0.5	1.5	(\$155,769)	\$143,076
CZ09	SCE	97,201	4,219	40.8	12.9%	\$286,116	\$190,963	\$450,181	0.7	1.6	(\$95,153)	\$164,065
CZ09-2	LA	97,201	4,219	40.8	12.9%	\$286,116	\$139,885	\$450,181	0.5	1.6	(\$146,231)	\$164,065
CZ10	SDG&E	99,958	4,299	41.3	13.5%	\$286,116	\$285,225	\$466,595	1.0	1.6	(\$891)	\$180,479
CZ10-2	SCE	99,958	4,299	41.3	13.5%	\$286,116	\$195,786	\$466,595	0.7	1.6	(\$90,330)	\$180,479
CZ11	PG&E	95,178	4,508	41.1	11.0%	\$286,116	\$419,666	\$480,873	1.5	1.7	\$133,550	\$194,757
CZ12	PG&E	93,947	4,409	40.6	13.7%	\$286,116	\$413,614	\$465,064	1.4	1.6	\$127,498	\$178,948
CZ12-2	SMUD	93,947	4,409	40.6	13.7%	\$286,116	\$237,457	\$465,064	0.8	1.6	(\$48,659)	\$178,948
CZ13	PG&E	94,100	4,474	40.6	10.8%	\$286,116	\$415,973	\$465,800	1.5	1.6	\$129,857	\$179,684
CZ14	SDG&E	106,148	4,570	43.2	11.7%	\$286,116	\$284,010	\$476,415	1.0	1.7	(\$2,106)	\$190,299
CZ14-2	SCE	106,148	4,570	43.2	11.7%	\$286,116	\$202,061	\$476,415	0.7	1.7	(\$84,055)	\$190,299
CZ15	SCE	119,391	4,184	41.7	11.1%	\$286,116	\$214,278	\$505,715	0.7	1.8	(\$71,838)	\$219,599
CZ16	PG&E	94,189	5,080	44.5	15.1%	\$286,116	\$411,819	\$420,226	1.4	1.5	\$125,703	\$134,110
CZ16-2	LA	94,189	5,080	44.5	15.1%	\$286,116	\$158,859	\$420,226	0.6	1.5	(\$127,257)	\$134,110

#### 4.1.2 All-Electric

The Reach Code Team initially analyzed several AE packages. Figure 14 demonstrates that AE HVAC packages, due to low or negligible upfront costs and significant TDV savings, can be TDV cost effective in all CZs.

Figure 15 shows the cost-effectiveness results for adding HPWH, electric space heating, and efficiency measures. With hot water efficiency measures, the service hot water demand is reduced substantially, and a smaller heat pump hot water system can be installed. Without hot water efficiency measures, the AE SHW package would not be cost effective in any CZs due to the high upfront costs of the HPWH. See Section 7.3 Basis of Design for Restaurants for further description of how these measures enable reduction in upfront cost and operational cost. As a result of the reduced hot water demand, this package is now cost effective and with a positive compliance margin in several CZs. Results improve to cost-effective outcomes in all CZs when analyzed under 2022 TDV, as shown in Figure 16.

Figure 14. Cost Effectiveness for FSR: All-Electric Eff HVAC

CZ	Utility	Annual Elec Savings (kWh)	Annual Gas Savings (therms)	Annual GHG Reductions (mtons)	Compliance Margin	Upfront Incremental Package Cost	Lifecycle Utility Cost Savings	Lifecycle \$TDV Savings	B/C Ratio (On-bill)	B/C Ratio (TDV)	NPV (On-bill)	NPV (TDV)
CZ01	PG&E	(53,021)	9,942	44.7	0.6%	(\$11,739)	\$16,228	\$39,427	>1	>1	\$27,967	\$51,166
CZ02	PG&E	(30,176)	7,520	34.8	10.8%	(\$12,469)	\$50,211	\$73,768	>1	>1	\$62,680	\$86,237
CZ03	PG&E	(22,899)	6,649	31.8	11.5%	(\$12,489)	\$55,254	\$69,093	>1	>1	\$67,742	\$81,581
CZ03-2	PCE	(22,899)	6,649	31.8	11.5%	(\$12,489)	\$56,649	\$69,093	>1	>1	\$69,138	\$81,581
CZ04	PG&E	(13,856)	5,853	29.0	15.0%	(\$13,502)	\$71,767	\$82,773	>1	>1	\$85,269	\$96,276
CZ04-2	CPAU	(13,856)	5,853	29.0	15.0%	(\$13,502)	\$78,280	\$82,773	>1	>1	\$91,782	\$96,276
CZ05	PG&E	(27,972)	7,162	32.9	9.6%	(\$11,607)	\$46,048	\$63,558	>1	>1	\$57,655	\$75,166
CZ05-2	SCG	(27,972)	7,162	32.9	9.6%	(\$11,607)	(\$563)	\$63,558	20.6	>1	\$11,045	\$75,166
CZ06	SCE	(2,613)	4,433	22.7	16.9%	(\$11,605)	\$42,686	\$82,293	>1	>1	\$54,290	\$93,898
CZ06-2	LA	(2,613)	4,433	22.7	16.9%	(\$11,605)	\$41,674	\$82,293	>1	>1	\$53,279	\$93,898
CZ07	SDG&E	2,375	3,594	19.9	18.0%	(\$12,811)	\$66,428	\$78,591	>1	>1	\$79,238	\$91,402
CZ08	SCE	2,960	3,969	21.5	18.2%	(\$13,982)	\$52,357	\$87,981	>1	>1	\$66,339	\$101,963
CZ08-2	LA	2,960	3,969	21.5	18.2%	(\$13,982)	\$51,234	\$87,981	>1	>1	\$65,217	\$101,963
CZ09	SCE	(88)	4,340	23.2	16.5%	(\$15,382)	\$49,080	\$85,674	>1	>1	\$64,462	\$101,056
CZ09-2	LA	(88)	4,340	23.2	16.5%	(\$15,382)	\$63,976	\$85,674	>1	>1	\$79,358	\$101,056
CZ10	SDG&E	(1,208)	4,661	24.5	16.4%	(\$17,332)	\$50,703	\$89,914	>1	>1	\$68,035	\$107,247
CZ10-2	SCE	(1,208)	4,661	24.5	16.4%	(\$17,332)	\$44,526	\$89,914	>1	>1	\$61,858	\$107,247
CZ11	PG&E	(18,133)	6,362	30.4	12.4%	(\$10,405)	\$71,185	\$81,911	>1	>1	\$81,590	\$92,316
CZ12	PG&E	(19,314)	6,497	31.0	12.6%	(\$12,789)	\$68,878	\$81,958	>1	>1	\$81,667	\$94,747
CZ12-2	SMUD	(19,314)	6,497	31.0	12.6%	(\$12,789)	\$79,340	\$81,958	>1	>1	\$92,130	\$94,747
CZ13	PG&E	(14,893)	6,021	29.1	12.6%	(\$10,343)	\$74,927	\$83,644	>1	>1	\$85,269	\$93,986
CZ14	SDG&E	(15,718)	6,241	29.5	14.5%	(\$13,402)	\$2,273	\$90,203	>1	>1	\$15,675	\$103,605
CZ14-2	SCE	(15,718)	6,241	29.5	14.5%	(\$13,402)	\$33,370	\$90,203	>1	>1	\$46,772	\$103,605
CZ15	SCE	16,341	2,920	18.0	16.4%	(\$19,630)	\$55,388	\$97,595	>1	>1	\$75,018	\$117,225
CZ16	PG&E	(60,841)	9,660	41.3	-9.9%	(\$13,431)	(\$3,188)	(\$1,999)	4.2	6.7	\$10,243	\$11,432
CZ16-2	LA	(60,841)	9,660	41.3	-9.9%	(\$13,431)	\$50,333	(\$1,999)	>1	6.7	\$63,765	\$11,432

Figure 15. Cost Effectiveness for FSR: All-Electric Eff HVAC SHW

CZ	Utility	Annual Elec Savings (kWh)	Annual Gas Savings (therms)	Annual GHG Reductions (mtons)	Compliance Margin	Upfront Incremental Package Cost	Lifecycle Utility Cost Savings	Lifecycle \$TDV Savings	B/C Ratio (On-bill)	B/C Ratio (TDV)	NPV (On-bill)	NPV (TDV)
CZ01	PG&E	(107,352)	14,754	59.7	-21.7%	\$32,336	(\$76,858)	(\$35,421)	-2.4	-1.1	(\$109,194)	(\$67,758)
CZ02	PG&E	(78,490)	12,078	49.5	-2.3%	\$36,481	(\$25,826)	\$22,191	-0.7	0.6	(\$62,307)	(\$14,290)
CZ03	PG&E	(71,691)	11,176	46.0	-7.8%	\$36,162	(\$23,741)	\$8,817	-0.7	0.2	(\$59,903)	(\$27,345)
CZ03-2	PCE	(71,691)	11,176	46.0	-7.8%	\$36,162	(\$18,679)	\$8,817	-0.5	0.2	(\$54,841)	(\$27,345)
CZ04	PG&E	(60,259)	10,299	43.3	1.3%	\$35,163	\$62	\$33,827	0.0	1.0	(\$35,101)	(\$1,336)
CZ04-2	CPAU	(60,259)	10,299	43.3	1.3%	\$35,163	\$61,152	\$33,827	1.7	1.0	\$25,989	(\$1,336)
CZ05	PG&E	(78,042)	11,739	47.2	-10.7%	\$32,529	(\$36,752)	\$453	-1.1	0.0	(\$69,281)	(\$32,075)
CZ05-2	SCG	(78,042)	11,739	47.2	-10.7%	\$32,529	(\$116,332)	\$453	-3.6	0.0	(\$148,861)	(\$32,075)
CZ06	SCE	(46,522)	8,710	36.5	3.1%	\$32,438	\$32,035	\$37,285	1.0	1.1	(\$402)	\$4,847
CZ06-2	LA	(46,522)	8,710	36.5	3.1%	\$32,438	\$65,268	\$37,285	2.0	1.1	\$32,831	\$4,847
CZ07	SDG&E	(40,532)	7,806	33.7	3.1%	\$31,995	(\$8,044)	\$34,817	-0.3	1.1	(\$40,039)	\$2,822
CZ08	SCE	(38,499)	8,146	35.3	7.9%	\$30,942	\$42,192	\$51,525	1.4	1.7	\$11,250	\$20,583
CZ08-2	LA	(38,499)	8,146	35.3	7.9%	\$30,942	\$75,528	\$51,525	2.4	1.7	\$44,586	\$20,583
CZ09	SCE	(42,376)	8,540	37.1	7.2%	\$28,745	\$39,232	\$47,743	1.4	1.7	\$10,487	\$18,999
CZ09-2	LA	(42,376)	8,540	37.1	7.2%	\$28,745	\$80,893	\$47,743	2.8	1.7	\$52,148	\$18,999
CZ10	SDG&E	(42,852)	8,868	38.4	8.6%	\$27,591	\$5,996	\$56,566	0.2	2.1	(\$21,595)	\$28,975
CZ10-2	SCE	(42,852)	8,868	38.4	8.6%	\$27,591	\$42,778	\$56,566	1.6	2.1	\$15,186	\$28,975
CZ11	PG&E	(62,425)	10,760	45.1	3.8%	\$34,537	\$7,058	\$40,522	0.2	1.2	(\$27,480)	\$5,984
CZ12	PG&E	(64,266)	10,931	45.7	2.8%	\$32,229	\$2,692	\$39,463	0.1	1.2	(\$29,537)	\$7,234
CZ12-2	SMUD	(64,266)	10,931	45.7	2.8%	\$32,229	\$98,804	\$39,463	3.1	1.2	\$66,575	\$7,234
CZ13	PG&E	(58,234)	10,360	43.6	3.8%	\$34,553	\$12,997	\$41,565	0.4	1.2	(\$21,555)	\$7,013
CZ14	SDG&E	(59,240)	10,673	44.7	6.7%	\$30,526	(\$49,630)	\$53,201	-1.6	1.7	(\$80,156)	\$22,675
CZ14-2	SCE	(59,240)	10,673	44.7	6.7%	\$30,526	\$27,339	\$53,201	0.9	1.7	(\$3,187)	\$22,675
CZ15	SCE	(16,661)	6,629	31.1	12.4%	\$24,473	\$53,656	\$75,004	2.2	3.1	\$29,182	\$50,530
CZ16	PG&E	(101,609)	14,648	60.6	-15.3%	\$30,691	(\$47,448)	(\$23,330)	-1.5	-0.8	(\$78,139)	(\$54,021)
CZ16-2	LA	(101,609)	14,648	60.6	-15.3%	\$30,691	\$82,636	(\$23,330)	2.7	-0.8	\$51,946	(\$54,021)

Figure 16. Cost Effectiveness for FSR: All-Electric Eff HVAC SHW, 2022 TDV

CZ	Utility	Elec Savings (kWh)	Gas Savings (therms)	GHG Reductions (mtons)	Compliance Margin	Incremental Package Cost	Lifecycle Utility Cost Savings	\$TDV Savings	B/C Ratio (On-bill)	B/C Ratio (TDV)	NPV (On-bill)	NPV (TDV)
CZ01	PG&E	(104,296)	14,569	58.6	<0	\$32,336	(\$71,683)	\$36,930	-2.2	1.1	(\$104,020)	\$4,593
CZ02	PG&E	(75,647)	11,676	46.6	>0	\$36,481	(\$26,047)	\$78,752	-0.7	2.2	(\$62,528)	\$42,271
CZ03	PG&E	(64,889)	10,566	43.2	>0	\$36,162	(\$14,330)	\$73,548	-0.4	2.0	(\$50,492)	\$37,386
CZ03-2	PCE	(64,889)	10,566	43.2	>0	\$36,162	(\$9,692)	\$73,548	-0.3	2.0	(\$45,854)	\$37,386
CZ04	PG&E	(52,557)	9,589	39.9	>0	\$35,163	\$11,389	\$88,226	0.3	2.5	(\$23,774)	\$53,063
CZ04-2	CPAU	(52,557)	9,589	39.9	>0	\$35,163	\$64,468	\$88,226	1.8	2.5	\$29,305	\$53,063
CZ05	PG&E	(66,306)	10,671	42.6	>0	\$32,529	(\$18,338)	\$55,992	-0.6	1.7	(\$50,867)	\$23,464
CZ05-2	SCG	(66,306)	10,671	42.6	>0	\$32,529	(\$91,357)	\$55,992	-2.8	1.7	(\$123,886)	\$23,464
CZ06	SCE	(37,780)	7,821	33.2	>0	\$32,438	\$38,339	\$75,988	1.2	2.3	\$5,901	\$43,550
CZ06-2	LA	(37,780)	7,821	33.2	>0	\$32,438	\$69,512	\$75,988	2.1	2.3	\$37,074	\$43,550
CZ07	SDG&E	(33,603)	7,403	32.2	>0	\$31,995	\$2,673	\$75,587	0.1	2.4	(\$29,321)	\$43,592
CZ08	SCE	(32,276)	7,607	32.9	>0	\$30,942	\$48,273	\$89,745	1.6	2.9	\$17,331	\$58,803
CZ08-2	LA	(32,276)	7,607	32.9	>0	\$30,942	\$71,895	\$89,745	2.3	2.9	\$40,953	\$58,803
CZ09	SCE	(33,671)	7,989	34.8	>0	\$28,745	\$49,881	\$97,976	1.7	3.4	\$21,137	\$69,231
CZ09-2	LA	(33,671)	7,989	34.8	>0	\$28,745	\$86,535	\$97,976	3.0	3.4	\$57,791	\$69,231
CZ10	SDG&E	(34,826)	8,434	36.4	>0	\$27,591	\$23,614	\$105,948	0.9	3.8	(\$3,978)	\$78,357
CZ10-2	SCE	(34,826)	8,434	36.4	>0	\$27,591	\$50,538	\$105,948	1.8	3.8	\$22,946	\$78,357
CZ11	PG&E	(57,971)	10,310	42.5	>0	\$34,537	\$12,079	\$97,620	0.3	2.8	(\$22,458)	\$63,083
CZ12	PG&E	(60,114)	10,437	42.7	>0	\$32,229	\$5,128	\$90,003	0.2	2.8	(\$27,101)	\$57,774
CZ12-2	SMUD	(60,114)	10,437	42.7	>0	\$32,229	\$98,903	\$90,003	3.1	2.8	\$66,674	\$57,774
CZ13	PG&E	(49,088)	9,620	40.6	>0	\$34,553	\$28,186	\$102,527	0.8	3.0	(\$6,366)	\$67,975
CZ14	SDG&E	(54,290)	10,082	41.4	>0	\$30,526	(\$34,601)	\$103,071	-1.1	3.4	(\$65,127)	\$72,545
CZ14-2	SCE	(54,290)	10,082	41.4	>0	\$30,526	\$28,781	\$103,071	0.9	3.4	(\$1,745)	\$72,545
CZ15	SCE	(6,074)	6,325	30.7	>0	\$24,473	\$72,073	\$135,782	2.9	5.5	\$47,600	\$111,308
CZ16	PG&E	(96,116)	13,972	57.3	<0	\$30,691	(\$44,465)	\$31,516	-1.4	1.0	(\$75,156)	\$825
CZ16-2	LA	(96,116)	13,972	57.3	<0	\$30,691	\$76,534	\$31,516	2.5	1.0	\$45,843	\$825

The Reach Code Team analyzed the following AE cooking equipment FSR packages but found they are not cost effective under current assumptions. Discussion on these results is available in Section 7.5 Additional Restaurant All-Electric Package Analysis.

- All-Electric (AE HE)
- All-Electric + Efficiency (AE Eff HE)
- All-Electric + KOF + Efficiency (AE Eff KOF)
- All-Electric + Efficiency + Solar PV and Battery (AE Eff KOF PVB)
- Hybrid + Efficiency + Solar PV and Battery (HB Eff KOF PVB)

All these packages include electric cooking appliances, which is the biggest barrier to TDV and on-bill cost effectiveness. Although there are minimal technical barriers in replacing gas cooking appliances with electric alternatives, the utility cost and TDV (code compliance) penalties are significant, primarily because the cooking activities are coincident with high TDV and utility rate periods. Nonetheless, switching to HE electric cooking appliances can save 30 to 50% of the energy consumption, but this falls short of the differences in cost of electric energy versus natural gas, which is about 400% higher per kBtu. The keys to electrify cooking include utility rate offerings to address the operational cost barrier, as well as education and training to address the market actor concerns.

It is challenging to electrify SHW using HPWH technology, both in terms of technical feasibility and practicality, due to the large volume and high peaks of hot water demand. High efficiency SHW design approaches substantially reduce hot water demand and enable the low-demand electric SHW plant design. Reducing peak hot water demand also improves HPWH operation efficiency, as the HPWH system does not need to engage backup electric resistance to keep up with demand. It should be noted that, not only are there limited demonstrations of the HPWH technology in restaurants, but the efficiency measures used in this study are emerging best practices and not widely implemented by the food service design industry. See more detailed discussion in Section 7.3.3.

## 4.2 QSRs

### 4.2.1 Mixed-Fuel

Figure 17 shows the energy efficiency measure packages are cost effective in all CZs. The QSR prototype achieved lower energy savings than the FSR prototype, because the lighting efficiency measures are only applicable to FSR and because of lower transfer air potential in the QSR to reduce the makeup air requirement and commensurate HVAC load reductions. Compliance margins in CZs 1, 3-7, and 16 are higher compared to other CZs because the HVAC units are smaller, which enables application of the economizer, two-stage compressor cooling, and variable speed fan energy efficiency measures, which are otherwise required by code for larger units.

When adding HE cooking appliances (Figure 18), the packages are still both TDV and on-bill cost effective. Compared to the Mixed-Fuel + Eff package, there are significant gas savings from using more efficient cooking appliances. However, the cost effectiveness in some colder CZs decreases due to increases in space heating energy use and associated fan power.

Figure 19 shows that the solar PV and battery package is also TDV cost effective.

Figure 17. Cost Effectiveness for QSR: Mixed-Fuel + Eff

CZ	Utility	Annual Elec Savings (kWh)	Annual Gas Savings (therms)	Annual GHG Reductions (mtons)	Compliance Margin	Upfront Incremental Package Cost	Lifecycle Utility Cost Savings	Lifecycle \$TDV Savings	B/C Ratio (On-bill)	B/C Ratio (TDV)	NPV (On-bill)	NPV (TDV)
CZ01	PG&E	12,334	1,447	10.14	29.7%	\$12,578	\$68,650	\$54,634	5.5	4.3	\$56,071	\$42,056
CZ02	PG&E	6,011	815	5.43	15.2%	\$10,036	\$35,537	\$31,064	3.5	3.1	\$25,501	\$21,028
CZ03	PG&E	12,320	742	6.21	27.1%	\$12,578	\$54,856	\$42,046	4.4	3.3	\$42,278	\$29,467
CZ03-2	PCE	12,320	742	6.21	27.1%	\$12,578	\$53,986	\$42,046	4.3	3.3	\$41,407	\$29,467
CZ04	PG&E	12,645	652	5.76	25.7%	\$12,643	\$54,272	\$43,660	4.3	3.5	\$41,629	\$31,017
CZ04-2	CPAU	12,645	652	5.76	25.7%	\$12,643	\$42,416	\$43,660	3.4	3.5	\$29,773	\$31,017
CZ05	PG&E	12,489	789	6.53	27.8%	\$12,643	\$56,354	\$43,637	4.5	3.5	\$43,712	\$30,994
CZ05-2	SCG	12,489	789	6.53	27.8%	\$12,643	\$51,251	\$43,637	4.1	3.5	\$38,609	\$30,994
CZ06	SCE	12,673	508	4.95	26.4%	\$12,643	\$24,825	\$39,913	2.0	3.2	\$12,182	\$27,270
CZ06-2	LA	12,673	508	4.95	26.4%	\$12,643	\$22,087	\$39,913	1.7	3.2	\$9,444	\$27,270
CZ07	SDG&E	15,135	430	4.93	31.6%	\$12,643	\$51,927	\$44,311	4.1	3.5	\$39,284	\$31,668
CZ08	SCE	5,899	457	3.44	17.9%	\$10,036	\$33,928	\$26,684	3.4	2.7	\$23,891	\$16,648
CZ08-2	LA	5,899	457	3.44	17.9%	\$10,036	\$15,857	\$26,684	1.6	2.7	\$5,821	\$16,648
CZ09	SCE	6,412	495	3.73	13.7%	\$10,036	\$17,007	\$24,555	1.7	2.4	\$6,971	\$14,518
CZ09-2	LA	6,412	495	3.73	13.7%	\$10,036	\$14,781	\$24,555	1.5	2.4	\$4,745	\$14,518
CZ10	SDG&E	5,221	532	3.73	15.0%	\$10,036	\$26,451	\$23,795	2.6	2.4	\$16,415	\$13,759
CZ10-2	SCE	5,221	532	3.73	15.0%	\$10,036	\$15,181	\$23,795	1.5	2.4	\$5,144	\$13,759
CZ11	PG&E	6,745	699	4.98	13.7%	\$10,036	\$36,736	\$32,913	3.7	3.3	\$26,699	\$22,877
CZ12	PG&E	6,689	709	4.97	15.2%	\$10,036	\$36,358	\$32,542	3.6	3.2	\$26,322	\$22,506
CZ12-2	SMUD	6,689	709	4.97	15.2%	\$10,036	\$25,858	\$32,542	2.6	3.2	\$15,822	\$22,506
CZ13	PG&E	8,129	660	4.95	12.6%	\$10,036	\$40,694	\$31,534	4.1	3.1	\$30,658	\$21,497
CZ14	SDG&E	6,447	678	4.77	14.2%	\$10,036	\$36,121	\$31,143	3.6	3.1	\$26,085	\$21,107
CZ14-2	SCE	6,447	678	4.77	14.2%	\$10,036	\$20,043	\$31,143	2.0	3.1	\$10,007	\$21,107
CZ15	SCE	11,580	349	3.73	12.5%	\$10,036	\$21,960	\$41,151	2.2	4.1	\$11,923	\$31,114
CZ16	PG&E	12,023	980	7.42	22.4%	\$12,643	\$58,785	\$46,016	4.6	3.6	\$46,143	\$33,374
CZ16-2	LA	12,023	980	7.42	22.4%	\$12,643	\$28,824	\$46,016	2.3	3.6	\$16,181	\$33,374

Figure 18. Cost Effectiveness for QSR: Mixed-Fuel + Eff + HE Cooking

CZ	Utility	Annual Elec Savings (kWh)	Annual Gas Savings (therms)	Annual GHG Reductions (mtons)	Compliance Margin	Upfront Incremental Package Cost	Lifecycle Utility Cost Savings	Lifecycle \$TDV Savings	B/C Ratio (On-bill)	B/C Ratio (TDV)	NPV (On-bill)	NPV (TDV)
CZ01	PG&E	11,918	3,845	23.50	26.0%	\$42,973	\$111,524	\$91,920	2.6	2.1	\$68,551	\$48,947
CZ02	PG&E	7,326	3,573	21.04	12.2%	\$40,431	\$90,896	\$75,425	2.2	1.9	\$50,465	\$34,994
CZ03	PG&E	13,429	3,459	21.61	24.9%	\$42,973	\$108,960	\$89,650	2.5	2.1	\$65,987	\$46,677
CZ03-2	PCE	13,429	3,459	21.61	24.9%	\$42,973	\$107,984	\$89,650	2.5	2.1	\$65,011	\$46,677
CZ04	PG&E	14,582	3,504	22.03	20.3%	\$43,037	\$113,731	\$90,706	2.6	2.1	\$70,694	\$47,669
CZ04-2	CPAU	14,582	3,504	22.03	20.3%	\$43,037	\$104,480	\$90,706	2.4	2.1	\$61,443	\$47,669
CZ05	PG&E	13,675	3,507	21.88	30.7%	\$43,037	\$110,503	\$91,479	2.6	2.1	\$67,466	\$48,442
CZ05-2	SCG	13,675	3,507	21.88	30.7%	\$43,037	\$88,731	\$91,479	2.1	2.1	\$45,694	\$48,442
CZ06	SCE	16,062	3,526	22.38	27.9%	\$43,037	\$66,756	\$95,748	1.6	2.2	\$23,719	\$52,711
CZ06-2	LA	16,062	3,526	22.38	27.9%	\$43,037	\$62,916	\$95,748	1.5	2.2	\$19,879	\$52,711
CZ07	SDG&E	19,324	3,495	22.87	33.5%	\$43,037	\$110,884	\$107,654	2.6	2.5	\$67,847	\$64,617
CZ08	SCE	9,546	3,517	21.13	14.5%	\$40,431	\$57,144	\$80,577	1.4	2.0	\$16,713	\$40,147
CZ08-2	LA	9,546	3,517	21.13	14.5%	\$40,431	\$57,654	\$80,577	1.4	2.0	\$17,224	\$40,147
CZ09	SCE	10,803	3,519	21.37	14.2%	\$40,431	\$61,946	\$82,986	1.5	2.1	\$21,515	\$42,556
CZ09-2	LA	10,803	3,519	21.37	14.2%	\$40,431	\$58,836	\$82,986	1.5	2.1	\$18,405	\$42,556
CZ10	SDG&E	10,611	3,548	21.38	11.6%	\$40,431	\$83,228	\$81,530	2.1	2.0	\$42,798	\$41,100
CZ10-2	SCE	10,611	3,548	21.38	11.6%	\$40,431	\$59,853	\$81,530	1.5	2.0	\$19,422	\$41,100
CZ11	PG&E	8,798	3,587	21.34	12.0%	\$40,431	\$96,330	\$88,396	2.4	2.2	\$55,899	\$47,965
CZ12	PG&E	7,707	3,561	20.99	18.0%	\$40,431	\$91,871	\$79,898	2.3	2.0	\$51,440	\$39,468
CZ12-2	SMUD	7,707	3,561	20.99	18.0%	\$40,431	\$80,635	\$79,898	2.0	2.0	\$40,204	\$39,468
CZ13	PG&E	8,727	3,571	21.18	12.1%	\$40,431	\$95,717	\$84,669	2.4	2.1	\$55,286	\$44,238
CZ14	SDG&E	8,218	3,624	21.36	9.4%	\$40,431	\$97,022	\$84,090	2.4	2.1	\$56,592	\$43,659
CZ14-2	SCE	8,218	3,624	21.36	9.4%	\$40,431	\$62,152	\$84,090	1.5	2.1	\$21,721	\$43,659
CZ15	SCE	17,392	3,540	22.57	12.5%	\$40,431	\$73,852	\$112,846	1.8	2.8	\$33,422	\$72,415
CZ16	PG&E	15,089	3,723	23.32	21.7%	\$43,037	\$119,993	\$98,472	2.8	2.3	\$76,957	\$55,436
CZ16-2	LA	15,089	3,723	23.32	21.7%	\$43,037	\$66,946	\$98,472	1.6	2.3	\$23,909	\$55,436

Figure 19. Cost Effectiveness for QSR: Mixed-Fuel + Eff + HE Cooking + PV + B

CZ	Utility	Annual Elec Savings (kWh)	Annual Gas Savings (therms)	Annual GHG Reductions (mtons)	Compliance Margin	Upfront Incremental Package Cost	Lifecycle Utility Cost Savings	Lifecycle \$TDV Savings	B/C Ratio (On-bill)	B/C Ratio (TDV)	NPV (On-bill)	NPV (TDV)
CZ01	PG&E	35,662	3,845	26.32	26.0%	\$154,616	\$191,522	\$188,244	1.2	1.2	\$36,906	\$33,628
CZ02	PG&E	35,773	3,573	24.33	12.2%	\$152,074	\$187,636	\$199,990	1.2	1.3	\$35,562	\$47,916
CZ03	PG&E	41,795	3,459	25.30	24.9%	\$154,616	\$206,677	\$208,332	1.3	1.3	\$52,061	\$53,716
CZ03-2	PCE	41,795	3,459	25.30	24.9%	\$154,616	\$203,526	\$208,332	1.3	1.3	\$48,911	\$53,716
CZ04	PG&E	44,059	3,504	25.63	20.3%	\$154,680	\$215,946	\$223,652	1.4	1.4	\$61,266	\$68,971
CZ04-2	CPAU	44,059	3,504	25.63	20.3%	\$154,680	\$169,595	\$223,652	1.1	1.4	\$14,915	\$68,971
CZ05	PG&E	44,250	3,507	25.99	30.7%	\$154,680	\$215,193	\$215,804	1.4	1.4	\$60,513	\$61,123
CZ05-2	SCG	44,250	3,507	25.99	30.7%	\$154,680	\$193,421	\$215,804	1.3	1.4	\$38,740	\$61,123
CZ06	SCE	45,087	3,526	25.65	27.9%	\$154,680	\$105,010	\$210,166	0.7	1.4	(\$49,670)	\$55,486
CZ06-2	LA	45,087	3,526	25.65	27.9%	\$154,680	\$98,624	\$210,166	0.6	1.4	(\$56,056)	\$55,486
CZ07	SDG&E	49,495	3,495	26.73	33.5%	\$154,680	\$204,679	\$223,053	1.3	1.4	\$49,999	\$68,373
CZ08	SCE	38,869	3,517	24.45	14.5%	\$152,074	\$90,760	\$203,189	0.6	1.3	(\$61,314)	\$51,115
CZ08-2	LA	38,869	3,517	24.45	14.5%	\$152,074	\$92,970	\$203,189	0.6	1.3	(\$59,104)	\$51,115
CZ09	SCE	41,046	3,519	24.83	14.2%	\$152,074	\$96,163	\$210,136	0.6	1.4	(\$55,911)	\$58,062
CZ09-2	LA	41,046	3,519	24.83	14.2%	\$152,074	\$95,263	\$210,136	0.6	1.4	(\$56,811)	\$58,062
CZ10	SDG&E	40,892	3,548	24.77	11.6%	\$152,074	\$129,085	\$210,342	0.8	1.4	(\$22,989)	\$58,268
CZ10-2	SCE	40,892	3,548	24.77	11.6%	\$152,074	\$93,611	\$210,342	0.6	1.4	(\$58,463)	\$58,268
CZ11	PG&E	38,042	3,587	24.41	12.0%	\$152,074	\$196,172	\$226,002	1.3	1.5	\$44,098	\$73,928
CZ12	PG&E	36,483	3,561	24.07	18.0%	\$152,074	\$190,818	\$210,781	1.3	1.4	\$38,744	\$58,707
CZ12-2	SMUD	36,483	3,561	24.07	18.0%	\$152,074	\$133,097	\$210,781	0.9	1.4	(\$18,977)	\$58,707
CZ13	PG&E	37,350	3,571	24.14	12.1%	\$152,074	\$193,292	\$215,686	1.3	1.4	\$41,218	\$63,612
CZ14	SDG&E	41,477	3,624	24.97	9.4%	\$152,074	\$146,404	\$217,226	1.0	1.4	(\$5,670)	\$65,153
CZ14-2	SCE	41,477	3,624	24.97	9.4%	\$152,074	\$99,076	\$217,226	0.7	1.4	(\$52,998)	\$65,153
CZ15	SCE	48,848	3,540	25.39	12.5%	\$152,074	\$106,478	\$236,666	0.7	1.6	(\$45,596)	\$84,592
CZ16	PG&E	46,033	3,723	27.21	21.7%	\$154,680	\$225,243	\$212,289	1.5	1.4	\$70,563	\$57,609
CZ16-2	LA	46,033	3,723	27.21	21.7%	\$154,680	\$103,723	\$212,289	0.7	1.4	(\$50,957)	\$57,609

#### 4.2.2 All-Electric

Figure 20 shows that AE HVAC packages with efficiency measures, due to low upfront costs and significant TDV savings, can be TDV and on-bill cost effective in most CZs. Compared to FSR, the efficiency measure incremental costs are higher because: 1) the lighting measure, which has cost savings, is not applicable to QSR, and 2) cost increases to include efficiency measures for smaller capacity HVAC units.

In contrast with the FSR, the lower cost water heater (AO Smith CHP 120) also allows for the cost-effective addition of AE water heating in nearly all CZs. This is shown in Figure 21, which shows the cost-effectiveness results for adding this HPWH in addition to electric space heating and efficiency measures. As with the FSR, cost effectiveness expands to all CZs when analyzed with 2022 TDV, shown in Figure 22.

Figure 20. Cost Effectiveness for QSR: All-Electric Eff HVAC

CZ	Utility	Annual Elec Savings (kWh)	Annual Gas Savings (therms)	Annual GHG Reductions (mtons)	Compliance Margin	Upfront Incremental Package Cost	Lifecycle Utility Cost Savings	Lifecycle \$TDV Savings	B/C Ratio (On-bill)	B/C Ratio (TDV)	NPV (On-bill)	NPV (TDV)
CZ01	PG&E	(16,488)	3,839	17.50	20.4%	\$938	\$20,835	\$23,093	22.2	24.6	\$19,898	\$22,155
CZ02	PG&E	(15,146)	2,540	10.42	12.2%	\$8,352	\$599	\$10,380	0.1	1.2	(\$7,753)	\$2,028
CZ03	PG&E	(2,901)	2,021	9.94	25.4%	\$7,464	\$30,706	\$26,894	4.1	3.6	\$23,242	\$19,430
CZ03-2	PCE	(2,901)	2,021	9.94	25.4%	\$7,464	\$30,851	\$26,894	4.1	3.6	\$23,387	\$19,430
CZ04	PG&E	(539)	1,738	8.85	24.0%	\$7,517	\$33,014	\$29,777	4.4	4.0	\$25,497	\$22,260
CZ04-2	CPAU	(539)	1,738	8.85	24.0%	\$7,517	\$30,817	\$29,777	4.1	4.0	\$23,300	\$22,260
CZ05	PG&E	(5,476)	2,292	10.71	24.5%	\$8,267	\$26,923	\$25,679	3.3	3.1	\$18,656	\$17,412
CZ05-2	SCG	(5,476)	2,292	10.71	24.5%	\$8,267	\$11,673	\$25,679	1.4	3.1	\$3,406	\$17,412
CZ06	SCE	4,100	1,209	6.61	26.1%	\$8,278	(\$5,401)	\$31,063	-0.7	3.8	(\$13,679)	\$22,786
CZ06-2	LA	4,100	1,209	6.61	26.1%	\$8,278	\$26,114	\$31,063	3.2	3.8	\$17,837	\$22,786
CZ07	SDG&E	10,293	798	5.73	32.1%	\$8,225	\$44,277	\$38,157	5.4	4.6	\$36,052	\$29,932
CZ08	SCE	(1,205)	1,013	4.73	17.0%	\$9,159	\$7,190	\$19,020	0.8	2.1	(\$1,969)	\$9,861
CZ08-2	LA	(1,205)	1,013	4.73	17.0%	\$9,159	\$13,204	\$19,020	1.4	2.1	\$4,045	\$9,861
CZ09	SCE	(1,927)	1,159	5.43	15.9%	\$2,386	\$7,273	\$15,762	3.0	6.6	\$4,888	\$13,376
CZ09-2	LA	(1,927)	1,159	5.43	15.9%	\$2,386	\$12,007	\$15,762	5.0	6.6	\$9,621	\$13,376
CZ10	SDG&E	(4,678)	1,322	5.74	17.0%	\$1,569	(\$2,990)	\$13,774	-1.9	8.8	(\$4,559)	\$12,205
CZ10-2	SCE	(4,678)	1,322	5.74	17.0%	\$1,569	\$3,464	\$13,774	2.2	8.8	\$1,895	\$12,205
CZ11	PG&E	(10,612)	2,149	8.98	13.2%	\$9,155	\$9,441	\$17,812	1.0	1.9	\$286	\$8,657
CZ12	PG&E	(11,312)	2,129	8.81	12.8%	\$9,139	\$6,108	\$12,068	0.7	1.3	(\$3,031)	\$2,928
CZ12-2	SMUD	(11,312)	2,129	8.81	12.8%	\$9,139	\$17,513	\$12,068	1.9	1.3	\$8,374	\$2,928
CZ13	PG&E	(8,951)	1,983	8.42	12.4%	\$3,048	\$11,753	\$12,313	3.9	4.0	\$8,705	\$9,265
CZ14	SDG&E	(12,360)	2,102	8.17	12.9%	\$3,149	(\$16,471)	\$13,381	-5.2	4.2	(\$19,619)	\$10,233
CZ14-2	SCE	(12,360)	2,102	8.17	12.9%	\$3,149	\$54	\$13,381	0.0	4.2	(\$3,095)	\$10,233
CZ15	SCE	4,207	698	3.95	12.4%	\$1,652	\$9,936	\$25,742	6.0	15.6	\$8,284	\$24,090
CZ16	PG&E	(25,130)	3,656	14.72	0.2%	\$7,535	(\$7,729)	(\$13,697)	-1.0	-1.8	(\$15,264)	(\$21,232)
CZ16-2	LA	(25,130)	3,656	14.72	0.2%	\$7,535	\$34,581	(\$13,697)	4.6	-1.8	\$27,046	(\$21,232)

Figure 21. Cost Effectiveness for QSR: All-Electric Eff HVAC SHW

CZ	Utility	Annual Elec Savings (kWh)	Annual Gas Savings (therms)	Annual GHG Reductions (mtons)	Compliance Margin	Upfront Incremental Package Cost	Lifecycle Utility Cost Savings	Lifecycle \$TDV Savings	B/C Ratio (On-bill)	B/C Ratio (TDV)	NPV (On-bill)	NPV (TDV)
CZ01	PG&E	(27,689)	5,294	23.13	14.7%	\$7,423	\$8,433	\$13,970	1.1	1.9	\$1,010	\$6,547
CZ02	PG&E	(25,125)	3,923	15.89	9.6%	\$14,837	(\$8,583)	\$6,080	-0.6	0.4	(\$23,420)	(\$8,758)
CZ03	PG&E	(13,038)	3,395	15.29	21.0%	\$13,949	\$20,687	\$20,480	1.5	1.5	\$6,739	\$6,531
CZ03-2	PCE	(13,038)	3,395	15.29	21.0%	\$13,949	\$21,622	\$20,480	1.6	1.5	\$7,673	\$6,531
CZ04	PG&E	(10,231)	3,088	14.18	21.5%	\$14,002	\$24,249	\$25,593	1.7	1.8	\$10,247	\$11,591
CZ04-2	CPAU	(10,231)	3,088	14.18	21.5%	\$14,002	\$35,925	\$25,593	2.6	1.8	\$21,923	\$11,591
CZ05	PG&E	(15,854)	3,680	16.11	19.7%	\$14,752	\$16,239	\$18,729	1.1	1.3	\$1,487	\$3,977
CZ05-2	SCG	(15,854)	3,680	16.11	19.7%	\$14,752	(\$7,642)	\$18,729	-0.5	1.3	(\$22,394)	\$3,977
CZ06	SCE	(5,088)	2,511	11.76	23.8%	\$14,763	(\$2,392)	\$27,495	-0.2	1.9	(\$17,155)	\$12,733
CZ06-2	LA	(5,088)	2,511	11.76	23.8%	\$14,763	\$36,124	\$27,495	2.4	1.9	\$21,362	\$12,733
CZ07	SDG&E	1,288	2,081	10.83	29.6%	\$14,710	(\$9,627)	\$34,486	-0.7	2.3	(\$24,337)	\$19,775
CZ08	SCE	(10,044)	2,287	9.80	15.3%	\$15,644	\$10,306	\$16,538	0.7	1.1	(\$5,338)	\$894
CZ08-2	LA	(10,044)	2,287	9.80	15.3%	\$15,644	\$19,304	\$16,538	1.2	1.1	\$3,660	\$894
CZ09	SCE	(10,663)	2,439	10.57	14.7%	\$8,871	\$10,209	\$13,744	1.2	1.5	\$1,338	\$4,873
CZ09-2	LA	(10,663)	2,439	10.57	14.7%	\$8,871	\$32,867	\$13,744	3.7	1.5	\$23,996	\$4,873
CZ10	SDG&E	(13,497)	2,605	10.88	15.8%	\$8,054	(\$4,580)	\$11,507	-0.6	1.4	(\$12,634)	\$3,453
CZ10-2	SCE	(13,497)	2,605	10.88	15.8%	\$8,054	\$7,140	\$11,507	0.9	1.4	(\$914)	\$3,453
CZ11	PG&E	(19,663)	3,486	14.39	12.5%	\$15,640	\$2,909	\$16,214	0.2	1.0	(\$12,731)	\$574
CZ12	PG&E	(20,704)	3,476	14.21	11.3%	\$15,624	(\$1,553)	\$9,114	-0.1	0.6	(\$17,178)	(\$6,511)
CZ12-2	SMUD	(20,704)	3,476	14.21	11.3%	\$15,624	\$28,030	\$9,114	1.8	0.6	\$12,405	(\$6,511)
CZ13	PG&E	(18,222)	3,303	13.68	11.0%	\$9,533	\$4,054	\$9,254	0.4	1.0	(\$5,479)	(\$279)
CZ14	SDG&E	(21,614)	3,449	13.64	11.7%	\$9,634	(\$17,508)	\$10,701	-1.8	1.1	(\$27,142)	\$1,067
CZ14-2	SCE	(21,614)	3,449	13.64	11.7%	\$9,634	\$3,782	\$10,701	0.4	1.1	(\$5,852)	\$1,067
CZ15	SCE	(2,771)	1,837	8.69	12.1%	\$8,137	\$14,536	\$25,075	1.8	3.1	\$6,399	\$16,938
CZ16	PG&E	(33,322)	5,162	21.36	2.0%	\$14,020	(\$8,911)	(\$10,172)	-0.6	-0.7	(\$22,931)	(\$24,192)
CZ16-2	LA	(33,322)	5,162	21.36	2.0%	\$14,020	\$48,559	(\$10,172)	3.5	-0.7	\$34,539	(\$24,192)

Figure 22. Cost Effectiveness for QSR: All-Electric Eff HVAC SHW, 2022 TDV

CZ	Utility	Elec Savings (kWh)	Gas Savings (therms)	GHG Reductions (mtons)	Compliance Margin	Incremental Package Cost	Lifecycle Utility Cost Savings	\$TDV Savings	B/C Ratio (On-bill)	B/C Ratio (TDV)	NPV (On-bill)	NPV (TDV)
CZ01	PG&E	(26,352)	5,172	22.45	>0	\$7,423	\$9,976	\$37,013	1.3	5.0	\$2,554	\$29,590
CZ02	PG&E	(23,481)	3,751	14.77	>0	\$14,837	(\$6,719)	\$24,468	-0.5	1.6	(\$21,557)	\$9,631
CZ03	PG&E	(10,888)	3,158	14.10	>0	\$13,949	\$22,768	\$38,165	1.6	2.7	\$8,820	\$24,216
CZ03-2	PCE	(10,888)	3,158	14.10	>0	\$13,949	\$23,572	\$38,165	1.7	2.7	\$9,623	\$24,216
CZ04	PG&E	(8,005)	2,841	12.93	>0	\$14,002	\$26,808	\$42,422	1.9	3.0	\$12,806	\$28,419
CZ04-2	CPAU	(8,005)	2,841	12.93	>0	\$14,002	\$36,155	\$42,422	2.6	3.0	\$22,153	\$28,419
CZ05	PG&E	(11,632)	3,222	14.09	>0	\$14,752	\$21,345	\$34,170	1.4	2.3	\$6,594	\$19,418
CZ05-2	SCG	(11,632)	3,222	14.09	>0	\$14,752	\$322	\$34,170	0.0	2.3	(\$14,430)	\$19,418
CZ06	SCE	(1,547)	2,149	10.46	>0	\$14,763	\$21,444	\$40,213	1.5	2.7	\$6,681	\$25,450
CZ06-2	LA	(1,547)	2,149	10.46	>0	\$14,763	\$25,542	\$40,213	1.7	2.7	\$10,779	\$25,450
CZ07	SDG&E	2,003	1,987	10.33	>0	\$14,710	(\$9,617)	\$42,846	-0.7	2.9	(\$24,327)	\$28,136
CZ08	SCE	(7,375)	2,113	9.16	>0	\$15,644	\$13,934	\$28,080	0.9	1.8	(\$1,710)	\$12,436
CZ08-2	LA	(7,375)	2,113	9.16	>0	\$15,644	\$19,489	\$28,080	1.2	1.8	\$3,845	\$12,436
CZ09	SCE	(8,193)	2,243	9.75	>0	\$8,871	\$14,316	\$33,393	1.6	3.8	\$5,445	\$24,522
CZ09-2	LA	(8,193)	2,243	9.75	>0	\$8,871	\$21,037	\$33,393	2.4	3.8	\$12,166	\$24,522
CZ10	SDG&E	(12,219)	2,473	10.06	>0	\$8,054	\$2,282	\$24,904	0.3	3.1	(\$5,772)	\$16,850
CZ10-2	SCE	(12,219)	2,473	10.06	>0	\$8,054	\$9,707	\$24,904	1.2	3.1	\$1,653	\$16,850
CZ11	PG&E	(16,745)	3,298	13.50	>0	\$15,640	\$8,784	\$34,797	0.6	2.2	(\$6,856)	\$19,157
CZ12	PG&E	(18,223)	3,291	13.27	>0	\$15,624	\$2,941	\$26,575	0.2	1.7	(\$12,684)	\$10,951
CZ12-2	SMUD	(18,223)	3,291	13.27	>0	\$15,624	\$30,866	\$26,575	2.0	1.7	\$15,242	\$10,951
CZ13	PG&E	(14,520)	3,003	12.52	>0	\$9,533	\$10,277	\$34,598	1.1	3.6	\$743	\$25,064
CZ14	SDG&E	(19,146)	3,206	12.39	>0	\$9,634	(\$15,317)	\$21,871	-1.6	2.3	(\$24,951)	\$12,237
CZ14-2	SCE	(19,146)	3,206	12.39	>0	\$9,634	\$4,392	\$21,871	0.5	2.3	(\$5,242)	\$12,237
CZ15	SCE	(2,540)	1,744	8.14	>0	\$8,137	\$15,868	\$30,001	2.0	3.7	\$7,731	\$21,865
CZ16	PG&E	(30,488)	4,812	19.75	>0	\$14,020	(\$7,969)	\$6,622	-0.6	0.5	(\$21,989)	(\$7,398)
CZ16-2	LA	(30,488)	4,812	19.75	>0	\$14,020	\$45,018	\$6,622	3.2	0.5	\$30,998	(\$7,398)

The Reach Code Team analyzed the following AE packages but, as with the AE FSR, was unable to determine cost-effective outcomes for packages including electrification of cooking appliances due to the efficiency of these appliances, as well as time of use utility rates. These results are available in Appendix 7.5 Additional Restaurant All-Electric Package Analysis.

- All-Electric (AE HE)
- All-Electric + Efficiency (AE Eff HE)
- All-Electric + Efficiency + Solar PV and Battery (AE Eff HE PVB)
- Hybrid + Efficiency + Solar PV and Battery (HB Eff HE PVB)

All these packages include electric cooking appliances, which is the biggest barrier to TDV and on-bill cost effectiveness. Although there are minimal technical barriers in replacing gas cooking appliances with electric alternatives, the utility cost and TDV (code compliance) penalties are significant, primarily because the cooking activities are coincident with high TDV and utility rate periods. Nonetheless, switching to HE electric cooking appliances can save 30 to 50% of the energy consumption, but this falls short of the differences in cost of electric energy versus natural gas, which is about 400% higher per kBtu. The keys to electrify cooking include utility rate offerings to address the operational cost barrier, as well as education and training to address the market actor concerns.

## 5 Summary of Results

The Reach Code Team developed packages of energy efficiency measures as well as packages combining energy efficiency with PV generation and battery storage systems, simulated them in CBECC-Com, and gathered costs to determine the cost effectiveness of multiple scenarios. The Reach Code Team coordinated assumptions with multiple utilities, cities, and restaurant and building community experts to develop a set of assumptions considered reasonable in the current market. Changing assumptions, such as the period of analysis, measure selection, cost assumptions, energy escalation rates, or utility tariffs are likely to change results.

Figure 23 and Figure 24 summarize results for each prototype and depict the compliance margins achieved for each CZ and package. Because local reach codes must both exceed the CEC performance budget (i.e., have a positive compliance margin) and be cost effective, the Reach Code Team highlighted cells meeting these two requirements to help clarify the potential for reach code policies:

- Cells highlighted in green depict a positive compliance margin and cost-effective results using both on-bill and TDV approaches.
- Cells highlighted in yellow depict a positive compliance and cost-effective results using either the on-bill or TDV approach.
- Cells not highlighted either depict a negative compliance margin or a package that was not cost effective using either the on-bill or TDV approach.

The Reach Code Team provides the following high-level takeaways from the results for both the FSR and QSR.

- Mixed-fuel packages with efficiency measures are cost effective in all CZs using both on-bill and TDV metrics. Adding PV with battery measures is cost effective in all CZs using TDV, and in many CZs using the on-bill approach.
- Electrifying HVAC and adding efficiency measures is most cost effective. Additionally, electrifying SHW is generally cost effective when hot water efficiency measures are included.
- Reach codes may be adopted in several CZs that require higher efficiency mixed-fuel restaurants, AE HVAC, or AE HVAC + SHW + Efficiency.
- A cost-effective pathway has not yet been determined for packages including AE kitchen appliances. Minor exceptions occur in CPAU and LADWP territories for QSR packages that include solar PV and battery storage, depicted in Figure 58 in the appendix.
- All end uses including HVAC, SHW, and cooking appliances can be installed to comply to the Energy Code without significant barriers: heat pump HVAC and SHW results in positive compliance margins, and cooking process loads do not affect compliance margins except for slight interactive effects with HVAC equipment.

Figure 23. FSR Summary of Compliance Margin and Cost Effectiveness

CZ	Utility	Mixed-Fuel			All-Electric		AE Eff HVAC SHW, 2022 TDV
		MF Eff	MF Eff HE	MF Eff HE PVB	AE Eff HVAC	AE Eff HVAC SHW	
CZ01	PG&E	8%	14%	14%	1%	-22%	<0
CZ02	PG&E	13%	14%	14%	11%	-2%	>0
CZ03	PG&E	12%	16%	16%	11%	-8%	>0
CZ03-2	PCE	12%	16%	16%	11%	-8%	>0
CZ04	PG&E	16%	16%	16%	15%	1%	>0
CZ04-2	CPAU	16%	16%	16%	15%	1%	>0
CZ05	PG&E	12%	16%	16%	10%	-11%	>0
CZ05-2	SCG	12%	16%	16%	10%	-11%	>0
CZ06	SCE	17%	18%	18%	17%	3%	>0
CZ06-2	LA	17%	18%	18%	17%	3%	>0
CZ07	SDG&E	16%	21%	21%	18%	3%	>0
CZ08	SCE	18%	16%	16%	18%	8%	>0
CZ08-2	LA	18%	16%	16%	18%	8%	>0
CZ09	SCE	15%	13%	13%	17%	7%	>0
CZ09-2	LA	15%	13%	13%	17%	7%	>0
CZ10	SDG&E	17%	14%	14%	16%	9%	>0
CZ10-2	SCE	17%	14%	14%	16%	9%	>0
CZ11	PG&E	15%	11%	11%	12%	4%	>0
CZ12	PG&E	14%	14%	14%	13%	3%	>0
CZ12-2	SMUD	14%	14%	14%	13%	3%	>0
CZ13	PG&E	17%	11%	11%	13%	4%	>0
CZ14	SDG&E	18%	12%	12%	15%	7%	>0
CZ14-2	SCE	18%	12%	12%	15%	7%	>0
CZ15	SCE	19%	11%	11%	16%	12%	>0
CZ16	PG&E	11%	15%	15%	-10%	-15%	<0
CZ16-2	LA	11%	15%	15%	-10%	-15%	<0

Figure 24. QSR Summary of Compliance Margin and Cost Effectiveness

CZ	Utility	Mixed-Fuel			All-Electric		
		MF Eff	MF Eff HE	MF Eff HE PVB	AE Eff HVAC	AE Eff HVAC SHW	AE Eff HVAC SHW, 2022 TDV
CZ01	PG&E	30%	26%	26%	20%	15%	>0
CZ02	PG&E	15%	12%	12%	12%	10%	>0
CZ03	PG&E	27%	25%	25%	25%	21%	>0
CZ03-2	PCE	27%	25%	25%	25%	21%	>0
CZ04	PG&E	26%	20%	20%	24%	22%	>0
CZ04-2	CPAU	26%	20%	20%	24%	22%	>0
CZ05	PG&E	28%	31%	31%	24%	20%	>0
CZ05-2	SCG	28%	31%	31%	24%	20%	>0
CZ06	SCE	26%	28%	28%	26%	24%	>0
CZ06-2	LA	26%	28%	28%	26%	24%	>0
CZ07	SDG&E	32%	33%	33%	32%	30%	>0
CZ08	SCE	18%	15%	15%	17%	15%	>0
CZ08-2	LA	18%	15%	15%	17%	15%	>0
CZ09	SCE	14%	14%	14%	16%	15%	>0
CZ09-2	LA	14%	14%	14%	16%	15%	>0
CZ10	SDG&E	15%	12%	12%	17%	16%	>0
CZ10-2	SCE	15%	12%	12%	17%	16%	>0
CZ11	PG&E	14%	12%	12%	13%	12%	>0
CZ12	PG&E	15%	18%	18%	13%	11%	>0
CZ12-2	SMUD	15%	18%	18%	13%	11%	>0
CZ13	PG&E	13%	12%	12%	12%	11%	>0
CZ14	SDG&E	14%	9%	9%	13%	12%	>0
CZ14-2	SCE	14%	9%	9%	13%	12%	>0
CZ15	SCE	13%	12%	12%	12%	12%	>0
CZ16	PG&E	22%	22%	22%	0%	2%	>0
CZ16-2	LA	22%	22%	22%	0%	2%	>0

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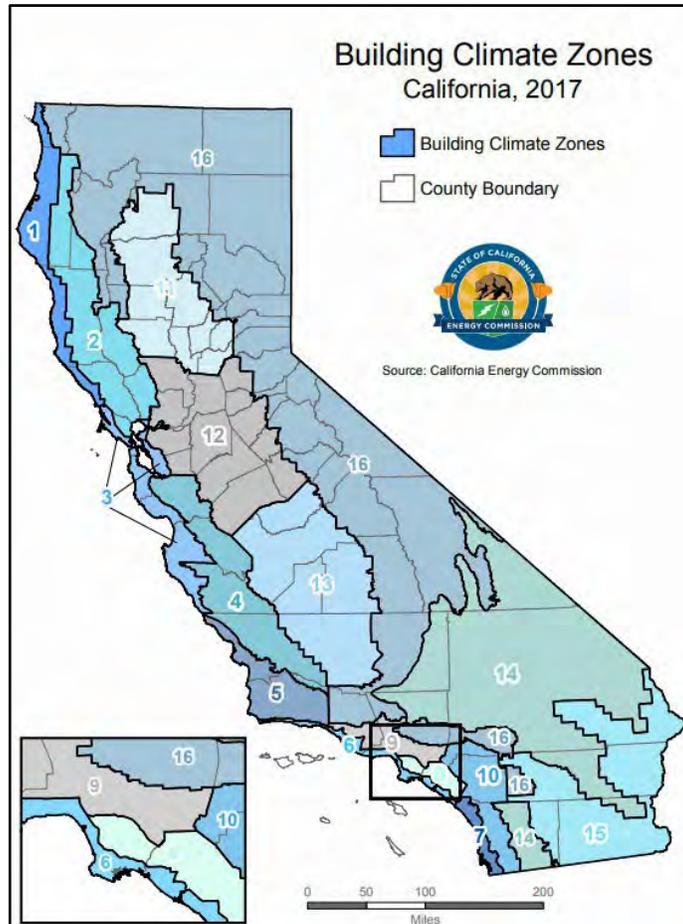
## 7 Appendices

### 7.1 Map of California CZs

CZ geographical boundaries are depicted in Figure 25. The map in Figure 25 along with a zip-code search directory is available at:

[https://ww2.energy.ca.gov/maps/renewable/building\\_climate\\_zones.html](https://ww2.energy.ca.gov/maps/renewable/building_climate_zones.html)

Figure 25. Map of California CZs



### 7.2 Utility Rate Schedules

The Reach Code Team used the IOU rate tariffs listed in Some climate zones have two options for rates as it varies by energy demand of different measure packages.

Figure 26 to determine the on-bill savings for each prototype. Some climate zones have two options for rates as it varies by energy demand of different measure packages.

**Figure 26. Utility Tariffs Analyzed Based on CZ: Detailed View**

CZ	Electric/Gas Utility	Electricity (TOU)		Natural Gas
		QSR	FSR	All Prototypes
CZ01	PG&E	B-1	B-1 or B-10	G-NR1
CZ02	PG&E	B-1	B-1 or B-10	G-NR1
CZ03	PG&E	B-1	B-1 or B-10	G-NR1
CZ04	PG&E	B-1	B-1 or B-10	G-NR1
CZ04-2	CPAU	E-2	E-2	G-2
CZ05	PG&E	B-1	B-1 or B-10	G-NR1
CZ05-2	PG&E/SOCALGAS	B-1	B-1 or B-10	G-10 (GN-10)
CZ06	SCE/SOCALGAS	TOU-GS-1 or TOU-GS-2	TOU-GS-2	G-10 (GN-10)
CZ06-2	LADWP/SOCALGAS	A-1 or A-2	A-2	G-10 (GN-10)
CZ07	SDG&E	TOU-A or AL-TOU+EECC	AL-TOU+EECC	GN-3
CZ08	SCE/SOCALGAS	TOU-GS-1 or TOU-GS-2	TOU-GS-2	G-10 (GN-10)
CZ08-2	LADWP/SOCALGAS	A-1 or A-2	A-2	G-10 (GN-10)
CZ09	SCE/SOCALGAS	TOU-GS-2	TOU-GS-2	G-10 (GN-10)
CZ09-2	LADWP/SOCALGAS	A-1 or A-2	A-2	G-10 (GN-10)
CZ10	SDG&E	AL-TOU+EECC	AL-TOU+EECC	GN-3
CZ10-2	SCE/SOCALGAS	TOU-GS-2	TOU-GS-2	G-10 (GN-10)
CZ11	PG&E	B-1 or B-10	B-1 or B-10	G-NR1
CZ12	PG&E	B-1 or B-10	B-1 or B-10	G-NR1
CZ12-2	SMUD/PG&E	GSN or GSS	GSS	G-NR1
CZ13	PG&E	B-1 or B-10	B-1 or B-10	G-NR1
CZ14	SDG&E	AL-TOU+EECC	AL-TOU+EECC	GN-3
CZ14-2	SCE/SOCALGAS	TOU-GS-2	TOU-GS-2	G-10 (GN-10)
CZ15	SCE/SOCALGAS	TOU-GS-2	TOU-GS-2	G-10 (GN-10)
CZ16	PG&E	B-1 or B-10	B-1 or B-10	G-NR1
CZ16-2	LADWP/PG&E	A-1 or A-2	A-1 or A-2	G-NR1

Utility rates are assumed to escalate over time, using assumptions from research conducted by Energy and Environmental Economics (E3) in the 2019 study Residential Building Electrification in California (Energy & Environmental Economics 2019) and escalation rates used in the development of the 2022 TDV multipliers. Figure 27 below demonstrates the escalation rates used for nonresidential buildings.

**Figure 27. Real Utility Rate Escalation Rate Assumptions Above Inflation**

Year	Source	Statewide Electric Nonresidential Average Rate (%/year, real)	Natural Gas Nonresidential Core Rate (%/year, real)
2020	E3 2019	2.0%	4.3%
2021	E3 2019	2.0%	4.3%
2022	E3 2019	2.0%	2.7%
2023	E3 2019	2.0%	4.0%
2024	2022 TDV	0.7%	7.7%
2025	2022 TDV	0.5%	5.5%
2026	2022 TDV	0.7%	5.6%
2027	2022 TDV	0.2%	5.6%
2028	2022 TDV	0.6%	5.7%
2029	2022 TDV	0.7%	5.7%
2030	2022 TDV	0.6%	5.8%
2031	2022 TDV	0.6%	3.3%
2032	2022 TDV	0.6%	3.6%
2033	2022 TDV	0.6%	3.4%
2034	2022 TDV	0.6%	3.4%

### 7.3 Basis of Design for Restaurants

The Reach Code Team developed these bases of designs to develop simulation inputs for restaurants after exhaustive literature review and interviews with food service subject matter experts. Note that where ‘\*\*\*\*’ is used in the model name and number, it is a placeholder representing multiple model options.

#### 7.3.1 Kitchen hooded cooking appliances

The BOD for kitchen hooded cooking appliances covers four scenarios:

- Baseline gas appliances
- HE gas appliances, defined as either ENERGY STAR compliant or qualified for IOU rebates
- High-efficiency electric appliances, including induction appliances.
- KOF AE for FSR only. In addition to the AE package that focuses on one-to-one replacement of each gas appliance, the Reach Code Team also investigated using advanced AE cooking appliance package to reduce space requirements, improve energy efficiency and reduce cook time. The KOF involves careful design and selection of more advanced electric appliances that combine cooking processes. For example, combination and rapid cook ovens are used to replace broilers, convection ovens, range oven, and stock pot.

The selected appliances in each package can achieve equivalent cooking capacity and needs. Energy efficiency comes from improved technologies.

7.3.1.1 FSR

Figure 28 shows the cooking appliance included in the BOD for FSR mixed-fuel baseline scenario.

**Figure 28. Hooded cooking appliance for FSR - Baseline Gas Appliance**

Hooded Cooking Appliances	Number of units	Model	Width	Name plate power (Btu/hr)	Idle energy (Btu/hr)	Duty	Source	Cost/unit
Broiler, Underfired	1	Vulcan HGB34	3	96,000	73,900	Heavy	Market data	\$2,745
French Fryer	2	Frymaster GF40	1.3	122000	9000	Medium	Market data	\$2,144
Griddle, single sided	1	Imperial ITG-36	3	90,000	20,400	Medium	Market data	\$2,747
Broiler, Salamander	1	Vulcan Sar 34R	2.8	35,000	33,300	Light	RP 1362	\$2,875
Oven, convection	2	Montague Vectaire R85	3.188	85,000	12000	Light	Market data	\$14,340
Oven, Range	2	Wolf C36C -6, oven	3	25,000	7,400	Light	RP 1362	Combined cost with Range, Open Top, 6 burner
Range, Open Burner	2	Wolf C36C -6	3.0	180,000	181,800	Medium	GTI and Fisher Nickel (2013) Table 12	\$5,095
Range, Stock pot	2	Royal RSP18	1.5	90,000	90,900	Medium	Market data	\$868

Figure 29 shows the cooking appliances included in the BOD for FSR high efficiency gas scenario.

**Figure 29. Hooded cooking appliance for FSR: HE Gas Appliance**

Hooded Cooking Appliances	Number of units	Model	Width	Name plate power (Btu/hr)	Idle energy (Btu/hr)	Duty	Source	Cost/unit
Broiler, Underfired	1	Vulcan VTEC36	3	66,000	51,000	Heavy	DEER <sup>9</sup>	\$5,304
French Fryer	2	Frymaster PH155	1	80,000	5,604	Medium	IOU Rebate	\$4,537
Griddle, single sided	1	AccuTemp GGF1201A3650	3	70,000	11,850	Medium	IOU Rebate	\$6,554
Broiler, Salamander	1	Vulcan Sar 34R	2.8	35,000	33,300	Light	RP 1362	\$2,875
Oven, convection	2	Blodgett HVH100G	3.2	60,000	9,082	Light	IOU Rebate	\$15,378
Oven, Range	2	Southbend C0300, oven	3	25,000	7,400	Light	RP 1362	Combined cost with Range, Open top, 6 burner
Range, Open Burner <sup>10</sup> with turbo pot	2	Montague 136-5	3	120,000	121,200	Medium	GTI and Fisher Nickel (2013) Table 13	\$9,666
Range, Stock pot	2	Royal RSP18	1.5	90,000	90,900	Medium	Market data	\$7,578

Figure 30 shows the cooking appliances included in the BOD for FSR electric scenario.

**Figure 30. Hooded cooking appliance for FSR: Electric Appliance**

Hooded Cooking Appliances	Number of units	Model	Width	Nameplate power (W)	Idle energy (W)	Duty	Source	Cost/unit
Broiler, chain	1	Nieco JF63	3	18,000	15,120	Medium	Market data	\$23,427
French Fryer	2	Frymaster RE14***	1	14,000	620	Medium	IOU Rebate	\$5,609
Griddle, single sided	1	AccuTemp EGF****A3650	3	15,250	2,034	Medium	IOU Rebate	\$6,760
Broiler, Salamander	1	Garland SERC	2.8	7,003	6,827	Light	RP 1362	\$4,444
Oven, convection	2	Blodgett Zephaire-100-E	3.2	11,000	1,400	Light	IOU Rebate	\$6,114

<sup>9</sup> Efficiency is based on DEER commercial underfired broiler workpaper for IR Plate Broiler with 17,000 Btu/hr/ft idle rate

<sup>10</sup> HE gas scenario includes replacing high-input burners with low-input burners in combination with turbo pot.

Oven, Range	2	Garland GME36-I20C Oven	3	5,100	1,224	Light	Market data	Combined cost with Range, Open top, 6 burner
Range, Open burner induction	2	Garland GME36-120C	3	21,000	0	Light	Market data	\$15,936
Range, Stock pot induction	2	CookTek MSP7000-200	1.8	7,000	0	Light	Market data	\$5,845

Figure 31 shows the cooking appliances included in the BOD for FSR kitchen on the future scenario.

**Figure 31. Hooded cooking appliance for FSR: Electric Appliance – KOF**

Hooded Cooking Appliances	Number of units	Model	Width (ft)	Rated Input (W)	Idle Energy Rate (W)	Duty	Source	Cost/unit
French Fryer	2	Frymaster RE14***	1	14,000	620	Medium	IOU Rebate	\$5,609
Griddle, single sided <sup>a</sup>	1	AccuTemp EGF****A4850	4	14,250	2,657	Medium	IOU Rebate	\$6,760
Oven, Combination <sup>b</sup>	1	Rational ICP 6-FULL E	3.5	22,400	950	Light	IOU Rebate	\$18,196
Oven, Combination <sup>b</sup>	1	Rational ICP 10-FULL E	3.5	37,400	1,150	Light	Market Data	\$22,395
Range, Induction Hot Top	2	CookTek Six-Burner Range	3	21,000	0	Light	Market data	\$13,405
Range, Induction Hot Top <sup>c</sup>	2	CookTek Four-Burner Range	3	17,000	0	Light	Market data	\$9,845
Rapid Cook Oven <sup>d</sup>	2	TurboChef Sota	1.2	6,200	800	Light	Market Data	\$9,606

<sup>a</sup> One four-foot griddle replaces the broiler cooking process

<sup>b</sup> One full-size, six-hot pan combination oven stacked atop one full size, ten hotel pan combination oven replaces the convection oven, range oven, stock pot, and charbroiler cooking processes

<sup>c</sup> One four-burner induction range burner replaces the oven, range burner cooking processes

<sup>d</sup> Two rapid cook ovens replace the broiler, salamander cooking/finishing process

### 7.3.1.2 QSR: Burger Diner

Figure 32 shows the cooking appliances included in the BOD for QSR mixed-fuel baseline scenario.

**Figure 32. Hooded cooking appliances for QSR: Baseline Gas Appliance**

Hooded Cooking Appliances	Number of units	Model	Width (ft)	Nameplate power (Btu/hr)	Idle energy (Btu/hr)	Duty (ASHRAE 2020)	Source	Cost/unit
French Fryer, small	4	Frymaster GF40	1.3	122,000	9,000	Medium	Market data	\$2,144
Griddle, single sided	2	Imperial ITG-36	3	90,000	20,400	Medium	Market data	\$2,747
Oven, half-size electric convection*	1	Montague Vectaire EK8	2.5	26,955	5,390	Light	Market data	\$7,578

\*Interviewees suggested that a half-size electric oven is commonly used for gas QSR, with no exhaust hood is required.

Figure 33 shows the cooking appliances included in the BOD for QSR high efficiency gas scenario.

**Figure 33. Hooded cooking appliances for QSR: HE Gas Appliance**

Hooded Cooking Appliances	Number	Model	Width (ft)	Nameplate power (Btu/hr)	Idle energy (Btu/hr)	Duty	Source	Cost/unit
French Fryer, small	4	Frymaster PH155	1	80,000	5,604	Medium	IOU Rebate	\$4,537
Griddle, single sided	2	AccuTemp GGF1201A3650	3	70,000	7,900	Medium	IOU Rebate	\$6,554
Oven, half-size electric convection*	1	Montague Vectaire EK8	2.5	26,955	5390	Light	Market data	\$7,578

Figure 34 shows the cooking appliances included in the BOD for QSR electric scenario.

**Figure 34. Hooded cooking appliances for QSR: Electric Appliance**

Hooded Cooking Appliances	Number of units	Model	Width (ft)	Nameplate power (W)	Idle energy (W)	Duty	Source	Cost/unit
French Fryer, small	4	Frymaster RE14***	1	14,000	620	Medium	IOU Rebate	\$5,609
Griddle, single sided	2	AccuTemp EGF****A3650	3	15,250	2,034	Medium	IOU Rebate	\$6,760
Oven, convection	1	Blodgett CBT	2.5	5,600	300	Light	IOU Rebate	\$6,114

7.3.1.3 QSR: Taqueria

Figure 35 shows the cooking appliances included in the BOD for QSR mixed-fuel baseline scenario.

**Figure 35. Hooded cooking appliances for QSR: Baseline Gas Appliance**

Hooded Cooking Appliances	Number of units	Model	Width (ft)	Nameplate power (Btu/hr)	Idle energy (Btu/hr)	Duty	Source	Cost/unit
Broiler, Underfired	1	Vulcan HGB34	3	96,000	73,900	Heavy	RP 1362	\$2,745
French Fryer, small	1	Frymaster GF40	1.3	122,000	9,000	Medium	Market data	\$2,144
Griddle, single sided	1	Imperial ITG-36	3	90,000	20,400	Medium	Market data	\$2,747
Oven, half-size electric convection	1	Montague Vectaire EK8	2.5	26,955	5,390	Light	Market data	\$7,578
Oven, Range	1	Wolf C36C -6, oven	3	25,000	7,400	Light	RP 1362	Combined cost with Range, Open burner
Range, Open Burner	1	Wolf C36C -6	3.0	180,000	181,800	Medium	GTI and Fisher Nickel (2013) Table 12	\$5,095

Figure 36 shows the cooking appliances included in the BOD for QSR high efficiency gas scenario.

**Figure 36. Hooded cooking appliances for QSR: HE Gas Appliance**

Hooded Cooking Appliances	Number	Model	Width (ft)	Nameplate power (Btu/hr)	Idle energy (Btu/hr)	Duty	Source	Cost/unit
Broiler, Underfired	1	Vulcan VTEC36	3	66,000	51,000	Heavy	DEER	\$5,304
French Fryer, small	1	Frymaster H55	1	80,000	5,604	Medium	IOU Rebate	\$4,537
Griddle, single sided	1	AccuTemp GGF1201A3650	3	70,000	7,900	Medium	IOU Rebate	\$6,554
Oven, half-size electric convection*	1	Montague Vectaire EK8	2.5	26,955	5,390	Light	Market data	\$7,578
Oven, Range	1	Southbend C0300, oven	3	25,000	7,400	Light	RP 1362	Combined cost with Range,

								Open Burner with turbo pot
Range, Open Burner with turbo pot	1	Montague 136-5	3	120,000	121,200	Medium	GTI and Fisher Nickel (2013) Table 13	\$9,666

Figure 37 shows the cooking appliances included in the BOD for QSR electric scenario.

**Figure 37. Hooded cooking appliances for QSR: Electric Appliance**

Hooded Cooking Appliances	Number of units	Model	Width (ft)	Nameplate power (W)	Idle energy (W)	Duty	Source	Cost/unit
Broiler, chain	1	Nieco JF63	3	18,000	15,120	Medium	Market data	\$23,437
French Fryer, small	1	Frymaster RE14***	1	14,000	620	Medium	IOU Rebate	\$5,609
Griddle, single sided	1	AccuTemp EGF***A3650	3	15,250	2,034	Medium	IOU Rebate	\$6,760
Oven, convection	1	Blodgett CBT	2.5	5,600	300	Light	IOU Rebate	\$6,114
Range, Open burner induction	1	Garland GME36-120C	3	21,000	0	Light	Market data	\$15,936
Range, Stock pot induction	1	CookTek MSP7000-200	1.8	7,000	0	Light	Market data	\$5,845

**7.3.1.4 Annual Cooking Energy Use**

The Reach Code Team used a bottom-up approach to estimate annual cooking energy usage. We developed hourly load profiles for each appliance based on occupancy schedule, equipment nameplate power, idle energy rate, and energy input as a function of appliance cooking state if data is available.

Figure 38 shows the aggregated cooking appliances load profile for the FSR. The annual energy use for each scenario is:

- Baseline gas appliances: 248 kBtu/ft2
- HE gas appliances: 188 kBtu/ft2
- All-electric appliances: 40 kWh/ft2 (136 kBtu/ft2)
- All-electric KOF appliances: 26 kWh/ft2 (89 kBtu/ft2)

**Figure 38. FSR Weekday Cooking Appliance Load Profiles, Percent of Total Capacity**

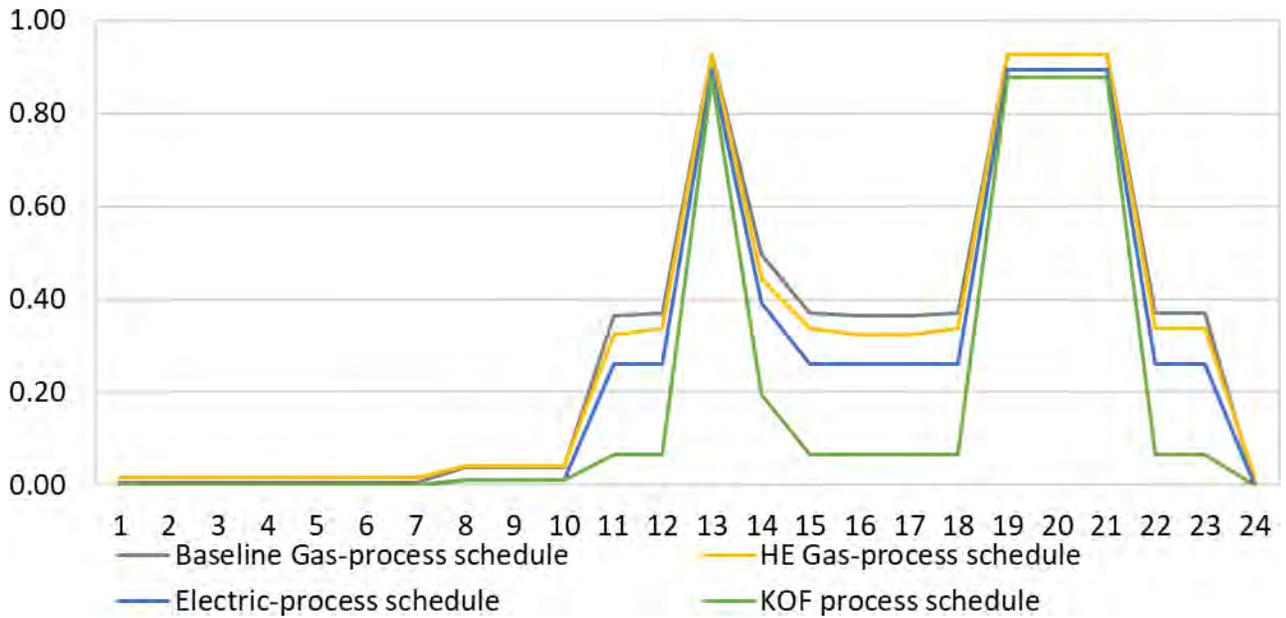
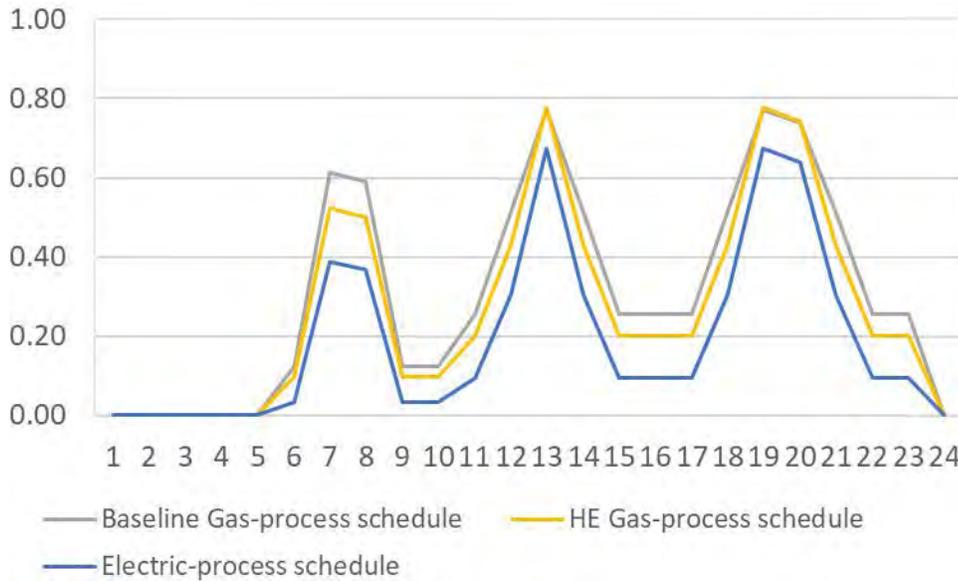


Figure 39 shows the aggregated cooking appliances load profile for the QSR-Burger. The annual energy uses for each scenario are:

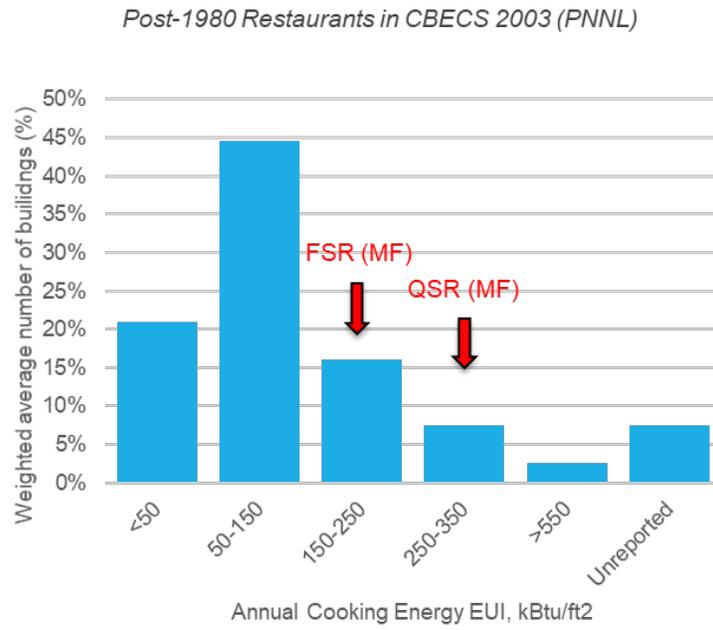
- Baseline gas appliances: 293 kBtu/ft<sup>2</sup> for gas consumption and 3.3 kWh/ft<sup>2</sup> for electric convection oven
- HE gas appliances: 190.5 kBtu/ft<sup>2</sup> for gas consumption and 3.3 kWh/ft<sup>2</sup> for electric convection oven
- All-electric appliances: 42.3 kwh/ft<sup>2</sup> (144 kBtu/ft<sup>2</sup>)

**Figure 39. QSR Weekday Cooking Appliance Load Profiles, Percent of Total Capacity**

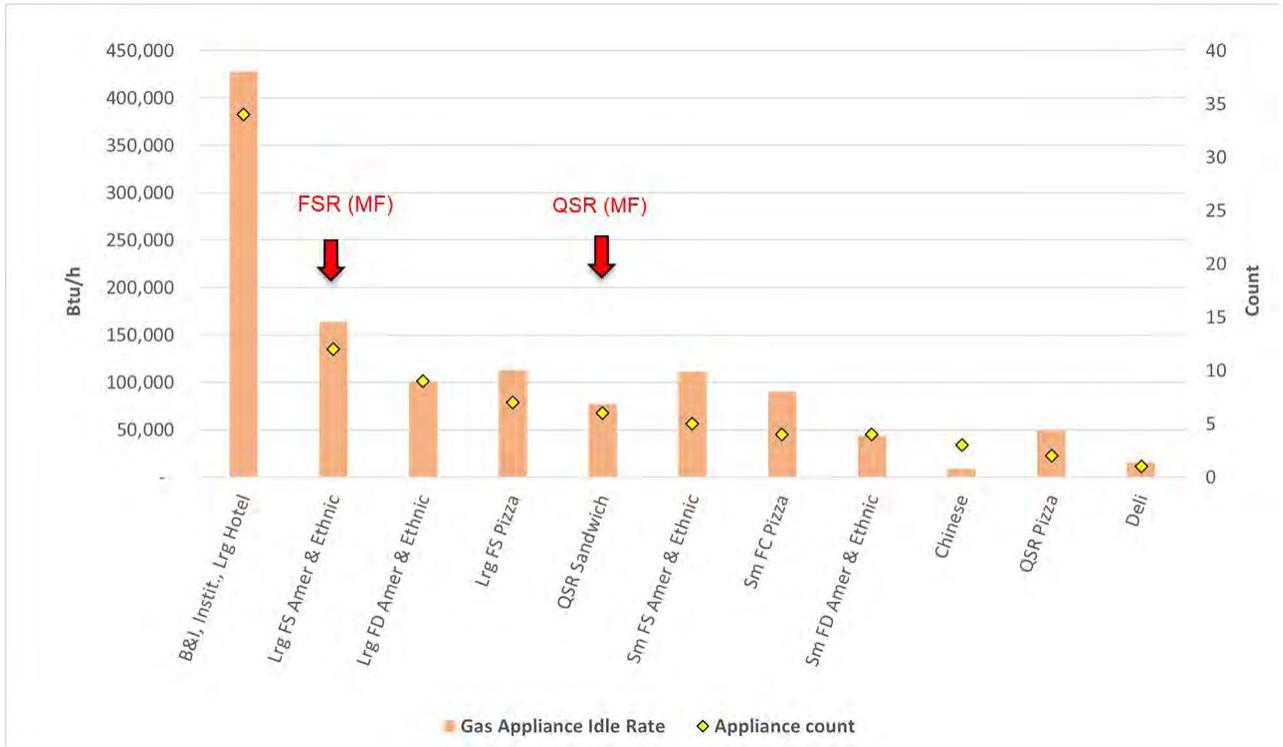


As a reference, 2003 Commercial Building Energy Consumption Survey (CBECS) has a wide range of restaurant annual cooking energy use index (EUI) for, as shown in Figure 40. CBECS data includes restaurants serving different menus, including sandwich or cafés, which use much less energy than a burger restaurant. A Pacific Northwest National Laboratory (PNNL) report suggests a cooking EUI of 400 to 450 kBtu/ft<sup>2</sup> as reasonable for a burger QSR (PNNL 2010). Figure 41 also demonstrates where the mixed-fuel prototypes fall in comparison to a wider range of restaurants—the selected prototypes generally have more gas appliances and a higher cumulate idle rate (which is indicative of the energy use intensity). Thus, the annual energy use the Reach Code Team developed for the FSR and QSR baseline scenarios are appropriately on the higher end of PNNL’s EUI findings.

Figure 40. Annual Cooking Energy EUI of Post-1980 Restaurants from CBECS 2003 (PNNL 2010)



**Figure 41. Gas Cooking Energy Idle Rate in Different Types of Commercial Kitchens<sup>11</sup>**



**7.3.2 Kitchen Exhaust Hood**

The Reach Code Team determined the exhaust hood length by adding all appliance widths and six inches of overhang on each side. This is the approach used in the ASHRAE 154 Appendix example. The total exhaust rate is the maximum airflow allowed by 2019 Title 24 Table 140.9. For control, if total exhaust rate exceeds 5,000 ft<sup>3</sup>/min, DCKV is specified per 2019 Title 24 prescriptive requirement.

**Figure 42. FSR Type I exhaust hood design**

	Length (ft)	Exhaust rate	Equipment Duty	Control
Gas baseline	26	7,280	Heavy	DCKV
HE gas	26	7,280	Heavy	DCKV
Electric	26	5,460	Medium	DCKV
Kitchen of Future	22	4620	Medium	DCKV

<sup>11</sup> The reach code team developed this graph with support from subject matter experts at Food Service Technology Center, Frontier Energy, Inc.

**Figure 43. QSR Type I exhaust hood design**

	Length (ft)	Exhaust rate (ft <sup>3</sup> /min)	Equipment Duty	Control
Gas baseline	13	2,730	Medium	Constant
HE gas	13	2,730	Medium	Constant
Electric	13	2,730	Medium	Constant

For cooking appliances, the Reach Code Team focused on gas cooking appliances that require a Type I exhaust hood<sup>12</sup>. Compared to appliances needing a Type II exhaust hood, Type I appliances present the biggest challenges for electrification and have large impacts on HVAC loads. Most appliances requiring Type II are already electrical appliances and the amount of exhaust air required is small.

### 7.3.3 Hot Water System

Design parameters for the hot water systems are based on research by PG&E and Fisher-Nickel (Fisher-Nickel and PG&E 2010), California Energy Wise design guide (California Energy Wise 2020) and subject matter expert interviews. The baseline scenarios represent design practice with typical hot water use appliances and fixtures for a medium QSR and medium FSR. Fixture types and counts assumed in the FSR and QSR are presented in Figure 44.

**Figure 44. Fixture Type and Counts Included in the FSR and QSR Baselines**

Fixture type	FSR	QSR
Restroom sinks	4	2
Hand sinks	6	2
3-comp sink (18"x18")	2	1
Dishwasher - Undercounter	1	0
Dishwasher - door type	1	0
Pre-rinse valve	1	0
Mop sink	1	1
Utility sink	2	1
Dipper well	1	0

<sup>12</sup> Type I hoods are installed over cooking appliances, and they include listed grease filters, baffles, and a fire suppression system. Type II hood may or may not have grease filters or baffles and is not designed to have a fire-suppression system. Compared to Type II hoods, Type I hoods have higher exhaust rate requirements and thus have a larger energy impact. Thus, Type I hoods require more design optimization and control.

Hot water use in restaurants features high demand for an extended period, which can be very challenging for a cost-effective heat pump water design. HPWHs have low recovery rates compared to gas heaters, and their capacity reduces significantly when there is a large difference between supply hot water temperature and incoming cold-water temperature.

For the AE baseline scenario with typical hot water design load, the design uses large capacity split heat pump (i.e., Colmac), which are much more expensive than a gas storage water heater. Alternatively, the design can use integrated heat pumps (i.e., AO Smith), which are less expensive than the split heat pumps. However, the high hot water demand in a restaurant, in particularly for FSR, would require several integrated heat pumps supplemented by an electric resistance heater, which may not be a practical design solution.

To address these issues, the team investigated high efficiency SHW design approaches to drastically reduce hot water demand and supply hot water temperature requirement, which are critical to improve the feasibility and cost effectiveness of a HPWH design. The measures investigated include the following:

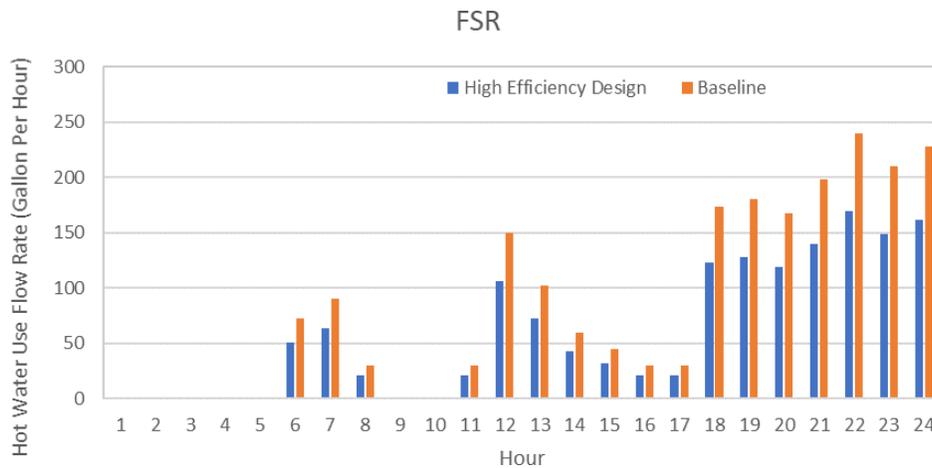
- **Low-flow pre-rinse valves:** Specifies PRSV qualified for IOU rebates to reduce design flowrate from 45 gallon per hour (gph) to 24 gph.
- **Low-flow restroom and hand sinks:** Specifies highly efficient faucet aerators in restroom and hand-washing sinks in the kitchen to reduce design flowrate from 1.8 to 1.0 gpm.
- **Heat recovery dishwasher in the FSR:** For the FSR design, specifies dishwasher that includes heat recovery function such that it only needs connection to cold water and reduces hot water demand and sizes of the central SHW system. Typical design supply hot water temperature for FSR is 140°F for both high-temperature and low-temperature dishwasher types. With heat recovery function at dishwasher, the central house SHW system only needs to provide 125°F hot water to meet other demands. The lowered temperature significantly improves the practicality of an AE solution that uses a HPWH, which has much lower output capacity when supplying a higher supply temperature, especially during the winter when the design temperature rise is at the highest. Although market penetration of heat recovery dishwasher is low, they appear to be a critical piece to electrify SHW in restaurant.
- **Highly efficient dishwasher in QSR:** QSRs typically specify a three-compartment sink for dishwashing, and this measure would add a dishwasher to reduce total hot water load.
- **Compact design to avoid recirculation loop in FSR:** the team investigated this measure but did not include it in the final package. Recirculation loops are typically included in designs where hot water end use locations are far away from the water heater. For example, when the restroom hand sinks are far away from the heater, the hot water delivery time between heater and sink would be unacceptable (30 seconds or greater) without a recirculation loop. The need for a recirculation loop depends on the architectural floor layout, which is not within the scope of the study. Designers could consider the use of a point-of-use heater for far-away end uses, such as the restroom, to eliminate recirculation loop. The energy impact would be about the same for the baseline and AE design scenarios, so the Reach Code Team decided to not analyze this scenario.

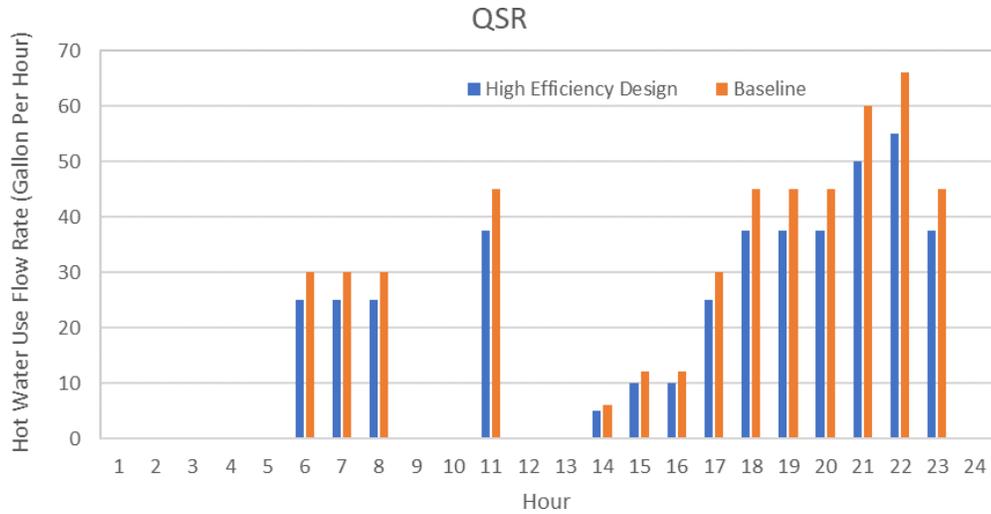
The design parameters for baseline and low-demand scenarios are presented in Figure 45, and the hot water load profiles are presented in Figure 46. The team consulted with design-build contractors and representatives from water heater manufacturers COLMAC and A.O. Smith for equipment selection. The team also leveraged data and lessons learned from 2022 Title 24 CASE work on central HPWH for multifamily buildings. ((CEC) California Energy Commission 2021) Figure 48 provides equipment selection for each design scenario.

**Figure 45. Design Parameters for Hot Water Systems**

Design Parameters	FSR Baseline	QSR Baseline	FSR – Low-Demand	QSR – Low-Demand
Daily hot water usage (gal)	2000	500	1450	420
Minimum recovery rate gallons per hour (gph)	240	66	170	55
Hot water supply temperature (°F)	140	125	125	125
Winter cold water inlet temperature (°F)	50	50	50	50
Design temperature rise (°F)	90	75	75	75

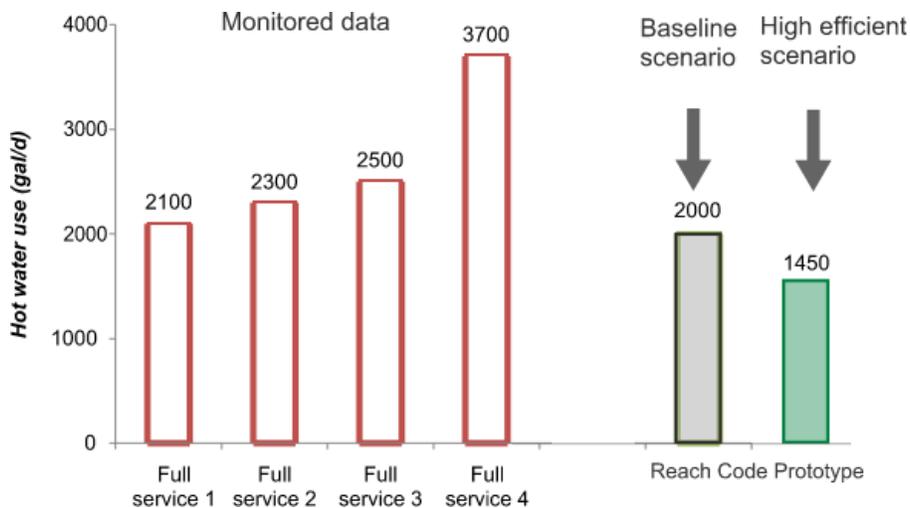
**Figure 46. Hot Water Daily Usage Profile (based on Fisher and Pietrucha, 2008 (Fisher, et al. 2008) and interviews for FSR and QSR**





Like energy use for cooking, hot water consumption in restaurants varies significantly depending on the food they serve, their operation schedule, and number of customers. Figure 47 compares monitored daily hot water use in several national chain restaurants and the assumptions used for the reach code analysis. The baseline assumption is consistent with recommendation in the California Energy Wise design guide for a typical medium full-service restaurant. Since monitored data were from existing restaurants, the team assumed more efficient hot water fixtures are used in new construction restaurants. For FSR, designers must carefully select hot water appliances and fixtures and use design approach that can achieve deep hot water savings to enable cost-effective HPWH solutions.

**Figure 47. Monitored Daily Hot Water Use in Full-service Restaurants vs. Daily Hot Water Use in Reach Code FSR Prototype (Fisher-Nickel and PG&E 2010)**



**Figure 48. Hot Water Equipment Selection**

Measure	HW System	FSR	QSR
Gas baseline water heater	Type	Storage water heater	Storage water heater
	Number of heaters	2	1
	Heater Product	Bosch Buderus G234X/55	A.O Smith gas storage water heater
	Total rated input rate (Btu/hr)	400,000	150,000
	Storage capacity (gal)	150	100
	Distribution system	Recirculation system with recirculation pump	No recirculation
Electric water heater	Type	HPWH with storage	HPWH with storage
	Number of heaters	4	1
	HPWH Model	Colmac CxV-5 or 2 CxV-15	A.O. Smith CHP 120, with 12 W built-in resistive electric element
	HPWH recovery rate (gph)	240	66
	Electric resistance heater for temperature maintenance	5 kW	n/a
	Primary storage capacity (gal)	500	120
	Recirculation tank (gal)	120	n/a
	Distribution system	Recirculation system with recirculation pump	No recirculation
Low-demand electric water heater	Type	HPWH with storage	HPWH with storage
	Number of primary heaters	2	1
	HPWH Model	A.O. Smith CHP 120	A.O. Smith CHP 120
	HPWH recovery rate (gph)	170	55
	Electric resistance heater for loop temperature maintenance	12 kW	n/a
	Primary storage capacity (gal)	240	120
	Recirculation tank (gal)	120	n/a
	Distribution system	Recirculation system with recirculation pump	No recirculation

## 7.4 Mixed-Fuel Baseline Energy Figures

Figure 49 and Figure 50 show the annual electricity and natural gas consumption and cost, compliance TDV, and GHG emissions for each prototype under the mixed-fuel design baseline. The compliance margins are non-zero in some cases and represent typical baseline compliance margins with prescriptive prototypes. The non-zero compliance margins are largely a result of compliance software complexities, and they are not expected to significantly impact the proposed case results or nature of recommendations.

Figure 49. FSR: Mixed-Fuel Baseline

CZ	Utility	Annual Electricity Consumption (kWh)	Annual Natural Gas Consumption (therms)	Annual Electricity Cost	Annual Natural Gas Cost	Compliance TDV	Annual GHG Emissions (mton)
CZ01	PG&E	86,953	28,678	\$22,750	\$31,140	-2.6%	175
CZ02	PG&E	105,553	26,003	\$28,227	\$28,362	-1.0%	163
CZ03	PG&E	90,394	25,101	\$23,831	\$27,375	-1.8%	156
CZ03-2	PCE	90,394	25,101	\$23,323	\$27,375	-1.8%	156
CZ04	PG&E	101,561	24,223	\$27,093	\$26,455	-0.6%	153
CZ04-2	CPAU	101,561	24,223	\$17,531	\$29,686	-0.6%	153
CZ05	PG&E	89,869	25,664	\$23,552	\$27,930	-1.9%	158
CZ05-2	SCG	89,869	25,664	\$23,552	\$19,287	-1.9%	158
CZ06	SCE	103,218	22,635	\$15,370	\$17,158	-0.2%	144
CZ06-2	LA	103,218	22,635	\$10,041	\$17,158	-0.2%	144
CZ07	SDG&E	96,695	21,731	\$27,565	\$16,471	0.1%	138
CZ08	SCE	112,859	22,071	\$16,656	\$16,762	0.7%	142
CZ08-2	LA	112,859	22,071	\$11,003	\$16,762	0.7%	142
CZ09	SCE	121,912	22,465	\$18,132	\$17,039	1.7%	146
CZ09-2	LA	121,912	22,465	\$12,216	\$17,039	1.7%	146
CZ10	SDG&E	128,726	22,793	\$38,166	\$17,154	1.4%	149
CZ10-2	SCE	128,726	22,793	\$18,812	\$17,269	1.4%	149
CZ11	PG&E	134,324	24,685	\$36,433	\$27,051	0.8%	161
CZ12	PG&E	119,068	24,856	\$32,107	\$27,211	-0.2%	159
CZ12-2	SMUD	119,068	24,856	\$16,976	\$27,211	-0.2%	159
CZ13	PG&E	135,872	24,284	\$36,757	\$26,635	0.5%	159
CZ14	SDG&E	135,580	24,598	\$36,634	\$18,315	1.0%	160
CZ14-2	SCE	135,580	24,598	\$18,700	\$18,538	1.0%	160
CZ15	SCE	187,946	20,554	\$25,095	\$15,695	3.1%	146
CZ16	PG&E	103,255	28,573	\$27,467	\$31,234	-2.2%	178
CZ16-2	LA	103,255	28,573	\$9,076	\$21,332	-2.2%	178

Figure 50. QSR: Mixed-Fuel Baseline

CZ	Utility	Annual Electricity Consumption (kWh)	Annual Natural Gas Consumption (therms)	Annual Electricity Cost	Annual Natural Gas Cost	Compliance TDV	Annual GHG Emissions (mton)
CZ01	PG&E	61,491.00	12,748.11	\$16,272	\$13,944	4.5%	82
CZ02	PG&E	63,815.76	11,377.20	\$17,142	\$12,494	5.1%	74
CZ03	PG&E	64,188.51	10,848.91	\$17,031	\$11,917	5.3%	72
CZ03-2	PCE	64,188.51	10,848.91	\$16,669	\$11,917	5.3%	72
CZ04	PG&E	69,215.47	10,542.25	\$18,473	\$11,593	5.3%	71
CZ04-2	CPAU	69,215.47	10,542.25	\$12,040	\$13,571	5.3%	71
CZ05	PG&E	64,110.03	11,133.94	\$16,942	\$12,205	5.4%	73
CZ05-2	SCG	64,110.03	11,133.94	\$16,942	\$9,074	5.4%	73
CZ06	SCE	70,937.68	9,964.84	\$9,206	\$8,253	5.7%	68
CZ06-2	LA	70,937.68	9,964.84	\$7,512	\$8,253	5.7%	68
CZ07	SDG&E	71,753.72	9,535.35	\$17,124	\$8,137	5.7%	66
CZ08	SCE	68,037.04	9,740.74	\$10,504	\$8,095	5.8%	66
CZ08-2	LA	68,037.04	9,740.74	\$7,403	\$8,095	5.8%	66
CZ09	SCE	71,935.81	9,893.01	\$11,169	\$8,202	5.7%	68
CZ09-2	LA	71,935.81	9,893.01	\$7,885	\$8,202	5.7%	68
CZ10	SDG&E	74,683.54	10,058.72	\$21,701	\$8,577	11.4%	69
CZ10-2	SCE	74,683.54	10,058.72	\$11,303	\$8,319	11.4%	69
CZ11	PG&E	78,011.57	10,939.98	\$21,200	\$12,063	5.7%	75
CZ12	PG&E	69,910.56	10,929.67	\$18,896	\$12,044	5.4%	73
CZ12-2	SMUD	69,910.56	10,929.67	\$10,005	\$12,044	5.4%	73
CZ13	PG&E	78,795.13	10,757.24	\$21,367	\$11,871	4.8%	74
CZ14	SDG&E	79,339.50	10,902.78	\$22,813	\$9,212	6.1%	74
CZ14-2	SCE	79,339.50	10,902.78	\$11,876	\$8,912	6.1%	74
CZ15	SCE	108,848.18	9,291.38	\$15,185	\$7,779	1.7%	70
CZ16	PG&E	69,867.29	12,616.29	\$18,620	\$13,877	6.2%	83
CZ16-2	LA	69,867.29	12,616.29	\$7,223	\$10,116	6.2%	83

## 7.5 Additional Restaurant All-Electric Package Analysis

The Reach Code Team tested multiple packages that include electric cooking and or TDV multipliers that were developed for the 2022 Title 24 code to test the potential impact on cost effectiveness. Results generally do not change Summary of Results in Section 5.

### 7.5.1 2019 TDV Results

#### 7.5.1.1 FSR

Figure 51 shows the AE HVAC, SHW, and cooking package is not cost effective nor compliant. Electric cooking appliances contribute negative total TDV and utility cost savings because they have load profiles coincident with peak utility rates and electricity TDV values (reference Figure 9 depiction of the increase in process load TDV in AE packages as compared to the mixed-fuel cases). Additions to electric cooking to the efficiency package (Figure 52), KOF (Figure 53), and solar PV with Battery (Figure 54) are not enough to make AE cost effective when compared to the mixed-fuel baseline.

Figure 55 shows the hybrid package—using AE appliances except for the baseline gas storage SHW system—improves cost effectiveness of the measure package, but not enough to achieve TDV or on-bill cost effectiveness.

Figure 51. Cost Effectiveness for FSR: All-Electric + HE Cooking

CZ	Utility	Annual Elec Savings (kWh)	Annual Gas Savings (therms)	Annual GHG Reductions (mtons)	Compliance Margin	Upfront Incremental Package Cost	Lifecycle Utility Cost Savings	Lifecycle \$TDV Savings	B/C Ratio (On-bill)	B/C Ratio (TDV)	NPV (On-bill)	NPV (TDV)
CZ01	PG&E	(334,036)	28,678	94.0	-44.2%	\$181,293	(\$545,242)	(\$551,560)	-3.0	-3.0	(\$726,534)	(\$732,853)
CZ02	PG&E	(310,560)	26,003	82.9	-23.6%	\$187,707	(\$526,051)	(\$459,586)	-2.8	-2.4	(\$713,758)	(\$647,292)
CZ03	PG&E	(304,959)	25,101	79.0	-32.8%	\$189,475	(\$536,633)	(\$511,423)	-2.8	-2.7	(\$726,108)	(\$700,897)
CZ03-2	PCE	(304,959)	25,101	79.0	-32.8%	\$189,475	(\$557,814)	(\$511,423)	-2.9	-2.7	(\$747,288)	(\$700,897)
CZ04	PG&E	(295,999)	24,223	75.9	-25.3%	\$188,176	(\$526,035)	(\$439,423)	-2.8	-2.3	(\$714,211)	(\$627,599)
CZ04-2	CPAU	(295,999)	24,223	75.9	-25.3%	\$188,176	(\$171,390)	(\$439,423)	-0.9	-2.3	(\$359,566)	(\$627,599)
CZ05	PG&E	(310,769)	25,664	80.6	-34.9%	\$181,429	(\$540,490)	(\$510,647)	-3.0	-2.8	(\$721,919)	(\$692,076)
CZ05-2	SCG	(310,769)	25,664	80.6	-34.9%	\$181,429	(\$690,743)	(\$510,647)	-3.8	-2.8	(\$872,172)	(\$692,076)
CZ06	SCE	(285,613)	22,635	68.7	-22.2%	\$181,071	(\$249,587)	(\$448,864)	-1.4	-2.5	(\$430,658)	(\$629,936)
CZ06-2	LA	(285,613)	22,635	68.7	-22.2%	\$181,071	(\$30,572)	(\$448,864)	-0.2	-2.5	(\$211,643)	(\$629,936)
CZ07	SDG&E	(279,622)	21,731	65.6	-24.2%	\$183,154	(\$958,172)	(\$454,810)	-5.2	-2.5	(\$1,141,326)	(\$637,964)
CZ08	SCE	(279,188)	22,071	67.0	-18.2%	\$182,105	(\$248,762)	(\$407,775)	-1.4	-2.2	(\$430,866)	(\$589,879)
CZ08-2	LA	(279,188)	22,071	67.0	-18.2%	\$182,105	(\$31,366)	(\$407,775)	-0.2	-2.2	(\$213,470)	(\$589,879)
CZ09	SCE	(277,870)	22,465	69.6	-13.4%	\$177,640	(\$242,077)	(\$389,394)	-1.4	-2.2	(\$419,717)	(\$567,034)
CZ09-2	LA	(277,870)	22,465	69.6	-13.4%	\$177,640	(\$23,616)	(\$389,394)	-0.1	-2.2	(\$201,257)	(\$567,034)
CZ10	SDG&E	(278,574)	22,793	71.0	-8.9%	\$178,754	(\$908,526)	(\$378,392)	-5.1	-2.1	(\$1,087,281)	(\$557,147)
CZ10-2	SCE	(278,574)	22,793	71.0	-8.9%	\$178,754	(\$235,924)	(\$378,392)	-1.3	-2.1	(\$414,678)	(\$557,147)
CZ11	PG&E	(296,328)	24,685	78.2	-11.2%	\$185,929	(\$496,290)	(\$392,542)	-2.7	-2.1	(\$682,220)	(\$578,471)
CZ12	PG&E	(298,811)	24,856	78.7	-16.4%	\$183,548	(\$510,013)	(\$412,960)	-2.8	-2.2	(\$693,562)	(\$596,509)
CZ12-2	SMUD	(298,811)	24,856	78.7	-16.4%	\$183,548	(\$93,913)	(\$412,960)	-0.5	-2.2	(\$277,461)	(\$596,509)
CZ13	PG&E	(292,257)	24,284	76.5	-13.7%	\$185,811	(\$491,772)	(\$423,342)	-2.6	-2.3	(\$677,584)	(\$609,153)
CZ14	SDG&E	(296,349)	24,598	77.5	-11.3%	\$179,323	(\$957,121)	(\$393,913)	-5.3	-2.2	(\$1,136,445)	(\$573,236)
CZ14-2	SCE	(296,349)	24,598	77.5	-11.3%	\$179,323	(\$248,742)	(\$393,913)	-1.4	-2.2	(\$428,066)	(\$573,236)
CZ15	SCE	(250,391)	20,554	63.9	-3.4%	\$173,302	(\$229,121)	(\$358,323)	-1.3	-2.1	(\$402,423)	(\$531,625)
CZ16	PG&E	(322,335)	28,573	96.2	-19.8%	\$179,749	(\$507,852)	(\$483,272)	-2.8	-2.7	(\$687,601)	(\$663,020)
CZ16-2	LA	(322,335)	28,573	96.2	-19.8%	\$179,749	\$42	(\$483,272)	0.0	-2.7	(\$179,707)	(\$663,020)

Figure 52. Cost Effectiveness for FSR: All-Electric + Eff+ HE Cooking

CZ	Utility	Annual Elec Savings (kWh)	Annual Gas Savings (therms)	Annual GHG Reductions (mtons)	Compliance Margin	Upfront Incremental Package Cost	Lifecycle Utility Cost Savings	Lifecycle \$TDV Savings	B/C Ratio (On-bill)	B/C Ratio (TDV)	NPV (On-bill)	NPV (TDV)
CZ01	PG&E	(281,651)	28,678	104.2	-25.3%	\$119,385	(\$405,377)	(\$417,527)	-3.4	-3.5	(\$524,762)	(\$536,913)
CZ02	PG&E	(261,809)	26,003	92.4	-3.8%	\$123,530	(\$389,019)	(\$327,659)	-3.1	-2.7	(\$512,549)	(\$451,189)
CZ03	PG&E	(261,781)	25,101	87.6	-12.9%	\$123,211	(\$418,620)	(\$395,437)	-3.4	-3.2	(\$541,831)	(\$518,648)
CZ03-2	PCE	(261,781)	25,101	87.6	-12.9%	\$123,211	(\$438,223)	(\$395,437)	-3.6	-3.2	(\$561,434)	(\$518,648)
CZ04	PG&E	(253,467)	24,223	84.3	-2.8%	\$122,212	(\$406,548)	(\$319,692)	-3.3	-2.6	(\$528,760)	(\$441,904)
CZ04-2	CPAU	(253,467)	24,223	84.3	-2.8%	\$122,212	(\$72,233)	(\$319,692)	-0.6	-2.6	(\$194,445)	(\$441,904)
CZ05	PG&E	(265,469)	25,664	89.7	-13.5%	\$119,578	(\$416,746)	(\$390,982)	-3.5	-3.3	(\$536,324)	(\$510,560)
CZ05-2	SCG	(265,469)	25,664	89.7	-13.5%	\$119,578	(\$566,999)	(\$390,982)	-4.7	-3.3	(\$686,577)	(\$510,560)
CZ06	SCE	(245,889)	22,635	76.5	-0.4%	\$119,487	(\$189,630)	(\$338,006)	-1.6	-2.8	(\$309,117)	(\$457,493)
CZ06-2	LA	(245,889)	22,635	76.5	-0.4%	\$119,487	\$10,201	(\$338,006)	0.1	-2.8	(\$109,286)	(\$457,493)
CZ07	SDG&E	(244,333)	21,731	72.6	-3.1%	\$119,044	(\$866,203)	(\$358,685)	-7.3	-3.0	(\$985,247)	(\$477,729)
CZ08	SCE	(239,524)	22,071	74.8	3.5%	\$117,991	(\$187,823)	(\$297,770)	-1.6	-2.5	(\$305,814)	(\$415,761)
CZ08-2	LA	(239,524)	22,071	74.8	3.5%	\$117,991	\$7,846	(\$297,770)	0.1	-2.5	(\$110,145)	(\$415,761)
CZ09	SCE	(236,169)	22,465	77.6	9.2%	\$115,794	(\$177,311)	(\$274,493)	-1.5	-2.4	(\$293,104)	(\$390,287)
CZ09-2	LA	(236,169)	22,465	77.6	9.2%	\$115,794	\$18,037	(\$274,493)	0.2	-2.4	(\$97,757)	(\$390,287)
CZ10	SDG&E	(233,451)	22,793	79.6	11.4%	\$114,640	(\$783,964)	(\$258,035)	-6.8	-2.3	(\$898,605)	(\$372,675)
CZ10-2	SCE	(233,451)	22,793	79.6	11.4%	\$114,640	(\$167,646)	(\$258,035)	-1.5	-2.3	(\$282,286)	(\$372,675)
CZ11	PG&E	(243,930)	24,685	88.3	7.9%	\$121,586	(\$351,964)	(\$256,420)	-2.9	-2.1	(\$473,550)	(\$378,006)
CZ12	PG&E	(249,538)	24,856	88.3	3.3%	\$119,278	(\$371,580)	(\$280,136)	-3.1	-2.3	(\$490,858)	(\$399,414)
CZ12-2	SMUD	(249,538)	24,856	88.3	3.3%	\$119,278	(\$11,425)	(\$280,136)	-0.1	-2.3	(\$130,703)	(\$399,414)
CZ13	PG&E	(240,983)	24,284	86.5	6.4%	\$121,602	(\$349,767)	(\$287,419)	-2.9	-2.4	(\$471,369)	(\$409,020)
CZ14	SDG&E	(242,130)	24,598	87.8	12.2%	\$117,575	(\$817,932)	(\$246,507)	-7.0	-2.1	(\$935,507)	(\$364,082)
CZ14-2	SCE	(242,130)	24,598	87.8	12.2%	\$117,575	(\$168,900)	(\$246,507)	-1.4	-2.1	(\$286,475)	(\$364,082)
CZ15	SCE	(201,608)	20,554	72.8	16.5%	\$111,522	(\$155,208)	(\$225,957)	-1.4	-2.0	(\$266,730)	(\$337,480)
CZ16	PG&E	(271,393)	28,573	106.0	0.2%	\$117,740	(\$369,535)	(\$348,127)	-3.1	-3.0	(\$487,275)	(\$465,867)
CZ16-2	LA	(271,393)	28,573	106.0	0.2%	\$117,740	\$48,620	(\$348,127)	0.4	-3.0	(\$69,120)	(\$465,867)

Figure 53. Cost Effectiveness for FSR: All-Electric + Eff+ KOF Cooking

CZ	Utility	Annual Elec Savings (kWh)	Annual Gas Savings (therms)	Annual GHG Reductions (mtons)	Compliance Margin	Upfront Incremental Package Cost	Lifecycle Utility Cost Savings	Lifecycle \$TDV Savings	B/C Ratio (On-bill)	B/C Ratio (TDV)	NPV (On-bill)	NPV (TDV)
CZ01	PG&E	(194,483)	28,678	117.3	-24.0%	\$148,141	(\$203,963)	(\$215,095)	-1.4	-1.5	(\$352,104)	(\$363,236)
CZ02	PG&E	(172,481)	26,003	105.8	2.6%	\$152,286	(\$179,298)	(\$103,284)	-1.2	-0.7	(\$331,584)	(\$255,570)
CZ03	PG&E	(174,943)	25,101	100.6	-7.4%	\$151,966	(\$216,514)	(\$188,471)	-1.4	-1.2	(\$368,480)	(\$340,438)
CZ03-2	PCE	(174,943)	25,101	100.6	-7.4%	\$151,966	(\$232,945)	(\$188,471)	-1.5	-1.2	(\$384,911)	(\$340,438)
CZ04	PG&E	(165,497)	24,223	97.4	4.7%	\$150,968	(\$201,068)	(\$92,275)	-1.3	-0.6	(\$352,036)	(\$243,242)
CZ04-2	CPAU	(165,497)	24,223	97.4	4.7%	\$150,968	\$128,879	(\$92,275)	0.9	-0.6	(\$22,088)	(\$243,242)
CZ05	PG&E	(177,882)	25,664	102.8	-10.2%	\$148,333	(\$213,750)	(\$180,925)	-1.4	-1.2	(\$362,083)	(\$329,259)
CZ05-2	SCG	(177,882)	25,664	102.8	-10.2%	\$148,333	(\$364,002)	(\$180,925)	-2.5	-1.2	(\$512,336)	(\$329,259)
CZ06	SCE	(157,632)	22,635	89.8	6.9%	\$148,242	(\$94,719)	(\$112,475)	-0.6	-0.8	(\$242,962)	(\$260,717)
CZ06-2	LA	(157,632)	22,635	89.8	6.9%	\$148,242	\$87,068	(\$112,475)	0.6	-0.8	(\$61,174)	(\$260,717)
CZ07	SDG&E	(156,528)	21,731	85.7	4.3%	\$147,799	(\$761,894)	(\$134,492)	-5.2	-0.9	(\$909,693)	(\$282,291)
CZ08	SCE	(150,585)	22,071	88.2	12.4%	\$146,746	(\$91,045)	(\$57,225)	-0.6	-0.4	(\$237,791)	(\$203,972)
CZ08-2	LA	(150,585)	22,071	88.2	12.4%	\$146,746	\$88,792	(\$57,225)	0.6	-0.4	(\$57,954)	(\$203,972)
CZ09	SCE	(146,929)	22,465	91.1	13.6%	\$144,549	(\$78,277)	(\$34,388)	-0.5	-0.2	(\$222,826)	(\$178,937)
CZ09-2	LA	(146,929)	22,465	91.1	13.6%	\$144,549	\$101,622	(\$34,388)	0.7	-0.2	(\$42,927)	(\$178,937)
CZ10	SDG&E	(143,725)	22,793	93.1	17.5%	\$143,396	(\$673,368)	(\$20,675)	-4.7	-0.1	(\$816,764)	(\$164,071)
CZ10-2	SCE	(143,725)	22,793	93.1	17.5%	\$143,396	(\$69,371)	(\$20,675)	-0.5	-0.1	(\$212,767)	(\$164,071)
CZ11	PG&E	(152,463)	24,685	102.2	10.8%	\$150,342	(\$136,220)	(\$8,371)	-0.9	-0.1	(\$286,562)	(\$158,712)
CZ12	PG&E	(159,679)	24,856	101.8	9.5%	\$148,033	(\$160,602)	(\$41,217)	-1.1	-0.3	(\$308,635)	(\$189,250)
CZ12-2	SMUD	(159,679)	24,856	101.8	9.5%	\$148,033	\$121,718	(\$41,217)	0.8	-0.3	(\$26,315)	(\$189,250)
CZ13	PG&E	(149,412)	24,284	100.5	11.4%	\$150,357	(\$133,107)	(\$41,908)	-0.9	-0.3	(\$283,464)	(\$192,265)
CZ14	SDG&E	(150,571)	24,598	101.8	16.5%	\$146,330	(\$702,930)	\$1,120	-4.8	0.0	(\$849,260)	(\$145,210)
CZ14-2	SCE	(150,571)	24,598	101.8	16.5%	\$146,330	(\$67,864)	\$1,120	-0.5	0.0	(\$214,194)	(\$145,210)
CZ15	SCE	(106,606)	20,554	87.3	21.5%	\$140,278	(\$49,938)	\$29,545	-0.4	0.2	(\$190,216)	(\$110,732)
CZ16	PG&E	(180,444)	28,573	119.9	2.6%	\$146,495	(\$154,418)	(\$115,209)	-1.1	-0.8	(\$300,913)	(\$261,704)
CZ16-2	LA	(180,444)	28,573	119.9	2.6%	\$146,495	\$131,113	(\$115,209)	0.9	-0.8	(\$15,382)	(\$261,704)

Figure 54. Cost Effectiveness for FSR: All-Electric + Eff + KOF Cooking + PV + B

CZ	Utility	Annual Elec Savings (kWh)	Annual Gas Savings (therms)	Annual GHG Reductions (mtons)	Compliance Margin	Upfront Incremental Package Cost	Lifecycle Utility Cost Savings	Lifecycle \$TDV Savings	B/C Ratio (On-bill)	B/C Ratio (TDV)	NPV (On-bill)	NPV (TDV)
CZ01	PG&E	(142,255)	28,678	123.1	-24.0%	\$458,582	(\$84,502)	\$36,324	-0.2	0.1	(\$543,085)	(\$422,259)
CZ02	PG&E	(110,425)	26,003	114.2	2.6%	\$462,727	(\$23,183)	\$210,160	-0.1	0.5	(\$485,910)	(\$252,568)
CZ03	PG&E	(112,753)	25,101	108.5	-7.4%	\$462,408	(\$64,325)	\$118,596	-0.1	0.3	(\$526,734)	(\$343,813)
CZ03-2	PCE	(112,753)	25,101	108.5	-7.4%	\$462,408	(\$78,551)	\$118,596	-0.2	0.3	(\$540,959)	(\$343,813)
CZ04	PG&E	(101,202)	24,223	106.3	4.7%	\$461,409	(\$38,944)	\$252,841	-0.1	0.5	(\$500,353)	(\$208,569)
CZ04-2	CPAU	(101,202)	24,223	106.3	4.7%	\$461,409	\$271,225	\$252,841	0.6	0.5	(\$190,184)	(\$208,569)
CZ05	PG&E	(110,815)	25,664	111.1	-10.2%	\$458,775	(\$54,243)	\$142,081	-0.1	0.3	(\$513,018)	(\$316,694)
CZ05-2	SCG	(110,815)	25,664	111.1	-10.2%	\$458,775	(\$204,495)	\$142,081	-0.4	0.3	(\$663,270)	(\$316,694)
CZ06	SCE	(94,469)	22,635	98.0	6.9%	\$458,684	(\$21,345)	\$169,117	0.0	0.4	(\$480,029)	(\$289,567)
CZ06-2	LA	(94,469)	22,635	98.0	6.9%	\$458,684	\$130,281	\$169,117	0.3	0.4	(\$328,403)	(\$289,567)
CZ07	SDG&E	(90,737)	21,731	94.7	4.3%	\$458,241	(\$672,119)	\$147,694	-1.5	0.3	(\$1,130,360)	(\$310,547)
CZ08	SCE	(86,897)	22,071	97.0	12.4%	\$457,188	(\$16,674)	\$234,972	0.0	0.5	(\$473,862)	(\$222,217)
CZ08-2	LA	(86,897)	22,071	97.0	12.4%	\$457,188	\$131,704	\$234,972	0.3	0.5	(\$325,484)	(\$222,217)
CZ09	SCE	(81,251)	22,465	100.3	13.6%	\$454,991	(\$775)	\$273,910	0.0	0.6	(\$455,766)	(\$181,081)
CZ09-2	LA	(81,251)	22,465	100.3	13.6%	\$454,991	\$148,185	\$273,910	0.3	0.6	(\$306,806)	(\$181,081)
CZ10	SDG&E	(77,971)	22,793	102.2	17.5%	\$453,838	(\$581,396)	\$300,918	-1.3	0.7	(\$1,035,234)	(\$152,920)
CZ10-2	SCE	(77,971)	22,793	102.2	17.5%	\$453,838	\$7,124	\$300,918	0.0	0.7	(\$446,714)	(\$152,920)
CZ11	PG&E	(88,872)	24,685	110.4	10.8%	\$460,783	\$23,343	\$359,919	0.1	0.8	(\$437,441)	(\$100,864)
CZ12	PG&E	(97,060)	24,856	110.0	9.5%	\$458,475	(\$2,593)	\$296,102	0.0	0.6	(\$461,068)	(\$162,373)
CZ12-2	SMUD	(97,060)	24,856	110.0	9.5%	\$458,475	\$216,440	\$296,102	0.5	0.6	(\$242,035)	(\$162,373)
CZ13	PG&E	(87,239)	24,284	108.5	11.4%	\$460,799	\$22,313	\$292,973	0.0	0.6	(\$438,485)	(\$167,826)
CZ14	SDG&E	(78,108)	24,598	110.7	16.5%	\$456,772	(\$605,090)	\$314,281	-1.3	0.7	(\$1,061,863)	(\$142,492)
CZ14-2	SCE	(78,108)	24,598	110.7	16.5%	\$456,772	\$13,619	\$314,281	0.0	0.7	(\$443,154)	(\$142,492)
CZ15	SCE	(38,556)	20,554	95.0	21.5%	\$450,720	\$25,170	\$337,443	0.1	0.7	(\$425,550)	(\$113,277)
CZ16	PG&E	(112,673)	28,573	128.3	2.6%	\$456,937	\$12,901	\$168,274	0.0	0.4	(\$444,036)	(\$288,663)
CZ16-2	LA	(112,673)	28,573	128.3	2.6%	\$456,937	\$175,901	\$168,274	0.4	0.4	(\$281,036)	(\$288,663)

Figure 55. Cost Effectiveness for FSR: All-Electric Hybrid + Eff + KOF Cooking + PV + B

CZ	Utility	Annual Elec Savings (kWh)	Annual Gas Savings (therms)	Annual GHG Reductions (mtons)	Compliance Margin	Upfront Incremental Package Cost	Lifecycle Utility Cost Savings	Lifecycle \$TDV Savings	B/C Ratio (On-bill)	B/C Ratio (TDV)	NPV (On-bill)	NPV (TDV)
CZ01	PG&E	(87,423)	23,866	108.7	10.1%	\$443,203	(\$11,234)	\$95,946	0.0	0.2	(\$454,437)	(\$347,257)
CZ02	PG&E	(61,438)	21,444	99.9	21.2%	\$442,473	\$36,890	\$233,583	0.1	0.5	(\$405,583)	(\$208,890)
CZ03	PG&E	(63,098)	20,573	94.8	19.9%	\$442,453	(\$1,058)	\$149,844	0.0	0.3	(\$443,512)	(\$292,610)
CZ03-2	PCE	(63,098)	20,573	94.8	19.9%	\$442,453	(\$13,433)	\$149,844	0.0	0.3	(\$455,886)	(\$292,610)
CZ04	PG&E	(53,738)	19,778	92.2	24.0%	\$441,440	\$18,765	\$261,573	0.0	0.6	(\$422,675)	(\$179,867)
CZ04-2	CPAU	(53,738)	19,778	92.2	24.0%	\$441,440	\$270,663	\$261,573	0.6	0.6	(\$170,777)	(\$179,867)
CZ05	PG&E	(60,153)	21,086	97.5	18.7%	\$443,334	\$12,181	\$174,920	0.0	0.4	(\$431,153)	(\$268,415)
CZ05-2	SCG	(60,153)	21,086	97.5	18.7%	\$443,334	(\$128,011)	\$174,920	-0.3	0.4	(\$571,346)	(\$268,415)
CZ06	SCE	(49,686)	18,358	84.8	25.5%	\$443,337	(\$20,680)	\$193,921	0.0	0.4	(\$464,017)	(\$249,416)
CZ06-2	LA	(49,686)	18,358	84.8	25.5%	\$443,337	\$96,039	\$193,921	0.2	0.4	(\$347,298)	(\$249,416)
CZ07	SDG&E	(47,262)	17,519	81.5	24.3%	\$442,131	(\$595,683)	\$172,494	-1.3	0.4	(\$1,037,814)	(\$269,637)
CZ08	SCE	(44,216)	17,894	83.6	26.6%	\$440,960	(\$19,482)	\$257,840	0.0	0.6	(\$460,442)	(\$183,120)
CZ08-2	LA	(44,216)	17,894	83.6	26.6%	\$440,960	\$94,278	\$257,840	0.2	0.6	(\$346,681)	(\$183,120)
CZ09	SCE	(38,444)	18,265	86.6	26.3%	\$439,560	(\$5,658)	\$290,269	0.0	0.7	(\$445,218)	(\$149,290)
CZ09-2	LA	(38,444)	18,265	86.6	26.3%	\$439,560	\$108,934	\$290,269	0.2	0.7	(\$330,626)	(\$149,290)
CZ10	SDG&E	(35,010)	18,586	88.7	29.6%	\$437,609	(\$520,564)	\$310,499	-1.2	0.7	(\$958,174)	(\$127,111)
CZ10-2	SCE	(35,010)	18,586	88.7	29.6%	\$437,609	\$2,881	\$310,499	0.0	0.7	(\$434,728)	(\$127,111)
CZ11	PG&E	(44,271)	20,287	95.8	22.9%	\$444,537	\$70,379	\$347,447	0.2	0.8	(\$374,157)	(\$97,090)
CZ12	PG&E	(51,150)	20,422	95.6	23.7%	\$442,153	\$49,803	\$301,783	0.1	0.7	(\$392,349)	(\$140,369)
CZ12-2	SMUD	(51,150)	20,422	95.6	23.7%	\$442,153	\$210,602	\$301,783	0.5	0.7	(\$231,551)	(\$140,369)
CZ13	PG&E	(43,206)	19,946	94.1	23.7%	\$444,599	\$71,373	\$298,783	0.2	0.7	(\$373,226)	(\$145,816)
CZ14	SDG&E	(33,875)	20,166	95.7	27.5%	\$441,539	(\$549,211)	\$340,114	-1.2	0.8	(\$990,751)	(\$101,425)
CZ14-2	SCE	(33,875)	20,166	95.7	27.5%	\$441,539	\$7,138	\$340,114	0.0	0.8	(\$434,401)	(\$101,425)
CZ15	SCE	(3,412)	16,845	82.5	28.4%	\$435,312	\$12,948	\$346,781	0.0	0.8	(\$422,364)	(\$88,531)
CZ16	PG&E	(72,797)	23,585	109.1	9.5%	\$441,511	\$36,082	\$164,952	0.1	0.4	(\$405,428)	(\$276,559)
CZ16-2	LA	(72,797)	23,585	109.1	9.5%	\$441,511	\$121,463	\$164,952	0.3	0.4	(\$320,048)	(\$276,559)

### 7.5.1.2 QSR

Results for the AE QSR are similar to the AE FSR. Due to the higher upfront costs of cooking equipment compared to a mixed-fuel baseline and compounded by the negative on-bill and TDV impacts, there are very limited cost-effective QSR AE measure packages.

Figure 56 shows the AE HVAC, SHW, and cooking package is not cost effective nor compliant in the majority of CZs. Electric cooking appliances contribute negative total TDV and utility cost savings, because they have load profiles coincident with peak utility rates and electricity TDV values. Additions to electric cooking to the efficiency package (Figure 57) improve compliance margins, but not cost effectiveness. Adding solar PV with Battery (Figure 58) does deliver narrowly cost-effective packages in CPAU and LADWP territories, as well as CZ11 in PG&E territory.

Figure 59 shows that the hybrid package—using AE appliances except for the baseline gas storage SHW system—reduces cost effectiveness slightly compared to the gas baseline. This is likely because a HPWH has improved efficiency, has a similar cost to the gas baseline, and is well suited for the smaller SHW loads in a QSR.

Figure 56. Cost Effectiveness for QSR: All-Electric + HE Cooking

CZ	Utility	Annual Elec Savings (kWh)	Annual Gas Savings (therms)	Annual GHG Reductions (mtons)	Compliance Margin	Upfront Incremental Package Cost	Lifecycle Utility Cost Savings	Lifecycle \$TDV Savings	B/C Ratio (On-bill)	B/C Ratio (TDV)	NPV (On-bill)	NPV (TDV)
CZ01	PG&E	(154,265)	12,748	40.44	-16.8%	\$26,155	(\$282,251)	(\$244,966)	-10.8	-9.4	(\$308,406)	(\$271,121)
CZ02	PG&E	(138,275)	11,377	35.67	-3.8%	\$36,112	(\$254,008)	(\$207,937)	-7.0	-5.8	(\$290,120)	(\$244,048)
CZ03	PG&E	(132,470)	10,849	33.93	-7.4%	\$32,681	(\$245,456)	(\$213,494)	-7.5	-6.5	(\$278,137)	(\$246,175)
CZ03-2	PCE	(132,470)	10,849	33.93	-7.4%	\$32,681	(\$235,433)	(\$213,494)	-7.2	-6.5	(\$268,114)	(\$246,175)
CZ04	PG&E	(128,033)	10,542	33.10	-3.3%	\$32,670	(\$236,035)	(\$191,535)	-7.2	-5.9	(\$268,706)	(\$224,206)
CZ04-2	CPAU	(128,033)	10,542	33.10	-3.3%	\$32,670	(\$62,917)	(\$191,535)	-1.9	-5.9	(\$95,587)	(\$224,206)
CZ05	PG&E	(139,042)	11,134	33.91	-8.8%	\$33,420	(\$263,124)	(\$226,021)	-7.9	-6.8	(\$296,544)	(\$259,441)
CZ05-2	SCG	(139,042)	11,134	33.91	-8.8%	\$33,420	(\$317,553)	(\$226,021)	-9.5	-6.8	(\$350,973)	(\$259,441)
CZ06	SCE	(120,958)	9,965	30.95	-2.8%	\$33,431	(\$115,302)	(\$179,993)	-3.4	-5.4	(\$148,733)	(\$213,424)
CZ06-2	LA	(120,958)	9,965	30.95	-2.8%	\$33,431	\$13,326	(\$179,993)	0.4	-5.4	(\$20,105)	(\$213,424)
CZ07	SDG&E	(115,852)	9,535	29.96	-2.7%	\$33,378	(\$437,431)	(\$176,282)	-13.1	-5.3	(\$470,809)	(\$209,660)
CZ08	SCE	(117,826)	9,741	30.48	-0.7%	\$36,918	(\$97,520)	(\$159,488)	-2.6	-4.3	(\$134,438)	(\$196,406)
CZ08-2	LA	(117,826)	9,741	30.48	-0.7%	\$36,918	\$9,397	(\$159,488)	0.3	-4.3	(\$27,521)	(\$196,406)
CZ09	SCE	(119,266)	9,893	31.17	1.3%	\$30,145	(\$97,384)	(\$162,234)	-3.2	-5.4	(\$127,530)	(\$192,379)
CZ09-2	LA	(119,266)	9,893	31.17	1.3%	\$30,145	\$9,522	(\$162,234)	0.3	-5.4	(\$20,624)	(\$192,379)
CZ10	SDG&E	(120,834)	10,059	31.66	1.2%	\$29,329	(\$420,413)	(\$168,278)	-14.3	-5.7	(\$449,741)	(\$197,607)
CZ10-2	SCE	(120,834)	10,059	31.66	1.2%	\$29,329	(\$99,796)	(\$168,278)	-3.4	-5.7	(\$129,124)	(\$197,607)
CZ11	PG&E	(131,828)	10,940	34.38	-2.9%	\$36,914	(\$228,801)	(\$181,323)	-6.2	-4.9	(\$265,716)	(\$218,238)
CZ12	PG&E	(132,045)	10,930	34.28	-2.7%	\$36,899	(\$232,235)	(\$185,092)	-6.3	-5.0	(\$269,134)	(\$221,990)
CZ12-2	SMUD	(132,045)	10,930	34.28	-2.7%	\$36,899	(\$44,251)	(\$185,092)	-1.2	-5.0	(\$81,150)	(\$221,990)
CZ13	PG&E	(129,405)	10,757	33.82	-0.2%	\$30,808	(\$223,912)	(\$190,461)	-7.3	-6.2	(\$254,720)	(\$221,269)
CZ14	SDG&E	(131,110)	10,903	34.05	2.2%	\$30,908	(\$429,199)	(\$167,130)	-13.9	-5.4	(\$460,107)	(\$198,038)
CZ14-2	SCE	(131,110)	10,903	34.05	2.2%	\$30,908	(\$103,941)	(\$167,130)	-3.4	-5.4	(\$134,849)	(\$198,038)
CZ15	SCE	(107,160)	9,291	30.16	3.6%	\$29,411	(\$90,145)	(\$144,816)	-3.1	-4.9	(\$119,557)	(\$174,227)
CZ16	PG&E	(151,772)	12,616	40.34	-17.0%	\$32,688	(\$248,377)	(\$247,149)	-7.6	-7.6	(\$281,066)	(\$279,837)
CZ16-2	LA	(151,772)	12,616	40.34	-17.0%	\$32,688	\$15,368	(\$247,149)	0.5	-7.6	(\$17,321)	(\$279,837)

Figure 57. Cost Effectiveness for QSR: All-Electric + Eff + HE Cooking

CZ	Utility	Annual Elec Savings (kWh)	Annual Gas Savings (therms)	Annual GHG Reductions (mtons)	Compliance Margin	Upfront Incremental Package Cost	Lifecycle Utility Cost Savings	Lifecycle \$TDV Savings	B/C Ratio (On-bill)	B/C Ratio (TDV)	NPV (On-bill)	NPV (TDV)
CZ01	PG&E	(124,885)	12,748	46.07	14.9%	\$38,734	(\$183,777)	(\$170,267)	-4.7	-4.4	(\$222,510)	(\$209,000)
CZ02	PG&E	(119,881)	11,377	39.16	13.8%	\$46,148	(\$191,867)	(\$158,493)	-4.2	-3.4	(\$238,016)	(\$204,641)
CZ03	PG&E	(109,485)	10,849	38.29	22.0%	\$45,260	(\$168,361)	(\$155,579)	-3.7	-3.4	(\$213,621)	(\$200,839)
CZ03-2	PCE	(109,485)	10,849	38.29	22.0%	\$45,260	(\$159,999)	(\$155,579)	-3.5	-3.4	(\$205,259)	(\$200,839)
CZ04	PG&E	(105,434)	10,542	37.37	23.5%	\$45,313	(\$160,344)	(\$134,758)	-3.5	-3.0	(\$205,657)	(\$180,071)
CZ04-2	CPAU	(105,434)	10,542	37.37	23.5%	\$45,313	(\$10,249)	(\$134,758)	-0.2	-3.0	(\$55,562)	(\$180,071)
CZ05	PG&E	(111,949)	11,134	39.13	26.4%	\$46,063	(\$172,028)	(\$155,920)	-3.7	-3.4	(\$218,091)	(\$201,983)
CZ05-2	SCG	(111,949)	11,134	39.13	26.4%	\$46,063	(\$226,457)	(\$155,920)	-4.9	-3.4	(\$272,520)	(\$201,983)
CZ06	SCE	(99,192)	9,965	35.08	26.9%	\$46,074	(\$84,031)	(\$125,013)	-1.8	-2.7	(\$130,105)	(\$171,087)
CZ06-2	LA	(99,192)	9,965	35.08	26.9%	\$46,074	\$32,417	(\$125,013)	0.7	-2.7	(\$13,656)	(\$171,087)
CZ07	SDG&E	(92,941)	9,535	34.24	31.9%	\$46,021	(\$384,333)	(\$119,238)	-8.4	-2.6	(\$430,354)	(\$165,259)
CZ08	SCE	(103,720)	9,741	33.20	17.7%	\$46,955	(\$74,367)	(\$122,155)	-1.6	-2.6	(\$121,321)	(\$169,109)
CZ08-2	LA	(103,720)	9,741	33.20	17.7%	\$46,955	\$25,644	(\$122,155)	0.5	-2.6	(\$21,311)	(\$169,109)
CZ09	SCE	(104,055)	9,893	34.06	17.7%	\$40,182	(\$73,115)	(\$123,015)	-1.8	-3.1	(\$113,296)	(\$163,196)
CZ09-2	LA	(104,055)	9,893	34.06	17.7%	\$40,182	\$26,619	(\$123,015)	0.7	-3.1	(\$13,563)	(\$163,196)
CZ10	SDG&E	(106,784)	10,059	34.36	14.3%	\$39,365	(\$376,815)	(\$132,244)	-9.6	-3.4	(\$416,180)	(\$171,609)
CZ10-2	SCE	(106,784)	10,059	34.36	14.3%	\$39,365	(\$77,422)	(\$132,244)	-2.0	-3.4	(\$116,787)	(\$171,609)
CZ11	PG&E	(112,209)	10,940	38.11	16.9%	\$46,951	(\$170,129)	(\$122,073)	-3.6	-2.6	(\$217,080)	(\$169,024)
CZ12	PG&E	(114,713)	10,930	37.62	13.3%	\$46,935	(\$182,035)	(\$138,002)	-3.9	-2.9	(\$228,970)	(\$184,937)
CZ12-2	SMUD	(114,713)	10,930	37.62	13.3%	\$46,935	(\$14,336)	(\$138,002)	-0.3	-2.9	(\$61,271)	(\$184,937)
CZ13	PG&E	(110,569)	10,757	37.40	16.7%	\$40,844	(\$168,494)	(\$138,788)	-4.1	-3.4	(\$209,338)	(\$179,632)
CZ14	SDG&E	(113,770)	10,903	37.37	16.0%	\$40,944	(\$376,256)	(\$121,979)	-9.2	-3.0	(\$417,200)	(\$162,923)
CZ14-2	SCE	(113,770)	10,903	37.37	16.0%	\$40,944	(\$76,213)	(\$121,979)	-1.9	-3.0	(\$117,157)	(\$162,923)
CZ15	SCE	(92,859)	9,291	32.78	13.3%	\$39,448	(\$66,525)	(\$106,292)	-1.7	-2.7	(\$105,973)	(\$145,739)
CZ16	PG&E	(127,418)	12,616	44.81	4.6%	\$45,331	(\$190,284)	(\$184,224)	-4.2	-4.1	(\$235,615)	(\$229,555)
CZ16-2	LA	(127,418)	12,616	44.81	4.6%	\$45,331	\$37,353	(\$184,224)	0.8	-4.1	(\$7,978)	(\$229,555)

Figure 58. Cost Effectiveness for QSR: All-Electric + Eff + HE Cooking + PV + B

CZ	Utility	Annual Elec Savings (kWh)	Annual Gas Savings (therms)	Annual GHG Reductions (mtons)	Compliance Margin	Upfront Incremental Package Cost	Lifecycle Utility Cost Savings	Lifecycle \$TDV Savings	B/C Ratio (On-bill)	B/C Ratio (TDV)	NPV (On-bill)	NPV (TDV)
CZ01	PG&E	(100,655)	12,748	47.98	14.9%	\$202,810	(\$107,401)	(\$64,877)	-0.5	-0.3	(\$310,211)	(\$267,688)
CZ02	PG&E	(90,953)	11,377	41.63	13.8%	\$210,225	(\$98,425)	(\$14,214)	-0.5	-0.1	(\$308,650)	(\$224,439)
CZ03	PG&E	(80,544)	10,849	40.77	22.0%	\$209,336	(\$74,363)	(\$17,861)	-0.4	-0.1	(\$283,699)	(\$227,198)
CZ03-2	PCE	(80,544)	10,849	40.77	22.0%	\$209,336	(\$68,001)	(\$17,861)	-0.3	-0.1	(\$277,338)	(\$227,198)
CZ04	PG&E	(75,494)	10,542	40.09	23.5%	\$209,390	(\$60,653)	\$25,125	-0.3	0.1	(\$270,043)	(\$184,265)
CZ04-2	CPAU	(75,494)	10,542	40.09	23.5%	\$209,390	\$55,979	\$25,125	0.3	0.1	(\$153,411)	(\$184,265)
CZ05	PG&E	(80,690)	11,134	41.76	26.4%	\$210,139	(\$71,407)	(\$13,392)	-0.3	-0.1	(\$281,547)	(\$223,531)
CZ05-2	SCG	(80,690)	11,134	41.76	26.4%	\$210,139	(\$125,836)	(\$13,392)	-0.6	-0.1	(\$335,976)	(\$223,531)
CZ06	SCE	(69,738)	9,965	37.55	26.9%	\$210,150	(\$53,646)	\$2,114	-0.3	0.0	(\$263,797)	(\$208,036)
CZ06-2	LA	(69,738)	9,965	37.55	26.9%	\$210,150	\$53,803	\$2,114	0.3	0.0	(\$156,348)	(\$208,036)
CZ07	SDG&E	(62,194)	9,535	36.85	31.9%	\$210,098	(\$344,334)	\$7,932	-1.6	0.0	(\$554,431)	(\$202,166)
CZ08	SCE	(74,018)	9,741	35.89	17.7%	\$211,031	(\$43,475)	\$11,046	-0.2	0.1	(\$254,506)	(\$199,985)
CZ08-2	LA	(74,018)	9,741	35.89	17.7%	\$211,031	\$46,918	\$11,046	0.2	0.1	(\$164,113)	(\$199,985)
CZ09	SCE	(73,421)	9,893	36.88	17.7%	\$204,258	(\$41,252)	\$17,232	-0.2	0.1	(\$245,511)	(\$187,026)
CZ09-2	LA	(73,421)	9,893	36.88	17.7%	\$204,258	\$48,498	\$17,232	0.2	0.1	(\$155,760)	(\$187,026)
CZ10	SDG&E	(76,116)	10,059	37.17	14.3%	\$203,442	(\$336,511)	\$14,687	-1.7	0.1	(\$539,953)	(\$188,755)
CZ10-2	SCE	(76,116)	10,059	37.17	14.3%	\$203,442	(\$45,667)	\$14,687	-0.2	0.1	(\$249,109)	(\$188,755)
CZ11	PG&E	(82,625)	10,940	40.69	16.9%	\$211,028	(\$101,008)	\$49,715	-0.5	0.2	(\$312,035)	(\$161,312)
CZ12	PG&E	(85,578)	10,930	40.14	13.3%	\$211,012	(\$85,340)	\$18,455	-0.4	0.1	(\$296,352)	(\$192,557)
CZ12-2	SMUD	(85,578)	10,930	40.14	13.3%	\$211,012	\$29,085	\$18,455	0.1	0.1	(\$181,927)	(\$192,557)
CZ13	PG&E	(81,654)	10,757	39.95	16.7%	\$204,921	(\$100,534)	\$15,719	-0.5	0.1	(\$305,454)	(\$189,202)
CZ14	SDG&E	(79,987)	10,903	40.06	16.0%	\$205,021	(\$331,139)	\$20,271	-1.6	0.1	(\$536,160)	(\$184,750)
CZ14-2	SCE	(79,987)	10,903	40.06	16.0%	\$205,021	(\$41,990)	\$20,271	-0.2	0.1	(\$247,011)	(\$184,750)
CZ15	SCE	(61,148)	9,291	35.27	13.3%	\$203,524	(\$34,785)	\$27,887	-0.2	0.1	(\$238,309)	(\$175,637)
CZ16	PG&E	(95,839)	12,616	47.34	4.6%	\$209,407	(\$89,297)	(\$57,418)	-0.4	-0.3	(\$298,705)	(\$266,826)
CZ16-2	LA	(95,839)	12,616	47.34	4.6%	\$209,407	\$59,956	(\$57,418)	0.3	-0.3	(\$149,452)	(\$266,826)

Figure 59. Cost Effectiveness for QSR: All-Electric Hybrid + Eff + HE Cooking + PV + B

CZ	Utility	Annual Elec Savings (kWh)	Annual Gas Savings (therms)	Annual GHG Reductions (mtons)	Compliance Margin	Upfront Incremental Package Cost	Lifecycle Utility Cost Savings	Lifecycle \$TDV Savings	B/C Ratio (On-bill)	B/C Ratio (TDV)	NPV (On-bill)	NPV (TDV)
CZ01	PG&E	(89,496)	11,293	42.36	20.5%	\$64,657	(\$96,820)	(\$55,907)	-1.5	-0.9	(\$161,477)	(\$120,564)
CZ02	PG&E	(81,020)	9,994	36.16	16.4%	\$72,072	(\$91,016)	(\$9,996)	-1.3	-0.1	(\$163,088)	(\$82,068)
CZ03	PG&E	(70,456)	9,475	35.44	26.5%	\$71,183	(\$66,113)	(\$11,547)	-0.9	-0.2	(\$137,296)	(\$82,731)
CZ03-2	PCE	(70,456)	9,475	35.44	26.5%	\$71,183	(\$60,542)	(\$11,547)	-0.9	-0.2	(\$131,725)	(\$82,731)
CZ04	PG&E	(65,848)	9,192	34.78	26.1%	\$71,237	(\$53,641)	\$29,213	-0.8	0.4	(\$124,878)	(\$42,023)
CZ04-2	CPAU	(65,848)	9,192	34.78	26.1%	\$71,237	\$30,726	\$29,213	0.4	0.4	(\$40,510)	(\$42,023)
CZ05	PG&E	(70,404)	9,746	36.38	30.9%	\$71,986	(\$62,667)	(\$6,575)	-0.9	-0.1	(\$134,653)	(\$78,562)
CZ05-2	SCG	(70,404)	9,746	36.38	30.9%	\$71,986	(\$104,112)	(\$6,575)	-1.4	-0.1	(\$176,099)	(\$78,562)
CZ06	SCE	(60,614)	8,663	32.40	29.3%	\$71,997	(\$52,797)	\$5,617	-0.7	0.1	(\$124,795)	(\$66,381)
CZ06-2	LA	(60,614)	8,663	32.40	29.3%	\$71,997	\$45,610	\$5,617	0.6	0.1	(\$26,388)	(\$66,381)
CZ07	SDG&E	(53,274)	8,252	31.76	34.5%	\$71,945	(\$337,760)	\$11,444	-4.7	0.2	(\$409,705)	(\$60,501)
CZ08	SCE	(65,353)	8,467	30.79	19.2%	\$72,878	(\$42,475)	\$13,094	-0.6	0.2	(\$115,353)	(\$59,785)
CZ08-2	LA	(65,353)	8,467	30.79	19.2%	\$72,878	\$40,513	\$13,094	0.6	0.2	(\$32,366)	(\$59,785)
CZ09	SCE	(64,673)	8,613	31.75	19.1%	\$66,105	(\$40,802)	\$19,370	-0.6	0.3	(\$106,907)	(\$46,735)
CZ09-2	LA	(64,673)	8,613	31.75	19.1%	\$66,105	\$40,087	\$19,370	0.6	0.3	(\$26,018)	(\$46,735)
CZ10	SDG&E	(67,129)	8,776	32.07	15.9%	\$65,289	(\$328,618)	\$17,509	-5.0	0.3	(\$393,907)	(\$47,780)
CZ10-2	SCE	(67,129)	8,776	32.07	15.9%	\$65,289	(\$44,017)	\$17,509	-0.7	0.3	(\$109,305)	(\$47,780)
CZ11	PG&E	(73,742)	9,603	35.25	17.0%	\$72,875	(\$69,732)	\$50,019	-1.0	0.7	(\$142,607)	(\$22,855)
CZ12	PG&E	(76,159)	9,583	34.75	15.2%	\$72,859	(\$79,219)	\$21,817	-1.1	0.3	(\$152,078)	(\$51,042)
CZ12-2	SMUD	(76,159)	9,583	34.75	15.2%	\$72,859	\$18,785	\$21,817	0.3	0.3	(\$54,073)	(\$51,042)
CZ13	PG&E	(72,827)	9,437	34.60	17.7%	\$66,768	(\$100,918)	\$17,645	-1.5	0.3	(\$167,686)	(\$49,123)
CZ14	SDG&E	(71,083)	9,556	34.53	16.2%	\$66,868	(\$327,890)	\$20,508	-4.9	0.3	(\$394,759)	(\$46,360)
CZ14-2	SCE	(71,083)	9,556	34.53	16.2%	\$66,868	(\$41,728)	\$20,508	-0.6	0.3	(\$108,596)	(\$46,360)
CZ15	SCE	(53,953)	8,152	30.55	13.3%	\$65,371	(\$36,429)	\$28,027	-0.6	0.4	(\$101,801)	(\$37,344)
CZ16	PG&E	(87,481)	11,110	40.76	3.3%	\$71,255	(\$89,044)	(\$60,056)	-1.2	-0.8	(\$160,298)	(\$131,310)
CZ16-2	LA	(87,481)	11,110	40.76	3.3%	\$71,255	\$50,044	(\$60,056)	0.7	-0.8	(\$21,210)	(\$131,310)

### 7.5.2 2022 TDV Results

The Figure 60 through Figure 63 show cost-effectiveness results using 2022 TDV and 2022 weather files, calculated using 15-year non-residential TDV, to determine if the new metric would result in cost-effective outcomes.<sup>13</sup> Note that Figure 16, the FSR AE HVAC with HPWH and efficiency measures is TDV cost effective across all CZs and has been included in Section 4.1.2. However, the packages including electric cooking measures are not cost effective, as shown in Figure 60 and Figure 61. These results largely match those analyzed with 2019 TDV.

Similarly, the QSR AE HVAC with HPWH and efficiency measures shows TDV cost effectiveness for most CZs except CZ 16. Note that Figure 22, the QSR AE HVAC with HPWH and efficiency measures is TDV cost effective across all CZs and has been included in Section 4.2.2. Figure 62 and Figure 63 show that including electric cooking measures are not cost effective in the majority of scenarios, except narrowly in CPAU or LADWP territory that include solar PV and battery storage. These results largely match those analyzed with 2019 TDV.

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<sup>13</sup> TDV multipliers can be found in the “2022 TDV CH4 20yr 15RA” workbook. <https://www.energy.ca.gov/event/workshop/2020-03/staff-workshop-2022-energy-code-compliance-metrics>

7.5.2.1 FSR

Figure 60. Cost Effectiveness for FSR: All-Electric + Eff + KOF Cooking + PV + B, 2022 TDV

CZ	Utility	Elec Savings (kWh)	Gas Savings (therms)	GHG Reductions (mtons)	Compliance Margin	Incremental Package Cost	Lifecycle Utility Cost Savings	\$TDV Savings	B/C Ratio (On-bill)	B/C Ratio (TDV)	NPV (On-bill)	NPV (TDV)
CZ01	PG&E	(144,388)	28,494	130.2	<0	\$458,582	(\$50,645)	\$162,912	-0.1	0.4	(\$509,228)	(\$295,671)
CZ02	PG&E	(113,290)	25,601	119.6	>0	\$462,727	(\$3,017)	\$363,929	0.0	0.8	(\$465,745)	(\$98,798)
CZ03	PG&E	(111,923)	24,491	114.4	>0	\$462,408	(\$30,546)	\$279,401	-0.1	0.6	(\$492,954)	(\$183,008)
CZ03-2	PCE	(111,923)	24,491	114.4	>0	\$462,408	(\$44,615)	\$279,401	-0.1	0.6	(\$507,023)	(\$183,008)
CZ04	PG&E	(96,877)	23,514	111.3	>0	\$461,409	\$6,529	\$333,228	0.0	0.7	(\$454,880)	(\$128,181)
CZ04-2	CPAU	(96,877)	23,514	111.3	>0	\$461,409	\$265,855	\$333,228	0.6	0.7	(\$195,555)	(\$128,181)
CZ05	PG&E	(106,720)	24,595	116.0	>0	\$458,775	(\$17,051)	\$220,613	0.0	0.5	(\$475,826)	(\$238,162)
CZ05-2	SCG	(106,720)	24,595	116.0	>0	\$458,775	(\$160,743)	\$220,613	-0.4	0.5	(\$619,518)	(\$238,162)
CZ06	SCE	(84,839)	21,746	104.9	>0	\$458,684	\$7,301	\$282,594	0.0	0.6	(\$451,383)	(\$176,090)
CZ06-2	LA	(84,839)	21,746	104.9	>0	\$458,684	\$124,186	\$282,594	0.3	0.6	(\$334,498)	(\$176,090)
CZ07	SDG&E	(88,561)	21,328	100.5	>0	\$458,241	(\$688,128)	\$126,776	-1.5	0.3	(\$1,146,369)	(\$331,465)
CZ08	SCE	(79,653)	21,531	102.6	>0	\$457,188	(\$13,524)	\$273,421	0.0	0.6	(\$470,712)	(\$183,767)
CZ08-2	LA	(79,653)	21,531	102.6	>0	\$457,188	\$113,657	\$273,421	0.2	0.6	(\$343,531)	(\$183,767)
CZ09	SCE	(75,509)	21,913	105.6	>0	\$454,991	(\$3,190)	\$297,906	0.0	0.7	(\$458,181)	(\$157,085)
CZ09-2	LA	(75,509)	21,913	105.6	>0	\$454,991	\$127,843	\$297,906	0.3	0.7	(\$327,148)	(\$157,085)
CZ10	SDG&E	(72,361)	22,359	108.1	>0	\$453,838	(\$600,702)	\$281,048	-1.3	0.6	(\$1,054,540)	(\$172,789)
CZ10-2	SCE	(72,361)	22,359	108.1	>0	\$453,838	\$9,401	\$281,048	0.0	0.6	(\$444,437)	(\$172,789)
CZ11	PG&E	(91,618)	24,235	114.3	>0	\$460,783	(\$9,851)	\$249,117	0.0	0.5	(\$470,634)	(\$211,666)
CZ12	PG&E	(97,106)	24,362	114.1	>0	\$458,475	(\$31,519)	\$231,080	-0.1	0.5	(\$489,994)	(\$227,395)
CZ12-2	SMUD	(97,106)	24,362	114.1	>0	\$458,475	\$196,776	\$231,080	0.4	0.5	(\$261,699)	(\$227,395)
CZ13	PG&E	(83,010)	23,544	112.4	>0	\$460,799	\$2,722	\$249,536	0.0	0.5	(\$458,077)	(\$211,263)
CZ14	SDG&E	(77,187)	24,006	116.8	>0	\$456,772	(\$632,042)	\$327,711	-1.4	0.7	(\$1,088,814)	(\$129,061)
CZ14-2	SCE	(77,187)	24,006	116.8	>0	\$456,772	\$10,897	\$327,711	0.0	0.7	(\$445,875)	(\$129,061)
CZ15	SCE	(36,927)	20,250	102.6	>0	\$450,720	\$29,604	\$314,575	0.1	0.7	(\$421,115)	(\$136,145)
CZ16	PG&E	(116,104)	27,897	132.6	>0	\$456,937	(\$27,933)	\$199,948	-0.1	0.4	(\$484,870)	(\$256,989)
CZ16-2	LA	(116,104)	27,897	132.6	>0	\$456,937	\$155,685	\$199,948	0.3	0.4	(\$301,252)	(\$256,989)

Figure 61. Cost Effectiveness for FSR: All-Electric Hybrid + Eff + KOF Cooking + PV + B, 2022 TDV

CZ	Utility	Elec Savings (kWh)	Gas Savings (therms)	GHG Reductions (mtons)	Compliance Margin	Incremental Package Cost	Lifecycle Utility Cost Savings	\$TDV Savings	B/C Ratio (On-bill)	B/C Ratio (TDV)	NPV (On-bill)	NPV (TDV)
CZ01	PG&E	(88,396)	23,682	114.3	>0	\$443,203	\$23,348	\$211,406	0.1	0.5	(\$419,855)	(\$231,797)
CZ02	PG&E	(63,053)	21,043	103.3	>0	\$442,473	\$47,146	\$371,125	0.1	0.8	(\$395,327)	(\$71,348)
CZ03	PG&E	(61,250)	19,964	98.3	>0	\$442,453	\$22,368	\$283,878	0.1	0.6	(\$420,085)	(\$158,575)
CZ03-2	PCE	(61,250)	19,964	98.3	>0	\$442,453	\$10,131	\$283,878	0.0	0.6	(\$432,322)	(\$158,575)
CZ04	PG&E	(49,348)	19,068	94.7	>0	\$441,440	\$49,346	\$348,731	0.1	0.8	(\$392,094)	(\$92,709)
CZ04-2	CPAU	(49,348)	19,068	94.7	>0	\$441,440	\$265,475	\$348,731	0.6	0.8	(\$175,965)	(\$92,709)
CZ05	PG&E	(55,525)	20,018	99.5	>0	\$443,334	\$36,702	\$236,724	0.1	0.5	(\$406,633)	(\$206,611)
CZ05-2	SCG	(55,525)	20,018	99.5	>0	\$443,334	(\$96,930)	\$236,724	-0.2	0.5	(\$540,265)	(\$206,611)
CZ06	SCE	(39,471)	17,468	88.5	>0	\$443,337	(\$1,586)	\$290,161	0.0	0.7	(\$444,923)	(\$153,176)
CZ06-2	LA	(39,471)	17,468	88.5	>0	\$443,337	\$89,778	\$290,161	0.2	0.7	(\$353,559)	(\$153,176)
CZ07	SDG&E	(44,881)	17,116	85.6	>0	\$442,131	(\$618,940)	\$152,200	-1.4	0.3	(\$1,061,071)	(\$289,931)
CZ08	SCE	(36,981)	17,354	87.5	>0	\$440,960	(\$18,592)	\$301,452	0.0	0.7	(\$459,552)	(\$139,508)
CZ08-2	LA	(36,981)	17,354	87.5	>0	\$440,960	\$78,076	\$301,452	0.2	0.7	(\$362,884)	(\$139,508)
CZ09	SCE	(31,708)	17,714	90.1	>0	\$439,560	(\$6,461)	\$323,063	0.0	0.7	(\$446,021)	(\$116,496)
CZ09-2	LA	(31,708)	17,714	90.1	>0	\$439,560	\$92,353	\$323,063	0.2	0.7	(\$347,207)	(\$116,496)
CZ10	SDG&E	(29,041)	18,152	92.6	>0	\$437,609	(\$540,420)	\$304,840	-1.2	0.7	(\$978,029)	(\$132,769)
CZ10-2	SCE	(29,041)	18,152	92.6	>0	\$437,609	\$3,094	\$304,840	0.0	0.7	(\$434,515)	(\$132,769)
CZ11	PG&E	(46,295)	19,836	98.2	>0	\$444,537	\$40,140	\$272,379	0.1	0.6	(\$404,397)	(\$172,158)
CZ12	PG&E	(50,070)	19,927	97.9	>0	\$442,153	\$21,137	\$257,540	0.0	0.6	(\$421,016)	(\$184,613)
CZ12-2	SMUD	(50,070)	19,927	97.9	>0	\$442,153	\$194,144	\$257,540	0.4	0.6	(\$248,009)	(\$184,613)
CZ13	PG&E	(38,865)	19,206	96.3	>0	\$444,599	\$50,280	\$271,274	0.1	0.6	(\$394,319)	(\$173,326)
CZ14	SDG&E	(31,339)	19,575	99.3	>0	\$441,539	(\$565,713)	\$348,379	-1.3	0.8	(\$1,007,252)	(\$93,160)
CZ14-2	SCE	(31,339)	19,575	99.3	>0	\$441,539	\$4,940	\$348,379	0.0	0.8	(\$436,599)	(\$93,160)
CZ15	SCE	(383)	16,541	88.6	>0	\$435,312	\$18,078	\$327,174	0.0	0.8	(\$417,234)	(\$108,138)
CZ16	PG&E	(72,759)	22,909	111.5	>0	\$441,511	\$1,901	\$185,982	0.0	0.4	(\$439,610)	(\$255,529)
CZ16-2	LA	(72,759)	22,909	111.5	>0	\$441,511	\$109,937	\$185,982	0.2	0.4	(\$331,573)	(\$255,529)

7.5.2.2 QSR

Figure 62. Cost Effectiveness for QSR: All-Electric + Eff + HE Cooking + PV + B, 2022 TDV

CZ	Utility	Elec Savings (kWh)	Gas Savings (therms)	GHG Reductions (mtons)	Compliance Margin	Incremental Package Cost	Lifecycle Utility Cost Savings	\$TDV Savings	B/C Ratio (On-bill)	B/C Ratio (TDV)	NPV (On-bill)	NPV (TDV)
CZ01	PG&E	(99,735)	12,626	47.96	>0	\$202,810	(\$106,390)	(\$4,736)	-0.5	0.0	(\$309,201)	(\$207,546)
CZ02	PG&E	(90,139)	11,205	40.30	>0	\$210,225	(\$101,236)	\$38,849	-0.5	0.2	(\$311,461)	(\$171,376)
CZ03	PG&E	(77,979)	10,612	40.69	>0	\$209,336	(\$69,325)	\$37,580	-0.3	0.2	(\$278,662)	(\$171,757)
CZ03-2	PCE	(77,979)	10,612	40.69	>0	\$209,336	(\$63,230)	\$37,580	-0.3	0.2	(\$272,567)	(\$171,757)
CZ04	PG&E	(72,295)	10,295	38.84	>0	\$209,390	(\$58,895)	\$48,226	-0.3	0.2	(\$268,285)	(\$161,164)
CZ04-2	CPAU	(72,295)	10,295	38.84	>0	\$209,390	\$58,536	\$48,226	0.3	0.2	(\$150,854)	(\$161,164)
CZ05	PG&E	(75,929)	10,676	39.92	>0	\$210,139	(\$65,548)	(\$2,227)	-0.3	0.0	(\$275,688)	(\$212,367)
CZ05-2	SCG	(75,929)	10,676	39.92	>0	\$210,139	(\$117,120)	(\$2,227)	-0.6	0.0	(\$327,259)	(\$212,367)
CZ06	SCE	(62,958)	9,603	36.99	>0	\$210,150	(\$30,946)	\$29,149	-0.1	0.1	(\$241,097)	(\$181,001)
CZ06-2	LA	(62,958)	9,603	36.99	>0	\$210,150	\$55,667	\$29,149	0.3	0.1	(\$154,483)	(\$181,001)
CZ07	SDG&E	(63,720)	9,441	41.11	>0	\$210,098	(\$360,924)	\$880	-1.7	0.0	(\$571,021)	(\$209,218)
CZ08	SCE	(71,879)	9,567	40.16	>0	\$211,031	(\$37,987)	\$23,241	-0.2	0.1	(\$249,018)	(\$187,790)
CZ08-2	LA	(71,879)	9,567	40.16	>0	\$211,031	\$38,836	\$23,241	0.2	0.1	(\$172,196)	(\$187,790)
CZ09	SCE	(71,849)	9,698	41.00	>0	\$204,258	(\$37,235)	\$27,745	-0.2	0.1	(\$241,493)	(\$176,514)
CZ09-2	LA	(71,849)	9,698	41.00	>0	\$204,258	\$39,553	\$27,745	0.2	0.1	(\$164,705)	(\$176,514)
CZ10	SDG&E	(75,319)	9,927	41.41	>0	\$203,442	(\$339,770)	\$12,314	-1.7	0.1	(\$543,212)	(\$191,128)
CZ10-2	SCE	(75,319)	9,927	41.41	>0	\$203,442	(\$40,361)	\$12,314	-0.2	0.1	(\$243,802)	(\$191,128)
CZ11	PG&E	(82,459)	10,752	43.99	>0	\$211,028	(\$106,940)	\$10,513	-0.5	0.0	(\$317,967)	(\$200,515)
CZ12	PG&E	(84,621)	10,745	43.62	>0	\$211,012	(\$86,585)	(\$7,400)	-0.4	0.0	(\$297,597)	(\$218,412)
CZ12-2	SMUD	(84,621)	10,745	43.62	>0	\$211,012	\$23,635	(\$7,400)	0.1	0.0	(\$187,377)	(\$218,412)
CZ13	PG&E	(78,820)	10,457	43.32	>0	\$204,921	(\$102,116)	\$3,724	-0.5	0.0	(\$307,037)	(\$201,197)
CZ14	SDG&E	(78,828)	10,660	44.55	>0	\$205,021	(\$335,962)	\$29,143	-1.6	0.1	(\$540,983)	(\$175,878)
CZ14-2	SCE	(78,828)	10,660	44.55	>0	\$205,021	(\$36,595)	\$29,143	-0.2	0.1	(\$241,616)	(\$175,878)
CZ15	SCE	(61,570)	9,198	40.12	>0	\$203,524	(\$28,136)	\$30,623	-0.1	0.2	(\$231,660)	(\$172,902)
CZ16	PG&E	(95,629)	12,266	50.81	>0	\$209,407	(\$93,413)	(\$39,751)	-0.4	-0.2	(\$302,820)	(\$249,159)
CZ16-2	LA	(95,629)	12,266	50.81	>0	\$209,407	\$47,414	(\$39,751)	0.2	-0.2	(\$161,993)	(\$249,159)

Figure 63. Cost Effectiveness for QSR: All-Electric Hybrid + Eff + HE Cooking + PV + B, 2022 TDV

CZ	Utility	Elec Savings (kWh)	Gas Savings (therms)	GHG Reductions (mtons)	Compliance Margin	Incremental Package Cost	Lifecycle Utility Cost Savings	\$TDV Savings	B/C Ratio (On-bill)	B/C Ratio (TDV)	NPV (On-bill)	NPV (TDV)
CZ01	PG&E	(88,459)	11,170	42.38	>0	\$228,734	(\$95,400)	(\$2,845)	-0.4	0.0	(\$324,134)	(\$231,579)
CZ02	PG&E	(79,997)	9,822	34.87	>0	\$236,149	(\$93,082)	\$35,947	-0.4	0.2	(\$329,230)	(\$200,202)
CZ03	PG&E	(67,931)	9,238	35.36	>0	\$235,260	(\$61,186)	\$35,946	-0.3	0.2	(\$296,446)	(\$199,314)
CZ03-2	PCE	(67,931)	9,238	35.36	>0	\$235,260	(\$55,880)	\$35,946	-0.2	0.2	(\$291,140)	(\$199,314)
CZ04	PG&E	(62,924)	8,945	33.47	>0	\$235,313	(\$52,840)	\$46,009	-0.2	0.2	(\$288,153)	(\$189,304)
CZ04-2	CPAU	(62,924)	8,945	33.47	>0	\$235,313	\$32,715	\$46,009	0.1	0.2	(\$202,599)	(\$189,304)
CZ05	PG&E	(65,675)	9,288	34.55	>0	\$236,063	(\$56,919)	(\$2,229)	-0.2	0.0	(\$292,982)	(\$238,293)
CZ05-2	SCG	(65,675)	9,288	34.55	>0	\$236,063	(\$95,507)	(\$2,229)	-0.4	0.0	(\$331,570)	(\$238,293)
CZ06	SCE	(53,767)	8,300	31.86	>0	\$236,074	(\$29,001)	\$25,874	-0.1	0.1	(\$265,075)	(\$210,200)
CZ06-2	LA	(53,767)	8,300	31.86	>0	\$236,074	\$50,315	\$25,874	0.2	0.1	(\$185,759)	(\$210,200)
CZ07	SDG&E	(54,967)	8,158	35.96	>0	\$236,021	(\$355,393)	(\$2,569)	-1.5	0.0	(\$591,415)	(\$238,591)
CZ08	SCE	(63,278)	8,293	35.04	>0	\$236,955	(\$38,039)	\$18,099	-0.2	0.1	(\$274,994)	(\$218,856)
CZ08-2	LA	(63,278)	8,293	35.04	>0	\$236,955	\$31,767	\$18,099	0.1	0.1	(\$205,188)	(\$218,856)
CZ09	SCE	(63,147)	8,417	35.87	>0	\$230,182	(\$36,875)	\$23,033	-0.2	0.1	(\$267,057)	(\$207,150)
CZ09-2	LA	(63,147)	8,417	35.87	>0	\$230,182	\$32,598	\$23,033	0.1	0.1	(\$197,584)	(\$207,150)
CZ10	SDG&E	(66,530)	8,645	36.29	>0	\$229,365	(\$336,827)	\$8,373	-1.5	0.0	(\$566,192)	(\$220,993)
CZ10-2	SCE	(66,530)	8,645	36.29	>0	\$229,365	(\$40,186)	\$8,373	-0.2	0.0	(\$269,551)	(\$220,993)
CZ11	PG&E	(73,153)	9,415	38.61	>0	\$236,951	(\$105,411)	\$5,479	-0.4	0.0	(\$342,362)	(\$231,472)
CZ12	PG&E	(75,267)	9,398	38.24	>0	\$236,936	(\$80,713)	(\$11,266)	-0.3	0.0	(\$317,649)	(\$248,202)
CZ12-2	SMUD	(75,267)	9,398	38.24	>0	\$236,936	\$12,925	(\$11,266)	0.1	0.0	(\$224,011)	(\$248,202)
CZ13	PG&E	(69,940)	9,137	37.95	>0	\$230,844	(\$101,063)	\$135	-0.4	0.0	(\$331,908)	(\$230,709)
CZ14	SDG&E	(69,831)	9,314	39.01	>0	\$230,945	(\$334,448)	\$19,299	-1.4	0.1	(\$565,393)	(\$211,646)
CZ14-2	SCE	(69,831)	9,314	39.01	>0	\$230,945	(\$36,803)	\$19,299	-0.2	0.1	(\$267,748)	(\$211,646)
CZ15	SCE	(54,086)	8,058	35.47	>0	\$229,448	(\$29,308)	\$20,209	-0.1	0.1	(\$258,756)	(\$209,239)
CZ16	PG&E	(86,884)	10,760	44.26	>0	\$235,331	(\$92,095)	(\$52,388)	-0.4	-0.2	(\$327,426)	(\$287,719)
CZ16-2	LA	(86,884)	10,760	44.26	>0	\$235,331	\$37,208	(\$52,388)	0.2	-0.2	(\$198,124)	(\$287,719)