CALIFORNIA ENERGY CODES & STANDARDS
A STATEWIDE UTILITY PROGRAM

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2022 Cost-Effectiveness Study: Single Family 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

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

CFI – California Flexible Installation

CFM – Cubic Feet per Minute

CO_2 – 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

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)**
9/12/2022	Original Release	N/A
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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 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.

The following summarizes key results from the study:

- 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 Reach Codes Team found all-electric new construction to be feasible and cost effective based on TDV in all cases. In many cases all-electric code minimum 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 natural gas rates result in lower overall utility bills.
- 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. 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 an all-electric reach code for single family buildings also include an efficiency requirement with EDR2 margins consistent with the all-electric code minimum package.
- The code compliance margins for the ADU all-electric code minimum package are lower than for the single family prototype and code compliance can be more challenging for smaller dwelling units. As a result, the Reach Codes Team does not recommend an additional efficiency requirement for all-electric ADU ordinances.
- Electrification combined with increased PV capacity results in utility cost savings and was found to be On-Bill cost effective in all cases. These results were based on today's net energy metering rules and do not account for future changes to utility agreements, which are expected to decrease the value of PV to the consumer.
- For jurisdictions interested in a reach code that allows for mixed fuel buildings, the mixed fuel efficiency, PV, and battery package was found to be cost effective based on TDV in all cases. Cost effectiveness was marginal because of the high cost of the battery system. EDR2 margins ranged from 7 to 30 for the cost-effective packages.
- Applying the CARE rates 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 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. 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. Local jurisdictions that are considering adopting an ordinance may contact the program for further technical support at 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 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).[1] Packages include combinations of efficiency measures, on-site renewable energy, and battery energy storage.

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, 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.

[1] 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-Res 2022.1.0.

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 (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, replacements, 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 for measures with lifetimes less than the 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 (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

$$NPV\ Savings = PV\ of\ lifetime\ benefit - PV\ of\ lifetime\ cost$$

Equation 2

$$Benefit - to - Cost\ Ratio = \frac{PV\ of\ lifetime\ benefit}{PV\ of\ lifetime\ cost}$$

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

$$PV\ of\ lifetime\ cost\ or\ benefit = \sum_{t=0}^{n} \frac{(Annual\ cost\ or\ benefit)_t}{(1+r)^t}$$

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-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

$$TDV\ PV\ of\ lifetime\ benefit = TDV\ energy\ savings * NPV\ factor$$

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.

First-year utility costs were calculated using hourly electricity and natural gas output from CBECC-Res 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. Appendix 7.2 Utility Rate Schedules includes details of each utility tariff. For cases with PV generation, the approved NEM2 tariffs were applied along with minimum daily use billing and mandatory non-bypassable charges. Future changes to the NEM tariffs are likely and the California Public Utilities Commission (CPUC) has issued a proposed decision with suggested changes that is expected to be finalized in 2022.[2] The ADU was assumed to have separate electric and gas meters from the main house.

Table 1. Utility Tariffs Used Based on Climate Zone

Climate Zones	Electric / Gas Utility	Electricity	Natural Gas
IOUs			
1-5,11-13,16	PG&E / PG&E	E-TOU Option C	G1
5	PG&E / SoCalGas	E-TOU Option C	GR
6, 8-10, 14, 15	SCE / SoCalGas	TOU-D Option 4-9	GR
7, 10, 14	SDG&E / SDG&E	TOU-DR-1	GR
POUs			
4	CPAU / CPAU	E-1	G-2
12	SMUD / PG&E	R-TOD (RT02)	G1

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 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

[2] https://www.cpuc.ca.gov/nemrevisit

climate zones, and another for Southern California climate zones.[3] GHG emissions are reported as average annual metric tons of CO_2 equivalent over the 30-year building lifetime.

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.

Furthermore, EDR2 is composed of two components for compliance purposes. The Efficiency EDR2 which represents the energy efficiency features of a home. The PV/Flexibility EDR2 includes the effects of PV and battery storage systems. Total EDR2 combines 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 are required:

1. The Proposed EDR1 must be equal to or less than the 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 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 on 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. Referencing the margin results in similar requirements across a variety of designs. 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

$$EDR\ Margin = Standard\ Design\ EDR - Proposed\ Design\ EDR$$

[3] 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).

3 Prototypes, Measure Packages, and Costs

This section describes the prototypes and the scope of analysis drawing from previous 2019 Reach Code research where necessary.

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^2	2,700 ft^2	625 ft^2
Num. of Stories	1	2	1
Num. of Bedrooms	3	3	1
Window-to-Floor Area Ratio	20%	20%	20%

The Energy Commission's protocol for the two single family prototypes is to weight the simulated energy impacts by a factor that represents the distribution of single-story and two-story homes being built statewide. This study assumed 50 percent single-story and 50 percent two-story. Simulation results in this study are characterized according to this ratio, which is approximately equivalent to a 2,400-square foot (ft^2) house.[4] ADU results are presented separately.

[4] 2,400 ft^2 = (50% x 2,100 ft^2) + (50% x 2,700 ft^2)

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. Each prototype building has the following features:

- Slab-on-grade foundation.
- Vented attic.
- High performance attic in climate zones where prescriptively required (CZ 4, 8-16) with insulation installed at the ceiling and below the roof deck per Option B. (Refer to Table 150.1-A in the 2022 Standards.)
- Ductwork located in the attic.

Table 3 describes additional 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 and water heating establishing a heat pump baseline. In each climate zone one heat pump is prescriptively required. 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 3: Base case Characteristics of the Prototypes

Characteristic	Single Family	ADU
Space Heating/Cooling[1,2]	CZs 1-2,5-12,15-16: Natural gas furnace, split AC 80 AFUE, 14 SEER, 11.7 EER CZs 3-4,13-14: Split heat pump – 8.2 HSPF, 14 SEER, 11.7 EER	Same as single family
Water Heater[1,2]	CZs 1-2,5-12,15-16: Heat pump water heater (HPWH) UEF = 2.0 located in the garage CZs 3-4,13-14: 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[3]
Hot Water Distribution	Code minimum, all hot water lines insulated CZs 1,16: Basic compact distribution credit	Same as single family
Drain Water Heat Recovery Efficiency	CZ 16: 65%, equal flow to shower & water heater	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 5.33 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 1.74 kW to 2.56 kW, see Table 4.[4]

[1] Equipment efficiencies are equal to minimum federal appliance efficiency standards.
[2] AFUE = annual fuel utilization efficiency. SEER = seasonal energy efficiency ratio. EER = energy efficiency ratio. HSPF = heating seasonal performance factor. UEF = uniform energy factor.
[3] 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.
[4] Exception 2 to Section 150.1(c)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 Equation150.1-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 summarizes the PV capacities for the base case packages.

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

Climate Zone	Base Package	
	Single Family	ADU
CZ01	3.54	0
CZ02	2.99	0
CZ03	2.81	0
CZ04	2.90	0
CZ05	2.62	0
CZ06	2.64	0
CZ07	2.84	0
CZ08	3.13	0
CZ09	2.97	0
CZ10	3.19	1.74
CZ11	3.91	2.07
CZ12	3.12	0
CZ13	4.08	2.11
CZ14	3.16	0
CZ15	5.33	2.56
CZ16	2.90	0

3.3 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.

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.[5] 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 best estimate 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

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.

[5] 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.

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)[6] 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 climates.

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

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 2022 Title 24 specifies a prescriptive ASR of 0.20 for Climate Zones 10 through 15.

Increased Ceiling Insulation: Increase ceiling level insulation in a vented attic to 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. 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).

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.[7] 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 prototypes only.

R-8 Duct Insulation: Increase duct insulation to R-8 in the climate zones where R-6 insulation is prescriptive.

Ductless Mini-Split Heat Pump: In the ADU prototype replace the ducted split system with 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.

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.

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

[6] Whole house leakage tested at a pressure difference of 50 Pascals between indoors and outdoors.
[7] The duct systems in the Central Valley Research Homes Project Final Project Report are illustrative of this approach (Proctor, Wilcox, & Chitwood, 2018).

violate net energy metering (NEM) rules.[8] In all cases, PV is evaluated in CBECC-Res according to the California Flexible Installation (CFI) assumptions.

The Reach Codes Team used two options within the CBECC-Res software for sizing the PV system, described below. 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. For the PV packages, the second option was used with a scaling of 100 percent. The Reach Codes Team evaluated an all-electric single family and ADU home with a PV system sized to offset 100 and 90 percent of the total calculated electricity use. Sizing to 100 percent proved to be more cost-effective based on customer utility bills in most cases. As a result, the PV packages were sized to offset 100 percent of electricity use.

- Standard Design PV – the same PV capacity as is required for the Standard Design case[9]
- Specify PV System Scaling – a PV system sized to offset a specified percentage 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 kWh. 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 battery system was evaluated in CBECC-Res with control type set to "Advanced Demand Response Control" and with default efficiencies of 95% for both charging and discharging. The "Advanced Demand Response Control" option assumes the battery system will charge or discharge depending on the needs of the grid. To qualify for the Advanced Demand Response Control the battery system must meet the requirements outlined in the 2022 Reference Appendices JA13.3.3.2 (California Energy Commission, 2021b).

[8] NEM rules apply to the IOU territories only.
[9] 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.

Table 5: Incremental Cost Assumptions

Measure	Performance Level	Incremental Cost (2023 PV$)[1]		Source & Notes
		Single Family	ADU	
Non-Preempted Measures				
Reduced Infiltration	3.0 vs 5.0 ACH50	$591	$362	$0.115/ft^2 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^2 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^2 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.
Low Pressure Drop Ducts	0.35 vs 0.45 W/cfm	$99	$49	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).

Measure	Performance Level	Incremental Cost (2023 PV$)[1]		Source & Notes
		Single Family	ADU	
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-feet venting at $14.69 per linear foot to locate water heater on interior garage wall, less 20-feet savings for PEX and pipe insulation at $5.98 per linear foot. Costs 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 + Battery				
PV System	First Cost	$3.21/W	$3.21/W	First costs from LBNL's Tracking the Sun 2021 costs (Barbose, Darghouth, O'Shaughnessy, & Forrester, 2021) and represent median costs in California in 2020 of $3.90/WDC for residential systems. The first cost was reduced by the solar energy Investment Tax Credit of 30%.[2] Costs are presented as the average of 2023, 2024, and 2025.
	Inverter replacement	$0.14/W	$0.14/W	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).
	Maintenance	$0.31/W	$0.31/W	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).

Measure	Performance Level	Incremental Cost (2023 PV$)[1]		Source & Notes
		Single Family	ADU	
Battery	First cost	$617/kWh	$617/kWh	Costs are based on research conducted for the 2021 Batteries in Single Family Homes reach code report (Statewide Reach Codes Team, 2021a). $1,000/kWh first cost in 2020 based on Self-Generation Incentive Program (SGIP) residential participant cost data. To estimate the first cost in future years this was reduced by 7% annually based on SDG&E's Behind-the-Meter Battery Market Study (E-Source companies, 2020). The first cost is reduced by the solar energy Investment Tax Credit of 30%.[2] Costs are presented as the average of 2023, 2024, and 2025. No SGIP incentives are included. Replacement cost at year 10 and 20 was calculated based on the 2023 cost reduced by 7% annually over the next 10 years for a future value cost of $389 (present value of $290 in year 10 and $216 in year 20).
	Replacement cost	$505/kWh	$505/kWh	

[1]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.

[2]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

3.3.2 All-Electric

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. In these cases, 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 were included.

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.

Incremental costs for natural gas infrastructure to a single family building are presented in Table 6 through Table 11. 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. 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. The CA IOU costs for single family homes presented are based primarily on cost data provided by PG&E.

Table 6 presents assumed gas main distribution line extension costs within gas CA IOU territory. Total distribution line extension costs are based on cost data provided by PG&E for new greenfield development. Total costs are reduced to account for deductions per the Utility Gas Main Extensions rules.[10] These rules categorize distribution line extensions as “refundable” costs, which are offset or subsidized by all other ratepayers. Refundable costs are first subsidized by appliance allowances, which are defined in Table 7. If there are additional costs in excess of the allowances, the developer has the option to either be refunded for the remaining amount over ten years or receive a 50 percent discount at time of application. The latter discount option is assumed in this analysis and is more commonly used by developers (California Public Utilities Commission, 2022). Two scenarios are presented in Table 6 since the appliance allowances differ by type of appliance. One is for the base case home with a prescriptive heat pump space heater which assumes a gas water heater, gas cooking, and gas clothes dryer (Climate Zones 3, 4, 13, and 14). The second is for the base case home with a prescriptive heat pump water heater which assumes a gas furnace, gas cooking, and gas clothes dryer. and a natural gas furnace for space heating (Climate Zones 1, 2, 5 through 12, 15, and 16).

The costs less the deductions were applied under the On-Bill cost-effectiveness methodology. The total costs before the deductions were applied under the TDV cost-effectiveness methodology to better reflect the full cost of gas main extensions since the deductions are subsidized by ratepayers and recovered via revenue from customers. This follows the analysis approach in the 2019 reach code study (Statewide Reach Codes Team, 2019) and was based on input received from the Energy Commission and agreement from the Reach Codes technical advisory team that the approach is appropriate. TDV cost savings impacts extend beyond the customer and account for societal impacts of energy use. Accounting for the full cost of the infrastructure upgrades was determined to be justified when evaluating under the TDV methodology.

The CPUC issued a Proposed Decision in August 2022 that recommends eliminating the subsidies effective July 1, 2023. At the time of publishing this report there had been no ruling on this decision and therefore this analysis assumes the existing rules will remain in place through the 2022 code cycle. A sensitivity analysis of how the results would change if the Proposed Decision were adopted is included in the results of this report.

[10] PG&E Rule 15: 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.

Table 6. Single Family IOU Natural Gas Main Distribution Line Extension Costs

	Total	Less Gas Extension Rule Deductions[1]		
		PG&E	SoCalGas	SDG&E
Gas Water Heater Base	$1,020	$0	$13	$0
Gas Space Heater Base		$0	$0	$0

[1]After Utility Gas Main Extension Rule deductions.

Table 7. Residential IOU Gas Line Extension Appliance Allowances

Appliance	PG&E	SoCalGas	SDG&E
Water Heating	$1,391	$682	$1,138
Space Heating	$987	$818	$987
Oven/Range	$84	$152	$201
Dryer Stub	$24	$160	$289
Total - Gas Water Heater Base	**$1,499**	**$994**	**$1,628**
Total – Gas Space Heater Base	**$1,095**	**$1,130**	**$1,477**

Table 8 presents costs for the extension of service lines from a main distribution line to the home within gas CA IOU territory. These costs are based on data provided by PG&E excluding trenching. Costs are presented separately for a new subdivision in an undeveloped area as well as an infill development. 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.

Table 8. Single Family IOU Natural Gas Service Line Extension Costs

New Subdivision	Infill Development	Average (80% New, 20% Infill)
$1,300	$6,750	$2,390

Table 9 presents other relative costs within gas CA IOU territory including gas meter installation and IOU plan review. These costs are based on data provided by PG&E.

Table 9. Single Family IOU Other Natural Gas Infrastructure Costs

Meter	$300
Plan Review	$850

Table 10 presents total costs including distribution and service line extensions, meter installation and plan review for the three gas CA IOUs for the two base case scenarios. Costs are based on the average service line extension costs from Table 8. 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 10. Single Family IOU Total Natural Gas Infrastructure Costs[1]

	Total	Less Gas Extension Rule Deductions[2]		
		PG&E	SoCalGas	SDG&E
Total - Gas Water Heater Base	$4,560	$3,540	$3,553	$3,540
Total - Gas Space Heater Base		$3,540	$3,540	$3,540

[1]Based on average service line extension costs from Table 8.
[1]After Utility Gas Main Extension Rule deductions.

CPAU provides gas service to its customers and therefore separate costs were evaluated based on CPAU gas service connection fees.[11] Table 11 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.

Table 11. Single Family CPAU Total Natural Gas Infrastructure Costs

Item	Cost
Service Extension	$5,892
Meter	$1,012
Plan Review Costs	$924
Total	**$7,828**

Table 12 presents incremental costs for natural gas infrastructure for the detached ADU. These costs are directly from the 2019 detached ADU reach code report (Statewide Reach Codes Team, 2021b) and were obtained from interviews and RS Means. For the ADU scenario it's assumed that natural gas 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 will need to be slightly upgraded for the all-electric design.

[11] 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 12. ADU Utility Infrastructure Costs

Mixed Fuel Measure	Mixed Fuel Cost	All-Electric Measure	All-Electric 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
Totals	**$7,164**		**$5,652**	**($1,512)**

Equipment lifetimes applied in this analysis for the water heating and space conditioning measures are summarized in Table 13. 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. Present value replacement costs are included in the total lifetime incremental costs.

Table 13: Lifetime of Water Heating & Space Conditioning Equipment Measures

Measure	Lifetime
Gas Furnace	17.5
Air Conditioner	17.5
Heat Pump	15
Gas Tankless Water Heater	20
Heat Pump Water Heater	15

Appliance incremental costs are shown in Table 14 and Table 15. Replacement costs are applied to HVAC and DHW equipment over the 30-year evaluation period. Costs were estimated to reflect costs to the building owner. All costs are provided as present value in 2023 (2023 PV$). Costs due to variations in furnace, air conditioner, and heat pump capacity by climate zone were not accounted for.

The Reach Codes Team determined that the typical first installed cost for electric appliances is similar to that for natural gas appliances. Cost differences include equipment cost and installation, costs for natural gas piping from the meter to the appliance, and costs for electrical wiring to service the appliances.

Space Heater: Typical HVAC incremental costs were based on material costs from the AC Wholesalers website and labor costs from 2022 RS Means. In most cases the Reach Codes Team found that the material costs were slightly higher for the heat pump, but the labor costs were slightly higher for the gas furnace/AC installation. Costs were calculated for capacities ranging from a 2-ton to a 5-ton and the incremental costs used in this study were based on a weighted average of the expected nominal capacities from CBECC-Res autosizing results for the 2,100 square foot prototype. Incremental replacement costs for the heat pump are based on a 17.5-year lifetime for the gas furnace and air conditioner and a 15-year lifetime for the heat pump. Residual value of the gas furnace/AC at the end of the 30-year analysis period was accounted for to represent the remaining life of the equipment.

Water Heater: Various cost sources were reviewed and the Reach Codes Team determined that installed first costs for a garage installed tankless gas water heater and HPWH are very similar and no incremental cost was applied for the equipment and installation (see below for details on costs for gas piping and electrical wiring). This accounts for slightly higher equipment costs for the HPWH but lower installation labor due to the elimination of the combustion gas venting. Incremental replacement costs account for a 15-year HPWH lifetime and a 20-year lifetime for the gas tankless water heater. Residual value of the gas tankless at the end of the 30-year analysis period was accounted for to represent the remaining life of the equipment. For the ADU analysis the water heater is evaluated within the conditioned space with the supply air ducted from the outside. An HVAC contractor provided a cost estimate for supply air ducting through the wall in an ADU where the water heater is in an interior room adjacent to an exterior wall. The estimated total cost for this was $652.

A high efficiency HPWH that meets the Northwest Energy Efficiency Alliance (NEEA)[12] Tier 3 rating was also evaluated. HPWHs certified to meet NEEA Tier 3 or Tier 4 are the dominant product on the market today. According to NEEA all major HPWH manufacturers are represented in NEEA's qualified product list[13] and there are only 11 listed products certified as Tier 1 or Tier 2.[14] While the Reach Codes Team evaluated a HPWH that just meets the federal minimum efficiency standards of close to 2.0 UEF to satisfy federal preemption requirements, the Reach Codes Team is not aware of any 2.0 UEF products that are available. The Reach Codes Team was unable to find any of the Tier 1 or Tier2 HPWHs for sale online and was unable to find any products for sale online that were not NEEA Tier 3 or Tier 4 certified. As a result, no incremental cost is assumed for a NEEA Tier 3 product versus a federal minimum efficiency product.

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 also similar.

Electric Service Upgrade: 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 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 comparable gas appliance. Incremental costs are applied for the space heater, 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 heater 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. 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.

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[12] 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.
[13] https://neea.org/success-stories/heat-pump-water-heaters
[14] https://neea.org/img/documents/residential-unitary-HPWH-qualified-products-list.pdf

Table 14. Single Family All-Electric Appliance Incremental Costs

Measure	Incremental Cost (2023 PV$)		
	First Cost	Replacement Cost	Total Lifetime Financed
Heat Pump vs Gas Furnace/Split AC			
Equipment & Installation	($151)	$703	$533
Electric Service Upgrade	$43	$0	$49
In-House Gas Piping	($580)	$0	($651)
Total	**($688)**	**$703**	**($69)**
Heat Pump Water Heater vs Gas Tankless			
Equipment & Installation	$0	$652	$652
Electric Service Upgrade	$43	$0	$49
In-House Gas Piping	($580)	$0	($651)
Total	**($537)**	**$652**	**$49**
NEEA Tier 3 HPWH vs Federal Minimum HPWH			
Equipment	$0	$0	$0
Total	**$0**	**$0**	**$0**
Electric Resistance vs Gas Cooking			
Equipment & Installation	$0	$0	$0
Electric Service Upgrade	$100	$0	$113
In-House Gas Piping	($580)	$0	($651)
Total	**($480)**	**$0**	**($539)**
Electric Resistance vs Gas Clothes Drying			
Equipment & Installation	$0	$0	$0
Electric Service Upgrade	$0	$0	$0
In-House Gas Piping	($580)	$0	($651)
Total	**($580)**	**$0**	**($651)**

Table 15. ADU All-Electric Appliance Incremental Costs

Measure	Incremental Cost (2023 PV$)		
	First Cost	Replacement Cost	Total Lifetime Financed
Heat Pump vs Gas Furnace/Split AC			
Equipment & Installation	($151)	$703	$533
Electric Service Upgrade	$43	$0	$49
In-House Gas Piping	($580)	$0	($651)
Total	**($688)**	**$703**	**($69)**
Heat Pump Water Heater vs Gas Tankless			
Equipment & Installation	$652	$652	$1,384
Electric Service Upgrade	$43	$0	$49
In-House Gas Piping	($580)	$0	($651)
Total	**$115**	**$652**	**$781**
NEEA Tier 3 HPWH vs Federal Minimum HPWH			
Equipment	$0	$0	$0
Total	**$0**	**$0**	**$0**
Electric Resistance vs Gas Cooking			
Equipment & Installation	$0	$0	$0
Electric Service Upgrade	$100	$0	$113
In-House Gas Piping	($580)	$0	($651)
Total	**($480)**	**$0**	**($539)**
Electric Resistance vs Gas Clothes Drying			
Equipment & Installation	$0	$0	$0
Electric Service Upgrade	$0	$0	$0
In-House Gas Piping	($580)	$0	($651)
Total	**($580)**	**$0**	**($651)**

3.4 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 Code Minimum: This package meets all the prescriptive requirements of the 2022 Title 24 Code. In some instances, the prescriptive minimum package did not comply with code and efficiency measures were added to meet minimum compliance requirements. The added efficiency measures can be found in Table 45 and Table 46.
2. Efficiency Only: This package uses only efficiency measures that don't trigger federal preemption issues including envelope and water heating or duct distribution efficiency measures.
3. Efficiency + NEEA (Preempted): This package was evaluated for the all-electric homes only and shows an alternative design that applies water heating equipment that is more efficient than federal standards meeting the NEEA Tier 3 rating. The Reach Codes Team considers this more reflective of how builders meet above code requirements in practice.
4. Efficiency + PV: Using the Efficiency Package as a starting point, PV capacity was added to offset most of the estimated electricity use.

5. Efficiency + PV + Battery: Using the Efficiency & PV Package as a starting point, a battery system was added. For mixed-fuel homes the package of efficiency measures differed from the Efficiency Package in some climate zones to arrive at a cost effective solution.

4 Results

4.1 2022 Metrics and Compliance

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. The impacts for the single family home and the ADU are presented in Figure 1 and Figure 2, respectively. The all-electric single family home prototype is code compliant with both EDR1 (source energy) and efficiency EDR2 (TDV energy) in all climate zones except Climate Zones 15 and 16. In addition to this climate zone, the all-electric ADU is also not compliant in Climate Zones 4 through 10 and 13 through 15. The four gas appliance single family home is presented in Figure 3. This case is not code compliant in any climate zone.

This analysis illustrates a couple of interesting points. One is that the new 2022 compliance metrics are important drivers encouraging electrification. The compliance penalties assessed the four gas appliance home scenarios are significant and will require deep efficiency measures to overcome. Another is that the 2022 Title 24 Code's new source energy metric combined with the heat pump baseline encourage all-electric construction, providing a compliance benefit, at least in larger homes, that allows for some amount of prescriptively required building efficiency to be traded off and still comply when using the performance method.

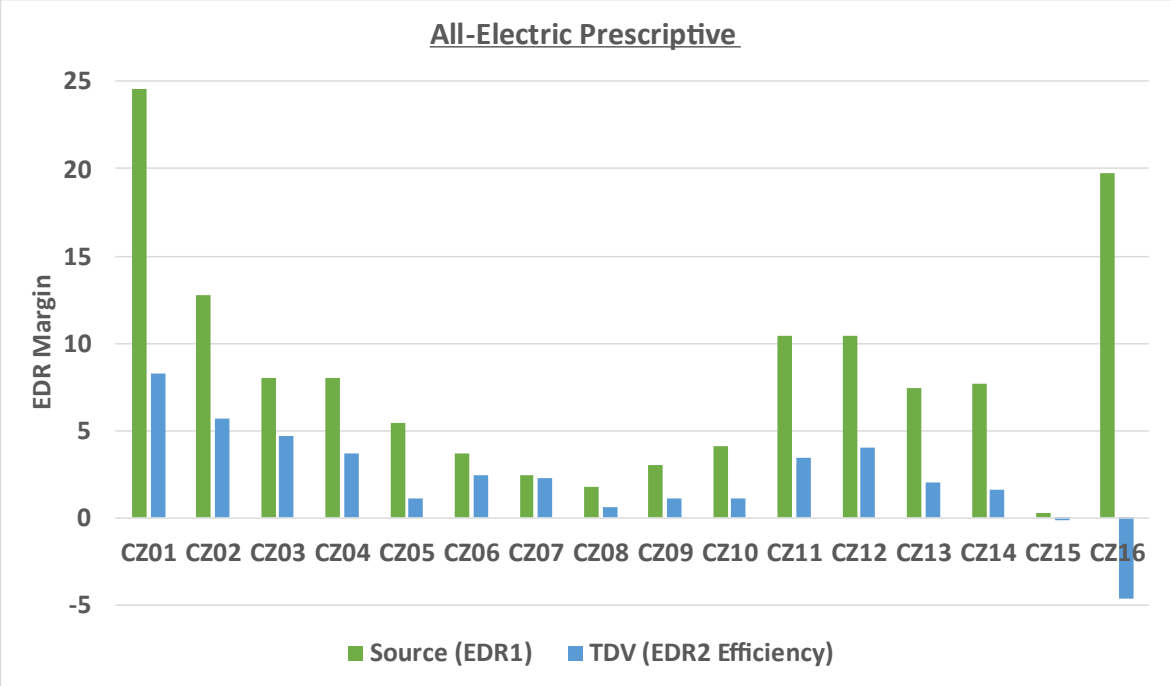

Figure 1: Single Family All-Electric Home Compliance Impacts

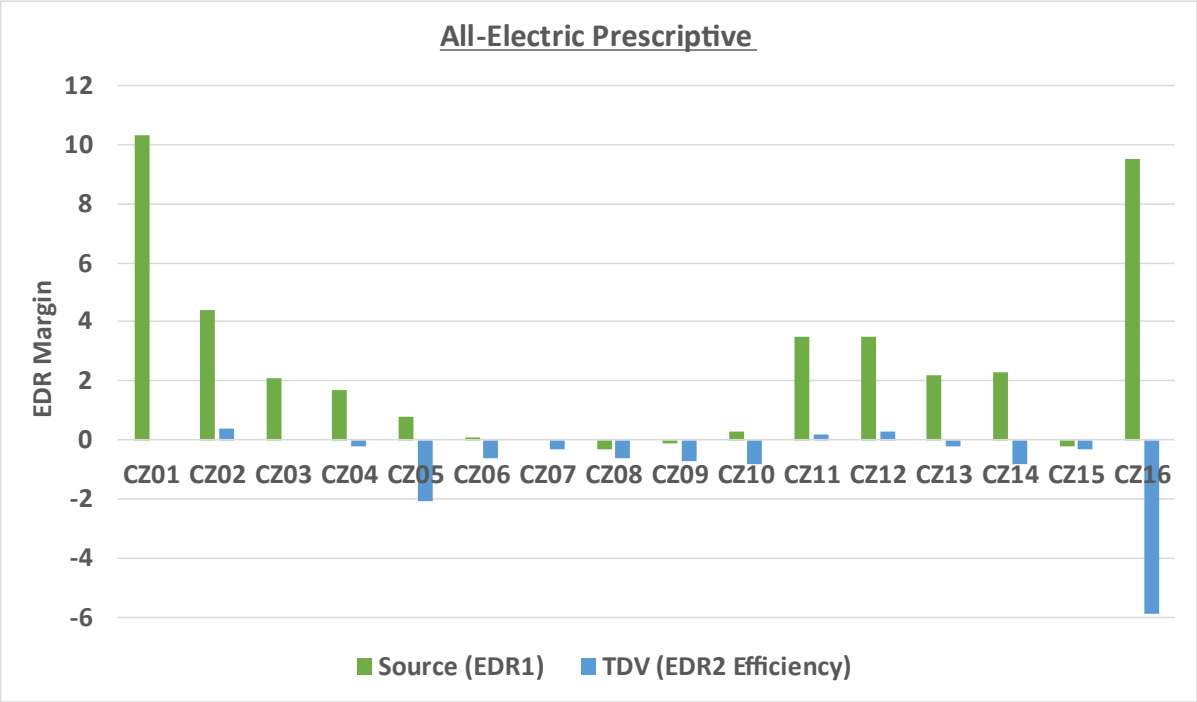

Figure 2: ADU All-Electric Home Compliance Impacts

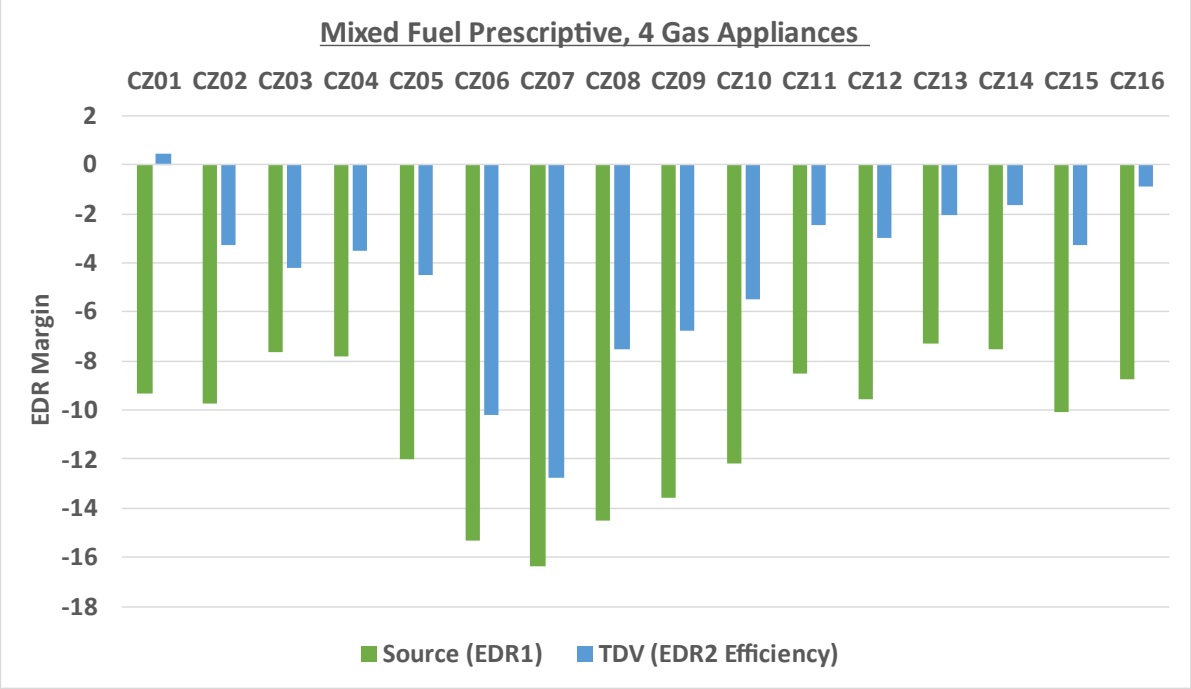

Figure 3: Single Family Four Gas Appliance Home Compliance Impacts

4.2 All-Electric Code Minimum Results

Table 16 shows results for the single family all-electric code minimum case compared to the 2022 baseline. This package reflects the prescriptive minimum requirements except in Climate Zones 15 and 16, where efficiency measures were added to meet minimum code compliance. Utility cost savings are negative, indicating an increase in utility costs for the all-electric building, in all cases except in CPAU and SMUD territories. In all cases the incremental cost is negative, which reflects a cost savings for the all-electric building due to eliminating the gas infrastructure costs. The package is cost effective based on TDV in all cases; however, it's only cost-effective On-Bill in Climate Zones 4 in CPAU territory, 6, 8, 9, 12 in SMUD territory, and 15.

Table 17 shows the all-electric code minimum case results for the ADU. This package reflects the prescriptive minimum requirements except in Climate Zones 4 through 10 and 13 through 16, where efficiency measures were added to meet minimum code compliance. The conclusions related to cost-effectiveness are similar for the ADU as for the single family analysis.

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 45 and Table 46.

Table 16. Single Family Cost-Effectiveness: All-Electric Code Minimum

Climate Zone	Electric /Gas Utility	Efficiency EDR2 Margin	Annual Elec Savings (kWh)	Annual Gas Savings (therms)	Average Annual GHG Reductions (metric tons)	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	8.3	-4,628	400	1.5	($721)	($10,848)	($5,288)	($5,234)	0.5	($5,614)	>1	$5,566
CZ02	PGE	5.7	-3,170	247	0.8	($581)	($10,060)	($5,288)	($5,234)	0.5	($4,826)	>1	$5,390
CZ03	PGE	4.7	-2,413	171	0.7	($510)	($9,954)	($5,136)	($5,116)	0.5	($4,838)	63.5	$4,414
CZ04	PGE	3.7	-2,233	163	0.7	($455)	($8,756)	($5,136)	($5,116)	0.6	($3,641)	>1	$4,929
CZ04	CPAU	3.7	-2,233	163	0.7	$21	$3,274	($9,424)	($9,931)	>1	$13,205	>1	$9,217
CZ05	PGE	1.1	-2,123	133	0.4	($452)	($8,930)	($5,288)	($5,234)	0.6	($3,696)	2.5	$2,776
CZ05	PGE/SCG	1.1	-2,123	133	0.4	($455)	($9,027)	($5,288)	($5,234)	0.6	($3,793)	2.5	$2,776
CZ06	SCE/SCG	2.5	-1,481	84	0.3	($269)	($5,120)	($5,288)	($5,234)	1.0	$115	3.2	$3,142
CZ07	SDGE	2.3	-1,328	69	0.2	($456)	($10,904)	($5,288)	($5,234)	0.5	($5,670)	3.1	$3,081
CZ08	SCE/SCG	0.6	-1,331	67	0.2	($249)	($4,864)	($5,288)	($5,234)	1.1	$371	2.8	$2,951
CZ09	SCE	1.2	-1,513	85	0.3	($269)	($5,109)	($5,288)	($5,234)	1.0	$126	3.3	$3,179
CZ10	SCE/SCG	1.1	-1,777	107	0.3	($307)	($5,720)	($5,288)	($5,234)	0.9	($486)	3.5	$3,285
CZ10	SDGE	1.1	-1,777	107	0.3	($657)	($15,474)	($5,288)	($5,234)	0.3	($10,239)	3.5	$3,285
CZ11	PGE	3.5	-2,934	227	0.7	($444)	($7,106)	($5,288)	($5,234)	0.7	($1,872)	>1	$5,135
CZ12	PGE	4.0	-2,751	213	0.7	($437)	($7,213)	($5,288)	($5,234)	0.7	($1,979)	>1	$5,002
CZ12	SMUD/PGE	4.0	-2,751	213	0.7	$58	$4,526	($5,288)	($5,234)	>1	$9,761	>1	$5,002
CZ13	PGE	2.1	-2,099	154	0.6	($383)	($7,136)	($5,136)	($5,116)	0.7	($2,021)	>1	$4,904
CZ14	SCE/SCG	1.6	-2,301	159	0.6	($411)	($7,590)	($5,136)	($5,116)	0.7	($2,475)	>1	$4,493
CZ14	SDGE	1.6	-2,301	159	0.6	($914)	($21,350)	($5,149)	($5,130)	0.2	($16,219)	>1	$4,506
CZ15	SCE/SCG	1.6	-944	53	0.2	($165)	($3,084)	($5,407)	($5,369)	1.7	$2,285	10.3	$4,247
CZ16	PG&E	6.0	-4,314	404	1.5	($545)	($6,642)	($3,257)	($2,954)	0.4	($3,687)	>1	$3,139

Table 17. ADU Cost-Effectiveness: All-Electric Code Minimum

Climate Zone	Electric /Gas Utility	Efficiency EDR2 Margin	Annual Elec Savings (kWh)	Annual Gas Savings (therms)	Average Annual GHG Reductions (metric tons)	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	-1,832	114	0.4	($346)	($6,791)	($3,260)	($2,957)	0.4	($3,834)	1.2	$489
CZ02	PGE	0.4	-1,380	75	0.2	($353)	($7,539)	($3,260)	($2,957)	0.4	($4,582)	1.2	$403
CZ03	PGE	0.0	-1,665	123	0.5	($384)	($7,667)	($2,457)	($2,106)	0.3	($5,560)	2.0	$888
CZ04	PGE	0.2	-1,591	118	0.5	($351)	($6,970)	($3,260)	($2,957)	0.4	($4,013)	15.9	$2,395
CZ04	CPAU	0.2	-1,591	118	0.5	$42	$3,285	($3,260)	($2,957)	>1	$6,242	15.9	$2,395
CZ05	PGE	0.4	-1,031	49	0.1	($268)	($5,966)	($3,260)	($2,957)	0.5	($3,009)	1.2	$460
CZ05	PGE/SCG	0.4	-1,031	49	0.1	($226)	($4,656)	($3,260)	($2,957)	0.6	($1,699)	1.2	$460
CZ06	SCE/SCG	0.2	-909	38	0.1	($215)	($4,435)	($3,260)	($2,957)	0.7	($1,478)	1.4	$666
CZ07	SDGE	0.4	-879	37	0.1	($384)	($9,528)	($3,260)	($2,957)	0.3	($6,571)	1.4	$771
CZ08	SCE/SCG	0.6	-864	36	0.1	($212)	($4,397)	($3,216)	($2,908)	0.7	($1,489)	1.5	$876
CZ09	SCE	0.6	-901	38	0.1	($190)	($3,861)	($3,216)	($2,908)	0.8	($953)	1.6	$896
CZ10	SCE/SCG	0.4	-962	43	0.1	($184)	($3,663)	($3,216)	($2,908)	0.8	($755)	1.7	$1,055
CZ10	SDGE	0.4	-962	43	0.1	($404)	($9,951)	($3,216)	($2,908)	0.3	($7,043)	1.7	$1,055
CZ11	PGE	0.2	-1,322	71	0.2	($297)	($6,281)	($3,260)	($2,957)	0.5	($3,324)	1.5	$843
CZ12	PGE	0.3	-1,283	69	0.2	($298)	($6,354)	($3,260)	($2,957)	0.5	($3,397)	1.4	$716
CZ12	SMUD/PGE	0.3	-1,283	69	0.2	($75)	($1,053)	($3,260)	($2,957)	2.8	$1,904	1.4	$716
CZ13	PGE	0.1	-1,594	112	0.4	($296)	($5,748)	($3,260)	($2,957)	0.5	($2,791)	11.3	$2,330
CZ14	SCE/SCG	0.4	-1,658	115	0.4	($282)	($5,107)	($3,216)	($2,908)	0.6	($2,199)	12.6	$2,313
CZ14	SDGE	0.4	-1,658	115	0.4	($455)	($10,294)	($3,216)	($2,908)	0.3	($7,386)	12.6	$2,313
CZ15	SCE/SCG	1.3	-783	36	0.1	($146)	($2,872)	($3,216)	($2,908)	1.0	$35	2.3	$1,408
CZ16	PG&E	0.1	-1,807	122	0.4	($348)	($6,698)	($2,640)	($2,261)	0.3	($4,437)	1.0	$22

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

Table 18 and Table 19 compare cost-effectiveness results for the all-electric packages for the single family and ADU prototypes, respectively. In all cases the packages are cost effective based on TDV. On-Bill cost effectiveness generally improves with the addition of efficiency measures, improves significantly with an upsized PV system, and then declines again once batteries are added.

Table 18. Single Family Cost-Effectiveness: All-Electric Energy Efficiency + Additional PV + Battery

Climate Zone	Electric /Gas Utility	All Electric Efficiency				All Electric Efficiency + NEEA				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	($1,256)	>1	$8,122	4.0	$2,407	>1	$10,497	2.8	$22,471	1.9	$9,517	1.5	$11,220	1.4	$9,062
CZ02	PGE	0.6	($1,957)	>1	$7,579	1.1	$236	>1	$8,957	3.5	$16,261	2.9	$10,678	1.3	$4,955	1.9	$13,716
CZ03	PGE	0.5	($3,826)	>1	$4,674	0.6	($1,851)	>1	$6,023	3.5	$10,584	2.9	$7,145	0.96	($685)	1.6	$9,058
CZ04	PGE	0.5	($3,085)	>1	$5,328	0.7	($1,599)	>1	$6,220	3.7	$9,560	3.7	$8,348	0.9	($1,607)	1.8	$10,519
CZ04	CPAU	>1	$12,524	>1	$9,616	>1	$13,328	>1	$10,508	>1	$13,692	>1	$12,636	1.4	$3,815	2.6	$14,807
CZ05	PGE	0.6	($2,601)	12.6	$3,140	1.1	$363	>1	$5,239	4.9	$11,566	3.3	$6,058	1.0	$583	1.6	$7,976
CZ05	PGE/SCG	0.6	($2,698)	12.6	$3,140	1.1	$266	>1	$5,239	4.8	$11,469	3.3	$6,058	1.0	$486	1.6	$7,976
CZ06	SCE/SCG	0.9	($500)	21.3	$2,785	1.2	$554	>1	$3,582	5.3	$6,705	4.9	$5,331	0.96	($530)	1.6	$7,663
CZ07	SDGE	0.4	($5,221)	6.1	$2,929	0.5	($3,795)	>1	$3,706	13.2	$11,129	7.2	$4,840	0.97	($355)	1.5	$6,158
CZ08	SCE/SCG	1.0	$129	8.8	$3,006	1.4	$1,028	>1	$3,618	10.2	$6,404	10.7	$5,797	0.99	($82)	1.8	$8,401
CZ09	SCE	0.996	($14)	102.1	$3,357	1.3	$959	>1	$4,073	8.5	$7,052	8.7	$6,238	1.1	$626	1.9	$10,710
CZ10	SCE/SCG	0.9	($403)	>1	$3,475	1.2	$668	>1	$4,260	5.5	$7,389	5.5	$6,432	1.1	$1,597	1.7	$7,804
CZ10	SDGE	0.3	($9,171)	>1	$3,475	0.3	($7,637)	>1	$4,260	8.4	$12,063	5.5	$6,432	1.0	$514	1.7	$7,804
CZ11	PGE	1.1	$356	>1	$6,751	2.9	$1,988	>1	$7,863	3.9	$15,570	3.1	$9,509	1.3	$4,736	1.8	$12,035
CZ12	PGE	0.8	($923)	>1	$5,727	1.4	$840	>1	$6,925	3.8	$14,386	2.9	$8,684	1.2	$3,221	1.8	$11,629
CZ12	SMUD/PGE	>1	$8,792	>1	$5,727	>1	$9,445	>1	$6,925	3.2	$11,636	2.9	$8,684	1.1	$1,351	1.8	$11,629
CZ13	PGE	1.0	($134)	>1	$6,391	1.7	$1,204	>1	$7,315	4.5	$12,333	3.9	$8,944	1.1	$1,808	1.9	$12,609
CZ14	SCE/SCG	0.96	($226)	>1	$6,168	2.6	$1,429	>1	$7,337	3.5	$11,205	3.8	$10,769	1.4	$6,530	1.9	$13,315
CZ14	SDGE	0.2	($12,027)	>1	$6,181	0.2	($8,562)	>1	$7,350	4.2	$14,424	3.8	$10,782	1.2	$2,882	1.9	$13,328
CZ15	SCE/SCG	3.2	$2,088	>1	$4,185	10.7	$2,739	>1	$4,639	>1	$5,871	>1	$5,572	1.2	$2,471	1.7	$7,367
CZ16	PG&E	0.3	($2,843)	>1	$3,675	0.5	($1,291)	>1	$4,277	3.1	$22,017	1.9	$8,576	1.5	$10,722	1.6	$11,922

Table 19. ADU Cost-Effectiveness: All-Electric Energy Efficiency + Additional PV + Battery

Climate Zone	Electric /Gas Utility	All Electric Efficiency Only				All Electric Efficiency + NEEA				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	0.3	($2,010)	>1	$1,155	2.5	$610	>1	$3,162	2.2	$16,861	1.2	$2,976	1.2	$5,286	1.0	$168
CZ02	PGE	0.2	($4,208)	3.3	$481	0.3	($2,696)	>1	$1,403	2.5	$15,218	1.5	$4,707	1.2	$3,791	1.3	$6,522
CZ03	PGE	0.1	($6,115)	14.1	$325	0.1	($4,828)	>1	$1,206	2.3	$12,653	1.5	$4,249	1.1	$1,285	1.2	$4,720
CZ04	PGE	0.0	($5,883)	20.7	$992	0.0	($4,940)	34.2	$1,672	2.3	$13,081	1.7	$6,179	1.1	$1,797	1.4	$6,977
CZ04	CPAU	>1	$3,951	20.7	$992	>1	$4,509	34.2	$1,672	1.7	$6,738	1.7	$6,179	0.8	($4,973)	1.4	$6,977
CZ05	PGE	0.3	($4,141)	0.6	($698)	0.3	($2,912)	1.3	$222	2.9	$15,238	1.5	$3,921	1.2	$3,903	1.2	$3,473
CZ05	PGE/SCG	0.3	($2,831)	0.6	($698)	0.5	($1,602)	1.3	$222	3.1	$16,548	1.5	$3,921	1.3	$5,212	1.2	$3,473
CZ06	SCE/SCG	0.4	($2,272)	0.996	($5)	0.5	($1,672)	1.7	$444	2.6	$11,941	1.8	$5,275	1.1	$2,134	1.3	$5,984
CZ07	SDGE	0.2	($6,766)	1.0	$4	0.2	($5,978)	1.7	$435	3.8	$22,595	1.6	$4,364	1.6	$11,005	1.2	$3,943
CZ08	SCE/SCG	0.4	($2,380)	0.98	($23)	0.4	($1,832)	1.4	$334	2.5	$12,446	1.9	$6,579	1.2	$2,991	1.4	$7,829
CZ09	SCE	0.4	($1,858)	1.1	$53	0.5	($1,255)	1.5	$367	2.6	$12,699	1.9	$6,334	1.2	$3,232	1.5	$9,406
CZ10	SCE/SCG	0.5	($1,556)	1.4	$280	0.6	($800)	4.9	$828	2.7	$3,430	2.1	$2,156	0.6	($5,734)	1.2	$2,118
CZ10	SDGE	0.2	($7,442)	1.4	$280	0.2	($6,395)	4.9	$828	3.1	$4,264	2.1	$2,156	0.5	($7,385)	1.2	$2,118
CZ11	PGE	0.3	($2,749)	>1	$1,115	0.4	($1,634)	>1	$1,901	2.1	$3,811	1.8	$2,577	0.5	($7,415)	1.3	$4,046
CZ12	PGE	0.2	($3,692)	3.1	$430	0.3	($2,597)	>1	$1,320	2.6	$16,095	1.6	$5,047	1.2	$4,800	1.3	$6,745
CZ12	SMUD/PGE	3.1	$645	3.1	$430	>1	$1,076	>1	$1,320	1.4	$4,399	1.6	$5,047	0.7	($6,294)	1.3	$6,745
CZ13	PGE	0.0	($3,425)	17.9	$1,657	0.0	($2,455)	25.7	$2,419	1.7	$2,505	1.9	$3,158	0.4	($8,653)	1.4	$5,829
CZ14	SCE/SCG	0.0	($3,402)	4.0	$1,280	0.0	($2,270)	6.0	$2,097	2.4	$13,741	2.0	$8,807	1.2	$5,041	1.5	$10,045
CZ14	SDGE	0.0	($7,519)	4.0	$1,280	0.0	($5,884)	6.0	$2,097	3.8	$28,555	2.0	$8,807	1.8	$16,912	1.5	$10,045
CZ15	SCE/SCG	1.0	($47)	>1	$1,212	1.3	$204	>1	$1,264	3.5	$3,155	2.9	$2,387	0.6	($5,030)	1.3	$3,480
CZ16	PG&E	0.3	($3,414)	9.9	$748	0.3	($2,658)	>1	$1,580	2.8	$19,246	1.7	$6,200	1.4	$7,856	1.4	$7,321

4.4 Mixed Fuel Results

Table 20 and Table 21 show results for the Mixed Fuel Efficiency + PV + Battery package compared to the 2022 baseline for Single Family and ADU, respectively. This package is cost-effective based on TDV everywhere for the single family prototype. It's TDV cost-effective in most cases for the ADU with the exception of Climate Zones 1 and 10. The package is cost-effective On-Bill for the single family home only in Climate Zone 1. For the ADU the package is cost-effective On-Bill in Climate Zones 1, 2, 5, 7, 9, 12 in PG&E territory, 14, and 16. For the climate zones where there is no PV requirement in the base package, the addition of a new PV system substantially reduced utility costs and the high cost-effectiveness of the PV measure helped to offset the high cost of the battery system.

Table 20. Single Family Cost-Effectiveness: Mixed Fuel Efficiency + PV + Battery

Climate Zone	Electric /Gas Utility	Efficiency EDR2 Margin	Annual Elec Savings (kWh)	Annual Gas Savings (therms)	Average Annual GHG Reductions (metric tons)	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	30.0	1,577	118	1.1	$710	$18,829	$9,845	$17,192	1.1	$1,636	1.4	$5,664
CZ02	PGE	13.5	1,264	35	0.7	$419	$10,499	$8,951	$15,899	0.7	($5,400)	1.4	$6,396
CZ03	PGE	11.2	1,073	7	0.6	$295	$7,072	$7,718	$14,333	0.5	($7,261)	1.2	$2,956
CZ04	PGE	8.4	912	6	0.5	$244	$5,862	$8,056	$14,763	0.4	($8,902)	1.2	$3,219
CZ04	CPAU	8.4	912	6	0.5	$159	$3,839	$8,056	$14,763	0.3	($10,925)	1.2	$3,219
CZ05	PGE	16.8	1,186	43	0.8	$416	$10,571	$8,517	$15,361	0.7	($4,790)	1.3	$4,171
CZ05	PGE/SCG	16.8	1,186	43	0.8	$394	$9,850	$8,517	$15,361	0.6	($5,512)	1.3	$4,171
CZ06	SCE/SCG	9.2	894	6	0.5	$370	$8,721	$8,097	$14,780	0.6	($6,059)	1.2	$3,134
CZ07	SDGE	8.3	841	4	0.5	$358	$9,129	$8,029	$14,709	0.6	($5,579)	1.1	$1,612
CZ08	SCE/SCG	9.5	783	2	0.5	$381	$8,924	$7,494	$14,074	0.6	($5,150)	1.3	$3,991
CZ09	SCE	8.6	839	3	0.5	$390	$9,148	$7,509	$14,094	0.6	($4,946)	1.5	$5,914
CZ10	SCE/SCG	8.3	854	2	0.5	$416	$9,733	$7,139	$13,724	0.7	($3,990)	1.2	$2,863
CZ10	SDGE	8.3	854	2	0.5	$314	$7,983	$7,139	$13,724	0.6	($5,741)	1.2	$2,863
CZ11	PGE	11.0	1,034	27	0.7	$398	$9,903	$8,478	$15,286	0.6	($5,383)	1.4	$5,505
CZ12	PGE	11.0	1,107	23	0.6	$364	$9,006	$8,733	$15,626	0.6	($6,620)	1.4	$5,074
CZ12	SMUD/PGE	11.0	1,107	23	0.6	$252	$6,354	$8,733	$15,626	0.4	($9,272)	1.4	$5,074
CZ13	PGE	9.6	1,168	5	0.6	$407	$9,736	$8,713	$15,536	0.6	($5,801)	1.4	$5,562
CZ14	SCE/SCG	11.2	1,737	6	0.7	$663	$15,570	$9,664	$16,695	0.9	($1,125)	1.4	$5,435
CZ14	SDGE	11.2	1,737	6	0.7	$403	$10,291	$9,664	$16,695	0.6	($6,404)	1.4	$5,435
CZ15	SCE/SCG	8.5	532	2	0.5	$486	$11,372	$7,170	$13,536	0.8	($2,164)	1.3	$3,451
CZ16	PG&E	22.6	1,235	115	1.2	$571	$15,439	$10,780	$18,007	0.9	($2,568)	1.5	$8,024

Table 21. ADU Cost-Effectiveness: Mixed Fuel Efficiency + PV + Battery

Climate Zone	Electric /Gas Utility	Efficiency EDR2 Margin	Annual Elec Savings (kWh)	Annual Gas Savings (therms)	Average Annual GHG Reductions (metric tons)	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	24.3	3,642	79	0.8	$1,211	$29,946	$15,209	$25,617	1.2	$4,329	0.9	($1,365)
CZ02	PGE	14.5	3,451	40	0.6	$1,028	$25,019	$12,944	$22,587	1.1	$2,431	1.2	$4,938
CZ03	PGE	12.1	2,750	2	0.4	$715	$16,948	$11,077	$19,325	0.9	($2,377)	1.1	$1,349
CZ04	PGE	12.2	2,860	2	0.4	$759	$17,992	$11,523	$19,837	0.9	($1,845)	1.1	$2,417
CZ04	CPAU	12.2	2,860	2	0.4	$316	$7,490	$11,523	$19,837	0.4	($12,347)	1.1	$2,417
CZ05	PGE	7.8	3,293	14	0.5	$959	$22,944	$11,409	$20,621	1.1	$2,324	1.1	$1,409
CZ05	PGE/SCG	7.8	3,293	14	0.5	$952	$22,711	$11,409	$20,621	1.1	$2,090	1.1	$1,409
CZ06	SCE/SCG	9.8	3,292	3	0.5	$815	$19,093	$11,028	$20,110	0.9	($1,017)	1.2	$3,650
CZ07	SDGE	9.1	3,306	1	0.5	$1,172	$29,683	$11,381	$20,583	1.4	$9,100	1.1	$1,603
CZ08	SCE/SCG	10.1	3,527	1	0.5	$887	$20,746	$11,594	$20,867	0.99	($121)	1.3	$4,990
CZ09	SCE	8.9	3,512	3	0.5	$883	$20,676	$11,361	$20,556	1.0	$120	1.4	$6,682
CZ10	SCE/SCG	9.0	729	7	0.4	$244	$5,806	$7,005	$14,720	0.4	($8,914)	0.96	($473)
CZ10	SDGE	9.0	729	7	0.4	$206	$5,312	$7,005	$14,720	0.4	($9,408)	0.96	($473)
CZ11	PGE	13.1	870	36	0.5	$277	$7,182	$8,022	$15,995	0.4	($8,813)	1.1	$2,192
CZ12	PGE	12.6	3,589	33	0.6	$1,063	$25,738	$12,806	$22,393	1.1	$3,345	1.2	$4,771
CZ12	SMUD/PGE	12.6	3,589	33	0.6	$591	$14,577	$12,806	$22,393	0.7	($7,816)	1.2	$4,771
CZ13	PGE	12.8	359	1	0.4	$77	$1,846	$7,009	$13,789	0.1	($11,943)	1.2	$2,069
CZ14	SCE/SCG	14.2	3,624	2	0.5	$909	$21,262	$12,054	$20,466	1.0	$795	1.2	$4,545
CZ14	SDGE	14.2	3,624	2	0.5	$1,292	$32,729	$12,054	$20,466	1.6	$12,263	1.2	$4,545
CZ15	SCE/SCG	11.2	546	0	0.4	$252	$5,891	$6,588	$14,077	0.4	($8,186)	1.1	$964
CZ16	PG&E	16.2	3,652	87	0.8	$1,178	$29,323	$13,234	$23,007	1.3	$6,316	1.2	$4,937

Table 22 and Table 23 compare cost-effectiveness results across all the mixed fuel packages for the single family and ADU prototypes, respectively. The single family Efficiency Only package and Efficiency + PV package are cost effective based on On-Bill and TDV under most scenarios. The trends are similar for the ADU except the Efficiency Only package is not cost effective in many climate zones.

Table 22. Single Family Cost-Effectiveness: Mixed Fuel Packages

Climate Zone	Electric /Gas Utility	Mixed Fuel Efficiency Only				Mixed Fuel Efficiency + PV				Mixed Fuel Efficiency + PV + Battery			
		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	2.8	$3,619	2.7	$3,160	2.4	$8,979	1.6	$3,526	1.1	$1,636	1.4	$5,664
CZ02	PGE	2.0	$1,940	2.5	$2,664	2.2	$5,608	1.8	$3,565	0.7	($5,400)	1.4	$6,396
CZ03	PGE	1.1	$226	0.97	($56)	1.6	$2,688	1.2	$602	0.5	($7,261)	1.2	$2,956
CZ04	PGE	0.8	($379)	1.1	$107	1.4	$1,493	1.2	$862	0.4	($8,902)	1.2	$3,219
CZ04	CPAU	0.5	($1,159)	1.1	$107	0.8	($910)	1.2	$862	0.3	($10,925)	1.2	$3,219
CZ05	PGE	1.4	$516	1.3	$300	2.1	$4,449	1.4	$1,359	0.7	($4,790)	1.3	$4,171
CZ05	PGE/SCG	1.2	$303	1.3	$300	2.1	$4,235	1.4	$1,359	0.6	($5,512)	1.3	$4,171
CZ06	SCE/SCG	0.6	($696)	0.9	($180)	1.5	$1,950	1.2	$757	0.6	($6,059)	1.2	$3,134
CZ07	SDGE	1.3	$395	0.97	($36)	2.9	$5,981	1.3	$697	0.6	($5,579)	1.1	$1,612
CZ08	SCE/SCG	0.8	($238)	1.1	$103	1.7	$2,013	1.4	$1,099	0.6	($5,150)	1.3	$3,991
CZ09	SCE	0.9	($148)	1.2	$250	1.8	$2,266	1.5	$1,229	0.6	($4,946)	1.5	$5,914
CZ10	SCE/SCG	1.0	$5	1.2	$263	1.7	$2,323	1.4	$1,140	0.7	($3,990)	1.2	$2,863
CZ10	SDGE	1.6	$960	1.2	$263	2.6	$5,010	1.4	$1,140	0.6	($5,741)	1.2	$2,863
CZ11	PGE	2.0	$2,242	2.1	$2,187	2.2	$5,142	1.8	$2,824	0.6	($5,383)	1.4	$5,505
CZ12	PGE	1.4	$949	1.6	$1,207	1.9	$4,150	1.5	$2,039	0.6	($6,620)	1.4	$5,074
CZ12	SMUD/PGE	1.1	$131	1.6	$1,207	1.2	$933	1.5	$2,039	0.4	($9,272)	1.4	$5,074
CZ13	PGE	1.5	$1,236	1.5	$1,160	2.0	$4,442	1.5	$1,821	0.6	($5,801)	1.4	$5,562
CZ14	SCE/SCG	1.3	$981	1.5	$1,290	1.9	$4,917	1.6	$2,877	0.9	($1,125)	1.4	$5,435
CZ14	SDGE	2.3	$4,109	1.5	$1,290	1.9	$4,753	1.6	$2,877	0.6	($6,404)	1.4	$5,435
CZ15	SCE/SCG	1.7	$1,534	1.7	$1,444	1.7	$1,653	1.7	$1,465	0.8	($2,164)	1.3	$3,451
CZ16	PG&E	1.8	$3,124	2.2	$4,123	2.2	$8,324	1.9	$5,419	0.9	($2,568)	1.5	$8,024

Table 23. ADU Cost-Effectiveness: Mixed Fuel Packages

Climate Zone	Electric /Gas Utility	Mixed Fuel Efficiency				Mixed Fuel Efficiency + PV				Mixed Fuel Efficiency + PV + Battery			
		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	1.6	$1,228	1.3	$616	2.1	$15,985	1.2	$2,051	1.2	$4,329	0.9	($1,365)
CZ02	PGE	0.7	($634)	1.1	$148	2.3	$13,934	1.4	$3,499	1.1	$2,431	1.2	$4,938
CZ03	PGE	0.6	($666)	0.7	($475)	2.2	$9,045	1.3	$1,856	0.9	($2,377)	1.1	$1,349
CZ04	PGE	0.5	($941)	0.7	($515)	2.1	$9,487	1.4	$2,679	0.9	($1,845)	1.1	$2,417
CZ04	CPAU	0.3	($1,507)	0.7	($515)	0.99	($115)	1.4	$2,679	0.4	($12,347)	1.1	$2,417
CZ05	PGE	0.7	($456)	0.2	($1,141)	2.5	$13,761	1.3	$2,473	1.1	$2,324	1.1	$1,409
CZ05	PGE/SCG	0.5	($689)	0.2	($1,141)	2.5	$13,528	1.3	$2,473	1.1	$2,090	1.1	$1,409
CZ06	SCE/SCG	0.3	($976)	0.6	($638)	2.1	$9,282	1.5	$3,477	0.9	($1,017)	1.2	$3,650
CZ07	SDGE	0.4	($830)	0.5	($717)	3.3	$20,716	1.3	$2,676	1.4	$9,100	1.1	$1,603
CZ08	SCE/SCG	0.3	($1,069)	0.4	($819)	2.1	$10,035	1.5	$4,415	0.99	($121)	1.3	$4,990
CZ09	SCE	0.3	($1,024)	0.5	($780)	2.1	$10,242	1.5	$4,195	1.0	$120	1.4	$6,682
CZ10	SCE/SCG	0.4	($1,004)	0.5	($750)	1.4	$1,118	1.0	$71	0.4	($8,914)	0.96	($473)
CZ10	SDGE	1.5	$721	0.5	($750)	1.7	$2,230	1.0	$71	0.4	($9,408)	0.96	($473)
CZ11	PGE	1.0	($11)	1.2	$316	1.6	$2,473	1.3	$1,064	0.4	($8,813)	1.1	$2,192
CZ12	PGE	0.6	($761)	0.9	($224)	2.4	$14,704	1.4	$3,458	1.1	$3,345	1.2	$4,771
CZ12	SMUD/PGE	1.0	($70)	0.9	($224)	1.3	$2,975	1.4	$3,458	0.7	($7,816)	1.2	$4,771
CZ13	PGE	0.6	($850)	1.1	$206	0.6	($807)	1.1	$240	0.1	($11,943)	1.2	$2,069
CZ14	SCE/SCG	1.0	$20	1.0	$107	2.2	$10,862	1.6	$4,977	1.0	$795	1.2	$4,545
CZ14	SDGE	1.5	$1,310	1.0	$107	3.7	$23,840	1.6	$4,977	1.6	$12,263	1.2	$4,545
CZ15	SCE/SCG	1.2	$411	1.1	$205	1.4	$916	1.2	$388	0.4	($8,186)	1.1	$964
CZ16	PG&E	0.7	($456)	1.0	$52	2.6	$17,779	1.4	$4,505	1.3	$6,316	1.2	$4,937

4.5 CARE Rate Comparison

Table 24 and Table 25 present a comparison of On-Bill cost-effectiveness results for CARE tariffs relative to standard tariffs. The all-electric code minimum package for the single family and ADU prototypes is shown in Table 24. Applying the CARE rates lowers both electric and gas utility bills for the consumer and the net impact is lower overall bills for an all-electric home and improved cost-effectiveness relative to the standard tariffs. The opposite trend occurs for the mixed fuel packages shown in Table 25 where the CARE rate lowers utility cost savings and the benefit-to-cost ratios decline.

Table 24. 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	0.5	($5,614)	0.8	($997)	0.4	($3,834)	0.7	($1,505)
CZ02	PGE	0.5	($4,826)	0.8	($1,281)	0.4	($4,582)	0.6	($2,146)
CZ03	PGE	0.5	($4,838)	0.8	($924)	0.3	($5,560)	0.4	($2,733)
CZ04	PGE	0.6	($3,641)	0.96	($215)	0.4	($4,013)	0.7	($1,465)
CZ04	CPAU	>1	$13,205	>1	$9,931	>1	$6,242	>1	$2,957
CZ05	PGE	0.6	($3,696)	0.9	($647)	0.5	($3,009)	0.7	($1,158)
CZ05	PGE/SCG	0.6	($3,793)	1.1	$444	0.6	($1,699)	1.1	$243
CZ06	SCE/SCG	1.0	$115	1.6	$1,984	0.7	($1,478)	0.97	($98)
CZ07	SDGE	0.5	($5,670)	0.8	($1,636)	0.3	($6,571)	0.5	($3,441)
CZ08	SCE/SCG	1.1	$371	1.7	$2,073	0.7	($1,489)	0.95	($139)
CZ09	SCE	1.0	$126	1.6	$2,001	0.8	($953)	1.1	$261
CZ10	SCE/SCG	0.9	($486)	1.5	$1,703	0.8	($755)	1.2	$433
CZ10	SDGE	0.3	($10,239)	0.5	($4,330)	0.3	($7,043)	0.4	($3,645)
CZ11	PGE	0.7	($1,872)	1.1	$568	0.5	($3,324)	0.7	($1,344)
CZ12	PGE	0.7	($1,979)	1.1	$457	0.5	($3,397)	0.7	($1,395)
CZ12	SMUD/PGE	>1	$9,761	>1	$12,640	2.8	$1,904	>1	$4,281
CZ13	PGE	0.7	($2,021)	1.2	$783	0.5	($2,791)	0.7	($991)
CZ14	SCE/SCG	0.7	($2,475)	1.1	$505	0.6	($2,199)	0.9	($222)
CZ14	SDGE	0.2	($16,219)	0.4	($7,861)	0.3	($7,386)	0.5	($3,249)
CZ15	SCE/SCG	1.7	$2,285	2.6	$3,330	1.0	$35	1.5	$927
CZ16	PG&E	0.4	($3,687)	0.8	($825)	0.3	($4,437)	0.5	($2,157)

Table 25. 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	1.1	$1,636	0.7	($4,574)	1.2	$4,329	0.7	($6,549)
CZ02	PGE	0.7	($5,400)	0.4	($8,958)	1.1	$2,431	0.7	($6,728)
CZ03	PGE	0.5	($7,261)	0.3	($9,524)	0.9	($2,377)	0.6	($8,471)
CZ04	PGE	0.4	($8,902)	0.3	($10,706)	0.9	($1,845)	0.6	($8,329)
CZ04	CPAU	0.3	($10,925)	0.0	($14,763)	0.4	($12,347)	0.0	($19,837)
CZ05	PGE	0.7	($4,790)	0.5	($8,377)	1.1	$2,324	0.7	($6,030)
CZ05	PGE/SCG	0.6	($5,512)	0.4	($8,540)	1.1	$2,090	0.7	($6,067)
CZ06	SCE/SCG	0.6	($6,059)	0.3	($9,638)	0.9	($1,017)	0.6	($8,203)
CZ07	SDGE	0.6	($5,579)	0.5	($7,676)	1.4	$9,100	0.96	($836)
CZ08	SCE/SCG	0.6	($5,150)	0.4	($8,775)	0.99	($121)	0.6	($7,852)
CZ09	SCE	0.6	($4,946)	0.4	($8,642)	1.0	$120	0.6	($7,580)
CZ10	SCE/SCG	0.7	($3,990)	0.4	($7,862)	0.4	($8,914)	0.2	($11,587)
CZ10	SDGE	0.6	($5,741)	0.5	($7,396)	0.4	($9,408)	0.3	($10,388)
CZ11	PGE	0.6	($5,383)	0.4	($8,671)	0.4	($8,813)	0.3	($11,145)
CZ12	PGE	0.6	($6,620)	0.4	($9,617)	1.1	$3,345	0.7	($6,094)
CZ12	SMUD/PGE	0.4	($9,272)	0.1	($14,636)	0.7	($7,816)	0.1	($20,989)
CZ13	PGE	0.6	($5,801)	0.4	($9,016)	0.1	($11,943)	0.1	($12,502)
CZ14	SCE/SCG	0.9	($1,125)	0.6	($6,889)	1.0	$795	0.7	($7,099)
CZ14	SDGE	0.6	($6,404)	0.5	($8,940)	1.6	$12,263	1.1	$1,271
CZ15	SCE/SCG	0.8	($2,164)	0.5	($6,384)	0.4	($8,186)	0.2	($10,846)
CZ16	PG&E	0.9	($2,568)	0.6	($7,747)	1.3	$6,316	0.8	($4,356)

4.6 Utility Infrastructure Cost Sensitivity

Table 26 compares cost effectiveness results for the three natural gas service line extension cost scenarios presented in Table 8. The average cost scenario reflects the costs applied in the results presented in the prior sections (Table 16). The gas infrastructure cost savings are lower for the new subdivision case and higher for the infill development case. For the latter, the all-electric home is On-Bill cost-effective in all climate zones except Climate Zones 1, 2, 10 in SDG&E territory, and 14 in SDG&E territory. Table 27 presents the impact on On-Bill cost-effectiveness if the subsidies currently allowed under the utility gas main extension rules were removed per a recent CPUC Proposed Decision (see discussion in Section 3.3.2). If the subsidies were removed On-Bill cost-effectiveness improves but only enough to change the outcome in one case, Climate Zones 10 in SoCalGas territory.

Table 26. 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	0.5	($5,614)	>1	$5,566	0.4	($6,838)	>1	$4,476	0.9	($718)	>1	$9,926
CZ02	PGE	0.5	($4,826)	>1	$5,390	0.4	($6,050)	>1	$4,300	1.0	$70	>1	$9,750
CZ03	PGE	0.5	($4,838)	63.5	$4,414	0.4	($6,062)	48.1	$3,324	1.0	$57	125.3	$8,774
CZ04	PGE	0.6	($3,641)	>1	$4,929	0.4	($4,865)	>1	$3,839	1.1	$1,255	>1	$9,289
CZ04	CPAU	>1	$13,205	>1	$9,217	>1	$13,205	>1	$9,217	>1	$13,205	>1	$9,217
CZ05	PGE	0.6	($3,696)	2.5	$2,776	0.4	($4,920)	1.9	$1,686	1.1	$1,200	4.9	$7,136
CZ05	PGE/SCG	0.6	($3,793)	2.5	$2,776	0.4	($5,017)	1.9	$1,686	1.1	$1,103	4.9	$7,136
CZ06	SCE/SCG	1.0	$115	3.2	$3,142	0.8	($1,109)	2.4	$2,052	2.0	$5,011	6.2	$7,502
CZ07	SDGE	0.5	($5,670)	3.1	$3,081	0.4	($6,894)	2.3	$1,991	0.9	($774)	6.0	$7,441
CZ08	SCE/SCG	1.1	$371	2.8	$2,951	0.8	($853)	2.1	$1,861	2.1	$5,266	5.5	$7,311
CZ09	SCE	1.0	$126	3.3	$3,179	0.8	($1,098)	2.5	$2,089	2.0	$5,022	6.4	$7,539
CZ10	SCE/SCG	0.9	($486)	3.5	$3,285	0.7	($1,710)	2.7	$2,195	1.8	$4,410	6.9	$7,645
CZ10	SDGE	0.3	($10,239)	3.5	$3,285	0.3	($11,463)	2.7	$2,195	0.7	($5,344)	6.9	$7,645
CZ11	PGE	0.7	($1,872)	>1	$5,135	0.6	($3,096)	>1	$4,045	1.4	$3,024	>1	$9,495
CZ12	PGE	0.7	($1,979)	>1	$5,002	0.6	($3,203)	>1	$3,912	1.4	$2,917	>1	$9,362
CZ12	SMUD/PGE	>1	$9,761	>1	$5,002	>1	$8,537	>1	$3,912	>1	$14,656	>1	$9,362
CZ13	PGE	0.7	($2,021)	>1	$4,904	0.5	($3,245)	>1	$3,814	1.4	$2,875	>1	$9,264
CZ14	SCE/SCG	0.7	($2,475)	>1	$4,493	0.5	($3,699)	>1	$3,403	1.3	$2,421	>1	$8,853
CZ14	SDGE	0.2	($16,219)	>1	$4,506	0.2	($17,443)	>1	$3,416	0.5	($11,323)	>1	$8,866
CZ15	SCE/SCG	1.7	$2,285	10.3	$4,247	1.3	$1,061	7.9	$3,157	3.3	$7,181	19.8	$8,607
CZ16	PG&E	0.4	($3,687)	>1	$3,139	0.3	($4,911)	>1	$2,049	1.2	$1,208	>1	$7,499

Table 27. Single Family Cost-Effectiveness On-Bill Impact of CPUC Proposed Decision on Gas Line Extension Allowances: All-Electric Code Minimum

Climate Zone	Electric /Gas Utility	No Allowances			
		With Allowance		No Allowances	
		B/C Ratio	NPV	B/C Ratio	NPV
CZ01	PGE	0.5	($5,614)	0.6	($4,469)
CZ02	PGE	0.5	($4,826)	0.6	($3,681)
CZ03	PGE	0.5	($4,838)	0.6	($3,693)
CZ04	PGE	0.6	($3,641)	0.7	($2,495)
CZ04	CPAU	>1	$13,205	>1	$13,205
CZ05	PGE	0.6	($3,696)	0.7	($2,551)
CZ05	PGE/SCG	0.6	($3,793)	0.7	($2,647)
CZ06	SCE/SCG	1.0	$115	1.2	$1,260
CZ07	SDGE	0.5	($5,670)	0.6	($4,524)
CZ08	SCE/SCG	1.1	$371	1.3	$1,516
CZ09	SCE	1.0	$126	1.2	$1,271
CZ10	SCE/SCG	0.9	($486)	1.1	$660
CZ10	SDGE	0.3	($10,239)	0.4	($9,094)
CZ11	PGE	0.7	($1,872)	0.9	($726)
CZ12	PGE	0.7	($1,979)	0.9	($834)
CZ12	SMUD/PGE	>1	$9,761	>1	$10,906
CZ13	PGE	0.7	($2,021)	0.9	($875)
CZ14	SCE/SCG	0.7	($2,475)	0.8	($1,329)
CZ14	SDGE	0.2	($16,219)	0.3	($15,088)
CZ15	SCE/SCG	1.7	$2,285	2.1	$3,430
CZ16	PG&E	0.4	($3,687)	0.6	($2,542)

4.7 Greenhouse Gas Reductions

Table 28 and Table 29 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, 12, 13, and 16. 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.

Table 28: Single Family Greenhouse Gas Reductions (metric tons)

Climate Zone	Single Family All-Electric					Single Family Mixed Fuel		
	Code Minimum	Efficiency Only	Efficiency + NEEA	Efficiency + PV	Efficiency + PV + Battery	Efficiency Only	Efficiency + PV	Efficiency + PV + Battery
CZ01	1.5	1.6	1.7	1.8	2.2	0.4	0.5	1.1
CZ02	0.8	0.9	1.0	1.1	1.5	0.3	0.3	0.7
CZ03	0.7	0.8	0.8	0.9	1.3	0.1	0.1	0.6
CZ04	0.7	0.7	0.8	0.8	1.3	0.1	0.1	0.5
CZ05	0.4	0.4	0.5	0.6	1.1	0.1	0.1	0.8
CZ06	0.3	0.3	0.3	0.4	0.9	0.1	0.1	0.5
CZ07	0.2	0.2	0.3	0.3	0.8	0.0	0.1	0.5
CZ08	0.2	0.2	0.3	0.3	0.8	0.0	0.1	0.5
CZ09	0.3	0.3	0.3	0.4	0.9	0.0	0.1	0.5
CZ10	0.3	0.3	0.4	0.4	0.9	0.1	0.1	0.5
CZ11	0.7	0.9	0.9	1.0	1.4	0.2	0.2	0.7
CZ12	0.7	0.8	0.8	0.9	1.3	0.2	0.2	0.6
CZ13	0.6	0.7	0.7	0.8	1.3	0.1	0.1	0.6
CZ14	0.6	0.7	0.8	0.9	1.4	0.2	0.2	0.7
CZ15	0.2	0.2	0.2	0.3	0.7	0.1	0.1	0.5
CZ16	1.5	1.6	1.6	1.8	2.3	0.7	0.8	1.2

Table 29 ADU Greenhouse Gas Savings (metric tons)

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

5 Summary

The Reach Codes Team identified 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 30 (all-electric) and Table 31 (mixed fuel) summarize results for each prototype and depicts the efficiency EDR2 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 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.

Following are key takeaways and recommendations from the analysis.

- 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 Reach Codes Team found all-electric new construction to be feasible and cost effective based on TDV in all cases. In many cases all-electric code minimum 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.
- 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. 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 an all-electric reach code for single family buildings also include an efficiency requirement with EDR2 margins consistent with the all-electric code minimum package results in Table 30.
- The code compliance margins for the ADU all-electric code minimum package are lower than for the single family prototype and code compliance can be more challenging for smaller dwelling units. As a result, the Reach Codes Team does not recommend an additional efficiency requirement for all-electric ADU ordinances.
- Electrification combined with increased PV capacity results in utility cost savings and was found to be On-Bill cost effective in all cases. These results were based on today's net energy metering rules and do not account for future changes to utility agreements, which are expected to decrease the value of PV to the consumer.
- For jurisdictions interested in a reach code that allows for mixed fuel buildings the mixed fuel efficiency, PV, and battery package was found to be cost effective based on TDV in all cases. Cost effectiveness was marginal because of the high cost of the battery system. EDR2 margins ranged from 7 to 30 for the cost-effective packages as is shown in Table 31.
- Applying the CARE rates 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.

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 beyond state code minimums must demonstrate the proposed changes are cost-effective and obtain approval from the Energy Commission.

Table 30. Summary of All-Electric Efficiency EDR2 Margins and Cost-Effectiveness

Climate Zone	Electric /Gas Utility	Single Family				ADU			
		Code Min	EE	EE+PV	EE+PV/B	Code Min	EE	EE+PV	EE+PV/B
CZ01	PGE	8.3	18.8	18.8	29.6	0.0	15.1	15.1	24.6
CZ02	PGE	5.7	13.5	13.5	19.1	0.4	9.5	9.5	14.6
CZ03	PGE	4.7	10.5	10.5	15.8	0.0	5.7	5.7	10.5
CZ04	PGE	3.7	8.6	8.6	13.5	0.2	6.3	6.3	10.8
CZ04	CPAU	3.7	8.6	8.6	13.5	0.2	6.3	6.3	10.8
CZ05	PGE	1.1	6.1	6.1	14.3	0.4	2.4	2.4	7.9
CZ05	PGE/SCG	1.1	6.1	6.1	14.3	0.4	2.4	2.4	7.9
CZ06	SCE/SCG	2.5	7.8	7.8	11.6	0.2	6.2	6.2	9.8
CZ07	SDGE	2.3	7.0	7.0	9.9	0.4	6.3	6.3	9.1
CZ08	SCE/SCG	0.6	4.0	4.0	10.4	0.6	3.6	3.6	10.0
CZ09	SCE	1.2	4.6	4.6	9.9	0.6	3.7	3.7	8.8
CZ10	SCE/SCG	1.1	4.6	4.6	10.1	0.4	3.8	3.8	9.1
CZ10	SDGE	1.1	4.6	4.6	10.1	0.4	3.8	3.8	9.1
CZ11	PGE	3.5	8.4	8.4	14.1	0.2	7.7	7.7	13.2
CZ12	PGE	4.0	8.5	8.5	14.7	0.3	6.8	6.8	12.6
CZ12	SMUD/PGE	4.0	8.5	8.5	14.7	0.3	6.8	6.8	12.6
CZ13	PGE	2.1	6.8	6.8	12.0	0.1	6.8	6.8	11.9
CZ14	SCE/SCG	1.6	7.9	7.9	13.2	0.4	7.3	7.3	12.4
CZ14	SDGE	1.6	7.9	7.9	13.2	0.4	7.3	7.3	12.4
CZ15	SCE/SCG	1.6	4.2	4.2	8.6	1.3	6.5	6.5	11.1
CZ16	PG&E	6.0	9.7	9.7	18.1	0.1	8.8	8.8	16.4

Table 31. Summary of Mixed Fuel Efficiency EDR2 Margins and Cost-Effectiveness

Climate Zone	Electric /Gas Utility	Single Family			ADU		
		EE	EE+PV	EE+PV/B	EE	EE+PV	EE+PV/B
CZ01	PGE	12.0	12.0	30.0	14.9	14.9	24.3
CZ02	PGE	8.8	8.8	13.5	9.4	9.4	14.5
CZ03	PGE	5.7	5.7	11.2	6.3	6.3	12.1
CZ04	PGE	4.8	4.8	8.4	6.7	6.7	12.2
CZ04	CPAU	4.8	4.8	8.4	6.7	6.7	12.2
CZ05	PGE	4.8	4.8	16.8	2.3	2.3	7.8
CZ05	PGE/SCG	4.8	4.8	16.8	2.3	2.3	7.8
CZ06	SCE/SCG	6.1	6.1	9.2	6.1	6.1	9.8
CZ07	SDGE	5.5	5.5	8.3	6.3	6.3	9.1
CZ08	SCE/SCG	3.5	3.5	9.5	3.6	3.6	10.1
CZ09	SCE	3.6	3.6	8.6	3.7	3.7	8.9
CZ10	SCE/SCG	3.7	3.7	8.3	3.8	3.8	9.0
CZ10	SDGE	3.7	3.7	8.3	3.8	3.8	9.0
CZ11	PGE	5.7	5.7	11.0	7.5	7.5	13.1
CZ12	PGE	5.3	5.3	11.0	6.8	6.8	12.6
CZ12	SMUD/PGE	5.3	5.3	11.0	6.8	6.8	12.6
CZ13	PGE	4.7	4.7	9.6	7.2	7.2	12.8
CZ14	SCE/SCG	6.2	6.2	11.2	8.5	8.5	14.2
CZ14	SDGE	6.2	6.2	11.2	8.5	8.5	14.2
CZ15	SCE/SCG	4.3	4.3	8.5	6.6	6.6	11.2
CZ16	PG&E	14.9	14.9	22.6	8.7	8.7	16.2

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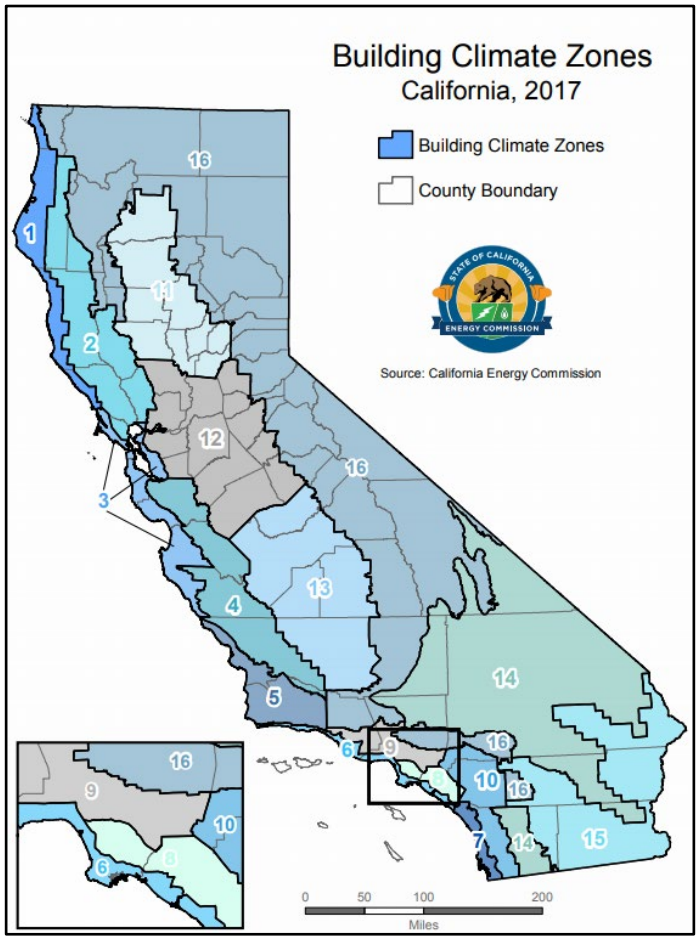
7 Appendices

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

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 2022 credits shows below.[15] 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
PG&E	$39.30						$39.30
SCE	$59.00						$59.00
SDG&E					$64.17	$64.17	

Residential Natural Gas California Climate Credit

The 2022 Natural Gas California Climate Credit is distributed in April.

	2018‡	2019	2020	2021	2022	Total Value Received Per Household 2018-2022
PG&E	$30	$25	$27	$25	$47.83	**$154**
SDG&E	*	$34	$21	$18	$43.06	**$116**
Southwest Gas	$22	$25	$27	$28	$49.44	**$150**
SoCalGas	*	$50	$26	$22	$44.17	**$142**

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 32 describes the baseline territories that were assumed for each climate zone. A net surplus compensation rate of $0.0362 / kWh was applied to any net annual electricity generation based on a one-year average of the rates between April 2021 and March 2022.

[15] https://www.cpuc.ca.gov/industries-and-topics/natural-gas/greenhouse-gas-cap-and-trade-program/california-climate-credit

Table 32: PG&E Baseline Territory by 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 for the 12-month period ending August 2021 according to the rates shown in Table 33. The corresponding CARE rates are shown in Table 34.

Table 33: PG&E Monthly Gas Rate ($/therm)

Month	Procurement Charge	Transportation Charge		Total Charge	
		Baseline	Excess	Baseline	Excess
Jan 2022	$0.76338	$1.33589	$1.79545	$2.09927	$2.55883
Feb 2022	$0.73412	$1.33589	$1.79545	$2.07001	$2.52957
Mar 2022	$0.61773	$1.33589	$1.79545	$1.95362	$2.41318
Apr 2021	$0.22304	$1.19868	$1.68034	$1.42172	$1.90338
May 2021	$0.21063	$1.19868	$1.68034	$1.40931	$1.89097
June 2021	$0.21778	$1.20019	$1.68243	$1.41797	$1.90021
July 2021	$0.19109	$1.20019	$1.68243	$1.39128	$1.87352
Aug 2021	$0.22551	$1.20019	$1.68243	$1.4257	$1.90794
Sept 2021	$0.44379	$1.20019	$1.68243	$1.64398	$2.12622
Oct 2021	$0.68120	$1.20019	$1.68243	$1.88139	$2.36363
Nov 2021	$0.81218	$1.20019	$1.68243	$2.01237	$2.49461
Dec 2021	$0.82555	$1.20019	$1.68243	$2.02574	$2.50798

Table 34: PG&E Monthly CARE (GL-1) Gas Rate ($/therm)

Month	CARE Discount		Total CARE Charge	
	Baseline	Excess	Baseline	Excess
Jan 2022	($0.41947)	($0.51139)	$1.67790	$2.04554
Feb 2022	($0.41362)	($0.50553)	$1.65449	$2.02214
Mar 2022	($0.39034)	($0.48226)	$1.56138	$1.92902
Apr 2021	($0.28372)	($0.38006)	$1.13490	$1.52022
May 2021	($0.28124)	($0.37757)	$1.12497	$1.51030
June 2021	($0.28297)	($0.37942)	$1.13190	$1.51769
July 2021	($0.27764)	($0.37408)	$1.11054	$1.49634
Aug 2021	($0.28452)	($0.38097)	$1.13808	$1.52387
Sept 2021	($0.32818)	($0.42462)	$1.31270	$1.69850
Oct 2021	($0.37566)	($0.47211)	$1.50263	$1.88842
Nov 2021	($0.40185)	($0.49830)	$1.60742	$1.99321
Dec 2021	($0.40453)	($0.50098)	$1.61811	$2.00390

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Revised Cal. P.U.C. Sheet No. 35436-G
Cancelling Revised Cal. P.U.C. Sheet No. 34288-G

GAS SCHEDULE G-1 Sheet 2
RESIDENTIAL SERVICE

BASELINE QUANTITIES: The delivered quantities of gas shown below are billed at the rates for baseline use.

BASELINE QUANTITIES (Therms Per Day Per Dwelling Unit)

Baseline Territories ***	Summer (April-October) Effective Apr. 1, 2020		Winter Off-Peak (Nov,Feb,Mar) Effective Nov. 1, 2019		Winter On-Peak (Dec, Jan) Effective Dec. 1, 2019		(T) | (T)
P	0.39	(R)	1.88	(R)	2.16	(I)	
Q	0.59	(R)	1.55	(R)	2.16	(I)	
R	0.36	(R)	1.28	(R)	1.97	(I)	
S	0.39	(R)	1.38	(R)	2.06	(I)	
T	0.59	(R)	1.38	(R)	1.81	(I)	
V	0.62	(R)	1.51	(R)	1.84	(I)	
W	0.39	(R)	1.18	(R)	1.84	(I)	
X	0.49	(R)	1.55	(R)	2.16	(I)	
Y	0.69	(R)	2.15	(R)	2.65	(I)	

SEASONAL CHANGES: The summer season is April-October, the winter off-peak season is November, February and March, and the winter on-peak season is December and January. Baseline quantities for bills that include the April 1, November 1 and December 1 seasonal changeover dates will be calculated by multiplying the applicable daily baseline quantity for each season by the number of days in each season for the billing period.

GAS SCHEDULE GL-1 Sheet 2
RESIDENTIAL CARE PROGRAM SERVICE

BASELINE QUANTITIES: The delivered quantities of gas shown below are billed at the rates for baseline use.

BASELINE QUANTITIES (Therms Per Day Per Dwelling Unit)

Baseline Territories **	Summer (April-October) Effective Apr. 1, 2020		Winter Off-Peak (Nov,Feb,Mar) Effective Nov. 1, 2019		Winter On-Peak (Dec, Jan) Effective Dec. 1, 2019		(T) | (T)
P	0.39	(R)	1.88	(R)	2.16	(I)	
Q	0.59	(R)	1.55	(R)	2.16	(I)	
R	0.36	(R)	1.28	(R)	1.97	(I)	
S	0.39	(R)	1.38	(R)	2.06	(I)	
T	0.59	(R)	1.38	(R)	1.81	(I)	
V	0.62	(R)	1.51	(R)	1.84	(I)	
W	0.39	(R)	1.18	(R)	1.84	(I)	
X	0.49	(R)	1.55	(R)	2.16	(I)	
Y	0.69	(R)	2.15	(R)	2.65	(I)	

SEASONAL CHANGES: The summer season is April-October, the winter off-peak season is November, February and March, and the winter on-peak season is December and January. Baseline quantities for bills that include the April 1, November 1 and December 1 seasonal changeover dates will be calculated by multiplying the applicable daily baseline quantity for each season by the number of days in each season for the billing period.

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Revised Cal. P.U.C. Sheet No. 52702-E
Cancelling Revised Cal. P.U.C. Sheet No. 52397-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 RATES

Total Energy Rates ($ per kWh)	PEAK		OFF-PEAK	
Summer				
Total Usage	$0.48814	(I)	$0.42470	(I)
Baseline Credit (Applied to Baseline Usage Only)	($0.09018)	(R)	($0.09018)	(R)
Winter				
Total Usage	$0.39106	(I)	$0.37373	(I)
Baseline Credit (Applied to Baseline Usage Only)	($0.09018)	(R)	($0.09018)	(R)
Delivery Minimum Bill Amount ($ per meter per day)	$0.34810	(I)		
California Climate Credit (per household, per semi-annual payment occurring in the April and October bill cycles)	($39.30)	(R)		

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 6509-E-A
Decision

Issued by
Robert S. Kenney
Vice President, Regulatory Affairs

Submitted February 25, 2022
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Pacific Gas and Electric Company
U 39 San Francisco, California

Revised Cal. P.U.C. Sheet No. 46190-E
Cancelling Revised Cal. P.U.C. Sheet No. 43414-E

ELECTRIC SCHEDULE E-TOU-C Sheet 4 (T)
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 (also see Rule 19 for additional allowances for medical needs):

BASELINE QUANTITIES (kWh PER DAY)

	Code B - Basic Quantities		Code H - All-Electric Quantities	
	Summer	Winter	Summer	Winter
Baseline Territory*	Tier I	Tier I	Tier I	Tier I
P	14.2	12.0	16.0	27.4
Q	10.3	12.0	8.9	27.4
R	18.6	11.3	20.9	28.1
S	15.8	11.1	18.7	24.9
T	6.8	8.2	7.5	13.6
V	7.5	8.8	10.9	16.9
W	20.2	10.7	23.6	20.0
X	10.3	10.5	8.9	15.4
Y	11.0	12.1	12.6	25.3
Z	6.2	8.1	7.0	16.5

2. TIME PERIODS FOR **E-TOU-C**: Times of the year and times of the day are defined as follows: (T)

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 5759-E Issued by Submitted February 14, 2020
Decision D.19-07-004 **Robert S. Kenney** Effective March 1, 2020
Vice President, Regulatory Affairs Resolution

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Revised Cal. P.U.C. Sheet No. 52659-E
Cancelling Revised Cal. P.U.C. Sheet No. 52371-E

ELECTRIC SCHEDULE E-1 Sheet 1
RESIDENTIAL SERVICES

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; to single-phase and polyphase service in common areas in a multifamily complex (see Special Condition 8); and to all single-phase and polyphase farm service on the premises operated by the person whose residence is supplied through the same meter.

The provisions of Schedule S—Standby Service Special Conditions 1 through 6 shall also apply to customers whose premises are regularly supplied in part (but not in whole) by electric energy from a nonutility source of supply. These customers will pay monthly reservation charges as specified under Section 1 of Schedule S, in addition to all applicable Schedule E-1 charges. See Special Conditions 11 and 12 of this rate schedule for exemptions to standby charges.

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

RATES: Total bundled service charges are calculated using the total rates below. Customers on this schedule are subject to the delivery minimum bill amount shown below applied to the delivery portion of the bill (i.e. to all rate components other than the generation rate). In addition, total bundled charges will include applicable generation charges per kWh for all kWh usage.

Customers receiving a medical baseline allowance shall pay for all usage based on the rates shown below, and shall not pay the Wildfire Fund Charge. Customers receiving a medical baseline allowance shall also receive a 50 percent discount on the delivery minimum bill amount shown below.

Direct Access (DA) and Community Choice Aggregation (CCA) charges shall be calculated in accordance with the paragraph in this rate schedule titled Billing.

TOTAL RATES

Total Energy Rates ($ per kWh)	
Baseline Usage	$0.31465 (I)
101% - 400% of Baseline	$0.39454 (I)
High Usage Over 400% of Baseline	$0.49318 (I)
Delivery Minimum Bill Amount ($ per meter per day)	$0.34810 (I)
California Climate Credit (per household, per semi-annual payment occurring in the April and October bill cycles)	($39.30) (R)

(Continued)

Advice 6509-E-A
Decision

Issued by
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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 **Robert S. Kenney** 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. Table 35 describes the baseline territories that were assumed for each climate zone. A net surplus compensation rate of $0.03339 / kWh was

applied to any net annual electricity generation based on a one-year average of the rates between April 2021 and March 2022.

Table 35: SCE Baseline Territory by 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

1. 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. 73153-E
Cancelling Revised Cal. PUC Sheet No. 72676-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 weekdays, 4:00 p.m. to 9:00 p.m., as described in Special Conditions 1 and 3, below:

	Delivery Service Total[1]	Generation[2] UG***	Generation[2] DWREC[3]
Option 4-9 PM / Option 4-9 PM-CPP			
Energy Charge - $/kWh			
Summer Season - On-Peak	0.31186 (I)	0.21245 (I)	0.00000
Mid-Peak	0.31186 (I)	0.11358 (I)	0.00000
Off-Peak	0.24154 (I)	0.08653 (I)	0.00000
Winter Season - Mid-Peak	0.31186 (I)	0.14750 (I)	0.00000
Off-Peak	0.24154 (I)	0.10679 (I)	0.00000
Super-Off-Peak	0.23317 (I)	0.08321 (I)	0.00000
Baseline Credit**** - $/kWh	(0.08844) (I)	0.00000	
Basic Charge - $/day			
Single-Family Residence	0.031		
Multi-Family Residence	0.024		
Minimum Charge** - $/day			
Single Family Residence	0.346		
Multi-Family Residence	0.346		
Minimum Charge (Medical Baseline)** - $/day			
Single Family Residence	0.173		
Multi-Family Residence	0.173		
California Climate Credit[10]	(59.00) (I)		
California Alternate Rates for Energy Discount - %[4]	100.00*		
Family Electric Rate Assistance Discount - [4]	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*****			
Summer Season		(0.68554) (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 ($0.00020) per kWh is recovered in the UG component of Generation. (R)
**** The Baseline Credit applies up to 100% of the Baseline Allocation, regardless of Time of Use. The Baseline Allocation is 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 4719-E
Decision
2C8

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Vice President

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

Revised Cal. PUC Sheet No. 73148-E
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Schedule D
DOMESTIC SERVICE

Sheet 2

(Continued)

RATES

	Delivery Service Total[1]	Generation[2] UG***	Generation[2] DWREC[3]
Energy Charge- $/kWh/Meter/Day			
Baseline Service			
Summer	0.17154 (I)	0.11259 (I)	0.00000
Winter	0.17154 (I)	0.11259 (I)	0.00000
Nonbaseline Service*			
101% - 400% of Baseline - Summer	0.25252 (I)	0.11259 (I)	0.00000
Winter	0.25252 (I)	0.11259 (I)	0.00000
High Usage Charge			
(Over 400% of Baseline) - Summer	0.34380 (I)	0.11259 (I)	0.00000
- Winter	0.34380 (I)	0.11259 (I)	0.00000
Basic Charge - $/Meter/Day			
Single-Family Accommodation	0.031		
Multi-Family Accommodation	0.024		
Minimum Charge** - $/Meter/Day			
Single-Family Accommodation	0.346		
Multi-Family Accommodation	0.346		
Minimum Charge (Medical Baseline)** - $/Meter/Day			
Single-Family Accommodation	0.173		
Multi-Family Accommodation	0.173		
California Climate Credit[10]	(59.00) (I)		

* Nonbaseline Service includes all kWh in excess of applicable Baseline allocations as described in Preliminary Statement, Part H, Baseline Service.
** The Minimum Charge is applicable when the Delivery Service Energy Charge, minus the DWRBC, plus the applicable Basic Charge is less than the Minimum Charge. The difference between these two amounts is the Balance of Minimum Charge and is included on a Customer's bill.
*** The ongoing Competition Transition Charge (CTC) of ($0.00020) per kWh is recovered in the UG component of Generation. (R)
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 Generation 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)

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2C8

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Rosemead, California (U 338-E) Cancelling Revised Cal. PUC Sheet No. 72673-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 28.5 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 $0.01070 per kWh and the Department of Water Resources Bond Charge of $0.00652 per kWh. The 28.5 percent discount (which includes the exemption of the Fixed Recovery Charge of $0.00016 per kWh) in addition to these exemptions result in an average effective CARE Discount of 32.5 percent. (I) (I) (I)

(Continued)

(To be inserted by utility) Issued by (To be inserted by Cal. PUC)
Advice 4719-E Michael Backstrom Date Submitted Feb 15, 2022
Decision Vice President Effective Mar 1, 2022

7.2.3 Southern California Gas

Following are the SoCalGas natural gas tariffs applied in this study. Table 36 describes the baseline territories that were assumed for each climate zone.

Table 36: SoCalGas Baseline Territory by 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 for the 12-month period ending August 2021 according to the rates shown in Table 37. Historical natural gas rate data was only available for SoCalGas' procurement charges.[16] To estimate total costs by month, the baseline and excess transmission charges were assumed to be relatively consistence and applied for the entire year based on January 2021 and April 2021 costs. CARE rates reflect the 20 percent discount per the GR tariff.

Table 37: SoCalGas Monthly Gas Rate ($/therm)

Month	Procurement Charge	Transportation Charge		Total Charge	
		Baseline	Excess	Baseline	Excess
Jan 2022	$0.83569	$0.82487	$1.23877	$1.66056	$2.07446
Feb 2022	$0.60655	$0.82487	$1.23877	$1.43142	$1.84532
Mar 2022	$0.55921	$0.82487	$1.23877	$1.38408	$1.79798
Apr 2021	$0.31373	$0.80599	$1.20562	$1.11972	$1.51935
May 2021	$0.35684	$0.80599	$1.20562	$1.16283	$1.56246
June 2021	$0.39460	$0.80599	$1.20562	$1.20059	$1.60022
July 2021	$0.42622	$0.80599	$1.20562	$1.23221	$1.63184
Aug 2021	$0.44599	$0.80599	$1.20562	$1.25198	$1.65161
Sept 2021	$0.44425	$0.82487	$1.23877	$1.26912	$1.68302
Oct 2021	$0.57580	$0.82487	$1.23877	$1.40067	$1.81457
Nov 2021	$0.63799	$0.82487	$1.23877	$1.46286	$1.87676
Dec 2021	$0.65129	$0.82487	$1.23877	$1.47616	$1.89006

[16] The SoCalGas procurement and transmission charges were obtained from the following site: https://www.socalgas.com/for-your-business/energy-market-services/gas-prices

SOUTHERN CALIFORNIA GAS COMPANY Revised CAL. P.U.C. SHEET NO. 59651-G
LOS ANGELES, CALIFORNIA CANCELING Revised CAL. P.U.C. SHEET NO. 59610-G

Schedule No. GR Sheet 1
RESIDENTIAL SERVICE
(Includes GR, GR-C and GT-R Rates)

APPLICABILITY

The GR rate is applicable to natural gas procurement service to individually metered residential customers.

The GR-C, cross-over rate, is a core procurement option for individually metered residential core transportation customers with annual consumption over 50,000 therms, as set forth in Special Condition 10.

The GT-R rate is applicable to Core Aggregation Transportation (CAT) service to individually metered residential customers, as set forth in Special Condition 11.

The California Alternate Rates for Energy (CARE) discount of 20%, reflected as a separate line item on the bill, is applicable to income-qualified households that meet the requirements for the CARE program as set forth in Schedule No. G-CARE.

TERRITORY

Applicable throughout the service territory.

RATES	GR	GR-C	GT-R
Customer Charge, per meter per day:	16.438¢	16.438¢	16.438¢
For "Space Heating Only" customers, a daily Customer Charge applies during the winter period from November 1 through April 30[1/]:	33.149¢	33.149¢	33.149¢

7.2.4 San Diego Gas & Electric

Following are the SDG&E electricity and natural gas tariffs applied in this study. Table 38 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 April 2021 and March 2022.

Table 38: SDG&E Baseline Territory by Climate Zone

	Baseline Territory
CZ07	Coastal
CZ10	Inland
CZ14	Mountain

The SDG&E monthly gas rate in $/therm was applied on a monthly basis for the 12-month period ending August 2021 according to the rates shown in Table 39. CARE rates reflect the 20 percent discount per the G-CARE tariff.

Table 39: SDG&E Monthly Gas Rate ($/therm)

Month	Procurement Charge	Transportation Charge		Total Charge	
		Baseline	Excess	Baseline	Excess
Jan 2022	$0.83668	$1.43201	$1.70577	$2.26869	$2.54245
Feb 2022	$0.60727	$1.43201	$1.70577	$2.03928	$2.31304
Mar 2022	$0.55988	$1.43201	$1.70577	$1.99189	$2.26565
Apr 2021	$0.31401	$1.44464	$1.70732	$1.75865	$2.02133
May 2021	$0.35719	$1.44464	$1.70732	$1.80183	$2.06451
June 2021	$0.39498	$1.44464	$1.70732	$1.83962	$2.10230
July 2021	$0.42663	$1.44464	$1.70732	$1.87127	$2.13395
Aug 2021	$0.44642	$1.44464	$1.70732	$1.89106	$2.15374
Sept 2021	$0.44468	$1.44464	$1.70732	$1.88932	$2.15200
Oct 2021	$0.57637	$1.38238	$1.63573	$1.95875	$2.21210
Nov 2021	$0.63862	$1.38238	$1.63573	$2.02100	$2.27435
Dec 2021	$0.65194	$1.38238	$1.63573	$2.03432	$2.28767

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

All Customers:	Daily Therm Allowance
Summer (May 1 to October 31, inclusive)	0.493
Winter (November 1 to April 30, inclusive)	1.546

San Diego Gas & Electric Company
San Diego, California

Revised Cal. P.U.C. Sheet No. 24598-G
Canceling Revised Cal. P.U.C. Sheet No. 17396-G

SCHEDULE G-CARE

Sheet 1

CALIFORNIA ALTERNATE RATES FOR ENERGY (CARE) PROGRAM

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 natural gas by the Utility.

DISCOUNT

The qualified customer will receive a 20% CARE discount on all customer, commodity, and transportation charges on their otherwise applicable service schedule. In addition, the customer will not pay the CARE portion of the Public Purpose Programs Surcharge as specified in Schedule G-PPPS.

SPECIAL CONDITIONS

ALL CUSTOMERS

1. Applicable Conditions. All special conditions contained in the customer's otherwise applicable schedule are applicable to service under this schedule.

2. Application and Eligibility Declaration.* An application and eligibility declaration, on a form authorized by the Commission, is required for service under the CARE program unless otherwise authorized by the Commission. Renewal of a customer's eligibility declaration, also referred to as recertification, will be required at the request of the Utility. N

3. Commencement of CARE Discount. Eligible customers shall begin receiving the CARE discount no later than one billing period after receipt of a completed and approved application by the Utility or as may otherwise be authorized by the Commission.

*Per SDG&E Advice Letter 3516-E-C/2854-G-C, submitted pursuant to Resolution M-4842, certain customer protections will be offered to eligible customers effective March 4, 2020 through April 16, 2021, or as otherwise extended. N N N

(Continued)

1C22
Advice Ltr. No. 2854-G-C
Decision No. M-4842

Issued by
Dan Skopec
Vice President
Regulatory Affairs

Submitted Jun 3, 2020
Effective Mar 4, 2020
Resolution No.

San Diego Gas & Electric Company
San Diego, California

Revised Cal. P.U.C. Sheet No. 35747-E
Canceling Revised Cal. P.U.C. Sheet No. 35358-E

Sheet 2

SCHEDULE TOU-DR1
RESIDENTIAL TIME-OF-USE

RATES

Total Rates:

Description – TOU DR1	UDC Total Rate		DWR BC + WF-NBC		EECC Rate + DWR Credit		Total Rate	
Summer:								
On-Peak	0.25074	I	0.00652	I	0.43976	I	0.69702	I
Off-Peak	0.25074	I	0.00652	I	0.19788	I	0.45514	I
Super Off-Peak	0.25074	I	0.00652	I	0.07083	I	0.32809	I
Winter:								
On-Peak	0.39008	I	0.00652	I	0.14857	I	0.54517	I
Off-Peak	0.39008	I	0.00652	I	0.08335	I	0.47995	I
Super Off-Peak	0.39008	I	0.00652	I	0.06442	I	0.46102	I
Summer Baseline Adjustment Credit up to 130% of Baseline	(0.10159)	R					(0.10159)	R
Winter Baseline Adjustment Credit up to 130% of Baseline	(0.10159)	R					(0.10159)	R
Minimum Bill ($/day)	0.350						0.350	

T

Note:
(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.
(2) Total Rates presented are for customers that receive commodity supply and delivery service from Utility.
(3) DWR-BC 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.

(Continued)

2C8
Advice Ltr. No. 3514-E
Decision No. D.20-01-021
Issued by
Dan Skopec
Vice President
Regulatory Affairs
Submitted Mar 26, 2020
Effective Apr 1, 2020
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
Basic Allowance				
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
All Electric**				
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. 35702-E
Canceling Revised Cal. P.U.C. Sheet No. 35307-E

SCHEDULE DR

Sheet 1

RESIDENTIAL SERVICE
(Includes Rates for DR-LI)

APPLICABILITY

This Schedule is optionally available to domestic service for lighting, heating, cooking, water heating, and power, or combination thereof, in single family dwellings, flats, and apartments, separately metered by the utility; to service used in common for residential purposes by tenants in multi-family dwellings under Special Condition 8; to any approved combination of residential and nonresidential service on the same meter; and to incidental farm service under Special Condition 7.

This schedule is also applicable to customers qualifying for the California Alternate Rates for Energy (CARE) Program and/or Medical Baseline, residing in single-family accommodations, separately metered by the Utility, and may include Non-profit Group Living Facilities and Qualified Agricultural Employee Housing Facilities, if such facilities qualify to receive service under the terms and conditions of Schedule E-CARE. The rates for CARE and Medical Baseline customers are identified in the rates tables below as DR-LI and DR-MB rates, respectively.

Customers on this schedule may also qualify for a semi-annual California Climate Credit $(64.17) per Schedule GHG-ARR. R

TERRITORY

Within the entire territory served by the Utility.

RATES

Total Rates: T

Description - DR Rates	UDC Total Rate		DWR BC + WF-NBC		EECC Rate + DWR Credit		Total Rate	
Summer:								
Up to 130% of Baseline Energy ($/kWh)	0.14915	R	0.00652	I	0.23639	I	0.39206	I
131% - 400% of Baseline ($/kWh)	0.25074	I	0.00652	I	0.23639	I	0.49365	I
Above 400% of Baseline ($/kWh)	0.25074	I	0.00652	I	0.23639	I	0.49365	I
Winter:								
Up to 130% of Baseline Energy ($/kWh)	0.28849	I	0.00652	I	0.09705	I	0.39206	I
131% - 400% of Baseline ($/kWh)	0.39008	I	0.00652	I	0.09705	I	0.49365	I
Above 400% of Baseline ($/kWh)	0.39008	I	0.00652	I	0.09705	I	0.49365	I
Minimum Bill ($/day)	0.350	I					0.350	I

(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
Effective Discount	**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 T

(Continued)

1C5 Issued by Submitted Dec 30, 2021
Advice Ltr. No. 3928-E **Dan Skopec** Effective Jan 1, 2022
Vice President

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 for the 12-month period ending August 2021 according to the rates shown

in Table 40. The distribution charge was $0.4835/therm for Tier 1 and $1.0426/therm for Tier 2. The monthly service charge applied was $10.94 per month per the G-1 tariff in effect at the time of the analysis.

Table 40: CPAU Monthly Gas Rate ($/therm)

Effective Date	Commodity Rate	Cap and Trade Compliance Charge	Transportation Charge	Carbon Offset Charge	G1 Tier 1 Volumetric Totals	G1 Tier 2 Volumetric Totals
Jan 2022	$0.77140	$0.04860	$0.15000	$0.04000	$1.53900	$1.83144
Feb 2022	$0.53600	$0.04860	$0.15000	$0.04000	$1.30360	$1.81874
Mar 2022	$0.53700	$0.04860	$0.15000	$0.04000	$1.30460	$1.8565
Apr 2022	$0.59750	$0.07680	$0.14404	$0.04000	$1.38734	$1.8363
May 2021	$0.39010	$0.04860	$0.12200	$0.04000	$1.10450	$1.8889
June 2021	$0.39820	$0.04860	$0.12214	$0.04000	$1.11274	$1.89714
July 2021	$0.48000	$0.04860	$0.12274	$0.04000	$1.22034	$2.04394
Aug 2021	$0.54920	$0.04860	$0.12274	$0.04000	$1.28954	$2.11314
Sept 2021	$0.52170	$0.04860	$0.12274	$0.04000	$1.26204	$1.78012
Oct 2021	$0.71750	$0.04860	$0.12274	$0.04000	$1.45784	$1.83222
Nov 2021	$0.75050	$0.04860	$0.12274	$0.04000	$1.49084	$1.83472
Dec 2021	$0.63210	$0.04860	$0.12274	$0.04000	$1.37244	$1.80442

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:

Per kilowatt-hour (kWh)	Commodity	Distribution	Public Benefits	Total
Tier 1 usage	$0.08339	$0.04971	$0.00447	$0.13757
Tier 2 usage Any usage over Tier 1	0.11569	0.07351	0.00447	0.19367
Minimum Bill ($/day)				0.3283

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:
This Rate Schedule applies anywhere the City of Palo Alto provides Electric Service.

C. RATE:
The following buyback rate shall apply to all electricity exported to the grid.

	Per kWh
Export electricity compensation rate	$0.1078

7.2.6 Sacramento Municipal Utilities District (Electric Only)

Following are the SMUD electricity tariffs applied in this study.

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
Time-of-Day (5-8 p.m.) Rate (RT02)			
Non-Summer Season (October - May)			
System Infrastructure Fixed Charge *per month per meter*	$22.70	$23.05	$23.50
Electricity Usage Charge			
Peak *$/kWh*	$0.1494	$0.1516	$0.1547
Off-Peak *$/kWh*	$0.1082	$0.1098	$0.1120
Summer Season (June - September)			
System Infrastructure Fixed Charge *per month per meter*	n/a	$23.05	$23.50
Electricity Usage Charge			
Peak *$/kWh*	n/a	$0.3215	$0.3279
Mid-Peak *$/kWh*	n/a	$0.1827	$0.1864
Off-Peak *$/kWh*	n/a	$0.1323	$0.1350

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

7.2.7 Fuel Escalation Assumptions

The average annual escalation rates in Table 41 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 41: 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 Summary of Measures by Package

Table 42 provides the details of the measures in each of the efficiency package by climate zone and case. Table 43 presents the measures for all the single family efficiency + PV + battery packages. Table 44 presents the measures for all the ADU efficiency packages.

Table 42: Single Family Efficiency Package Measures

Climate Zone	3 ACH50	R-10 Slab	Attic	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 vs R-38				X	
2		X	R-60 vs R-38			X	X	X
3			R-60 vs R-30			X	X	X
4		X	R-60 vs R-38			X	X	X
5			R-49 vs R-30			X	X	X
6			R-60 vs R-30			X	X	X
7			R-49 vs R-30				X	X
8			R-60 vs R-38			X	X	X
9			R-60 vs R-38			X	X	X
10			R-60 vs R-38	X		X	X	X
11		X	R-60 vs R-38	X		X	X	X
12		X	R-60 vs R-38	X		X	X	X
13		X	R-60 vs R-38	X		X	X	X
14	X	X	R-60 vs R-38	X		X	X	X
15		X	R-60 vs R-38	X		X	X	X
16			R-60 vs R-38		X	X	X	

Table 43: Single Family Mixed Fuel Efficiency + PV + Battery Package Measures

Climate Zone	3 ACH50	R-10 Slab	Attic	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	Basic Compact Hot Water Credit
1		X				X		X	
2		X	R- 49 vs R-38				X	X	X
3			R-38 vs R-30			X		X	X
4		X	R-49 vs R-38				X	X	X
5			R-49 vs R-30			X		X	X
6			R- 49 vs R-30				X	X	X
7			R-49 vs R-30					X	X
8			R- 49 vs R-38				X	X	X
9			R- 49 vs R-38				X	X	X
10				X			X	X	X
11		X	R-49 vs R-38	X			X	X	X
12		X	R- 49 vs R-38	X			X	X	X
13		X	R- 49 vs R-38	X			X	X	X
14	X	X	R- 49 vs R-38	X			X	X	X
15		X	R- 49 vs R-38	X			X	X	X
16			R- 49 vs R-38		X		X	X	

Table 44: ADU Efficiency Package Measures

Climate Zone	3 ACH50	R-10 Slab	0.25 Roof Solar Reflectance	0.24 U-Factor / 0.50 SHGC Windows	Ductless VCHP	Basic Compact Hot Water Credit
1		X			X	
2		X			X	X
3					X	X
4		X			X	X
5					X	X
6					X	X
7					X	X
8					X	X
9					X	X
10			X		X	X
11		X	X		X	X
12		X	X		X	X
13		X	X		X	X
14	X	X	X		X	X
15		X	X		X	X
16				X	X	

The efficiency measures added to the All-Electric prescriptive package in Climate Zones that were not compliant are shown in Table 45 and

Table 46.

Table 45: Single Family All-Electric Code Compliant Efficiency Measures

Climate Zone	0.24 U-Factor / 0.50 SHGC Windows	Basic Compact Hot Water Credit
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
11		
12		
13		
14		
15		X
16	X	

Table 46: ADU All-Electric Code Compliant Efficiency Measures

Climate Zone	3 ACH50	R-49 vs R-38 Attic Insulation	0.30 U-Factor / 0.50 SHGC Windows	0.24 U-Factor / 0.50 SHGC Windows	Improved HVAC Fan Efficiency: 0.35 W/cfm	Basic Compact Hot Water Credit
1						
2						
3						
4						X
5			X			X
6						X
7						X
8					X	X
9					X	X
10					X	X
11						
12						
13						X
14					X	X
15					X	X
16	X	X		X	X	

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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