

2019 Cost-Effectiveness Study: 2020 Analysis of High-Rise Residential New Construction

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Acronym List

2020 PV\$	Present Value costs in 2020 dollars
ACM	Alternative Calculation Method
B/C	Benefit-to-Cost as in Benefit-to-Cost ratio
BSC	Building Standards Commission
CALGreen	California Green Building Standards Code (California Code of Regulations Title 24, Part 11)
CASE	Codes and Standards Enhancement
CBECC-Com	California Building Energy Code Compliance software program developed by the California Energy Commission for use in demonstrating compliance with the Non-Residential California Building Energy Efficiency Standards
cfm	Cubic Feet per Minute
CPAU	City of Palo Alto Utilities
CPC	California Plumbing Code
CZ	California Climate Zone
DOAS	Dedicated Outdoor Air System
ERV/HRV	Energy- or Heat-Recovery Ventilation
EPS	Expanded Polystyrene
ft ²	Square foot
GHG	Greenhouse Gas
GRC	General Rate Case
HERS Rater	Home Energy Rating System Rater
HPWH	Heat Pump Water Heater
HVAC	Heating, Ventilation, and Air Conditioning
IOU	Investor-Owned Utility
kBtu	kilo-British thermal unit
kWh	kilowatt-hour
KWDC	Direct Current kilowatt. Nominal rated power of a photovoltaic system
LCC	Lifecycle Cost
NEM	Net Energy Metering
NPV	Net Present Value
PG&E	Pacific Gas and Electric Company
PV	Photovoltaic
SCE	Southern California Edison

SDG&E	San Diego Gas and Electric
SHGC	Solar Heat Gain Coefficient
SMUD	Sacramento Municipal Utility District
TDV	Time Dependent Valuation
therm	Unit for quantity of heat that equals 100,000 British thermal units
Title 24	California Code of Regulations Title 24, Part 6
TOU	Time-Of-Use
UEF	Uniform Energy Factor
W	Watt
WDC	Watt Direct Current.

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1 Introduction

The California Codes and Standards 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 and greenhouse gas (GHG) reduction goals. The program facilitates adoption and implementation of the code when requested by local jurisdictions by providing resources such as cost-effectiveness studies, model language, sample findings, and other supporting documentation. This cost-effectiveness study was sponsored by Pacific Gas and Electric Company (PG&E). Local jurisdictions that are considering adopting ordinances may contact the program for support through its website, [LocalEnergyCodes.com](https://www.localenergycodes.com).

The California Building Energy Efficiency Standards Title 24, or Title 24, Part 6 (Title 24) (California Energy Commission, 2018a) 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 result in buildings consuming less 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.

This report documents cost-effective combinations of measures that exceed the minimum state requirements, 2019 Title 24, effective January 1, 2020. Local jurisdictions in California may consider adopting local energy ordinances to achieve energy savings beyond what will be accomplished by enforcing building efficiency requirements that apply statewide. This report was developed in coordination with the California Statewide Investor-Owned Utilities (IOUs) Codes and Standards Program, key consultants, and engaged cities—collectively known as the Statewide Reach Codes Team.

The focus of this study is on new high-rise (eight stories and higher) multifamily residential construction. The analysis evaluates both mixed-fuel and all-electric residential construction, documenting performance requirements that can be met by either type of building design. Compliance package options and cost-effectiveness analysis in all 16 California climate zones (CZs) are presented (see Appendix A – Map of California Climate Zones for a graphical depiction of climate zone locations). This analysis complements the analysis conducted for mid-rise multifamily residential construction in June 2020 (Statewide Reach Codes Team, 2020).

2 Methodology and Assumptions

This analysis uses two different metrics to assess cost effectiveness. Both methodologies require estimating and quantifying the incremental costs and energy savings associated with energy efficiency measures. The main difference between the methodologies is the way 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 On-Bill savings using electricity and natural gas utility rate schedules over a 30-year duration accounting for discount rate and energy cost inflation.
- **Time Dependent Valuation (TDV):** Energy Commission LCC methodology, which is intended to capture the “societal value or cost” of energy use including 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. Electricity used (or saved) during peak periods has a much higher value than electricity used (or saved) during off-peak periods (Horii et al., 2014). This is the methodology used by the Energy Commission in evaluating cost effectiveness for efficiency measures in Title 24. Both 2019 and 2022 TDV multipliers are evaluated and documented in this analysis.

The general approach applied in this analysis is to evaluate performance and determine cost effectiveness of various packages of energy measures in high-rise multifamily dwelling units. The California Building Energy Code Compliance – Commercial (CBECC-Com) 2019.1.3 and 2022 beta compliance simulation tools were used to evaluate energy savings for all measures. 2022 weather files were used to evaluate site energy use and TDV cost effectiveness along with the 2022 TDV.

2.1 Building Prototypes

The Energy Commission defines building prototypes which it uses to evaluate the cost effectiveness of proposed changes to Title 24 requirements. The Energy Commission recently developed new prototype designs for multifamily buildings to more closely reflect typical designs for new multifamily buildings across the state. The new prototypes include two low-rise residential designs, a mid-rise, and a high-rise design. This analysis uses the new high-rise multifamily prototype (TRC, 2019), which is a variation of the previous ten-story high-rise prototype used in prior code cycles. The high-rise prototype is a ten-story building with two below-grade parking levels, ground floor commercial space, and nine stories of residential space. Table 1 describes the basic characteristics of the high-rise prototype and Figure 1 shows a depiction of the building.

Table 1: Prototype Characteristics

Multifamily 10-Story High-Rise	
Conditioned Floor Area	125,400 Square Foot (ft ²) Total: 24,960 ft ² Nonresidential ^a & 100,440 ft ² Residential
Number of Stories	12 Stories Total: 2-Story Parking Garage (below grade) 1 Story of Nonresidential Space 9 Stories of Residential Space
Number of Dwelling Units/Bedrooms	(18) Studios, (54) 1-Bed Units, & (45) 2-Bed Units
Foundation	Concrete Podium with Underground Parking
Wall Assembly	Steel Frame
Roof Assembly	Flat Roof
Window-to-Wall Area Ratio	40%
HVAC System	Ducted split system heat pumps at each dwelling unit. Dedicated outdoor air system for dwelling unit ventilation.
Domestic Hot Water System	Gas central boiler with solar thermal sized to meet the prescriptive requirements by climate zone.

^a. includes ground floor commercial space, corridors and common areas.

Source: TRC, 2019.



Figure 1: Ten-story high-rise multifamily prototype depiction.

Source: TRC, 2019.

The methodology used in the analyses for the prototypical building type begins with a design that meets the minimum 2019 Title 24 prescriptive requirements (zero compliance margin). Table 140.3-B and 140.3-C in the 2019 Title 24 (California Energy Commission, 2018a) list the prescriptive measures that determine the baseline design in each climate zone for the nonresidential and high-rise residential spaces, respectively. Other features are consistent with the Standard Design in the Nonresidential Alternative Calculation Method (ACM) Reference Manual (California Energy Commission, 2019a) with two exceptions:

1. The dwelling units use split system heat pumps instead of a split furnace and air conditioner that is prescribed in Table 2 of the Nonresidential ACM Reference Manual. This modeling choice was made to better reflect current market data, which shows heat pumps to be the most common system type and a very low prevalence of gas furnaces for multifamily buildings four stories and greater (TRC, 2019). In most climate zones the difference between a heat pump or gas furnace is nearly compliance neutral.
2. A dedicated outdoor air system (DOAS) is used for ventilation serving the dwelling units. This is based on anecdotal information that this practice is more common than individual ventilation systems in high-rise buildings. It also provides variability across the mid- and high-rise analysis, which is important so that this analysis provides more realistic solutions for the high-rise multifamily building type. The selection of a DOAS does not match the Standard Design, which applies individual balanced fans for ventilation at all residential spaces, and results in a small compliance penalty.¹

The analysis also assumed electric resistance cooking in the dwelling unit units to reflect the current market based on anecdotal information. Laundry was not addressed in this study. The building prototype assumes central laundry facilities and no laundry in the units.

2.2 Measure Analysis

EnergyPro software, using CBECC-Com as the simulation engine, was used to evaluate energy impacts and code compliance applying the 2019 Title 24 prescriptive standards as the benchmark. TDV is the energy metric used by Title 24 since 2005 to evaluate compliance. Although both the 2019 and 2022 compliance software were used for evaluation, the 2019 software was used for reporting compliance margins and the 2022 software, with the 2022 weather, was used for reporting site energy and utility bill impacts.

Using the 2019 baseline as the starting point, prospective energy efficiency measures were identified and modeled to determine the projected site energy (therm and kWh) and compliance impacts. Annual utility costs were calculated using hourly data output from CBECC-Com, and electricity and natural gas tariffs for each of the IOUs.

The Statewide Reach Codes Team selected measures for evaluation based on prior residential and nonresidential 2019 reach code analysis ((Statewide Reach Codes Team, 2019a), (Statewide Reach Codes Team, 2019b), (Statewide Reach Codes Team, 2020)) as well as experience with and outreach to architects, builders, and engineers and general knowledge of the relative acceptance of many measures. This analysis focuses on the residential dwelling units only. A prior study and report demonstrated the cost effectiveness of above code packages for nonresidential buildings (Statewide Reach Codes Team, 2019a).

2.2.1 Federal Preemption

The United States Department of Energy sets minimum efficiency standards for equipment and appliances that are federally regulated under the National Appliance Energy Conservation Act of 1975, including heating, cooling, and water heating equipment. Since state and local governments are prohibited from adopting policies that mandate higher minimum efficiencies than the federal standards require (federal preemption), the focus of this study is to identify and evaluate cost-effective packages that do not include high efficiency equipment. While this

¹ The compliance penalty is not reflected in the results in this analysis since the baseline and proposed designs both include a DOAS.

study is limited by federal preemption, in practice builders may use any package of compliant measures to achieve the performance goals, including high efficiency appliances. Often, these measures are the simplest and most affordable measures to increase energy performance.

2.2.2 Energy Efficiency Measures

Following are descriptions of each of the efficiency measures evaluated for the residential spaces under this analysis. Because not all of the measures described below were found to be cost-effective, and cost effectiveness varied by climate zone, not all measures are included in all packages and some of the measures listed are not included in any final package.

Improved Fenestration – Lower U-factor: Reduce window U-factor to 0.25 Btu/hour-ft²-°F. The prescriptive maximum U-factor is 0.36 in all climates. This measure applies to all windows on floors two through ten.

Improved Fenestration – Lower SHGC: Reduce window solar heat gain coefficient (SHGC) to 0.22. The prescriptive maximum SHGC is 0.25 for fixed windows in all climates. The Statewide Reach Codes Team evaluated increased SHGC in heating dominated climates (Climate Zones 1, 3, 5, and 16) but results were better with a lower SHGC. This measure applies to all windows on floors two through ten.

Exterior Wall Insulation: Additional R-4 exterior continuous insulation on exterior walls. To meet the prescriptive wall requirements, it is assumed that exterior wall insulation is used in the base case, therefore this measure adds the additional R-value to existing exterior insulation. This measure applies to all walls on floors two through ten.

HERS Verification of Hot Water Pipe Insulation: The California Plumbing Code (CPC) requires pipe insulation on all hot water lines. This measure provides credit for HERS Rater verification of pipe insulation requirements according to the procedures outlined in the 2019 Reference Appendices RA3.6.3. (California Energy Commission, 2018b).

Low Pressure Drop Ducts: Upgrade the duct distribution system to reduce external static pressure and meet a maximum fan efficacy of 0.25 watts (W) per cubic feet per minute (cfm) operating at full speed. This may involve upsizing ductwork, reducing the total effective length of ducts, and/or selecting low pressure drop components, such as filters. This measure is applied to the ducted split system heat pumps serving the dwelling units.

Energy- or Heat- Recovery Ventilation: An energy- or heat-recovery ventilation (ERV/HRV) system installed on the central DOAS with 67 percent sensible recovery effectiveness and 1.0 W/cfm fan efficacy (total including both supply and return fans). The DOAS in the base case model also has a 1.0 W/cfm fan efficacy, so there is no fan efficacy credit or penalty evaluated for this measure.

Solar Thermal: Prescriptively, central water heating systems require a solar thermal system with a 20 percent solar fraction in Climate Zones 1 through 9 and 35 percent solar fraction in Climate Zones 10 through 16. This measure upgrades the prescriptive solar thermal system to meet a 50 percent solar fraction in all climates, assuming there is available roof space for the additional collectors.

2.2.3 Equipment Fuel Substitution Measures – Water Heating

Since the base case prototype model assumes individual heat pumps for space heating and all-electric appliances in the dwelling units, the central domestic hot water system is the only equipment serving the dwelling unit spaces to electrify in the all-electric design. The Statewide Reach Codes Team evaluated two configurations for electric heat pump water heaters (HPWHs) described below.

New functionality was added to CBECC-Com 2019.1.3 with the ability to model central HPWH systems. There are two primary system types: “Small, Integrated, Packaged System” and “Large Single Pass Primary”. The former allows for modeling 40- to 85-gallon residential HPWHs including Northwest Energy Efficiency Alliance rated units and is how the clustered approach referred to in this analysis is modeled. The latter models large central HPWHs and covers various product models over six manufacturers (at the time of writing this report). CBECC-Com 2019.1.3 also provides a “Solar Thermal Flexibility Credit” to allow for projects with electric central water heating to use a photovoltaic (PV) system to offset the energy use of the solar thermal system in the Standard Design base case. Under these conditions, PV’s impact on compliance margin is limited to the value of the solar thermal credit.

Central HPWH with Recirculation: Per Section 150.1(c)8C of 2019 Title 24, the Energy Commission made an executive determination outlining requirements of a prescriptive approach for central heat pump water heating systems in December 2019 (California Energy Commission, 2019b). Key aspects of the prescriptive approach are described below:

- The system must be configured with a design similar to what is presented in the schematic in Figure 2, copied from the executive determination document.
- HPWH must be a single-pass split system with the compressor located outdoors and be able to operate down to -20°F.
- The system must include either a solar thermal water heating system that meets the current prescriptive requirements or 0.1 direct current kilowatt (kW_{DC}) of PV system capacity per dwelling unit/dwelling unit.

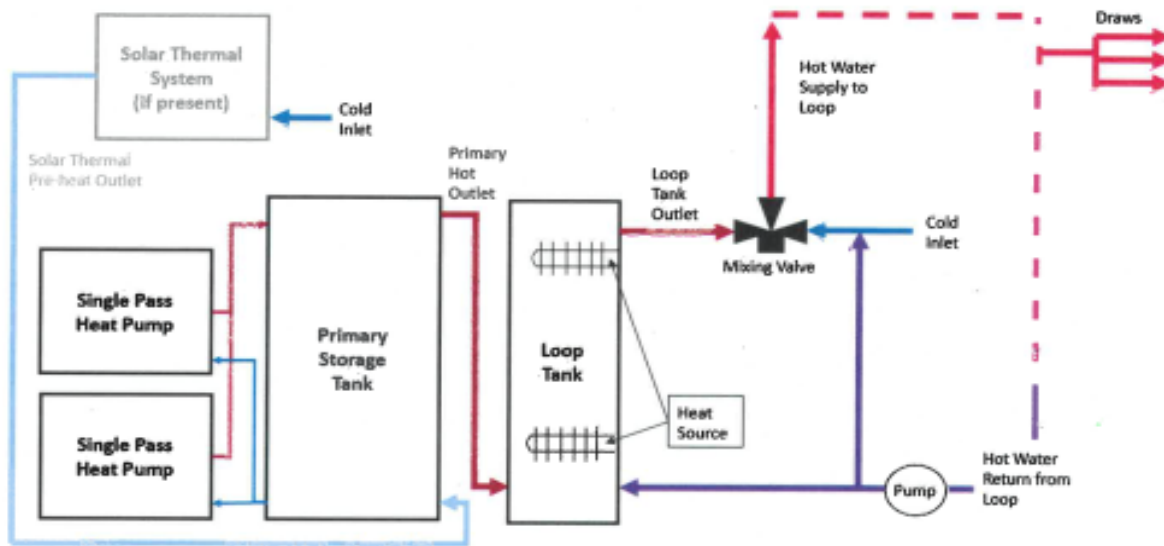


Figure 2: Prescriptive central HPWH system schematic.

Source: Energy Commission (California Energy Commission, 2019b).

For this configuration, the Statewide Reach Codes Team evaluated a central recirculating HPWH system using Sanden compressors that meet the prescriptive requirements. Based on the system sizing requirements, 19 Sanden units and 1,520 gallons of primary storage capacity are required for the 117-dwelling unit building. The system is modeled with the tanks located indoors in a conditioned zone and source air provided from outdoors with the Sanden units likely located on rooftops. The rooftop space required for the heat pump units and the prescriptive PV system (0.1 kW_{DC} per dwelling unit) will be similar or less than that required for the prescriptive solar thermal water heating system. The recirculation system is demand controlled meeting the requirements of the 2019 Reference Appendices RA4.4.13.

Clustered HPWH: This clustered design uses residential integrated storage HPWHs to serve more than one dwelling unit; four to five bedrooms on average for a total of 38 HPWHs in the 117-dwelling unit, 162-bed building. The water heaters are located in conditioned interior closets throughout the building and designed for short plumbing runs without using a hot water recirculation loop. A minimum efficiency 2.0 uniform energy factor (UEF) HPWH was used for this analysis (to avoid federal preemption). This approach has been selectively used in multifamily projects because of its reliance on lower cost, small capacity HPWH products. The clustered strategy is not a prescriptive option but is allowed in the performance path if the water heater serves no more than eight units. Since each water heater serves multiple dwelling units, the Standard Design includes a solar thermal water heating system and the project is penalized in compliance if a solar thermal or PV system is not included.

2.2.4 Renewable Energy

PV: There is no existing requirement for PV in the 2019 Title 24 nonresidential code for high-rise residential buildings (four or more stories). The PV sizing methodology was developed to offset a portion of annual residential electricity use and avoid oversizing which would violate net energy metering (NEM) rules. In all cases, PV is evaluated with the PV simulations within CBECC-Com using a standard module type, 180-degree azimuth, and 22-degree tilt. The analysis evaluated a PV system capacity equal to 0.1 and 0.2 kW_{DC} per dwelling unit. Assuming 15 W per ft² this requires 780 to 1,560 ft² of the 12,540 ft² rooftop. The benefit of the PV was applied to the dwelling units assuming virtual NEM.

2.2.5 Nonresidential and Common Area Spaces

Efficiency measure packages and electric equipment (for the all-electric analysis) found to be cost-effective in the nonresidential building reach code analysis were applied to the nonresidential spaces for evaluating performance relative to compliance, but the incremental costs and energy impacts of these measures on the nonresidential spaces were not included in this analysis. Refer to the nonresidential reach code study for more details (Statewide Reach Codes Team, 2019a).

2.3 Package Development

Three types of measure packages were evaluated for each climate zone to identify cost-effective combinations, as described below.

1. **Efficiency Packages:** These packages combine efficiency measures that do not trigger federal preemption including envelope, water heating distribution, and duct distribution efficiency measures.
2. **Fuel Substitution:** In addition to applying the efficiency measures these packages also use electric appliances in place of natural gas appliances. For the residential spaces, only water heating is converted from using natural gas to electricity.
 - a. For water heating both a central design with recirculation and a clustered design are evaluated.
3. **Efficiency and PV Packages (with or without fuel substitution):** In addition to applying efficiency measures these packages have a PV system to offset a portion of dwelling unit estimated electricity use.

2.4 Measure Cost

Measure costs were obtained from various sources, including prior reach code studies, past Title 24 Codes and Standards Enhancement (CASE) work (developed by the Statewide CASE Team), local contractors, internet searches, past projects, and technical reports.

2.4.1 Energy Efficiency and Renewable Measures

Table 2 summarizes the incremental cost assumptions for the residential measures evaluated in this study. Incremental costs represent the equipment, installation, replacement, and maintenance costs of the proposed measures relative to the base case. Replacement costs are applied to PV inverters and water heating equipment over the 30-year evaluation period. There is no assumed incremental maintenance on the envelope, HVAC, or water heating measures. Costs were estimated to reflect costs to the building owner. When costs were obtained from a source that did not already include builder overhead and profit, a markup of ten percent was added. All costs are provided as present value in 2020 (2020 PV\$). Costs due to variations in heat pump capacity by climate zone were not accounted for in the analysis. While the efficiency measures will reduce required cooling and heating capacities, in most cases they will not be reduced enough to drop to the next nominal capacity system.

Table 2: Incremental Cost Details

Measure	Performance Level	Incremental Cost (2020 PV\$)	Source & Notes
Non-Preempted Measures			
Window U-factor	0.25 vs 0.36	\$27,342	\$6.95/ft ² window area based on analysis conducted for the 2019 and 2022 Title 24 code cycles (Statewide CASE Team, 2018).
Window SHGC	0.22 vs 0.25	\$0	Data from CASE Report along with direct feedback from Statewide CASE Team that higher SHGC does not necessarily have any incremental cost impact (Statewide CASE Team, 2017b).
Exterior Wall Insulation	Add 1 inch	\$8,497	\$0.86/ft ² based on adding 1 inch of exterior insulation on exterior walls with some level of existing exterior insulation. Costs are averaged from two sources ((Statewide CASE Team, 2014), (Statewide CASE Team, 2017a)) and for both expanded polystyrene (EPS) and polyisocyanurate products with a 10% mark-up added to account for cost increases since the time of the report.
HERS Verified Pipe Insulation	HERS verified pipe insulation vs no verification	\$13,275	\$83 per dwelling unit for a HERS Rater to conduct verification of pipe insulation based on feedback from HERS Raters.
Low Pressure Drop Duct Design	0.25 W/cfm vs 0.35 W/cfm	\$16,824	\$144 per dwelling unit. Costs assume 1.5 hours labor per multifamily dwelling unit. Labor rate of \$96 per hour is from 2019 RSMeans for sheet metal workers and includes an average City Cost Index for labor for California cities.
ERV/HRV (on central DOAS)	67% sensible recovery effectiveness	\$110,331	Based on costs from the Multifamily Indoor Air Quality 2022 CASE Report (Statewide CASE Team, 2020b).
Solar Thermal System	50% solar fraction vs prescriptive 20%-35%	\$59,452 - \$84,932	Costs based on 2022 multifamily solar thermal measure CASE proposal (Statewide CASE Team, 2020a) and include first cost of \$70,727 and \$8,834 present value for replacement/maintenance costs.
Renewable Energy (PV)			
PV System	0.1 and 0.2 kW _{DC} per dwelling unit	\$3.17/W _{DC}	<p>First costs are from Lawrence Berkeley National Laboratory's Tracking the Sun 2018 costs (Barbose et al., 2018) and represent costs for the first half of 2018 of \$2.90/W_{DC} for nonresidential systems ≤ 500 kW_{DC}. These costs were reduced by 16% for the solar investment tax credit, which is the average credit over years 2020-2022.</p> <p>Inverter replacement cost of \$0.14/W_{DC} present value includes replacements at year 11 at \$0.15/W_{DC} (nominal) and at year 21 at \$0.12/W_{DC} (nominal) per the 2019 PV CASE Report (California Energy Commission, 2017).</p> <p>System maintenance costs of \$0.31/W_{DC} present value assumes additional \$0.02/W_{DC} (nominal) annually per the 2019 PV CASE Report (California Energy Commission, 2017).</p> <p>10% overhead and profit added to all costs.</p>

2.4.2 Equipment Fuel Substitution Measures – Water Heating

The Statewide Reach Codes Team reached out to stakeholders to collect project cost information for central gas boilers and central recirculating and clustered HPWH designs. Project data sources included Association for Energy Affordability, Redwood Energy, Mithun, Ecotope, and the All-Electric Multifamily Compliance Pathway 2022 CASE Report (Statewide CASE Team, 2020a). Costs are presented in Table 3 and do not include PV system costs. The cases were evaluated with and without PV even though PV or solar thermal is prescriptively required as part of the electric central water heating prescriptive approach.

Table 3: Gas and Electric Water Heating Equipment Present Value (2020\$) Costs over 30-Year Period of Analysis

	Central Gas Boiler (CZs 1-9)	Central Gas Boiler (CZs 10-16)	Central Recirculating HPWH	Clustered HPWH
System Quantity/Description	1 boiler recirculation		19 units, 1,547-gallon total	38 units, 80-gallon each
Total Equipment Cost	\$131,270		\$270,261	\$153,409
Solar Thermal System	(20% solar fraction) \$122,216	(35% solar fraction) \$147,696	-	-
Total First Cost	\$253,486	\$278,966	\$270,261	\$153,409
Maintenance/Replacement Cost (PV)	\$90,167	\$90,167	\$147,450	\$98,467
Total Cost (NPV)	\$343,653	\$369,133	\$417,710	\$251,876
Incremental Cost CZ 1-9 (PV)	-	-	\$74,057	(\$91,777)
Incremental Cost CZ 10-16 (PV)	-	-	\$48,577	(\$117,257)

Source: Statewide CASE Team, 2020a.

Typical costs for the water heating systems are based on the following assumptions:

Central Gas Boiler: Based on the average of total estimated project costs from contractors for four multi-family projects ranging from 32 to 340 dwelling units and cost estimates for mid- and high-rise buildings from the All-Electric Multifamily Compliance Pathway 2022 CASE Report (Statewide CASE Team, 2020a). The cost per dwelling unit ranged from \$547 to \$2,089 and the average cost applied in this analysis was \$1,122 per dwelling unit. Costs include installation of gas piping from the building meter to the water heater. Water heater lifetime is assumed to be 15 years and the net present value (NPV) replacement cost at year 15 is \$84,257.

Central Recirculating HPWH: Based on average total installed project costs from four multi-family projects with Sanden HPWHs ranging from four to 16 Sanden units per project. The cost per Sanden HPWH ranged from \$13,094 to \$15,766 and the average cost applied in this analysis was \$14,224 per HPWH. Based on the prescriptive system sizing requirements, 19 Sanden units are required for the 117-dwelling unit building, resulting in a total first cost of \$270,261. Water heater lifetime is assumed to be 15 years. Because Sanden HPWHs are an emerging technology in the United States, it is expected that over time their costs will decrease and for replacement at year 15 the costs are assumed to have decreased by 15 percent.

Clustered HPWH: Based on costs from one project with RHEEM HPWHs used in a clustered design. Costs include water heater interior closet, electrical outlets, and increased breaker size and sub feed. Water heater based on 2.0 UEF 80-gallon appliance with 38 total HPWHs serving the building (one per four to five bedrooms). Water heater lifetime is assumed to be 15 years and the NPV replacement cost at year 15 is \$98,467. While this has an impact on leasable floor area, the design impacts have been found to be minimal when addressed early in design and is equivalent to less than one percent of the residential floor area. This design assumes eight water heater closets per floor, at approximately 15 ft² per closet.

Solar Thermal: Based on system costs provided in the All-Electric Multifamily Compliance Pathway 2022 CASE Report (Statewide CASE Team, 2020a). First costs for materials for the 35 percent solar fraction case and the markup percentage reflect that presented in the CASE Report for the high-rise prototype. The labor costs and 20 percent solar fraction case costs are estimated based on detailed costs in the CASE Report. Replacement and maintenance costs assume replacement of the solar thermal tank at year 15 at \$6,110 and glycol replacement of \$1,300 each time at years 9, 18, and 27. The cost of the remaining useful life of the glycol at year 30 is deducted from the final cost. The CASE Report included costs for replacing the solar collectors at year 20. Collectors can have longer lifetimes up to 30 years if well maintained, therefore this analysis does not assume any replacement of the collectors over the 30-year analysis period. See Table 4 for details.

Table 4: Solar Thermal Detailed Costs over 30-Year Period of Analysis

Solar Fraction	20%	35%
Materials	\$39,854	\$57,450
Labor	\$56,001	\$58,390
Markup	27.5%	27.5%
First Cost	\$122,216	\$147,696
Replacement/Maintenance (2020 \$PV)	\$5,910	\$5,910
Total Cost (2020 \$PV)	\$128,126	\$153,605

Source: Statewide CASE Team, 2020a.

2.4.3 Natural Gas Infrastructure Costs

This analysis assumes that in an all-electric new construction project, natural gas would not be supplied to the building. Eliminating natural gas to the building would save costs associated with connecting a service line from the street main to the building, piping distribution within the building, and monthly meter customer charges from the utility. Incremental costs for natural gas infrastructure in the mixed-fuel building are presented in Table 5. Cost data for the plan review and service extension was estimated on a per building basis and then apportioned to the residential and nonresidential portions of the buildings based on annual gas consumption. For the base case prototype building 49 to 82 percent of estimated building annual gas use is attributed to the residential water heating system across all climate zones. A statewide average of 75 percent was calculated and applied to the costs in Table 5 based on housing starts provided by the Energy Commission for the 2019 Title 24 code development process. The meter costs were based on the service provided to the residential and nonresidential portion of the building separately. Following the table are descriptions of assumptions for each of the cost components. Costs for gas piping from the meter to the gas boilers are included in the central gas boiler costs above. Gas piping distribution costs were typically included in total project costs and could not be broken out in all cases.

Table 5: Natural Gas Infrastructure Cost Savings for All-Electric Building

Item	Source	Total	Nonresidential Portion	Residential Portion
Natural Gas Plan Review	(TRC, 2018)	\$2,316	\$588	\$1,728
Service Extension ^a	(PG&E, 2019)	\$4,600	\$1,169	\$3,431
Meter	(PG&E, 2019)	\$7,200	\$3,600	\$3,600
Total First Cost		\$14,116	\$5,357	\$8,759

^a Service extension costs include 50 percent reduction assuming portion of the costs are passed on to gas customers.

Natural Gas Plan Review: Total costs are based on TRC’s 2019 reach code analysis for Palo Alto (TRC, 2018) and then split between the residential and nonresidential spaces in the building proportionately according to annual gas consumption with 75 percent of the annual load is attributed to residential units on a statewide basis.

Service Extension: Service extension costs to the building were taken from a PG&E memo dated December 5, 2019 to Energy Commission staff. They include costs for trenching and assume nonresidential new construction within a developed area (see Appendix C – PG&E Gas Infrastructure Cost Memo). The total cost of \$9,200 from the memo is reduced by 50 percent to account for the portion of the costs paid for by all customers due to application of Utility Gas Main Extensions rules². The resultant cost is apportioned between the residential and nonresidential spaces in the building based on annual gas consumption of residential and nonresidential uses, with 75 percent of the annual natural gas use attributed to residential units on a statewide basis.

Meter: Cost per meter provided by PG&E for commercial meters (see Appendix C – PG&E Gas Infrastructure Cost Memo). Assume one meter for nonresidential boilers serving space heating and service water heating, and another for residential boilers serving domestic hot water.

2.5 Cost Effectiveness

Cost effectiveness was evaluated for all climate zones and is presented based on both TDV energy, using the Energy Commission’s LCC methodology, and an On-Bill approach using residential customer utility rates. Both methodologies require estimating and quantifying the value of the energy impact associated with energy efficiency measures over the life of the measures (30 years) as compared to the prescriptive Title 24 requirements.

Additional analysis included evaluating the measures using both the 2019 and proposed 2022 TDV multipliers. The proposed 2022 weather files were also used to calculate site energy use and evaluate On-Bill energy performance. The 2022 weather files were updated in 2019 and are considered to better represent conditions now and in the future. They tend to increase cooling and reduce space heating energy use, based on recent warming trends throughout the state.

Cost effectiveness is presented using both lifecycle NPV savings and benefit-to-cost (B/C) ratio metrics, which represent the cost effectiveness of a measure over a 30-year lifetime taking into account discounting of future savings and costs.

- **NPV Savings:** PV benefits minus PV costs is reported as a cost-effectiveness metric. If the net savings of a measure or package is positive, it is considered cost-effective. Negative savings represent net costs. A measure that has negative energy cost benefits (energy cost increase) can still be cost-effective if the costs to implement the measure are more negative (i.e., material and maintenance cost savings).
- **B/C Ratio:** Ratio of the present value of all benefits to the present value of all costs over 30 years (PV benefits divided by PV costs). The criterion 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 1.

Equation 1

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

² PG&E Rule 15: https://www.pge.com/tariffs/tm2/pdf/GAS_RULES_15.pdf

SoCalGas Rule 20: <https://www.socalgas.com/regulatory/tariffs/tm2/pdf/20.pdf>

SDG&E Rule 15: http://regarchive.sdge.com/tm2/pdf/GAS_GAS-RULES_GRULE15.pdf

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 by incremental first cost and replacement costs. However, some packages result in initial construction cost savings (negative incremental cost), and either energy cost savings (positive benefits), or increased energy costs (negative benefits). In cases where both construction costs and energy-related savings are negative, the construction cost savings are treated as the ‘benefit’ while the increased energy costs are the ‘cost.’ In cases where a measure or package is cost-effective immediately (i.e. upfront construction cost savings and lifetime energy cost savings), B/C ratio cost effectiveness is represented by “>1”. Because of these situations, NPV savings are also reported, which, in these cases, are positive values.

The lifetime costs or benefits are calculated according to Equation 2.

Equation 2

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

Where:

- n = analysis term
- r = discount rate
- t = year at which cost/benefit is incurred

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

- Analysis term of 30-years
- Real discount rate of three percent (does not include inflation)

2.5.1 On-Bill Customer LCC

Residential utility rates were used to calculate utility costs for all cases and determine On-Bill customer cost effectiveness for the proposed packages. Utility costs of the nonresidential spaces were not evaluated in this study, only dwelling unit and water heating energy use. The Statewide Reach Codes Team obtained the recommended utility rates from the representative utility based on the assumption that the reach codes go into effect in 2020. Annual utility costs were calculated using hourly electricity and gas output from CBECC-Com and applying the utility tariffs summarized in Table 6. Appendix B – Utility Rate Schedules includes details on the utility rate schedules used for this study. The applicable residential time-of-use (TOU) rate was applied to all cases. For cases with PV generation, the approved NEM2 tariffs were applied along with minimum daily use billing and mandatory non-bypassable charges. For the PV cases annual electric production was always less than annual electricity consumption; and therefore, no credits for surplus generation were necessary. Future changes to the NEM tariffs are likely; however, there is a lot of uncertainty about what those changes will be and when they will become effective.

There are no master metered multifamily service electric tariffs available from the IOUs. Based on guidance from the IOUs, the residential electric TOU tariffs that apply to individually metered residential dwelling units were also used to calculate electricity costs for the central water heating systems. Baseline allowances included in the electric tariff were applied on a per unit basis for all-electric service.

Based on guidance from the IOUs, master metered multifamily service gas tariffs were used to calculate gas costs for the central water heating systems. The baseline quantities were applied on a per unit basis, as is defined in the schedules, and when available water heating only baseline values were used.

Utility rates were applied to each climate zone based on the predominant IOU serving the population of each zone according to Table 6. Climate Zones 10 and 14 are 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 municipal utility rates were also evaluated, Sacramento Municipal Utility District (SMUD) in Climate Zone 12 and City of Palo Alto Utilities (CPAU) in Climate Zone 4.

Table 6: IOU Tariffs Applied Based on Climate Zone

Climate Zone	Electric/Gas Utility	Electricity (Dwelling Unit Use)	Electricity (Central Water Heating)	Natural Gas (Central Water Heating) ^a
1-5, 11-13, 16	PG&E	E-TOU-C	E-TOU-C	PG&E GM
5	PG&E/SoCalGas			SoCalGas GM-E
6, 8-10, 14, 15	SCE/SoCalGas	TOU-D (Option 4-9)	TOU-D (Option 4-9)	SoCalGas GM-E
7, 10, 14	SDG&E	TOU-DR1	TOU-DR1	SDG&E GM
12	SMUD/PG&E	R-TOD (RT02)	GSN-T	PG&E GM
4	CPAU	E-1	E-2	G-2

^a These rates are allowed assuming no gas is used in the dwelling units.

Utility rates are assumed to escalate over time, using assumptions from research conducted by Energy and Environmental Economics (E3) in the 2019 study Residential Building Electrification in California (Energy & Environmental Economics, 2019). Escalation of natural gas rates between 2019 and 2022 is based on the currently filed GRCs for PG&E, SoCalGas, and SDG&E. Consistent with the E3 study, gas rates are assumed to escalate at four percent per year above inflation from 2023 through 2025, which reflects historical rate increases between 2013 and 2018. Escalation of electricity rates from 2019 through 2025 is assumed to be two percent per year above inflation, based on electric utility estimates. After 2025 escalation rates for both natural gas and electric rates are assumed to drop to a more conservative one percent escalation per year above inflation for long-term rate trajectories beginning in 2026 through 2050. See Appendix B – Utility Rate Schedules for additional details.

2.5.2 TDV LCC

Cost effectiveness was also assessed using the Energy Commission’s TDV LCC methodology. TDV is a normalized monetary format developed and used by the Energy Commission for comparing electricity and natural gas savings, and it considers the cost of electricity and natural gas consumed during different times of the day and year. Two versions of TDV were evaluated in this study: the 2019 TDV values used under current 2019 Title 24 for compliance and the 2022 TDV values recently developed and approved by the Energy Commission for the upcoming 2022 Title 24 cycle which will become effective January 1, 2023.

The Energy Commission adopted the TDV methodology to more accurately reflect the variations in the value of energy used (or saved) based on the mix of generation resources and demand on the grid at any given time, as well as impacts on retail energy costs. The 2022 TDV values reflect changes in the generation mix as well as the shift in the peak demand time from mid-afternoon toward early evenings.

The TDV values are based on long term discounted costs of 30 years for all residential measures. The CBEC-Com simulation software results are expressed in terms of TDV kBtu. The present value of the energy cost savings in dollars is calculated by multiplying the TDV kBtu savings by a NPV factor, also developed by the Energy Commission. The 30-year NPV factor is \$0.154/TDV kBtu for nonresidential projects under both the 2019 and 2022 Title 24.

Like the customer B/C ratio, a TDV B/C ratio value of one indicates the savings over the life of the measure are equivalent to the incremental cost of that measure. A value greater than one represents a positive return on investment. The ratio is calculated according to Equation 3.

Equation 3

$$TDV \text{ Benefit} - to - Cost \text{ Ratio} = \frac{TDV \text{ energy savings} * NPV \text{ factor}}{PV \text{ of lifetime incremental cost}}$$

2.5.2.1 2019 and 2022 TDV Differences

There were key changes to the 2022 TDV methodology as compared to the 2019 TDV. Major updates include the following and are further described in the final 2022 TDV methodology report (Energy & Environmental Economics, 2020).

- Updated weather files to reflect historical data from recent years.
- New load profiles representing building and transportation electrification and renewable generation.
- Addition of internalized cost streams to account for carbon emissions.
- Shaped retail rate adjustment partially scaled to hourly marginal cost of service.
- Addition of non-combustion emissions from methane and refrigerant leakage.

The impact of these key changes for electricity TDV are lower values during the mid-day that correspond with an abundance of solar production and a shift of the peak TDV to later in the day as a result of increasing levels of rooftop PV systems. However, the overall magnitude of the electricity 2022 TDV does not increase significantly relative to 2019 TDV. For natural gas TDV there is a large increase in magnitude with the 2022 TDV roughly 40 percent higher than in 2019. This is driven by the new retail rate forecast, increased fixed costs for maintaining the distribution system, and the new carbon cost component.

The updated 2022 weather files represent an updated dataset based on historical weather sampled from recent years (1998-2017) to reflect the impacts of climate change. Cooling loads increase significantly, particularly for the mild climate zones where cooling energy use was previously low. Heating loads decrease on average 30 percent across all climate zones. The weather files used for the 2019 code cycle had not been updated since the 2013 code cycle and represented data only up until 2009. The Energy Commission and the Statewide Reach Codes Team contend that the updated 2022 weather files better reflect changing climate conditions in California. Therefore, the 2022 files are used for all the analysis reported in this study.

2.6 GHG Emissions Reductions

Equivalent CO₂ emission reductions were calculated based on estimates from Zero Code reports available in CBEC-Com simulation software.³ Electricity emissions vary by region and by hour of the year, accounting for time dependent energy use and carbon emissions based on source emissions, including renewable portfolio standard projections. Hourly profiles reflect Climate Zones 1 through 5 and 11 through 13 as a single region and Climate Zones 6 through 10 and 14 through 16 as another. For natural gas, a fixed factor of 11.7 pounds (lb) per therm is used. To compare the mixed-fuel and all-electric cases side-by-side, GHG emissions are presented as CO₂-equivalent (CO₂e) emissions per dwelling unit.

³ More information at: <https://zero-code.org/wp-content/uploads/2018/11/ZERO-Code-TSD-California.pdf>

3 Results

The primary objective of this evaluation is to identify cost-effective, non-preempted performance targets for high-rise multifamily buildings, under both mixed-fuel and all-electric cases, to support the design of local ordinances requiring new high-rise residential buildings to exceed the minimum state requirements. The packages presented are representative examples of designs and measures that can be used to meet the requirements. In practice, a builder can use any combination of non-preempted or preempted compliant measures to meet the requirements.

This analysis evaluated a package of efficiency measures applied to a mixed-fuel design and a similar package for an all-electric design. Each design was evaluated using the predominant utility rates in all climate zones. PV was also added to the efficiency packages.

The following measures are included in at least one package:

- Lower SHGC fenestration
- Wall insulation
- Low pressure-drop HVAC distribution system
- HERS verified pipe insulation

The following measures were evaluated but were found to not be cost-effective in any of the climate zones and were not included in any of the packages:

- Solar thermal system with higher solar fraction than prescriptive requirements
- ERV/HRV System
- Lower U-factor fenestration

Table 7 describes the efficiency measures included in the mixed-fuel and all-electric packages.

Table 7: Measure Package Summary

Climate Zone	MEASURE SPECIFICATION			
	Window SHGC	Add Exterior Wall Insulation (inch)	Fan Watt Draw (W/cfm)	HERS Pipe Insulation
1		+ 1	0.25	No
2	0.22		0.25	No
3	0.22	+ 1 (all-electric only)	0.25	Yes (all-electric only)
4	0.22		0.25	No
5	0.22	+ 1 (all-electric only)	0.25	Yes (all-electric only)
6	0.22		0.25	No
7	0.22		0.25	No
8	0.22		0.25	No
9	0.22		0.25	No
10	0.22		0.25	No
11	0.22	+ 1	0.25	No
12	0.22	+ 1	0.25	No
13	0.22	+ 1	0.25	No
14	0.22	+ 1	0.25	No
15	0.22	+ 1	0.25	No
16	0.22	+ 1	0.25	No

Table 8 presents results for the mixed-fuel packages and Table 9 through Table 11 present results for the all-electric packages. Both mixed-fuel and all-electric results are relative to the mixed-fuel 2019 Title 24 prescriptive baseline model with in-unit heat pumps for heating and cooling and central gas water heating. B/C ratios for all packages are calculated according to the On-Bill, 2019 TDV, and 2022 TDV methodologies. The all-electric results are presented both without PV and with a PV system sized based on 0.1 and 0.2 kW_{DC} per dwelling unit. The mixed-fuel package was also evaluated with 0.1 kW_{DC} per dwelling unit and results are presented in Appendix D – Detailed Results - Mixed Fuel. Appendix E – Detailed Results - All-Electric provides detailed results for the all-electric packages.

Compliance margins for the mixed-fuel efficiency packages range from six to eight percent (except in Climate Zone 1), which meets the Title 24, Part 11 (CALGreen) Tier 1 energy performance requirement for high-rise residential buildings (minimum five percent compliance margin). The packages are cost-effective based on all metrics in Climate Zones 2 through 16.

The all-electric efficiency packages with central recirculating HPWH equipment meet minimum Title 24 requirements in all climate zones except 1 and 16, with compliance margins ranging from 0.1 to 4.7 percent. The all-electric packages result in natural gas savings and an increase in electricity use. The central recirculating case is not cost-effective On-Bill with higher lifecycle utility costs except in SMUD territory but is cost-effective based on 2022 TDV in all climates.

The clustered HPWH case only meets minimum Title 24 requirements in Climate Zones 4, 6 through 9, and 15. Even though the clustered HPWH is cost-effective in almost all climate zones, it is not code compliant in many and may not be used to support a local reach code in those zones. The package is cost-effective On-Bill everywhere except Climate Zones 1, 3, 5, and 16. The clustered approach has lower installed costs compared to the mixed fuel baseline but results in higher utility costs in all Climate Zones except 8, 9, 15, 4 (in CPAU territory), and 12 (in SMUD territory). The clustered HPWH case is cost-effective based on TDV in all climates.

The all-electric packages become cost-effective On-Bill when either 0.1 or 0.2 kW_{DC} of PV per dwelling unit is installed, except with the central HPWH with recirculation design in Climate Zone 1. The all-electric packages in Climate Zones 1 and 16 are not code compliant with PV and may not be used to support a local reach code in those climate zones.

Table 8: Mixed-Fuel Package Results: Efficiency Only (Savings/Cost Per Dwelling Unit)^a

Climate Zone	Elec Utility	Gas Utility	Comp. Margin	Total Gas Savings (therm)	Total Electric Savings (kWh)	Utility Cost Savings (2020 PV\$)	Incremental Cost (2020 PV\$)	On-Bill		2019 TDV		2022 TDV	
								B/C Ratio	NPV	B/C Ratio	NPV	B/C Ratio	NPV
1	PGE	PGE	4.5%	0	39	\$199	\$216	0.9	(\$17)	0.6	(\$83)	0.8	(\$42)
2	PGE	PGE	6.5%	0	79	\$570	\$144	4.0	\$426	3.0	\$289	2.7	\$247
3	PGE	PGE	6.7%	0	60	\$420	\$144	2.9	\$276	2.3	\$184	1.9	\$131
4	PGE	PGE	7.2%	0	95	\$678	\$144	4.7	\$534	3.2	\$321	3.2	\$313
4	CPAU	CPAU	7.2%	0	95	\$394	\$144	2.7	\$250	3.2	\$321	3.2	\$313
5	PGE	PGE	6.8%	0	71	\$484	\$144	3.4	\$340	2.3	\$180	1.9	\$122
5	PGE	SCG	6.8%	0	71	\$484	\$144	3.4	\$340	2.3	\$180	1.9	\$122
6	SCE	SCG	7.8%	0	113	\$619	\$144	4.3	\$475	3.4	\$344	3.2	\$315
7	SDGE	SDGE	8.1%	0	105	\$789	\$144	5.5	\$645	3.4	\$339	2.8	\$264
8	SCE	SCG	7.8%	0	128	\$728	\$144	5.1	\$585	3.9	\$413	3.9	\$421
9	SCE	SCG	7.6%	0	125	\$695	\$144	4.8	\$551	4.2	\$461	3.9	\$413
10	SCE	SCG	7.5%	0	130	\$623	\$144	4.3	\$479	4.2	\$457	3.9	\$415
10	SDGE	SDGE	7.5%	0	130	\$972	\$144	6.8	\$828	4.2	\$457	3.9	\$415
11	PGE	PGE	7.7%	0	148	\$897	\$216	4.1	\$681	3.7	\$584	3.4	\$523
12	PGE	PGE	7.5%	0	122	\$736	\$216	3.4	\$519	3.1	\$448	2.8	\$397
12	SMUD	PGE	7.5%	0	122	\$401	\$216	1.9	\$185	3.1	\$448	2.8	\$397
13	PGE	PGE	7.4%	0	152	\$923	\$216	4.3	\$706	3.4	\$523	3.5	\$534
14	SCE	SCG	7.9%	0	152	\$735	\$216	3.4	\$518	3.6	\$556	3.5	\$532
14	SDGE	SDGE	7.9%	0	152	\$1,055	\$216	4.9	\$838	3.6	\$556	3.5	\$532
15	SCE	SCG	7.8%	0	213	\$1,021	\$216	4.7	\$804	4.5	\$768	4.4	\$725
16	PGE	PGE	6.0%	0	115	\$679	\$216	3.1	\$463	2.3	\$279	2.1	\$244

^a Values in red indicate B/C ratios less than 1 or negative values.

Table 9: All-Electric Package Results: Central Recirculating vs Clustered HPWH Approach with Efficiency (Savings/Cost Per Dwelling Unit)^{a, b}

Climate Zone	Elec Utility	Gas Utility	Total Gas Savings (therm)	Central Recirculating						Clustered					
				Comp Margin	Total Electric Savings (kWh)	Incremental Cost (2020 PV\$)	B/C Ratio			Comp Margin	Total Electric Savings (kWh)	Incremental Cost (2020 PV\$)	B/C Ratio		
							On-Bill	2019 TDV	2022 TDV				On-Bill	2019 TDV	2022 TDV
1	PGE	PGE	96	-4.6%	(671)	\$775	0.0	0.0	2.1	-6.2%	(770)	(\$643)	0.6	1.9	>1
2	PGE	PGE	87	1.0%	(557)	\$702	0.0	0.5	2.5	-0.8%	(648)	(\$715)	1.3	>1	>1
3	PGE	PGE	87	0.1%	(549)	\$888	0.0	0.3	1.9	-1.9%	(642)	(\$529)	0.9	>1	>1
4	PGE	PGE	81	4.1%	(495)	\$702	0.2	0.5	2.5	2.4%	(578)	(\$715)	2.3	>1	>1
4	CPAU	CPAU	81	4.1%	(495)	\$702	0.6	0.5	2.5	2.4%	(578)	(\$715)	>1	>1	>1
5	PGE	PGE	87	0.2%	(536)	\$888	0.0	0.3	1.7	-1.1%	(630)	(\$529)	1.0	>1	>1
5	PGE	SCG	87	0.2%	(536)	\$888	0.0	0.3	1.7	-1.1%	(630)	(\$529)	0.6	>1	>1
6	SCE	SCG	78	3.4%	(447)	\$702	0.6	0.7	2.4	0.6%	(532)	(\$715)	10.7	>1	>1
7	SDGE	SDGE	78	3.5%	(452)	\$702	0.2	0.7	2.2	1.1%	(537)	(\$715)	1.8	>1	>1
8	SCE	SCG	76	4.6%	(416)	\$702	0.7	0.9	2.7	1.4%	(492)	(\$715)	>1	>1	>1
9	SCE	SCG	76	4.2%	(428)	\$702	0.7	0.9	2.7	1.9%	(503)	(\$715)	>1	>1	>1
10	SCE	SCG	63	1.5%	(422)	\$484	0.0	0.4	2.5	-0.8%	(494)	(\$933)	2.2	>1	>1
10	SDGE	SDGE	63	1.5%	(422)	\$484	0.0	0.4	2.5	-0.8%	(494)	(\$933)	1.5	>1	>1
11	PGE	PGE	65	2.0%	(434)	\$557	0.0	0.7	2.4	-1.2%	(495)	(\$861)	2.0	>1	>1
12	PGE	PGE	68	1.4%	(474)	\$557	0.0	0.5	2.2	-1.9%	(550)	(\$861)	1.2	10.9	>1
12	SMUD	PGE	68	1.4%	(474)	\$557	1.5	0.5	2.2	-1.9%	(550)	(\$861)	>1	10.9	>1
13	PGE	PGE	63	1.7%	(411)	\$557	0.0	0.6	2.4	-1.9%	(467)	(\$861)	2.4	7.1	>1
14	SCE	SCG	65	2.3%	(433)	\$557	0.1	0.8	2.6	-0.7%	(498)	(\$861)	2.4	>1	>1
14	SDGE	SDGE	65	2.3%	(433)	\$557	0.0	0.8	2.6	-0.7%	(498)	(\$861)	1.4	>1	>1
15	SCE	SCG	51	4.7%	(252)	\$557	0.9	1.4	2.7	2.1%	(279)	(\$861)	>1	>1	>1
16	PGE	PGE	78	-7.5%	(622)	\$557	0.0	0.0	1.3	-7.1%	(698)	(\$861)	0.7	1.3	>1

^a Values in red indicate B/C ratios less than 1 or negative values. Values in grey indicate cases which are cost-effective but are not code compliant and cannot be used to support a reach code.

^b ">1" indicates cases where there are both incremental measure cost savings and energy cost savings.

Table 10: All-Electric Central Recirculating HPWH Results: With and Without PV (Savings/Cost Per Dwelling Unit)^{a, b}

Climate Zone	Elec Utility	Gas Utility	Comp Margin		No PV			0.1 kW _{DC} /dwelling unit			0.2 kW _{DC} /dwelling unit		
			No PV	With PV ^b	Total Electric Savings (kWh)	Incremental Cost (2020 PV\$)	On-Bill B/C Ratio	Total Electric Savings (kWh)	Incremental Cost (2020 PV\$)	On-Bill B/C Ratio	Total Electric Savings (kWh)	Incremental Cost (2020 PV\$)	On-Bill B/C Ratio
1	PGE	PGE	-4.6%	-2.5%	(671)	\$775	0.0	(538)	\$1,091	0.2	(406)	\$1,408	0.72
2	PGE	PGE	1.0%	3.0%	(557)	\$702	0.0	(400)	\$1,018	1.0	(242)	\$1,335	1.54
3	PGE	PGE	0.1%	3.0%	(549)	\$888	0.0	(386)	\$1,205	0.8	(224)	\$1,521	1.36
4	PGE	PGE	4.1%	6.1%	(495)	\$702	0.2	(329)	\$1,018	1.2	(163)	\$1,335	1.75
4	CPAU	CPAU	4.1%	6.1%	(495)	\$702	0.6	(329)	\$1,018	1.1	(163)	\$1,335	1.25
5	PGE	PGE	0.2%	2.3%	(536)	\$888	0.0	(362)	\$1,205	0.9	(188)	\$1,521	1.48
5	PGE	SCG	0.2%	2.3%	(536)	\$888	0.0	(362)	\$1,205	0.7	(188)	\$1,521	1.25
6	SCE	SCG	3.4%	5.7%	(447)	\$702	0.6	(270)	\$1,018	1.2	(94)	\$1,335	1.60
7	SDGE	SDGE	3.5%	5.6%	(452)	\$702	0.2	(288)	\$1,018	1.3	(123)	\$1,335	1.80
8	SCE	SCG	4.6%	6.6%	(416)	\$702	0.7	(246)	\$1,018	1.3	(75)	\$1,335	1.64
9	SCE	SCG	4.2%	5.8%	(428)	\$702	0.7	(250)	\$1,018	1.2	(72)	\$1,335	1.52
10	SCE	SCG	1.5%	5.7%	(422)	\$484	0.0	(244)	\$801	1.0	(67)	\$1,117	1.36
10	SDGE	SDGE	1.5%	5.7%	(422)	\$484	0.0	(244)	\$801	1.3	(67)	\$1,117	1.96
11	PGE	PGE	2.0%	6.7%	(434)	\$557	0.0	(275)	\$873	1.0	(116)	\$1,190	1.46
12	PGE	PGE	1.4%	6.3%	(474)	\$557	0.0	(311)	\$873	0.8	(147)	\$1,190	1.36
12	SMUD	PGE	1.4%	6.3%	(474)	\$557	1.5	(311)	\$873	1.5	(147)	\$1,190	1.51
13	PGE	PGE	1.7%	6.8%	(411)	\$557	0.0	(245)	\$873	1.1	(80)	\$1,190	1.56
14	SCE	SCG	2.3%	6.5%	(433)	\$557	0.1	(242)	\$873	1.0	(51)	\$1,190	1.40
14	SDGE	SDGE	2.3%	6.5%	(433)	\$557	0.0	(242)	\$873	1.2	(51)	\$1,190	1.90
15	SCE	SCG	4.7%	7.7%	(252)	\$557	0.9	(75)	\$873	1.4	102	\$1,190	1.66
16	PGE	PGE	-7.5%	-3.2%	(622)	\$557	0.0	(453)	\$873	0.3	(283)	\$1,190	1.03

^a Values in red indicate B/C ratios less than 1 or negative values.

^b 0.1 kW_{DC}/dwelling unit sufficient in all climate zones to achieve reported compliance margins except in Climate Zones 11-13 0.2 kW_{DC}/dwelling unit is necessary.

Table 11: All-Electric Clustered HPWH Results: With and Without PV (Savings/Cost Per Dwelling Unit)^{a, b}

Climate Zone	Elec Utility	Gas Utility	Comp Margin		No PV			0.1 kW _{DC} /dwelling unit			0.2 kW _{DC} /dwelling unit		
			No PV	With PV ^c	Total Electric Savings (kWh)	Incremental Cost (2020 PV\$)	On-Bill B/C Ratio	Total Electric Savings (kWh)	Incremental Cost (2020 PV\$)	On-Bill B/C Ratio	Total Electric Savings (kWh)	Incremental Cost (2020 PV\$)	On-Bill B/C Ratio
1	PGE	PGE	-6.2%	-4.1%	(770)	(\$643)	0.6	(637)	(\$326)	0.96	(504)	(\$10)	>1
2	PGE	PGE	-0.8%	1.2%	(648)	(\$715)	1.3	(490)	(\$399)	>1	(333)	(\$82)	>1
3	PGE	PGE	-1.9%	0.9%	(642)	(\$529)	0.9	(479)	(\$213)	>1	(317)	\$104	14.67
4	PGE	PGE	2.4%	4.3%	(578)	(\$715)	2.3	(412)	(\$399)	>1	(246)	(\$82)	>1
4	CPAU	CPAU	2.4%	4.3%	(578)	(\$715)	>1	(412)	(\$399)	>1	(246)	(\$82)	>1
5	PGE	PGE	-1.1%	0.9%	(630)	(\$529)	1.0	(457)	(\$213)	>1	(283)	\$104	16.38
5	PGE	SCG	-1.1%	0.9%	(630)	(\$529)	0.6	(457)	(\$213)	>1	(283)	\$104	12.97
6	SCE	SCG	0.6%	2.9%	(532)	(\$715)	10.7	(355)	(\$399)	>1	(179)	(\$82)	>1
7	SDGE	SDGE	1.1%	3.1%	(537)	(\$715)	1.8	(372)	(\$399)	>1	(207)	(\$82)	>1
8	SCE	SCG	1.4%	3.5%	(492)	(\$715)	>1	(322)	(\$399)	>1	(151)	(\$82)	>1
9	SCE	SCG	1.9%	3.4%	(503)	(\$715)	>1	(325)	(\$399)	>1	(148)	(\$82)	>1
10	SCE	SCG	-0.8%	3.5%	(494)	(\$933)	2.2	(316)	(\$617)	>1	(139)	(\$300)	>1
10	SDGE	SDGE	-0.8%	3.5%	(494)	(\$933)	1.5	(316)	(\$617)	>1	(139)	(\$300)	>1
11	PGE	PGE	-1.2%	3.5%	(495)	(\$861)	2.0	(336)	(\$544)	>1	(177)	(\$228)	>1
12	PGE	PGE	-1.9%	3.0%	(550)	(\$861)	1.2	(387)	(\$544)	>1	(223)	(\$228)	>1
12	SMUD	PGE	-1.9%	3.0%	(550)	(\$861)	>1	(387)	(\$544)	>1	(223)	(\$228)	>1
13	PGE	PGE	-1.9%	3.3%	(467)	(\$861)	2.4	(301)	(\$544)	>1	(136)	(\$228)	>1
14	SCE	SCG	-0.7%	3.5%	(498)	(\$861)	2.4	(308)	(\$544)	>1	(117)	(\$228)	>1
14	SDGE	SDGE	-0.7%	3.5%	(498)	(\$861)	1.4	(308)	(\$544)	>1	(117)	(\$228)	>1
15	SCE	SCG	2.1%	5.1%	(279)	(\$861)	>1	(102)	(\$544)	>1	75	(\$228)	>1
16	PGE	PGE	-7.1%	-2.9%	(698)	(\$861)	0.7	(529)	(\$544)	2.70	(359)	(\$228)	>1

^a Values in red indicate B/C ratios less than 1 or negative values. Values in grey indicate cases which are cost-effective but are not code compliant and cannot be used to support a reach code.

^b ">1" indicates cases where there are both incremental measure cost savings and energy cost savings.

^c 0.1 kW_{DC}/dwelling unit sufficient in all climate zones to achieve reported compliance margins except in Climate Zones 11-13 0.2 kW_{DC}/dwelling unit is necessary.

4 Conclusions and Summary

This report evaluated the feasibility and cost effectiveness of “above code” performance specifications for newly constructed high-rise multifamily buildings. The analysis included application of efficiency measures, electric appliances, and PV in all climate zones and found cost-effective packages across the state. For the building designs and climate zones where cost-effective packages were identified, the results of this analysis can be used by local jurisdictions to support the adoption of reach codes. Cost effectiveness was evaluated according to three metrics: On-Bill customer, 2019 TDV, and 2022 TDV LCC B/C ratio.

For mixed-fuel buildings, this analysis demonstrates that there are cost-effective efficiency packages based on at least one of the evaluated cost-effectiveness metrics that achieve a minimum five percent compliance margin in most climate zones. The exception is Climate Zone 1 where the package only resulted in a 4.5 percent compliance margin. Although the Climate Zone 1 package is not cost-effective based on either the 2019 TDV or the On-Bill methodologies, it is cost-effective based on 2022 TDV.

This study evaluated electrification of residential loads in new high-rise multifamily buildings. Based on typical construction across California, the base case condition incorporated all-electric appliances within the dwelling unit spaces. As a result, only central water heating was converted from natural gas to electric as part of this analysis. For all-electric buildings, this analysis demonstrates that there are cost-effective efficiency packages with a HPWH that are Title 24 compliant in all climate zones except Climate Zones 1 and 16.

The case with the central recirculating HPWH is cost-effective based on the 2022 TDV methodology in all climate zones. Additionally, in Climate Zone 15 it is cost-effective based on 2019 TDV and in Climate Zone 12 in SMUD territory it is cost-effective On-Bill. Utility cost savings were found in Climate Zones 2, 4, 5 (in PG&E territory), 6-9, 10 (in SCE territory), 12 (in SMUD territory), 14 (in SCE territory), and 15. This case (Table 9) demonstrates how the analysis results differ under the 2019 and 2022 TDV metrics. The B/C ratios are typically two to five times greater under 2022 than 2019 because of the higher relative gas versus electric TDV multipliers in 2022. When 0.1 to 0.2 kW_{DC} per dwelling unit is included, the package is cost-effective based on On-Bill in all climate zones except Climate Zone 1.

The central recirculating HPWH case is based on the Energy Commission’s approved prescriptive design and applies Sanden HPWHs, which are higher cost than other available products. As HPWHs gain market share, installed costs are anticipated to decrease as the labor force becomes more familiar with the technology, performance improvements are achieved, and available product options increase. It is also anticipated that modeling of central HPWHs will improve as results from field and lab testing inform the modeling algorithms. This will allow for more accurate modeling of system performance and modeling of other design strategies such as multi-pass HPWH systems.

The clustered HPWH case is cost-effective without PV On-Bill everywhere except Climate Zones 1, 3, 5 (in SoCalGas territory), and 16, although the package is not code compliant in numerous climate zones. It was found to have a much lower installed cost than the recirculating HPWH case but higher operating cost because federal minimum efficiency was assumed (2.0 UEF). When 0.1 to 0.2 kW_{DC} per dwelling unit is included, the package is cost-effective On-Bill in all climate zones, although still not code compliant in Climate Zone 1 or 16.

Table 12 summarizes compliance margin and cost-effectiveness results for the mixed-fuel and all-electric cases. Compliance margin is reported in the cells and cost effectiveness is indicated by the color of the cell according to the following:

- Cells highlighted in green depict cost-effective results using the On-Bill approach. In most cases results are also cost-effective based on TDV.
 - Cells highlighted in blue depict cost-effective results using both the 2019 and 2022 TDV approach, but not On-Bill.
 - Cells highlighted in yellow depict cost-effective results using the 2022 TDV approach only.
 - Cells highlighted in red depict a package that was not cost-effective using any metric.
- Red text depicts a negative compliance margin.

For more detail on the results, please refer to Appendix D – Detailed Results - Mixed Fuel and Appendix E – Detailed Results - All-Electric.

Table 12: High-Rise Multifamily Summary of Compliance Margin and Cost Effectiveness

Climate Zone	Elec Utility	Gas Utility	Mixed Fuel (No PV)	Central Recirculating HPWH			Clustered HPWH		
				No PV	0.1 kW _{DC} /apt	0.2 kW _{DC} /apt	No PV	0.1 kW _{DC} /apt	0.2 kW _{DC} /apt
1	PGE	PGE	4.5%	-4.6%	-2.5%	-2.5%	-6.2%	-4.1%	-4.1%
2	PGE	PGE	6.5%	1.0%	3.0%	3.0%	-0.8%	1.2%	1.2%
3	PGE	PGE	6.7%	0.1%	3.0%	3.0%	-1.9%	0.9%	0.9%
4	PGE	PGE	7.2%	4.1%	6.1%	6.1%	2.4%	4.3%	4.3%
4	CPAU	CPAU	7.2%	4.1%	6.1%	6.1%	2.4%	4.3%	4.3%
5	PGE	PGE	6.8%	0.2%	2.3%	2.3%	-1.1%	0.9%	0.9%
5	PGE	SCG	6.8%	0.2%	2.3%	2.3%	-1.1%	0.9%	0.9%
6	SCE	SCG	7.8%	3.4%	5.7%	5.7%	0.6%	2.9%	2.9%
7	SDGE	SDGE	8.1%	3.5%	5.6%	5.6%	1.1%	3.1%	3.1%
8	SCE	SCG	7.8%	4.6%	6.6%	6.6%	1.4%	3.5%	3.5%
9	SCE	SCG	7.6%	4.2%	5.8%	5.8%	1.9%	3.4%	3.4%
10	SCE	SCG	7.5%	1.5%	5.7%	5.7%	-0.8%	3.5%	3.5%
10	SDGE	SDGE	7.5%	1.5%	5.7%	5.7%	-0.8%	3.5%	3.5%
11	PGE	PGE	7.7%	2.0%	2.0%	6.7%	-1.2%	-1.2%	3.5%
12	PGE	PGE	7.5%	1.4%	1.4%	6.3%	-1.9%	-1.9%	3.0%
12	SMUD	PGE	7.5%	1.4%	1.4%	6.3%	-1.9%	-1.9%	3.0%
13	PGE	PGE	7.4%	1.7%	1.7%	6.8%	-1.9%	-1.9%	3.3%
14	SCE	SCG	7.9%	2.3%	6.5%	6.5%	-0.7%	3.5%	3.5%
14	SDGE	SDGE	7.9%	2.3%	6.5%	6.5%	-0.7%	3.5%	3.5%
15	SCE	SCG	7.8%	4.7%	7.7%	7.7%	2.1%	5.1%	5.1%
16	PGE	PGE	6.0%	-7.5%	-7.5%	-3.2%	-7.1%	-7.1%	-2.9%

4.1 Additional conclusions

- This study found that electrification of central domestic hot water loads, in combination with efficiency measures, can result in an overall benefit to the consumer through lower utility bills, depending on the HPWH strategy and electricity and gas tariff. The all-electric results demonstrate a trend with On-Bill cost effectiveness across the different electric utilities. B/C ratios and NPV in SCE, SMUD, and CPAU territories are typically higher than the cases in PG&E and SDG&E territories. This indicates that rate design can play an important role in encouraging or discouraging electrification. Refer to Appendix D – Detailed Results - Mixed Fuel and Appendix E – Detailed Results - All-Electric for utility cost data.
- Two electric water heating scenarios were evaluated. The most appropriate HPWH design approach for any particular building will depend on many aspects including number and size of dwelling units, building layout, and first costs.
- In multifamily buildings with central water heating where multiple people or entities are responsible for the utility bills, utility impacts may not align. If tenants pay dwelling unit utility bills and the owner pays the water heating bill, the benefits of efficiency measures or PV serving the dwelling unit will benefit the tenant and savings would not directly impact any water heating electrification cost increases.
- This study did not evaluate federally preempted high efficiency appliances. Specifying high efficiency equipment is a viable approach to meeting Title 24 compliance and local ordinance requirements and is commonly used by project teams. Other studies have found that efficiency packages and electrification packages that employ high efficiency equipment can be quite cost-effective ((Statewide Reach Codes Team, 2019b), (Energy & Environmental Economics, 2019)).
- When PV capacity is added to the all-electric packages, all cases are cost-effective based on the On-Bill metric (except Climate Zone 1 with the central recirculating HPWH). In some cases, PV improves cost effectiveness, and in other cases it reduces it. The cost effectiveness of adding PV as an independent measure results in On-Bill B/C ratios between 2.4 and 3.5 for PG&E territory, 2.4 to 2.7 for SCE territory, and 3.5 to 3.8 for SDG&E territory. The B/C ratio is 1.9 and 1.5 in CPAU and SMUD territories, respectively. Adding PV in addition to the efficiency packages improves cost effectiveness where the B/C ratios for the efficiency measures alone are lower than the B/C ratios for PV alone, and vice versa where they are higher. Annual base case electricity costs and annual utility savings from PV are lower in SCE territory than in PG&E and SDG&E territories. This is due to lower off-peak rates and a bigger difference in peak versus off-peak rates for the TOU-D SCE electricity rate tariff. Most PV production occurs during off-peak times (4 pm to 9 pm peak period).

5 References

- Barbose, Galen and Darghouth, Naim. 2018. Tracking the Sun. Installed Price Trends for Distributed Photovoltaic Systems in the United States – 2018 Edition. Lawrence Berkeley National Laboratory. September 2018. https://emp.lbl.gov/sites/default/files/tracking_the_sun_2018_edition_final_0.pdf
- California Energy Commission. 2017. Rooftop Solar PV System. Measure number: 2019-Res-PV-D Prepared by Energy and Environmental Economics, Inc. <https://efiling.energy.ca.gov/getdocument.aspx?tn=221366>
- California Energy Commission. 2018a. 2019 Building Energy Efficiency Standards for Residential and Nonresidential Buildings. CEC-400-2018-020-CMF. December 2018. California Energy Commission. <https://www.energy.ca.gov/2018publications/CEC-400-2018-020/CEC-400-2018-020-CMF.pdf>
- California Energy Commission. 2018b. 2019 Reference Appendices. CEC-400-2018-021-CMF. December 2018. California Energy Commission. <https://www.energy.ca.gov/2018publications/CEC-400-2018-021/CEC-400-2018-021-CMF.pdf>
- California Energy Commission. 2019a. 2019 Nonresidential Alternative Calculation Method Reference Manual. CEC-400-2019-006-CMF. May 2019. California Energy Commission. <https://ww2.energy.ca.gov/2019publications/CEC-400-2019-006/CEC-400-2019-006-CMF.pdf>
- California Energy Commission. 2019b. Executive Director Determination Pursuant to Section 150.1(c)8C for Central Heat Pump Water Heating System. December 26, 2019. <https://efiling.energy.ca.gov/GetDocument.aspx?tn=231318&DocumentContentId=63067>
- Energy & Environmental Economics. 2019. Residential Building Electrification in California. April 2019. https://www.ethree.com/wp-content/uploads/2019/04/E3_Residential_Building_Electrification_in_California_April_2019.pdf
- Energy & Environmental Economics. 2020. Time Dependent valuation of Energy for Developing Building Efficiency Standards. 2022 Time Dependent Valuation (TDV) and Source Energy Metric Data Sources and Inputs. Prepared for the California Energy Commission. May 2020. <https://efiling.energy.ca.gov/GetDocument.aspx?tn=233345&DocumentContentId=65837>
- Horii, B., E. Cutter, N. Kapur, J. Arent, and D. Conotyannis. 2014. “Time Dependent Valuation of Energy for Developing Building Energy Efficiency Standards.” http://www.energy.ca.gov/title24/2016standards/prerulemaking/documents/2014-07-09_workshop/2017_TDV_Documents/
- Statewide CASE Team. 2014. Codes and Standards Enhancement (CASE) Initiative Nonresidential Opaque Envelope. December 2014. <https://title24stakeholders.com/wp-content/uploads/2019/02/2016-T24-CASE-Report-NR-Opaque-Envelope-Dec2014-V3.pdf>
- Statewide CASE Team. 2017a. Codes and Standards Enhancement (CASE) Initiative High Performance Walls – Final Report. September 2017. http://title24stakeholders.com/wp-content/uploads/2017/09/2019-T24-CASE-Report-HPW_Final_September-2017.pdf
- Statewide CASE Team. 2017b. Codes and Standards Enhancement (CASE) Initiative Residential High Performance Windows & Doors – Final Report. August 2017. http://title24stakeholders.com/wp-content/uploads/2017/09/2019-T24-CASE-Report_Res-Windows-and-Doors_Final_September-2017.pdf
- Statewide CASE Team. 2018. Energy Savings Potential and Cost-Effectiveness Analysis of High Efficiency Windows in California. Prepared by Frontier Energy. May 2018. <https://www.etc-ca.com/reports/energy-savings-potential-and-cost-effectiveness-analysis-high-efficiency-windows-california>
- Statewide CASE Team. 2020a. All-Electric Multifamily Compliance Pathway Final CASE Report (Updated). Prepared by TRC. November 2020. https://title24stakeholders.com/wp-content/uploads/2020/11/2022-T24-Final-CASE-Report_MF-All-Electric_updated.pdf

Statewide CASE Team. 2020b. Multifamily Indoor Air Quality Draft CASE Report. Prepared by TRC.

https://title24stakeholders.com/wp-content/uploads/2018/10/MF-IAQ_Draft-CASE-Report_Statewide-CASE-Team.pdf

Statewide Reach Codes Team. 2019a. 2019 Nonresidential New Construction Reach Code Cost-Effectiveness Study. Prepared for Southern California Edison. Prepared by TRC. July 25, 2019.

https://localenergycodes.com/download/801/file_path/fieldList/2019%20NR%20NC%20Cost%20Effectiveness%20Study-2019-07-25.pdf

Statewide Reach Codes Team. 2019b. 2019 Cost-Effectiveness Study: Low-Rise Residential New Construction. Prepared for Pacific Gas and Electric Company. Prepared by Frontier Energy. August 1, 2019.

https://localenergycodes.com/download/800/file_path/fieldList/2019%20Res%20NC%20Reach%20Codes

Statewide Reach Codes Team. 2020. 2019 Mid-Rise New Construction Reach Code Cost-Effectiveness Study. Prepared for Pacific Gas and Electric Company. Prepared by Frontier Energy. June 22, 2020.

https://localenergycodes.com/download/492/file_path/fieldList/2019%20Mid-rise%20NC%20Cost-Eff%20Report

TRC. 2018. City of Palo Alto 2019 Title 24 Energy Reach Code Cost-Effectiveness Analysis Draft. September 2018. <https://cityofpaloalto.org/civicax/filebank/documents/66742>

TRC. 2019. Multifamily Prototypes. June 7, 2019. Submitted to Southern California Edison.

https://title24stakeholders.com/wp-content/uploads/2019/06/SCE-MFModeling_MultifamilyPrototypesReport_2019-06-07_clean.pdf

6 Appendices

6.1 Appendix A – Map of California Climate Zones

Climate zone geographical boundaries are depicted in Figure 3. The map in Figure 3 along with a zip-code search directory is available at: https://ww2.energy.ca.gov/maps/renewable/building_climate_zones.html.

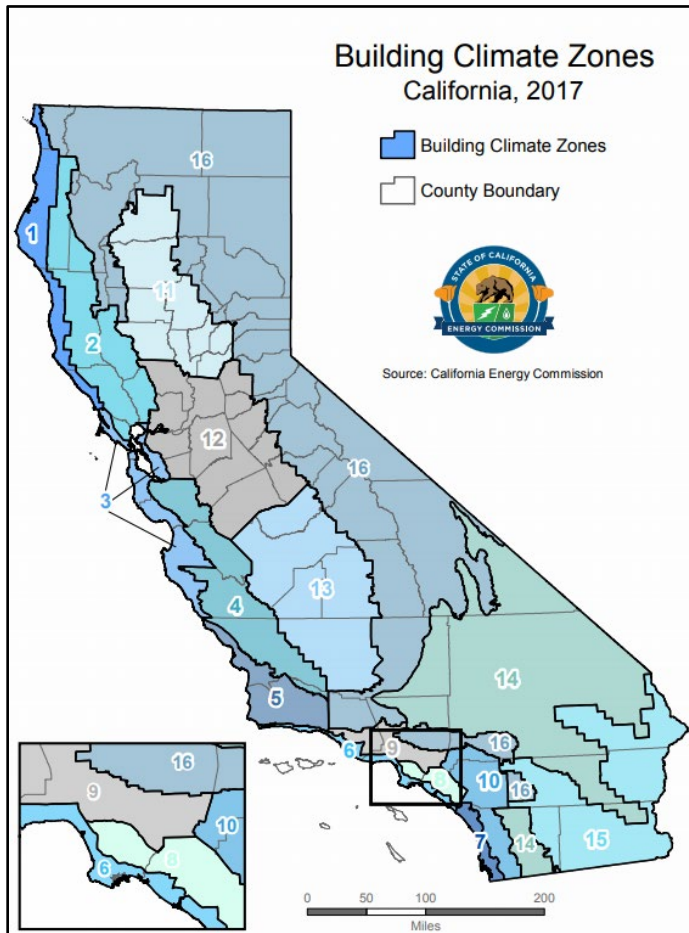


Figure 3: Map of California climate zones.

Source: Energy Commission.

6.2 Appendix B – Utility Rate Schedules

PG&E

The following pages provide details on the PG&E electricity and natural gas tariffs applied in this study. Table 13 describes the baseline territories that were assumed for each climate zone.

Table 13: PG&E Baseline Territory by Climate Zone

Climate Zone	Baseline Territory
1	V
2	X
3	T
4	X
5	T
11	R
12	S
13	R
16	Y

Source: PG&E.

The PG&E monthly gas rate in \$/therm was applied on a monthly basis for the 12-month period ending April 2020 according to the rates shown in Table 14. Rates are based on historical data provided by PG&E.⁴

Table 14: PG&E Monthly Gas Rate (\$/therm)

Month	Procurement Charge	Transportation Charge		Total Charge	
		Baseline	Excess	Baseline	Excess
Jan 2020	\$0.45813	\$0.99712	\$1.59540	\$1.45525	\$2.05353
Feb 2020	\$0.44791	\$0.99712	\$1.59540	\$1.44503	\$2.04331
Mar 2020	\$0.35346	\$1.13126	\$1.64861	\$1.48472	\$2.00207
Apr 2020	\$0.23856	\$1.13126	\$1.64861	\$1.36982	\$1.88717
May 2019	\$0.21791	\$0.99933	\$1.59892	\$1.21724	\$1.81683
June 2019	\$0.20648	\$0.99933	\$1.59892	\$1.20581	\$1.80540
July 2019	\$0.28462	\$0.99933	\$1.59892	\$1.28395	\$1.88354
Aug 2019	\$0.30094	\$0.96652	\$1.54643	\$1.26746	\$1.84737
Sept 2019	\$0.25651	\$0.96652	\$1.54643	\$1.22303	\$1.80294
Oct 2019	\$0.27403	\$0.98932	\$1.58292	\$1.26335	\$1.85695
Nov 2019	\$0.33311	\$0.96729	\$1.54767	\$1.30040	\$1.88078
Dec 2019	\$0.40178	\$0.96729	\$1.54767	\$1.36907	\$1.94945

Source: PG&E.

⁴ The PG&E procurement and transportation charges were obtained from the following site:
https://www.pge.com/tariffs/GRF_SHTML#RESGAS



Pacific Gas and Electric Company
 San Francisco, California

Revised Revised Cal. P.U.C. Sheet No. 35447-G
 Cancelling Revised Cal. P.U.C. Sheet No. 34307-G

GAS SCHEDULE GM
 MASTER-METERED MULTIFAMILY SERVICE

Sheet 3

BASELINE QUANTITIES: The above rates are applicable only to residential use. PG&E may require the Customer to submit a completed "Declaration of Eligibility for Baseline Quantities for Residential Rates." The delivered quantities of gas shown below are billed at the rates for baseline use. As an exception, service under this schedule not used to supply space heating but used to supply water heating from a central source to residential dwelling units that are individually metered by PG&E for either gas or electricity will be billed using a baseline quantity of 0.5 therms per dwelling unit per day (Code W) in all baseline territories and in both seasons.

Baseline Territories	BASELINE QUANTITIES (Therms Per Day Per Dwelling Unit)						(T) (T)
	Summer (April-October)		Winter Off-Peak (Nov, Feb, Mar)		Winter On-Peak (Dec, Jan)		
	Effective Apr. 1, 2020		Effective Nov. 1, 2019		Effective Dec. 1, 2019		
**							
P	0.29	(R)	0.87	(R)	1.00	(I)	
Q	0.49	(R)	0.64	(R)	0.77	(I)	
R	0.33	(R)	0.84	(R)	1.19	(I)	
S	0.29	(R)	0.54	(R)	0.68	(I)	
T	0.49	(R)	0.94	(R)	1.06	(R)	
V	0.56		1.18	(R)	1.29	(I)	
W	0.23	(R)	0.61	(R)	0.87	(R)	
X	0.33	(R)	0.64	(R)	0.77	(I)	
Y	0.36		0.87	(R)	1.00	(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.

STANDARD MEDICAL QUANTITIES: Additional medical quantities (Code M) are available as provided in Rule 19.

RESIDENTIAL DWELLING UNITS: It is the responsibility of the Customer to advise PG&E within 15 days following any change in the number of residential dwelling units, mobile home spaces, and permanent-residence RV units receiving gas service.

CENTRAL BOILERS: Service to central boilers for water and/or space heating will be billed with monthly baseline quantities related to the number of dwelling units furnished such water and/or space heating.



Pacific Gas and Electric Company
San Francisco, California

Cancelling Revised Cal. P.U.C. Sheet No. 46539-E
Revised Cal. P.U.C. Sheet No. 46325-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)	<u>PEAK</u>		<u>OFF-PEAK</u>	
<i>Summer</i>				
Total Usage	\$0.41333	(I)	\$0.34989	(I)
Baseline Credit (Applied to Baseline Usage Only)	(\$0.08633)	(R)	(\$0.08633)	(R)
<i>Winter</i>				
Total Usage	\$0.31624	(I)	\$0.29891	(I)
Baseline Credit (Applied to Baseline Usage Only)	(\$0.08633)	(R)	(\$0.08633)	(R)
Delivery Minimum Bill Amount (\$ per meter per day)	\$0.32854			
California Climate Credit (per household, per semi-annual payment occurring in the April and October bill cycles) ^f	(\$35.73)			(T)

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, DWR Bond, and New System Generation Charges based on kWh usage times the corresponding unbundled rate component per kWh, with any residual revenue assigned to Distribution.

^f Pursuant to D.20-04-027, distribution of the October 2020 California Climate Credit will be advanced and split to the May 2020 and June 2020 bill cycles, \$17.87 and \$17.86 respectively.. (N)

(Continued)

Advice	5661-E-B	Issued by	Submitted	April 28, 2020
Decision		Robert S. Kenney	Effective	May 1, 2020
		Vice President, Regulatory Affairs	Resolution	



Cancelling Revised Cal. P.U.C. Sheet No. 46540-E
 Revised Revised Cal. P.U.C. Sheet No. 46252-E

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

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

Energy Rates by Component (\$ per kWh)	PEAK		OFF-PEAK	
Generation:				
Summer (all usage)	\$0.16735	(R)	\$0.11391	(R)
Winter (all usage)	\$0.11859	(R)	\$0.10356	(R)
Distribution**:				
Summer (all usage)	\$0.12767	(I)	\$0.11767	(I)
Winter (all usage)	\$0.07935	(I)	\$0.07705	(I)
Conservation Incentive Adjustment (Baseline Usage)			(\$0.03294)	(I)
Conservation Incentive Adjustment (Over Baseline Usage)			\$0.05339	(I)
Transmission* (all usage)			\$0.03595	
Transmission Rate Adjustments* (all usage)			\$0.00314	
Reliability Services* (all usage)			(\$0.00086)	
Public Purpose Programs (all usage)			\$0.01296	(I)
Nuclear Decommissioning (all usage)			\$0.00101	(I)
Competition Transition Charges (all usage)			\$0.00096	(R)
Energy Cost Recovery Amount (all usage)			\$0.00005	(I)
DWR Bond (all usage)			\$0.00580	
New System Generation Charge (all usage)**			\$0.00571	(I)

* Transmission, Transmission Rate Adjustments and Reliability Service charges are combined for presentation on customer bills.
 ** Distribution and New System Generation Charges are combined for presentation on customer bills.

(Continued)

Advice Decision	5661-E-B	Issued by Robert S. Kenney Vice President, Regulatory Affairs	Submitted Effective Resolution	April 28, 2020 May 1, 2020
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Pacific Gas and Electric Company
San Francisco, California

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

Baseline Territory*	Code B - Basic Quantities		Code H - All-Electric Quantities	
	Summer	Winter	Summer	Winter
	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)

<i>Advice</i>	5759-E	<i>Issued by</i>	<i>Submitted</i>
<i>Decision</i>	D.19-07-004	Robert S. Kenney	<u>February 14, 2020</u>
		<i>Vice President, Regulatory Affairs</i>	<u>Effective</u>
			<u>March 1, 2020</u>
			<u>Resolution</u>

SCE

The following pages provide details on are the SCE electricity tariffs applied in this study. Table 15 describes the baseline territories that were assumed for each climate zone.

Table 15: SCE Baseline Territory by Climate Zone

Climate Zone	Baseline Territory
6	6
8	8
9	9
10	10
14	14
15	15

Source: SCE.

Summer Daily Allocations (June through September)

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

Winter Daily Allocations (October through May)

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

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

Sheet 12 (T)

SPECIAL CONDITIONS

- Applicable rate time periods are defined as follows:

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

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

(T)

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

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	UG ^{***}	DWREC ²
<u>Option 4-9 PM / Option 4-9 PM-CPP</u>			
Energy Charge - \$/kWh			
Summer Season - On-Peak	0.21574 (I)	0.17870 (I)	(0.00007)
Mid-Peak	0.21574 (I)	0.10434 (R)	(0.00007)
Off-Peak	0.17099 (I)	0.07584 (R)	(0.00007)
Winter Season - Mid-Peak	0.21574 (I)	0.12676 (R)	(0.00007)
Off-Peak	0.17099 (I)	0.08874 (R)	(0.00007)
Super-Off-Peak	0.16567 (I)	0.07025 (R)	(0.00007)
Baseline Credit ^{****} - \$/kWh	(0.07456) (R)	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 ⁴	(37.00) (I)		
California Alternate Rates for Energy Discount - %	100.00 [*]		
Family Electric Rate Assistance Discount - %	100.00		
<u>Option 4-9 PM-CPP</u>			
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		(0.58504) (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 \$0.00089 per kWh is recovered in the UG component of Generation. (I)
- **** The Baseline Credit applies up to 100% of the Baseline Allocation, regardless of Time of Use. 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.
- 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.

SoCalGas

Following are the SoCalGas natural gas tariffs applied in this study. Table 16 describes the baseline territories that were assumed for each climate zone.

Table 16: SoCalGas Baseline Territory by Climate Zone

Climate Zone	Baseline Territory
5	2
6	1
8	1
9	1
10	1
14	2
15	1

Source: SoCalGas.

The SoCalGas monthly gas rate in \$/therm was applied on a monthly basis for the 12-month period ending April 2020 according to the rates shown in Table 17. Historical natural gas rate data were only available for SoCalGas' procurement charges.⁵ To estimate total costs by month, the baseline and excess transmission charges were assumed to be consistent and applied for the entire year based on April 2020 costs.

Table 17: SoCalGas Monthly Gas Rate (\$/therm)

Month	Procurement Charge	Transmission Charge		Total Charge	
		Baseline	Excess	Baseline	Excess
Jan 2020	\$0.34730	\$0.81742	\$1.17186	\$1.16472	\$1.51916
Feb 2020	\$0.28008	\$0.81742	\$1.17186	\$1.09750	\$1.45194
Mar 2020	\$0.22108	\$0.81742	\$1.17186	\$1.03850	\$1.39294
Apr 2020	\$0.20307	\$0.81742	\$1.17186	\$1.02049	\$1.37493
May 2019	\$0.23790	\$0.81742	\$1.17186	\$1.05532	\$1.40976
June 2019	\$0.24822	\$0.81742	\$1.17186	\$1.06564	\$1.42008
July 2019	\$0.28475	\$0.81742	\$1.17186	\$1.10217	\$1.45661
Aug 2019	\$0.27223	\$0.81742	\$1.17186	\$1.08965	\$1.44409
Sept 2019	\$0.26162	\$0.81742	\$1.17186	\$1.07904	\$1.43348
Oct 2019	\$0.30091	\$0.81742	\$1.17186	\$1.11833	\$1.47277
Nov 2019	\$0.27563	\$0.81742	\$1.17186	\$1.09305	\$1.44749
Dec 2019	\$0.38067	\$0.81742	\$1.17186	\$1.19809	\$1.55253

Source: SoCalGas.

⁵ 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. 57458-G
 LOS ANGELES, CALIFORNIA CANCELING Revised CAL. P.U.C. SHEET NO. 57432-G

Schedule No. GM		Sheet 2
<u>MULTI-FAMILY SERVICE</u>		
(Includes GM-E, GM-C, GM-EC, GM-CC, GT-ME, GT-MC and all GMB Rates)		
(Continued)		
<u>APPLICABILITY</u> (Continued)		
<p>Multi-family Accommodations built prior to December 15, 1981 and currently served under this schedule may also be eligible for service under Schedule No. GS. If an eligible Multi-family Accommodation served under this schedule converts to an applicable submetered tariff, the tenant rental charges shall be revised for the duration of the lease to reflect removal of the energy related charges.</p> <p>Eligibility for service hereunder is subject to verification by the Utility.</p>		
<u>TERRITORY</u>		
Applicable throughout the service territory.		
<u>RATES</u>		
	<u>GM/GT-M</u>	<u>GMB/GT-MB</u>
Customer Charge, per meter, per day:	16.438¢	\$16.357
For "Space Heating Only" customers, a daily Customer Charge applies during the winter period from November 1 through April 30 ^{1/2} :	33.149¢	

SOUTHERN CALIFORNIA GAS COMPANY Revised CAL P.U.C. SHEET NO. 57168-G
 LOS ANGELES, CALIFORNIA CANCELING Revised CAL P.U.C. SHEET NO. 41015-G

Schedule No. GM		Sheet 5		
<u>MULTI-FAMILY SERVICE</u>				
(Includes GM-E, GM-C, GM-EC, GM-CC, GT-ME, GT-MC and all GMB Rates)				
(Continued)				
<u>SPECIAL CONDITIONS</u> (Continued)				
3. (Continued)				
Codes	Per Residence	Daily Therm Allowance for Climate Zones*		
		1	2	3
1	Space heating only			
	Summer	0.000	0.000	0.000
	Winter	1.210	1.343	2.470
2	Water heating and cooking	0.477	0.477	0.477
3	Cooking, water heating and space heating			
	Summer	0.473	0.473	0.473
	Winter	1.691	1.823	2.950
4	Cooking and space heating			
	Summer	0.088	0.088	0.088
	Winter	1.299	1.432	2.559
5	Cooking only	0.089	0.089	0.089
6	Water heating only	0.388	0.388	0.388
7	Water heating and space heating			
	Summer	0.385	0.385	0.385
	Winter	1.601	1.734	2.861
* Climate Zones are described in the Preliminary Statement.				
4. <u>Medical Baseline</u> : Upon completion of an application and verification by a state-licensed physician, nurse practitioner, physician's assistant, or osteopath (Form No. 4859-E), an additional Baseline allowance of 0.822 therms per day will be provided for paraplegic, quadriplegic, or hemiplegic persons, those afflicted with multiple sclerosis or scleroderma, or persons being treated for a life threatening illness or who have a compromised immune system.				
Where it is established that the energy required for a Life-Support Device, as defined in Rule No. 1, exceeds 0.822 therms per day, an additional uniform daily Baseline allowance will be provided. The amount of the additional allowance will be determined by the Utility from load and operating time data of the Life-Support Device.				
5. <u>Space Heating Only</u> : Applies to customers who are using gas primarily for space heating, as determined by survey or under the presumption that customers who use less than 11 Ccf per month during each of the regular billing periods ending in August and September qualify for Heat Only billing.				
(Continued)				

(TO BE INSERTED BY UTILITY)
 ADVICE LETTER NO. 5576-A
 DECISION NO. 02-04-026

ISSUED BY
Dan Skopec
 Vice President

(TO BE INSERTED BY CAL. PUC)
 SUBMITTED Jan 31, 2020
 EFFECTIVE Feb 27, 2020

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N

SDG&E

Following are the SDG&E electricity and natural gas tariffs applied in this study. Table 18 describes the baseline territories that were assumed for each climate zone. All-Electric baseline allowances were applied.

Table 18: SDG&E Baseline Territory by Climate Zone

Climate Zone	Baseline Territory
7	Coastal
10	Inland
14	Mountain

Source: SDG&E.

The SDG&E monthly gas rate in \$/therm was applied on a monthly basis for the 12-month period ending April 2020 according to the rates shown in Table 19. Historical natural gas rate data from SDG&E were reviewed to identify the procurement and transmission charges⁶ used to calculate the monthly total gas rate.

Table 19: SDG&E Monthly Gas Rate (\$/therm)

Month	Procurement Charge	Transmission Charge		Total Charge	
		Baseline	Excess	Baseline	Excess
Jan 2020	\$0.34761	\$1.36166	\$1.59166	\$1.70927	\$1.93927
Feb 2020	\$0.28035	\$1.36166	\$1.59166	\$1.64201	\$1.87201
Mar 2020	\$0.22130	\$1.36166	\$1.59166	\$1.58296	\$1.81296
Apr 2020	\$0.20327	\$1.35946	\$1.59125	\$1.56273	\$1.79452
May 2019	\$0.23804	\$1.06349	\$1.25253	\$1.30153	\$1.49057
June 2019	\$0.24838	\$1.06349	\$1.25253	\$1.31187	\$1.50091
July 2019	\$0.28491	\$1.06349	\$1.25253	\$1.34840	\$1.53744
Aug 2019	\$0.27239	\$1.06349	\$1.25253	\$1.33588	\$1.52492
Sept 2019	\$0.26178	\$1.06349	\$1.25253	\$1.32527	\$1.51431
Oct 2019	\$0.30109	\$1.06349	\$1.25253	\$1.36458	\$1.55362
Nov 2019	\$0.27580	\$1.06349	\$1.25253	\$1.33929	\$1.52833
Dec 2019	\$0.38090	\$1.06349	\$1.25253	\$1.44439	\$1.63343

Source: SDG&E.

⁶ The SDG&E procurement and transmission charges were obtained from the following sets of documents:

http://regarchive.sdge.com/tm2/pdf/GAS_GAS-SCHEDS_GM_2020.pdf

http://regarchive.sdge.com/tm2/pdf/GAS_GAS-SCHEDS_GM_2019.pdf

<u>RATES</u>	<u>GM</u>	<u>GM-C</u>	<u>GTC/GTCA¹</u>
Minimum Bill, per day ³			
Non-CARE customers.....	\$0.09863	\$0.09863	\$0.09863
CARE customers.....	\$0.07890	\$0.07890	\$0.07890

Baseline Usage. The following quantities of gas are to be billed at the baseline rate for multi-family units. Usage in excess of applicable baseline usage will be billed at non-baseline rates.

	<u>Daily Therm Allowance Per Residential Unit</u>
Summer (May 1 to October 31, inclusive)	0.345
Winter (November 1 to April 30, inclusive)	1.082



Revised Cal. P.U.C. Sheet No. 33144-E
 Canceling Revised Cal. P.U.C. Sheet No. 32930-E

SCHEDULE TOU-DR1		Sheet 2		
<u>RESIDENTIAL TIME-OF-USE</u>				
<u>RATES</u>				
<u>Total Rates:</u>				
Description – TOU DR1	UDC Total Rate	DWR-BC Rate	EECC Rate + DWR Credit	Total Rate
Summer:				
On-Peak	0.22374	I 0.00580	0.29042 R	0.51996 R
Off-Peak	0.22374	I 0.00580	0.09305 R	0.32259 R
Super Off-Peak	0.22374	I 0.00580	0.04743 R	0.27697 R
Winter:				
On-Peak	0.25734	R 0.00580	0.07844 R	0.34158 R
Off-Peak	0.25734	R 0.00580	0.06961 R	0.33275 R
Super Off-Peak	0.25734	R 0.00580	0.05981 R	0.32295 R
Summer Baseline Adjustment Credit up to 130% of Baseline	(0.07506)	I		(0.07506) I
Winter Baseline Adjustment Credit up to 130% of Baseline	(0.06833)	I		(0.06833) I
Minimum Bill (\$/day)	0.338			0.338

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

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)	6.8	9.2	15.6	17.5
Winter (November 1 to May 31)	10.4	13.4	23.4	18.1

* 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.

SMUD

Following are the SMUD electricity tariffs applied in this study.

RTOD Rate Schedule

II. Firm Service Rates

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

Non-Summer Prices* – January 1 through May 31

System Infrastructure Fixed Charge per month	\$21.05
Electricity Usage Charge	
Peak \$/kWh	\$0.1388
Off-Peak \$/kWh	\$0.1006

Summer Prices - June 1 through September 30

System Infrastructure Fixed Charge per month	\$21.05
Electricity Usage Charge	
Peak \$/kWh	\$0.2941
Mid-Peak \$/kWh	\$0.1671
Off-Peak \$/kWh	\$0.1209

Non-Summer Prices* – October 1 through December 31

System Infrastructure Fixed Charge per month	\$21.70
Electricity Usage Charge	
Peak \$/kWh	\$0.1430
Off-Peak \$/kWh	\$0.1035

* Non-Summer Season includes Fall (Oct 1 – Nov 30), Winter (Dec 1 – Mar 31) and Spring (Apr 1 – May 31) periods.

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 .

GSN_T Rate Schedule:

II. Firm Service Rates

Rate Category	Nondemand GSN_T	Flat GFN	Demand GSS_T
Winter Season – January 1 through May 31			
System Infrastructure Fixed Charge - per month per meter	\$21.15	\$9.45	\$25.75
Site Infrastructure Charge (per 12 months max kW or contract capacity)	n/a	n/a	\$7.94
Electricity Usage Charge			
All day \$/kWh	\$0.1365	\$0.1381	\$0.1071
Summer Season - June 1 through September 30			
System Infrastructure Fixed Charge - per month per meter	\$21.15	\$9.45	\$25.75
Site Infrastructure Charge (per 12 months max kW or contract capacity)	n/a	n/a	\$7.94
Electricity Usage Charge			
On-peak \$/kWh	\$0.3151	\$0.1381	\$0.2733
Off-peak \$/kWh	\$0.1152	\$0.1381	\$0.0948

Rate Category	Nondemand GSN_T	Flat GFN	Demand GSS_T
Winter Season - October 1 through December 31			
System Infrastructure Fixed Charge - per month per meter	\$21.80	\$9.70	\$26.50
Site Infrastructure Charge (per 12 months max kW or contract capacity)	n/a	n/a	\$8.18
Electricity Usage Charge			
All day \$/kWh	\$0.1406	\$0.1423	\$0.1103

D. Billing Periods

1. Winter (October 1 – May 31) All hours are off-peak.

2. Summer Time-of-Use Billing Periods (June 1 – September 30)

On-Peak	Summer weekdays between 3:00 p.m. and 6:00 p.m.
Off-Peak	All other hours, including holidays shown below

CPAU

Following are the CPAU electricity and natural gas tariffs applied in this study.

E1 Rate Schedule:

RESIDENTIAL ELECTRIC SERVICE

UTILITY RATE SCHEDULE E-1

A. APPLICABILITY:

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

B. TERRITORY:

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

C. UNBUNDLED RATES:

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

E2 Rate Schedule:

RESIDENTIAL MASTER-METERED AND SMALL NON-RESIDENTIAL ELECTRIC SERVICE

UTILITY RATE SCHEDULE E-2

A. APPLICABILITY:

This Rate Schedule applies to the following Customers receiving Electric Service from the City of Palo Alto Utilities:

1. Small non-residential Customers receiving Non-Demand Metered Electric Service; and
2. Customers with Accounts at Master-Metered multi-family facilities.

B. TERRITORY:

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

C. UNBUNDLED RATES:

<u>Per kilowatt-hour (kWh)</u>	<u>Commodity</u>	<u>Distribution</u>	<u>Public Benefits</u>	<u>Total</u>
Summer Period	\$0.11855	\$0.08551	\$0.00447	\$0.20853
Winter Period	0.08502	0.05675	0.00447	0.14624
<u>Minimum Bill (\$/day)</u>				0.8359

The CPAU monthly gas rate in \$/therm was applied on a monthly basis for the 12-month period ending June 2020 according to the rates shown in Table 20.

Table 20: CPAU Monthly Gas Rate (\$/therm)

Effective Date	Commodity Rate	Cap and Trade Compliance Charge	Transportation Charge	Carbon Offset Charge	G2 Total Volumetric Rate
1/1/20	\$0.3289	0.033	0.09941	0.040	1.11151
2/1/20	0.2466	0.033	0.09941	0.040	1.02921
3/1/20	0.2416	0.033	0.09891	0.040	1.02371
4/1/20	0.2066	0.033	0.09891	0.040	0.98871
5/1/20	0.2258	0.033	0.09891	0.040	1.00791
6/1/20	0.2279	0.033	0.09891	0.040	1.01001
7/1/19	0.2471	0.033	0.11757	0.040	1.04787
8/1/19	0.2507	0.033	0.10066	0.040	1.03456
9/1/19	0.2461	0.033	0.10066	0.040	1.02996
10/1/19	0.2811	0.033	0.10288	0.040	1.06718
11/1/19	0.2923	0.033	0.10288	0.040	1.07838
12/1/19	0.3781	0.033	0.10288	0.040	1.16418

Source: CPAU.

RESIDENTIAL MASTER-METERED AND COMMERCIAL GAS SERVICE

UTILITY RATE SCHEDULE G-2

A. APPLICABILITY:

This schedule applies to the following Customers receiving Gas Service from the City of Palo Alto Utilities:

1. Commercial Customers who use less than 250,000 therms per year at one site.
2. Master-metered residential Customers in multi-family residential facilities.

B. TERRITORY:

This schedule applies anywhere the City of Palo Alto provides Gas Service.

C. UNBUNDLED RATES:

Per Service

Monthly Service Charge:\$104.95

Per Therm

Supply Charges:

1. Commodity (Monthly Market Based) \$0.10-\$2.00
2. Cap and Trade Compliance Charges \$0.00-0.25
3. Transportation Charge.....\$0.00-\$0.15
4. Carbon Offset Charge\$0.00-\$0.10

Distribution Charge: \$0.6102

Escalation Assumptions

The average annual escalation rates in Table 21 were used in this study and are from E3’s 2019 study Residential Building Electrification in California (Energy & Environmental Economics, 2019). These rates are applied to the 2019 rate schedules over a 30-year period beginning in 2020. SDG&E was not covered in the E3 study. The Statewide Reach Codes Team reviewed SDG&E’s GRC filing and applied the same approach that E3 applied for PG&E and SoCalGas to arrive at average escalation rates between 2020 and 2022. The statewide electricity escalation rates were also applied to the analysis for SMUD and CPAU. PG&E gas escalation rates were applied to CPAU as the best available estimate since CPAU uses PG&E gas infrastructure.

Table 21: Real Utility Rate Escalation Rate Assumptions

Year	Statewide Electric Residential Average Rate Escalation (%/year, real)	Natural Gas Residential Core Rate Escalation (%/year, real)		
		PG&E	SoCalGas	SDG&E
2020	2.0%	1.48%	6.37%	5.00%
2021	2.0%	5.69%	4.12%	3.14%
2022	2.0%	1.11%	4.12%	2.94%
2023	2.0%	4.0%	4.0%	4.0%
2024	2.0%	4.0%	4.0%	4.0%
2025	2.0%	4.0%	4.0%	4.0%
2026	1.0%	1.0%	1.0%	1.0%
2027	1.0%	1.0%	1.0%	1.0%
2028	1.0%	1.0%	1.0%	1.0%
2029	1.0%	1.0%	1.0%	1.0%
2030	1.0%	1.0%	1.0%	1.0%
2031	1.0%	1.0%	1.0%	1.0%
2032	1.0%	1.0%	1.0%	1.0%
2033	1.0%	1.0%	1.0%	1.0%
2034	1.0%	1.0%	1.0%	1.0%
2035	1.0%	1.0%	1.0%	1.0%
2036	1.0%	1.0%	1.0%	1.0%
2037	1.0%	1.0%	1.0%	1.0%
2038	1.0%	1.0%	1.0%	1.0%
2039	1.0%	1.0%	1.0%	1.0%
2040	1.0%	1.0%	1.0%	1.0%
2041	1.0%	1.0%	1.0%	1.0%
2042	1.0%	1.0%	1.0%	1.0%
2043	1.0%	1.0%	1.0%	1.0%
2044	1.0%	1.0%	1.0%	1.0%
2045	1.0%	1.0%	1.0%	1.0%
2046	1.0%	1.0%	1.0%	1.0%
2047	1.0%	1.0%	1.0%	1.0%
2048	1.0%	1.0%	1.0%	1.0%
2049	1.0%	1.0%	1.0%	1.0%

Source: Energy & Environmental Economics, 2019.

6.3 Appendix C – PG&E Gas Infrastructure Cost Memo



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December 5, 2019

Energy Commission Staff:

On March 2, 2018, PG&E provided gas extension cost estimates for residential existing and new subdivisions (see attached memo). We have recently updated our estimates and are therefore providing an updated memo.

In addition to mainline and service extension costs, we are also providing estimates of the cost of gas meters for different building types including both residential and commercial customers. These estimates are based on PG&E historical jobs.

Developing gas extension cost estimates is complex and the actual costs are project dependent. Costs vary widely with location, terrain, distance to the nearest main, joint trenching, materials, number of dwellings per development, and several other site and job-specific conditions. For these reasons, it is not practical to come up with estimates that represent every case. Instead we are including estimates based on historical averages taken from projects within PG&E's territory. It is not recommended to compare specific project costs to these estimates as any number of factors could lead to higher or lower costs than these averages are representing.

We are also including estimates for in-house gas infrastructure costs and specific plan review costs. These estimates are from external sources, and are not based on PG&E data, but have been provided for the sake of completeness and for use in energy efficiency analysis.

To further anchor the estimates, several assumptions have been made:

1. It is assumed that during new construction, gas infrastructure will likely be joint trenched with electric infrastructure. As a result, the incremental cost of trenching associated with the gas infrastructure alone is minimal. Therefore, all mainline cost estimates exclude trench costs. Service extension cost estimates include both estimates with and without trench costs. In the case where new construction would require overhead electric and underground gas infrastructure, the estimates with trench costs included for service extensions should be utilized.
2. It is assumed that new construction in an existing subdivision would not generally require a mainline extension. In cases where a mainline extension would be required to an existing subdivision, the costs are highly dependent on the location, terrain, and distance to the nearest main.



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- These estimates are for total costs. The cost estimates have not been reduced to account for the portion of the costs paid by all customers due to application of Rule 15¹ and Rule 16² allowances. Hence, costs to the specific customer may be lower than the estimates below, as the specific customer benefits from the Rule 15 and Rule 16 allowances.

Table 1: PG&E Gas Infrastructure Cost Estimates

	Existing Subdivision/Development	New Greenfield Subdivision/Development
Mainline Extension	N/A ³	<u>Single-Family</u> \$17/ft ⁴ <u>Multi-Family</u> \$11/ft ⁴
Service Extension (Typically 1" pipe from mainline to the meter)	\$6750 per service/building ⁴ (excludes trench costs) \$9200 per service/building ⁴ (includes trench costs)	\$1300 per service/building ⁴ (includes mainline extension costs within the subdivision; excludes trench costs) \$1850 per service/building ⁴ (includes mainline extension costs within the subdivision; includes trench costs)
Meter	<u>Residential Single Family</u> \$300 per meter ⁵ <u>Residential Multi-Family</u> \$300 per meter + \$300 per meter manifold outlet ⁵ <u>Small/Medium Commercial</u> \$3600 per meter ⁶	<u>Residential Single Family</u> \$300 per meter ⁵ <u>Residential Multi-Family</u> \$300 per meter + \$300 per meter manifold outlet ⁵ <u>Small/Medium Commercial</u> \$3600 per meter ⁶

¹ https://www.pge.com/tariffs/tm2/pdf/ELEC_RULES_15.pdf

² https://www.pge.com/tariffs/tm2/pdf/ELEC_RULES_16.pdf

³ It is assumed that new construction in an existing subdivision would not require a main extension.

⁴ Estimates based on PG&E jobs from Jan 2016 - Dec 2017 from PG&E's Service Planning team.

⁵ Estimates from PG&E's Dedicated Estimating Team. For Multi-Family units, the costs of \$300 per meter and \$300 per meter manifold outlet should be combined for a total of \$600 per meter.

⁶ PG&E Marginal Customer Access Cost Estimates presented in the 2018 Gas Cost Allocation Proceedings (GCAP), A.17-09-006, Exhibit PG&E-2, Appendix A, Section A, Table A-1. The Average Connection Cost per Customer values were included in the MCAC workpaper that accompanied the GCAP testimony



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	<u>Large Commercial</u> \$32,000 per meter ⁶	<u>Large Commercial</u> \$32,000 per meter ⁶
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Note: Service extension cost estimates for New Greenfield Subdivisions include mainline extension costs as well. Therefore, mainline cost estimates can be ignored for the purpose of estimating total project costs.

Table 2: Gas Infrastructure Cost Estimates from Other Sources

	Existing Subdivision/Development	New Greenfield Subdivision/Development
In-House Infrastructure	<u>Single-Family</u> \$800 ⁷	<u>Single-Family</u> \$800 ⁷
	<u>Multi-Family</u> \$600 per unit ⁷	<u>Multi-Family</u> \$600 per unit ⁷
	<u>Medium Office</u> \$600-4500 ^{7,8}	<u>Medium Office</u> \$600-4500 ^{7,8}
	<u>Medium Retail</u> \$10,000 ⁸	<u>Medium Retail</u> \$10,000 ⁸
Plan Review (Will vary by city and often not a fixed fee)	<u>Residential</u> Palo Alto - \$850 ⁹	<u>Residential</u> Palo Alto - \$850 ⁹
	<u>Nonresidential</u> Palo Alto - \$2316 ⁹	<u>Nonresidential</u> Palo Alto - \$2316 ⁹

Please let us know if there are any follow-up questions or clarifications.

Best regards,

⁷ Frontier Energy, Inc., Misti Bruceri & Associates, LLC. 2019. "2019 Cost-effectiveness Study: Low Rise Residential New Construction." Available at: <https://localenergycodes.com/content/performance-ordinances>

⁸ TRC, EnergySoft. 2019. "2019 Nonresidential New Construction Reach Code Cost Effectiveness Study." Available at: <https://localenergycodes.com/content/performance-ordinances>

⁹ TRC. 2018. "City of Palo Alto 2019 Title 24 Energy Reach Code Cost Effectiveness Analysis Draft." Available at: <http://cityofpaloalto.org/civicax/filebank/documents/66742>

6.4 Appendix D – Detailed Results - Mixed Fuel

Table 22: Mixed-Fuel Efficiency Only Package Results (Savings/Cost Per Dwelling Unit)^a

Climate Zone	Elec Utility	Gas Utility	Dwelling Units		Central Water Heating			Total On-Bill Utility Inc. Cost			On-Bill		2019 TDV		2022 TDV	
			Elec Savings (kWh)	Year 1 Utility Cost Savings	Gas Savings (therm)	Elec Savings (kWh)	Year 1 Utility Cost Savings	GHG Savings (lb CO ₂)	Savings (2020 PV\$)	Cost (2020 PV\$)	B/C Ratio	NPV	B/C Ratio	NPV	B/C Ratio	NPV
1	PGE	PGE	39	\$8	0.0	0	\$0	26	\$199	\$216	0.9	(\$17)	0.6	(\$83)	0.8	(\$42)
2	PGE	PGE	79	\$24	0.0	0	\$0	45	\$570	\$144	4.0	\$426	3.0	\$289	2.7	\$247
3	PGE	PGE	60	\$18	0.0	0	\$0	33	\$420	\$144	2.9	\$276	2.3	\$184	1.9	\$131
4	PGE	PGE	95	\$29	0.0	0	\$0	54	\$678	\$144	4.7	\$534	3.2	\$321	3.2	\$313
4	CPAU	CPAU	95	\$17	0.0	0	\$0	54	\$394	\$144	2.7	\$250	3.2	\$321	3.2	\$313
5	PGE	PGE	71	\$20	0.0	0	\$0	39	\$484	\$144	3.4	\$340	2.3	\$180	1.9	\$122
5	PGE	SCG	71	\$20	0.0	0	\$0	39	\$484	\$144	3.4	\$340	2.3	\$180	1.9	\$122
6	SCE	SCG	113	\$26	0.0	0	\$0	62	\$619	\$144	4.3	\$475	3.4	\$344	3.2	\$315
7	SDGE	SDGE	105	\$33	0.0	0	\$0	59	\$789	\$144	5.5	\$645	3.4	\$339	2.8	\$264
8	SCE	SCG	128	\$31	0.0	0	\$0	72	\$728	\$144	5.1	\$585	3.9	\$413	3.9	\$421
9	SCE	SCG	125	\$29	0.0	0	\$0	70	\$695	\$144	4.8	\$551	4.2	\$461	3.9	\$413
10	SCE	SCG	130	\$26	0.0	0	\$0	73	\$623	\$144	4.3	\$479	4.2	\$457	3.9	\$415
10	SDGE	SDGE	130	\$41	0.0	0	\$0	73	\$972	\$144	6.8	\$828	4.2	\$457	3.9	\$415
11	PGE	PGE	148	\$38	0.0	0	\$0	91	\$897	\$216	4.1	\$681	3.7	\$584	3.4	\$523
12	PGE	PGE	122	\$31	0.0	0	\$0	74	\$736	\$216	3.4	\$519	3.1	\$448	2.8	\$397
12	SMUD	PGE	122	\$17	0.0	0	\$0	74	\$401	\$216	1.9	\$185	3.1	\$448	2.8	\$397
13	PGE	PGE	152	\$39	0.0	0	\$0	93	\$923	\$216	4.3	\$706	3.4	\$523	3.5	\$534
14	SCE	SCG	152	\$31	0.0	0	\$0	91	\$735	\$216	3.4	\$518	3.6	\$556	3.5	\$532
14	SDGE	SDGE	152	\$45	0.0	0	\$0	91	\$1,055	\$216	4.9	\$838	3.6	\$556	3.5	\$532
15	SCE	SCG	213	\$43	0.0	0	\$0	124	\$1,021	\$216	4.7	\$804	4.5	\$768	4.4	\$725
16	PGE	PGE	115	\$29	0.0	0	\$0	73	\$679	\$216	3.1	\$463	2.3	\$279	2.1	\$244

^a Values in red indicate B/C ratios less than 1.

Table 23: Mixed-Fuel Efficiency + 0.1 kW_{DC} PV per Dwelling Unit Results (Savings/Cost Per Dwelling Unit)^a

Climate Zone	Elec Utility	Gas Utility	Dwelling Units		Central Water Heating			Total			On-Bill		2019 TDV		2022 TDV	
			Elec Savings (kWh)	Year 1 Utility Cost Savings	Gas Savings (therm)	Elec Savings (kWh)	Year 1 Utility Cost Savings	GHG Savings (lb CO ₂)	On-Bill Utility Savings (2020 PV\$)	Inc. Cost (2020 PV\$)	B/C Ratio	NPV	B/C Ratio	NPV	B/C Ratio	NPV
1	PGE	PGE	172	\$40	0.0	0	\$0	81	\$955	\$533	1.8	\$422	1.2	\$93	1.0	\$21
2	PGE	PGE	236	\$67	0.0	0	\$0	112	\$1,597	\$460	3.5	\$1,137	2.2	\$574	1.9	\$417
3	PGE	PGE	222	\$62	0.0	0	\$0	102	\$1,472	\$460	3.2	\$1,011	2.0	\$455	1.6	\$290
4	PGE	PGE	261	\$74	0.0	0	\$0	125	\$1,762	\$460	3.8	\$1,302	2.4	\$628	2.2	\$538
4	CPAU	CPAU	261	\$43	0.0	0	\$0	125	\$1,025	\$460	2.2	\$565	2.4	\$628	2.2	\$538
5	PGE	PGE	245	\$67	0.0	0	\$0	113	\$1,596	\$460	3.5	\$1,136	2.1	\$498	1.7	\$312
5	PGE	SCG	245	\$67	0.0	0	\$0	113	\$1,596	\$460	3.5	\$1,136	2.1	\$498	1.7	\$312
6	SCE	SCG	290	\$63	0.0	0	\$0	138	\$1,489	\$460	3.2	\$1,029	2.4	\$650	2.2	\$558
7	SDGE	SDGE	270	\$81	0.0	0	\$0	130	\$1,918	\$460	4.2	\$1,458	2.4	\$664	2.0	\$441
8	SCE	SCG	299	\$66	0.0	0	\$0	146	\$1,573	\$460	3.4	\$1,113	2.6	\$750	2.5	\$712
9	SCE	SCG	303	\$63	0.0	0	\$0	147	\$1,502	\$460	3.3	\$1,042	2.8	\$807	2.5	\$697
10	SCE	SCG	308	\$58	0.0	0	\$0	150	\$1,376	\$460	3.0	\$916	2.7	\$779	2.5	\$682
10	SDGE	SDGE	308	\$90	0.0	0	\$0	150	\$2,132	\$460	4.6	\$1,671	2.7	\$779	2.5	\$682
11	PGE	PGE	307	\$76	0.0	0	\$0	160	\$1,800	\$533	3.4	\$1,267	2.7	\$903	2.3	\$695
12	PGE	PGE	286	\$70	0.0	0	\$0	144	\$1,663	\$533	3.1	\$1,130	2.4	\$755	2.1	\$579
12	SMUD	PGE	286	\$37	0.0	0	\$0	144	\$874	\$533	1.6	\$341	2.4	\$755	2.1	\$579
13	PGE	PGE	317	\$78	0.0	0	\$0	164	\$1,858	\$533	3.5	\$1,325	2.5	\$811	2.4	\$729
14	SCE	SCG	343	\$65	0.0	0	\$0	172	\$1,542	\$533	2.9	\$1,009	2.8	\$980	2.6	\$854
14	SDGE	SDGE	343	\$95	0.0	0	\$0	172	\$2,247	\$533	4.2	\$1,714	2.8	\$980	2.6	\$854
15	SCE	SCG	390	\$75	0.0	0	\$0	199	\$1,768	\$533	3.3	\$1,235	3.1	\$1,123	2.8	\$981
16	PGE	PGE	284	\$69	0.0	0	\$0	147	\$1,641	\$533	3.1	\$1,108	2.1	\$595	1.8	\$428

^a Values in red indicate B/C ratios less than 1 or negative values.

6.5 Appendix E – Detailed Results - All-Electric

Table 24: All-Electric Central Recirculating HPWH Efficiency Package Results (Savings/Cost Per Dwelling Unit)^{a, b}

Climate Zone	Elec Utility	Gas Utility	Dwelling Units		Central Water Heating			Total			On-Bill		2019 TDV		2022 TDV	
			Elec Savings (kWh)	Year 1 Utility Cost Savings	Gas Savings (therm)	Elec Savings (kWh)	Year 1 Utility Cost Savings	GHG Savings (lb CO ₂)	Utility Savings (2020 PV\$)	Inc. Cost (2020 PV\$)	B/C Ratio	NPV	B/C Ratio	NPV	B/C Ratio	NPV
1	PGE	PGE	39	\$8	95.7	(710)	(\$38)	838	(\$493)	\$775	0.0	(\$1,268)	0.0	(\$744)	2.1	\$850
2	PGE	PGE	78	\$24	86.9	(635)	(\$32)	785	\$5	\$702	0.0	(\$697)	0.5	(\$371)	2.5	\$1,067
3	PGE	PGE	70	\$20	86.7	(618)	(\$29)	788	(\$33)	\$888	0.0	(\$921)	0.3	(\$635)	1.9	\$763
4	PGE	PGE	95	\$29	81.4	(590)	(\$29)	750	\$174	\$702	0.2	(\$528)	0.5	(\$317)	2.5	\$1,084
4	CPAU	CPAU	95	\$17	81.4	(590)	(\$5)	750	\$447	\$702	0.6	(\$255)	0.5	(\$317)	2.5	\$1,084
5	PGE	PGE	80	\$22	86.7	(616)	(\$29)	792	\$30	\$888	0.0	(\$858)	0.3	(\$608)	1.7	\$656
5	PGE	SCG	80	\$22	86.7	(616)	(\$49)	792	(\$324)	\$888	0.0	(\$1,212)	0.3	(\$608)	1.7	\$656
6	SCE	SCG	113	\$26	78.3	(560)	(\$21)	732	\$399	\$702	0.6	(\$303)	0.7	(\$214)	2.4	\$960
7	SDGE	SDGE	105	\$33	78.0	(558)	(\$37)	727	\$174	\$702	0.2	(\$528)	0.7	(\$237)	2.2	\$810
8	SCE	SCG	128	\$31	75.5	(544)	(\$21)	715	\$501	\$702	0.7	(\$201)	0.9	(\$65)	2.7	\$1,174
9	SCE	SCG	125	\$29	76.3	(552)	(\$21)	721	\$463	\$702	0.7	(\$239)	0.9	(\$64)	2.7	\$1,217
10	SCE	SCG	130	\$26	63.2	(552)	(\$36)	555	\$10	\$484	0.0	(\$474)	0.4	(\$279)	2.5	\$745
10	SDGE	SDGE	130	\$41	63.2	(552)	(\$55)	555	(\$116)	\$484	0.0	(\$600)	0.4	(\$279)	2.5	\$745
11	PGE	PGE	147	\$38	64.8	(582)	(\$47)	580	(\$66)	\$557	0.0	(\$623)	0.7	(\$150)	2.4	\$767
12	PGE	PGE	122	\$31	67.7	(596)	(\$48)	589	(\$238)	\$557	0.0	(\$795)	0.5	(\$254)	2.2	\$682
12	SMUD	PGE	122	\$17	67.7	(596)	\$12	589	\$849	\$557	1.5	\$292	0.5	(\$254)	2.2	\$682
13	PGE	PGE	152	\$39	62.8	(562)	(\$45)	566	(\$9)	\$557	0.0	(\$566)	0.6	(\$200)	2.4	\$801
14	SCE	SCG	152	\$31	65.3	(585)	(\$39)	581	\$53	\$557	0.1	(\$503)	0.8	(\$126)	2.6	\$892
14	SDGE	SDGE	152	\$44	65.3	(585)	(\$59)	581	(\$121)	\$557	0.0	(\$678)	0.8	(\$126)	2.6	\$892
15	SCE	SCG	213	\$43	51.2	(465)	(\$31)	507	\$481	\$557	0.9	(\$76)	1.4	\$239	2.7	\$950
16	PGE	PGE	115	\$29	77.8	(737)	(\$66)	642	(\$696)	\$557	0.0	(\$1,252)	0.0	(\$997)	1.3	\$170

^a Values in red indicate B/C ratios less than 1 or negative values. Values in grey indicate cases which are cost-effective but are not code compliant and cannot be used to support a reach code.

^b “>1” indicates cases where there are both incremental measure cost savings and energy cost savings.

Table 25: All-Electric Central Recirculating HPWH + 0.1 kW_{DC} PV per Dwelling Unit Results (Savings/Cost Per Dwelling Unit)^{a, b}

Climate Zone	Elec Utility	Gas Utility	Dwelling Units		Central Water Heating			Total On-Bill Utility Savings Inc. Cost			On-Bill		2019 TDV		2022 TDV	
			Elec Savings (kWh)	Year 1 Utility Cost Savings	Gas Savings (therm)	Elec Savings (kWh)	Year 1 Utility Cost Savings	GHG Savings (lb CO ₂)	(2020 PV\$)	(2020 PV\$)	B/C Ratio	NPV	B/C Ratio	NPV	B/C Ratio	NPV
1	PGE	PGE	171	\$40	95.7	(710)	(\$38)	894	\$262	\$1,091	0.2	(\$829)	0.5	(\$569)	1.8	\$914
2	PGE	PGE	236	\$67	86.9	(635)	(\$32)	852	\$1,032	\$1,018	1.0	\$14	0.9	(\$87)	2.2	\$1,237
3	PGE	PGE	232	\$64	86.7	(618)	(\$29)	857	\$1,019	\$1,205	0.8	(\$185)	0.7	(\$364)	1.8	\$922
4	PGE	PGE	261	\$74	81.4	(590)	(\$29)	821	\$1,258	\$1,018	1.2	\$239	1.0	(\$10)	2.3	\$1,309
4	CPAU	CPAU	261	\$43	81.4	(590)	(\$5)	821	\$1,079	\$1,018	1.1	\$60	1.0	(\$10)	2.3	\$1,309
5	PGE	PGE	254	\$69	86.7	(616)	(\$29)	867	\$1,142	\$1,205	0.9	(\$62)	0.8	(\$290)	1.7	\$847
5	PGE	SCG	254	\$69	86.7	(616)	(\$49)	867	\$789	\$1,205	0.7	(\$416)	0.8	(\$290)	1.7	\$847
6	SCE	SCG	290	\$63	78.3	(560)	(\$21)	808	\$1,269	\$1,018	1.2	\$251	1.1	\$92	2.2	\$1,203
7	SDGE	SDGE	270	\$81	78.0	(558)	(\$37)	798	\$1,303	\$1,018	1.3	\$284	1.1	\$88	2.0	\$987
8	SCE	SCG	299	\$66	75.5	(544)	(\$21)	789	\$1,345	\$1,018	1.3	\$327	1.3	\$272	2.4	\$1,465
9	SCE	SCG	303	\$63	76.3	(552)	(\$21)	797	\$1,270	\$1,018	1.2	\$251	1.3	\$281	2.5	\$1,501
10	SCE	SCG	308	\$58	63.2	(552)	(\$36)	632	\$763	\$801	1.0	(\$37)	1.1	\$43	2.3	\$1,013
10	SDGE	SDGE	308	\$90	63.2	(552)	(\$55)	632	\$1,044	\$801	1.3	\$243	1.1	\$43	2.3	\$1,013
11	PGE	PGE	307	\$76	64.8	(582)	(\$47)	648	\$837	\$873	1.0	(\$36)	1.2	\$169	2.1	\$939
12	PGE	PGE	285	\$70	67.7	(596)	(\$48)	659	\$690	\$873	0.8	(\$184)	1.1	\$53	2.0	\$864
12	SMUD	PGE	285	\$37	67.7	(596)	\$12	659	\$1,321	\$873	1.5	\$448	1.1	\$53	2.0	\$864
13	PGE	PGE	317	\$78	62.8	(562)	(\$45)	637	\$926	\$873	1.1	\$52	1.1	\$87	2.1	\$997
14	SCE	SCG	343	\$65	65.3	(585)	(\$39)	663	\$861	\$873	1.0	(\$13)	1.3	\$299	2.4	\$1,214
14	SDGE	SDGE	343	\$95	65.3	(585)	(\$59)	663	\$1,071	\$873	1.2	\$198	1.3	\$299	2.4	\$1,214
15	SCE	SCG	390	\$75	51.2	(465)	(\$31)	582	\$1,228	\$873	1.4	\$354	1.7	\$594	2.4	\$1,206
16	PGE	PGE	284	\$69	77.8	(737)	(\$66)	716	\$266	\$873	0.3	(\$607)	0.2	(\$681)	1.4	\$353

^a Values in red indicate B/C ratios less than 1 or negative values. Values in grey indicate cases which are cost-effective but are not code compliant and cannot be used to support a reach code.

^b ">1" indicates cases where there are both incremental measure cost savings and energy cost savings.

Table 26: All-Electric Central Recirculating HPWH + 0.2 kW_{DC} PV per Dwelling Unit Results (Savings/Cost Per Dwelling Unit)^{a, b}

Climate Zone	Elec Utility	Gas Utility	Dwelling Units		Central Water Heating			GHG Savings (lb CO ₂)	Total On-Bill Utility Savings (2020 PV\$)	Inc. Cost (2020 PV\$)	On-Bill		2019 TDV		2022 TDV	
			Elec Savings (kWh)	Year 1 Utility Cost Savings	Gas Savings (therm)	Elec Savings (kWh)	Year 1 Utility Cost Savings				B/C Ratio	NPV	B/C Ratio	NPV	B/C Ratio	NPV
1	PGE	PGE	304	\$72	95.7	(710)	(\$38)	949	\$1,018	\$1,408	0.72	(\$390)	0.7	(\$393)	1.7	\$977
2	PGE	PGE	393	\$111	86.9	(635)	(\$32)	920	\$2,060	\$1,335	1.54	\$725	1.1	\$197	2.1	\$1,407
3	PGE	PGE	395	\$109	86.7	(618)	(\$29)	926	\$2,071	\$1,521	1.36	\$550	0.9	(\$93)	1.7	\$1,080
4	PGE	PGE	427	\$120	81.4	(590)	(\$29)	892	\$2,342	\$1,335	1.75	\$1,007	1.2	\$297	2.1	\$1,534
4	CPAU	CPAU	427	\$68	81.4	(590)	(\$5)	892	\$1,669	\$1,335	1.25	\$334	1.2	\$297	2.1	\$1,534
5	PGE	PGE	428	\$116	86.7	(616)	(\$29)	941	\$2,255	\$1,521	1.48	\$734	1.0	\$27	1.7	\$1,037
5	PGE	SCG	428	\$116	86.7	(616)	(\$49)	941	\$1,901	\$1,521	1.25	\$380	1.0	\$27	1.7	\$1,037
6	SCE	SCG	466	\$100	78.3	(560)	(\$21)	884	\$2,140	\$1,335	1.60	\$805	1.3	\$397	2.1	\$1,446
7	SDGE	SDGE	435	\$127	78.0	(558)	(\$37)	869	\$2,404	\$1,335	1.80	\$1,069	1.3	\$414	1.9	\$1,164
8	SCE	SCG	470	\$102	75.5	(544)	(\$21)	863	\$2,190	\$1,335	1.64	\$855	1.5	\$609	2.3	\$1,755
9	SCE	SCG	480	\$95	76.3	(552)	(\$21)	874	\$2,027	\$1,335	1.52	\$692	1.5	\$627	2.3	\$1,785
10	SCE	SCG	485	\$90	63.2	(552)	(\$36)	708	\$1,517	\$1,117	1.36	\$400	1.3	\$365	2.1	\$1,280
10	SDGE	SDGE	485	\$138	63.2	(552)	(\$55)	708	\$2,184	\$1,117	1.96	\$1,067	1.3	\$365	2.1	\$1,280
11	PGE	PGE	466	\$114	64.8	(582)	(\$47)	717	\$1,740	\$1,190	1.46	\$550	1.4	\$488	1.9	\$1,111
12	PGE	PGE	449	\$109	67.7	(596)	(\$48)	729	\$1,617	\$1,190	1.36	\$427	1.3	\$361	1.9	\$1,046
12	SMUD	PGE	449	\$57	67.7	(596)	\$12	729	\$1,793	\$1,190	1.51	\$604	1.3	\$361	1.9	\$1,046
13	PGE	PGE	482	\$118	62.8	(562)	(\$45)	708	\$1,861	\$1,190	1.56	\$671	1.3	\$375	2.0	\$1,192
14	SCE	SCG	534	\$99	65.3	(585)	(\$39)	744	\$1,668	\$1,190	1.40	\$478	1.6	\$723	2.3	\$1,537
14	SDGE	SDGE	534	\$145	65.3	(585)	(\$59)	744	\$2,263	\$1,190	1.90	\$1,073	1.6	\$723	2.3	\$1,537
15	SCE	SCG	567	\$106	51.2	(465)	(\$31)	657	\$1,975	\$1,190	1.66	\$785	1.8	\$949	2.2	\$1,463
16	PGE	PGE	454	\$110	77.8	(737)	(\$66)	789	\$1,228	\$1,190	1.03	\$38	0.7	(\$366)	1.5	\$537

^a Values in red indicate B/C ratios less than 1 or negative values. Values in grey indicate cases which are cost-effective but are not code compliant and cannot be used to support a reach code.

^b ">1" indicates cases where there are both incremental measure cost savings and energy cost savings.

Table 27: All-Electric Clustered HPWH Efficiency Only Package Results (Savings/Cost Per Dwelling Unit)^{a, b}

Climate Zone	Elec Utility	Gas Utility	Dwelling Units		Central Water Heating			Total			On-Bill		2019 TDV		2022 TDV	
			Elec Savings (kWh)	Year 1 Utility Cost Savings	Gas Savings (therm)	Elec Savings (kWh)	Year 1 Utility Cost Savings	GHG Savings (lb CO ₂)	On-Bill Utility Savings (2020 PV\$)	Inc. Cost (2020 PV\$)	B/C Ratio	NPV	B/C Ratio	NPV	B/C Ratio	NPV
1	PGE	PGE	39	\$8	95.7	(809)	(\$64)	838	(\$1,096)	(\$643)	0.6	(\$453)	1.9	\$297	>1	\$1,793
2	PGE	PGE	78	\$24	86.9	(726)	(\$55)	785	(\$535)	(\$715)	1.3	\$180	>1	\$843	>1	\$2,069
3	PGE	PGE	70	\$20	86.7	(711)	(\$53)	788	(\$583)	(\$529)	0.9	(\$54)	>1	\$542	>1	\$1,786
4	PGE	PGE	95	\$29	81.4	(673)	(\$50)	750	(\$317)	(\$715)	2.3	\$399	>1	\$908	>1	\$2,025
4	CPAU	CPAU	95	\$17	81.4	(673)	(\$19)	750	\$97	(\$715)	>1	\$813	>1	\$908	>1	\$2,025
5	PGE	PGE	80	\$22	86.7	(711)	(\$53)	792	(\$527)	(\$529)	1.0	\$2	>1	\$539	>1	\$1,782
5	PGE	SCG	80	\$22	86.7	(711)	(\$73)	792	(\$881)	(\$529)	0.6	(\$352)	>1	\$539	>1	\$1,782
6	SCE	SCG	113	\$26	78.3	(645)	(\$41)	732	(\$67)	(\$715)	10.7	\$649	>1	\$928	>1	\$2,042
7	SDGE	SDGE	105	\$33	78.0	(642)	(\$61)	727	(\$388)	(\$715)	1.8	\$328	>1	\$947	>1	\$2,080
8	SCE	SCG	128	\$31	75.5	(620)	(\$39)	715	\$71	(\$715)	>1	\$786	>1	\$994	>1	\$2,123
9	SCE	SCG	125	\$29	76.3	(628)	(\$40)	721	\$26	(\$715)	>1	\$742	>1	\$1,062	>1	\$2,202
10	SCE	SCG	130	\$26	63.2	(624)	(\$53)	555	(\$415)	(\$933)	2.2	\$518	>1	\$936	>1	\$1,832
10	SDGE	SDGE	130	\$41	63.2	(624)	(\$77)	555	(\$621)	(\$933)	1.5	\$313	>1	\$936	>1	\$1,832
11	PGE	PGE	147	\$38	64.8	(643)	(\$63)	580	(\$439)	(\$861)	2.0	\$421	>1	\$884	>1	\$1,926
12	PGE	PGE	122	\$31	67.7	(672)	(\$67)	589	(\$691)	(\$861)	1.2	\$170	10.9	\$781	>1	\$1,896
12	SMUD	PGE	122	\$17	67.7	(672)	(\$2)	589	\$515	(\$861)	>1	\$1,375	10.9	\$781	>1	\$1,896
13	PGE	PGE	152	\$39	62.8	(618)	(\$60)	566	(\$354)	(\$861)	2.4	\$506	7.1	\$740	>1	\$1,954
14	SCE	SCG	152	\$31	65.3	(650)	(\$56)	581	(\$363)	(\$861)	2.4	\$498	>1	\$942	>1	\$1,863
14	SDGE	SDGE	152	\$44	65.3	(650)	(\$80)	581	(\$610)	(\$861)	1.4	\$250	>1	\$942	>1	\$1,863
15	SCE	SCG	213	\$43	51.2	(492)	(\$42)	507	\$201	(\$861)	>1	\$1,062	>1	\$1,288	>1	\$2,068
16	PGE	PGE	115	\$29	77.8	(813)	(\$85)	642	(\$1,163)	(\$861)	0.7	(\$302)	1.3	\$189	>1	\$1,462

^a Values in red indicate B/C ratios less than 1 or negative values. Values in grey indicate cases which are cost-effective but are not code compliant and cannot be used to support a reach code.

^b ">1" indicates cases where there are both incremental measure cost savings and energy cost savings.

Table 28: All-Electric Clustered HPWH + 0.1 kW_{DC} PV per Dwelling Unit Results (Savings/Cost Per Dwelling Unit)^{a, b}

			Dwelling Units	Central Water Heating	Total	On-Bill	2019 TDV	2022 TDV
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High-Rise Residential New Construction Cost-Effectiveness Study

Climate Zone	Elec Utility	Gas Utility	Elec Savings (kWh)	Year 1 Utility Cost Savings	Gas Savings (therm)	Elec Savings (kWh)	Year 1 Utility Cost Savings	GHG Savings (lb CO ₂)	On-Bill Utility Savings (2020 PV\$)	Inc. Cost (2020 PV\$)	B/C Ratio	NPV	B/C Ratio	NPV	B/C Ratio	NPV
1	PGE	PGE	171	\$32	95.7	(809)	(\$64)	894	-\$341	(\$326)	0.96	(\$14)	>1	\$472	>1	\$1,856
2	PGE	PGE	236	\$43	86.9	(726)	(\$55)	852	\$492	(\$399)	>1	\$891	>1	\$1,127	>1	\$2,239
3	PGE	PGE	232	\$46	86.7	(711)	(\$53)	857	\$469	(\$213)	>1	\$682	>1	\$814	>1	\$1,945
4	PGE	PGE	261	\$46	81.4	(673)	(\$50)	821	\$768	(\$399)	>1	\$1,166	>1	\$1,215	>1	\$2,250
4	CPAU	CPAU	261	\$27	81.4	(673)	(\$19)	821	\$729	(\$399)	>1	\$1,128	>1	\$1,215	>1	\$2,250
5	PGE	PGE	254	\$49	86.7	(711)	(\$53)	867	\$585	(\$213)	>1	\$798	>1	\$856	>1	\$1,973
5	PGE	SCG	254	\$49	86.7	(711)	(\$73)	867	\$232	(\$213)	>1	\$445	>1	\$856	>1	\$1,973
6	SCE	SCG	290	\$37	78.3	(645)	(\$41)	808	\$803	(\$399)	>1	\$1,202	>1	\$1,233	>1	\$2,285
7	SDGE	SDGE	270	\$48	78.0	(642)	(\$61)	798	\$742	(\$399)	>1	\$1,141	>1	\$1,273	>1	\$2,256
8	SCE	SCG	299	\$36	75.5	(620)	(\$39)	789	\$915	(\$399)	>1	\$1,314	>1	\$1,331	>1	\$2,414
9	SCE	SCG	303	\$34	76.3	(628)	(\$40)	797	\$833	(\$399)	>1	\$1,232	>1	\$1,407	>1	\$2,486
10	SCE	SCG	308	\$32	63.2	(624)	(\$53)	632	\$338	(\$617)	>1	\$955	>1	\$1,258	>1	\$2,100
10	SDGE	SDGE	308	\$49	63.2	(624)	(\$77)	632	\$539	(\$617)	>1	\$1,156	>1	\$1,258	>1	\$2,100
11	PGE	PGE	307	\$38	64.8	(643)	(\$63)	648	\$464	(\$544)	>1	\$1,008	>1	\$1,203	>1	\$2,098
12	PGE	PGE	285	\$39	67.7	(672)	(\$67)	659	\$237	(\$544)	>1	\$781	>1	\$1,089	>1	\$2,078
12	SMUD	PGE	285	\$20	67.7	(672)	(\$2)	659	\$987	(\$544)	>1	\$1,531	>1	\$1,089	>1	\$2,078
13	PGE	PGE	317	\$39	62.8	(618)	(\$60)	637	\$581	(\$544)	>1	\$1,125	>1	\$1,027	>1	\$2,149
14	SCE	SCG	343	\$34	65.3	(650)	(\$56)	663	\$445	(\$544)	>1	\$989	>1	\$1,366	>1	\$2,185
14	SDGE	SDGE	343	\$50	65.3	(650)	(\$80)	663	\$582	(\$544)	>1	\$1,126	>1	\$1,366	>1	\$2,185
15	SCE	SCG	390	\$32	51.2	(492)	(\$42)	582	\$948	(\$544)	>1	\$1,492	>1	\$1,643	>1	\$2,324
16	PGE	PGE	284	\$41	77.8	(813)	(\$85)	716	-\$201	(\$544)	2.7	\$343	13.6	\$504	>1	\$1,645

^a Values in red indicate B/C ratios less than 1 or negative values. Values in grey indicate cases which are cost-effective but are not code compliant and cannot be used to support a reach code.

^b ">1" indicates cases where there are both incremental measure cost savings and energy cost savings.

Table 29: All-Electric Clustered HPWH + 0.2 kW_{DC} PV per Dwelling Unit Results (Savings/Cost Per Dwelling Unit)^{a, b}

Climate Zone	Elec Utility	Gas Utility	Dwelling Units		Central Water Heating			Total			On-Bill		2019 TDV		2022 TDV	
			Elec Savings (kWh)	Year 1 Utility Cost Savings	Gas Savings (therm)	Elec Savings (kWh)	Year 1 Utility Cost Savings	GHG Savings (lb CO ₂)	On-Bill Utility Savings (2020 PV\$)	Inc. Cost (2020 PV\$)	B/C Ratio	NPV	B/C Ratio	NPV	B/C Ratio	NPV
1	PGE	PGE	304	\$64	95.7	(809)	(\$64)	949	\$415	(\$10)	>1	\$425	>1	\$648	>1	\$1,919
2	PGE	PGE	393	\$87	86.9	(726)	(\$55)	920	\$1,520	(\$82)	>1	\$1,602	>1	\$1,411	>1	\$2,410
3	PGE	PGE	395	\$91	86.7	(711)	(\$53)	926	\$1,521	\$104	14.7	\$1,417	11.5	\$1,085	21.3	\$2,104
4	PGE	PGE	427	\$92	81.4	(673)	(\$50)	892	\$1,852	(\$82)	>1	\$1,934	>1	\$1,523	>1	\$2,474
4	CPAU	CPAU	427	\$52	81.4	(673)	(\$19)	892	\$1,319	(\$82)	>1	\$1,401	>1	\$1,523	>1	\$2,474
5	PGE	PGE	428	\$96	86.7	(711)	(\$53)	941	\$1,698	\$104	16.4	\$1,594	12.3	\$1,173	21.9	\$2,163
5	PGE	SCG	428	\$96	86.7	(711)	(\$73)	941	\$1,344	\$104	13.0	\$1,241	12.3	\$1,173	21.9	\$2,163
6	SCE	SCG	466	\$74	78.3	(645)	(\$41)	884	\$1,674	(\$82)	>1	\$1,756	>1	\$1,539	>1	\$2,528
7	SDGE	SDGE	435	\$94	78.0	(642)	(\$61)	869	\$1,842	(\$82)	>1	\$1,925	>1	\$1,598	>1	\$2,433
8	SCE	SCG	470	\$71	75.5	(620)	(\$39)	863	\$1,760	(\$82)	>1	\$1,842	>1	\$1,668	>1	\$2,705
9	SCE	SCG	480	\$66	76.3	(628)	(\$40)	874	\$1,590	(\$82)	>1	\$1,673	>1	\$1,752	>1	\$2,771
10	SCE	SCG	485	\$64	63.2	(624)	(\$53)	708	\$1,092	(\$300)	>1	\$1,392	>1	\$1,580	>1	\$2,368
10	SDGE	SDGE	485	\$97	63.2	(624)	(\$77)	708	\$1,680	(\$300)	>1	\$1,980	>1	\$1,580	>1	\$2,368
11	PGE	PGE	466	\$76	64.8	(643)	(\$63)	717	\$1,367	(\$228)	>1	\$1,594	>1	\$1,521	>1	\$2,270
12	PGE	PGE	449	\$78	67.7	(672)	(\$67)	729	\$1,164	(\$228)	>1	\$1,392	>1	\$1,396	>1	\$2,260
12	SMUD	PGE	449	\$40	67.7	(672)	(\$2)	729	\$1,459	(\$228)	>1	\$1,687	>1	\$1,396	>1	\$2,260
13	PGE	PGE	482	\$79	62.8	(618)	(\$60)	708	\$1,516	(\$228)	>1	\$1,743	>1	\$1,315	>1	\$2,344
14	SCE	SCG	534	\$68	65.3	(650)	(\$56)	744	\$1,252	(\$228)	>1	\$1,480	>1	\$1,791	>1	\$2,507
14	SDGE	SDGE	534	\$101	65.3	(650)	(\$80)	744	\$1,774	(\$228)	>1	\$2,002	>1	\$1,791	>1	\$2,507
15	SCE	SCG	567	\$63	51.2	(492)	(\$42)	657	\$1,695	(\$228)	>1	\$1,923	>1	\$1,998	>1	\$2,580
16	PGE	PGE	454	\$81	77.8	(813)	(\$85)	789	\$760	(\$228)	>1	\$988	>1	\$820	>1	\$1,829

^a Values in red indicate B/C ratios less than 1 or negative values. Values in grey indicate cases which are cost-effective but are not code compliant and cannot be used to support a reach code.

^b ">1" indicates cases where there are both incremental measure cost savings and energy cost savings.