

Title 24, Part 11
Local Energy Efficiency Ordinances

CALGreen All-Electric Cost Effectiveness Study

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Codes and Standards Program
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Last Modified: October 11, 2017

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1 Introduction

The California Building Energy Efficiency Standards Title 24, Part 6 (Title 24) (CEC, 2016b) is maintained and updated every three years by two state agencies, the California Energy Commission (CEC) and the Building Standards Commission (BSC). In addition to enforcing the code, local jurisdictions have the authority to adopt local energy efficiency ordinances, or reach codes, that exceed the minimum standards defined by Title 24 (as established by Public Resources Code Section 25402.1(h)2 and Section 10-106 of the Building Energy Efficiency Standards). Local jurisdictions must demonstrate that the requirements of the proposed ordinance are cost effective and do not result in buildings consuming more energy than is permitted by Title 24. In addition, the jurisdiction must obtain approval from the CEC and file the ordinance with the BSC for the ordinance to be legally enforceable.

The California Statewide Codes and Standards Team completed a feasibility and cost effectiveness study of requiring new low-rise single family and multifamily residential construction to exceed the 2016 Building Energy Efficiency Standards, which became effective January 1, 2017 (DEG, 2016). The 2016 report, last modified November 16, 2016, focused on mixed-fuel (gas/electric) homes only. This report presents the results from a similar analysis, focusing on all-electric designs. This evaluation, along with the prior report, provides local jurisdictions flexibility when adopting an energy efficiency ordinance by documenting that the requirement can be met either with a mixed-fuel (gas/electric) design or, in many cases, an all-electric design. Compliance package options and cost-effectiveness analysis for all-electric scenarios in all sixteen California climate zones (CZ) are presented here. All proposed package options include a combination of efficiency measures and on-site renewable energy. Some packages use heat pump water heaters (HPWH) that are more efficient than the DOE minimum and raise federal preemption issues. These results are provided to present alternative packages that are cost effective, but cannot be mandatory in local ordinances.

This analysis uses a customer-based lifecycle cost (LCC) approach to evaluating cost effectiveness of the proposed ordinance, whereas the CEC LCC methodology uses Time Dependent Valuation (TDV) as the primary metric for energy savings. Both methodologies require estimating and quantifying the energy savings associated with energy efficiency measures, as well as quantifying the costs associated with the measures. The main difference between the methodologies is the manner in which they value energy and thus the cost savings of reduced or avoided energy use. The CEC LCC Methodology uses TDV, which is intended to capture the societal impact of energy savings, while the customer-based life cycle cost methodology uses site energy use estimates, utility rate schedules and applies net energy metering rules to estimate cost savings from onsite PV generation to the customer.

2 Methodology and Assumptions

This all-electric analysis uses the same general methodology applied in the prior CALGreen Cost-Effectiveness Study (DEG, 2016). Details are provided below.

2.1 Building Prototypes

The CEC defines building prototypes which it uses to evaluate the cost-effectiveness of proposed changes to Title 24 requirements. There exist two single family prototypes and one multifamily prototype, all three of which are used in this analysis in development of the above-code efficiency packages. Table 1 describes the basic characteristics of each prototype. Additional details on the prototypes can be found in the ACM Approval Manual (CEC, 2016a).



Table 1: Prototype Characteristics

	<u>Single Family One-Story</u>	<u>Single Family Two-Story</u>	<u>Multifamily</u>
Conditioned Floor Area	2,100 ft ²	2,700 ft ²	6,960 ft ² : (4) 780 ft ² & (4) 960 ft ² units
Num. of Stories	1	2	2
Num. of Bedrooms	3	3	(4) 1-bed & (4) 2-bed units
Window-to-Floor Area Ratio	20%	20%	15%

The CEC’s standard protocol for the single family prototypes is to weight the simulated energy impacts by a factor that represents the distribution of single-story and two-story homes being built statewide, assuming 45% single-story homes and 55% two-story homes. Simulation results in this study are therefore characterized according to this ratio, which is approximately equivalent to a 2,430 ft² house¹.

2.2 Efficiency Measures & Package Development

The California Energy Commission (CEC) CBECC-Res 2016 compliance simulation software was used to evaluate energy impacts using the 2016 prescriptive standards as the benchmark and the 2016 time dependent valuation (TDV) values. TDV is the energy metric used by the CEC since the 2005 Title 24 energy code to evaluate compliance with the Title 24 standards. TDV values energy use differently depending on the fuel source (gas, electricity, and propane), time of day, and season. TDV was developed to reflect the “societal value or cost” of energy including long-term projected costs of energy such as the cost of providing energy during peak periods of demand and other societal costs such as projected costs for carbon emissions. Electricity used (or saved) during peak periods of the summer has a much higher value than electricity used (or saved) during off-peak periods (Horii et al, 2014).

The compliance simulation software was updated since the gas/electric analysis was conducted. The latest version of the compliance simulation software available at the time of this analysis, CBECC-RES 2016.3.0, was used for the all-electric analysis.

The methodology used in the analyses for each of the prototypical building types begins with a design that precisely meets the minimum 2016 prescriptive requirements (0% compliance margin). A table of prescriptive measures used in each base design by climate zone is located in Appendix A. Using the 2016 baseline as the starting point, performance and costs for the all-electric proposed case are compared to the compliance model standard design. Beginning with the Tier 1 and Tier 2 packages developed in the gas/electric study, the analysis team replaced the natural gas appliances in the model with the following electric appliances.

- Split-system electric heat pump that meets the minimum federal requirements for efficiency; 14 SEER, 11.7 EER for cooling and 8.2 HSPF for heating. Heating capacity was sized based on heating loads from CBECC-Res for the standard design.²
- Heat pump water heater (HPWH) that either meets or exceeds the minimum federal requirement for efficiency, where the latter has federal preemption issues.
- Electric cooking and electric clothes drying.

¹ 2,430 ft² = 45% * 2,100 ft² + 55% * 2,700 ft²

² Cooling capacity is not a user-input in CBECC.



Due to the effects of TDV, the all-electric designs generally result in lower overall compliance margins compared to the gas/electric designs. To compensate for the compliance penalty, efficiency measures were added as necessary to attain similar compliance margins as in the gas/electric study. The costs of the additional measures are included in the analysis of cost effectiveness. It is important to note that the packages contained in this report are examples only; any project meeting requirements of a local ordinance, both single family and multifamily, must independently evaluate and identify the most cost effective approach based on project-specific factors. Any local ordinance should avoid requiring any efficiency measures that trigger federal preemption issues.

Following are descriptions of each of the efficiency measures applied in this analysis.

Quality Insulation Installation (QII): HERS rater verification of installation quality of insulation according to the procedures outlined in the 2016 Reference Appendices RA3.5 (CEC, 2016c). QII is included in all cases since it is a pre-requisite for all the voluntary tiers in 2016 CALGreen.

Reduced Infiltration (ACH50): HERS rater field verification and diagnostic testing of building air leakage according to the procedures outlined in the 2016 Reference Appendices RA3.8 (CEC, 2016c). The default infiltration assumption for single family homes is 5 air changes per hour at 50 Pascals (ACH50)³ and the reduced level applied in this analysis is 3 ACH50. This measure was not applied to multifamily homes because the modeling software does not allow this credit unless each unit is modeled individually, which is not typical in the compliance process for multifamily buildings.

Window Performance: Reduce window U-factor from the prescriptive value of 0.32 to 0.30 in all climates and reduce the solar heat gain coefficient (SHGC) from the prescriptive value of 0.25 to 0.23 in Climate Zone 2, 4, 6 through 16. In Climate Zones 1, 3, and 5 there is no prescriptive SHGC requirement and the default value of 0.50 is left as is.

Door Performance: Install insulated doors that meet a U-value of 0.20 at the front entry and doors between the house and garage. It's assumed there is a single 3' x 6'8" entry door per single family home and multifamily unit as well as a second 3' x 6'8" door to the garage per single family home.

Cool Roof: Install a roofing product that's rated by the Cool Roof Rating Council to have an aged solar reflectance of 0.20. This measure only applies to climate zones where this is not already required prescriptively.

Exterior Wall Insulation: Increase wall cavity insulation from R-19 to R-21 in 2x6 walls.

High Performance Attics (HPA): For climates where HPA is not already prescriptive under the 2016 code (CZ 1-3, 5-7), increase attic ceiling insulation to R-38 and add insulation under the roof deck between framing (R-13 for roof with air space, R-18 for roof without air space).

High Efficacy Fan: Upgrade the fan in the furnace or air handler and the distribution system to meet an efficacy of 0.3 Watts / cfm or lower operating at full speed. This is possible with design and installation of low static pressure duct systems combined with a constant torque brushless permanent magnet motor. Fan watt draw is verified by a HERS rater according to the procedures outlined in the 2016 Reference Appendices RA3.3 (CEC, 2016c). New federal regulations that go into effect July 3, 2019 are expected to result in equivalent performance for all newly manufactured furnaces provided that the ducts are sized properly.

³ Whole house leakage tested at a pressure difference of 50 Pascals between indoors and outdoors.



Refrigerant Charge Verification: HERS rater verification of proper air conditioner refrigerant charge according to the procedures outlined in the 2016 Reference Appendices RA3.2 (CEC, 2016c). This measure only applies to climate zones where this is not already required prescriptively.

R-8 Duct Insulation: Increase duct insulation to R-8. This measure only applies to climate zones where R-8 ducts are not already required prescriptively.

Low Leakage Ducts in Conditioned Space: This credit requires HERS rater verification that duct leakage does not exceed 25 cfm to the outside. A blower door must be used for this test.

Hot Water Pipe Insulation: As of January 1, 2017 the 2016 California Plumbing Code requires pipe insulation levels that are close to that required if taking the Title-24 pipe insulation credit. This credit will be obsolete under the 2016 energy code, however, the HERS-Verified Pipe Insulation Credit, as defined in the 2016 Reference Appendices RA3.6.3 (CEC, 2016c), will remain. While CBECC-Res has not yet been updated to reflect this, for this analysis it was assumed that the revised HERS verified credit would be equivalent to the current credit for pipe insulation without HERS verification. This was determined based on simulations that demonstrated the HERS credit to be valued at roughly twice that for pipe insulation without verification in terms of TDV energy. This credit was only applied to single family residences. For costing purposes, 120 linear feet of 1/2in insulated pipe is assumed to be insulated.

Hot Water Compact Distribution: HERS rater verification of compact distribution system requirements according to the procedures outlined in the 2016 Reference Appendices RA3.6.5 (CEC, 2016c). This measure was applied to multifamily buildings only. Many multifamily buildings with individual water heaters are expected to easily meet this credit with little or no alteration to plumbing design. This measure also requires verification of pipe insulation per the HERS-Verified Pipe Insulation Credit. Assumption is 60 linear feet per dwelling unit of 1/2in insulated pipe.

Water Heater Located within Conditioned Space: Moving the water heater into conditioned space, particularly from an exterior closet as is the standard case in certain multifamily buildings, reduces water heater energy use and provides cooling to the space which is beneficial during the cooling season. The additional cooling load also increases heating energy use during the heating season. HPWHs in conditioned space can be ducted to minimize thermal impacts but this option was not evaluated because CBECC-Res does not currently have the ability to model ducting of inlet or exhaust air.

PV and PV Compliance Credit: A PV compliance credit (PVCC) is available in all climate zones except six and seven. To be eligible for this compliance credit a PV system with a minimum capacity of 2 kW DC per single family home with no more than 2,000 ft² of conditioned floor area or 1 kW DC per multifamily unit with no more than 1,000 ft² of conditioned floor area is required. For the single family 2,430 ft² prototype the minimum capacity as calculated by CBECC-Res is 2.0 kW to 2.4 kW depending on the climate zone. The multifamily apartment units in the prototype are all under 1,000 ft² and therefore require a 1 kW system. See Table 18 and Table 19 in Appendix C for minimum PV system capacity required to be eligible for the PVCC. PV was modeled in CBECC-Res according to the California Flexible Installation (CFI). For costing, a micro inverter is assumed which is expected to be replaced at year 20.

2.3 All-Electric Package

The CBECC-Res compliance software requires the user to specify whether natural gas is available at the site, and adjusts the baseline assumptions and TDV values based on the selection. For newly constructed buildings, natural gas is defined as being available on site in the 2016 ACM Manual if a gas service line



can be connected to the site without a gas main extension⁴. As the baseline assumptions have a significant impact on the compliance margin, this analysis evaluated the cost-effectiveness of the designs with, and without, the availability of natural gas at the site. In both cases, the proposed design is compared to a home with electric appliances, with the exception of a propane gas tankless water heater in the “No Natural Gas” scenario and a natural gas tankless water heater in the “Natural Gas Available” scenario. All other appliances are electric, consistent with the fuel selections in the proposed design. Because TDV energy use for natural gas is roughly half that of propane, the “Natural Gas Available” scenario, with a minimum efficiency HPWH of 2.0 EF produces compliance penalties relative to the “No Natural Gas” design making it challenging in some climates to even comply with code. As a result, the evaluation applied a Northwest Energy Efficiency Alliance (NEEA) rated HPWH with an energy factor equal to 3.17 in the model to attain comparable performance with the “No Natural Gas” scenario. Because this design includes a HPWH that exceeds minimum federal requirements, the “Natural Gas Available” scenario does not provide the basis for a local jurisdiction to specifically require the use of all electric equipment for new homes with access to natural gas. However, this analysis demonstrates that there are cost-effective all-electric options for buildings with natural gas available to provide builders the flexibility to select either a gas/electric or an all-electric design.

Table 2 summarizes the electric equipment measures applied in the proposed all-electric package compared with those assumed by the software in the standard design.

Table 2: Title 24 Standard Design (Baseline) Equipment Assumptions Compared with the Proposed All-Electric Package

Measure	Single Family				Multi-family			
	No Natural Gas ¹		Natural Gas Available		No Natural Gas		Natural Gas Available	
	Standard	Proposed	Standard	Proposed	Standard	Proposed	Standard	Proposed
Space Heating	Heat pump, 8.2 HSPF				Heat pump, 8.2 HSPF			
Water Heating	Propane tankless 0.82 EF ²	HPWH 2.00 EF ³	Nat. Gas tankless 0.82 EF	HPWH 3.17 EF ⁴	Propane tankless 0.82 EF	HPWH, 2.00 EF	Nat. Gas tankless 0.82 EF	HPWH, 3.17 EF
Water Heater Location	Garage				Exterior Closet			
Stove/Cooktop	Electric				Electric			
Clothes Dryer	Electric				Electric			

¹Refers to CBECC-Res checkbox “Natural Gas is available at the site”.

²Energy Factor

³Calculated according to the latest federal efficiency standards, which define a minimum uniform energy factor (UEF). Conversion factor equations were applied to convert UEF to EF, which is the required input for the CBECC-Res simulation. A 65 gallon heat pump electric water heater was assumed.

⁴Assumes a NEEA rated 66 gallon HPWH with an energy factor above the minimum federal efficiency requirements. DOE preemption regulations do not allow mandating the use of high efficiency federally-regulated equipment without appropriate options, thus restricting a local jurisdiction from making this package a stand-alone mandatory requirement.

⁴ 2016 Residential Alternative Calculation Method Reference Manual. Section 2.2.10
<http://www.energy.ca.gov/2015publications/CEC-400-2015-024/CEC-400-2015-024-CMF-REV2.pdf>



2.3.1 NEEA-rated Heat Pump Water Heaters (HPWH)

The water heater used in the “Natural Gas Available” scenario is a NEEA-rated unit that exceeds federal minimum efficiency requirements. The federal standard for residential electric water heaters greater than 55 gallons requires an Energy Factor of 2.0 that precludes the use of electric resistance technology. Based on operational challenges experienced in the past, Northwest Energy Efficiency Alliance (NEEA) established rating test criteria to ensure newly installed HPWHs perform adequately, especially in colder climates. The NEEA rating requires an Energy Factor equal to the ENERGY STAR performance level, and also includes requirements regarding noise and prioritizing heat pump use over supplemental electric resistance heating. According to NEEA, virtually all HPWH sales in the Pacific Northwest territory are NEEA-certified units.

To encourage manufacturers to test their products, the CEC CBECC-Res compliance software uses conservative performance assumptions when the unit is not tested, which result in a compliance penalty for non-NEEA rated HPWHs. Using the DOE minimum in CBECC-Res for the “Natural Gas Available” scenario results in a building that is in many climate zones non-compliant with 2016 Title 24, Part 6. In some mild climate zones where the water heating load is a substantial portion of the total compliance budget, this compliance penalty is larger than the combined heating and cooling budgets, and cannot be made up with efficiency measures alone.

2.4 Measure Costs

Table 3 below summarizes the costs applied for shifting from gas to electric appliances and the savings associated with eliminating new natural gas infrastructure where it isn’t already available. Cost details for other efficiency measures included in this analysis can be found in Appendix B.

Table 3: All-Electric Cost Assumptions

Measure	Incremental Cost				Source & Notes
	Single Family		MF – Per Unit		
	No NG	NG	No NG	NG	
Site Gas Infrastructure ¹	(\$350)	(\$1,500)	(\$350)	(\$500)	See description below.
In-house Gas Infrastructure ¹	(\$200)	(\$200)	(\$150)	(\$150)	
Electric Service Upgrade	\$200	\$200	\$200	\$200	
Heat Pump Water Heater	\$1,115	\$1,403	\$1,115	\$1,403	See description below.
Electric Dryer	\$0	(\$100)	\$0	\$0	Internet search comparing product pricing. Installation labor assumed the same as base.

1. Natural gas or propane.

The all-electric infrastructure and water heater costs are based on the following assumptions:

- **Site Gas Infrastructure (to Building Meter).** Natural gas infrastructure costs for installing a service gas line from the utility main to the point of service and providing a gas meter are \$1,500 for single family and \$500 per dwelling unit for multifamily. Estimates are based on multiple sources including a PG&E online calculator⁵, an EPRI study (EPRI, 2016), and costs provided by both single and multifamily builders and developers. Site infrastructure costs for multifamily are

⁵https://www.pge.com/en/myhome/customerservice/other/newconstruction/projectcosts/results.page?serviceType=gas&gasType=gas_new&electricOverType=&electricUnderType=&pevType=&proj=gas_new



on a per apartment unit basis assuming a single gas main run to the building, and all gas meters in a single location at the building. These costs are expected to be conservative for a new residential development, and don't include the full savings from eliminating natural gas infrastructure to serve entire subdivisions, particularly in locations with difficult or long gas piping and trenching requirements.

Costs for the "No Natural Gas" scenario represent those associated with installing a propane tank and providing propane service to the building. The \$350 for both single family and multifamily represent \$75 for a concrete pad, \$75 for a meter/regulator, and \$200 for piping. Many propane suppliers do not charge for the propane tank, provided the customer enters into a contract. To avoid overstating propane costs the analysis does not include the cost of the storage tank.

- **In-House Gas Infrastructure (from Meter to Appliances).** Installation costs to run a gas line from the meter to the appliance location is \$200 per appliance for single family and \$150 for multifamily. The cost estimates include providing gas to the water heater only. This estimate was based on the EPRI study and costs provided by builders.
- **Electric Service Upgrade.** The EPRI study estimated \$600 for additional electric service including panel upgrades and running 220V service to the water heater, air handler, dryer, and stove. For this analysis, the incremental cost only represents additional service for the water heater, for both single family and multifamily, and the dryer for single family. It is assumed that typical practice in a mixed fuel home is to run both gas and 220V service for the dryer, therefore there is no assumed incremental cost for the electric dryer. The assumed incremental cost is \$200 for both single family and multifamily.
- **Water Heater (HPWH).** Incremental costs for the heat pump water heater are relative to a gas tankless 0.82 EF water heater which meets minimum prescriptive requirements, and include equipment, labor and replacement costs. Details are provided in Table 4 below. The "No Natural Gas" case in Table 3 is based on the 2.0 Energy Factor HPWH. The "Natural Gas Available" case is based on the NEEA-rated HPWH.

Table 4: HPWH Cost Assumptions

Component	Gas Tankless	2.0 EF HPWH	NEEA HPWH	Source & Notes
First material cost	\$1,150	\$1,368	\$1,570	Internet search comparing products
First labor cost	\$326	\$468	\$468	Itron cost study (Itron, 2014)
Present value of replacement	\$513	\$1,269	\$1,354	Assumes 13 year equipment life for HPWHs ⁶ , 20-year life for tankless water heaters (DOE, 2016), and the lifecycle terms described in Section 2.6.
Total Cost	\$1,989	\$3,105	\$3,392	
Incremental Cost	-	\$1,115	\$1,403	

2.5 PV Performance Packages

Two performance packages that include photovoltaic (PV) systems were evaluated for the all-electric scenarios, as the study assumes projects complying with an all-electric above code local ordinance will also be incorporating PV systems. Efficiency-only packages are not included in this analysis, because based on customer utility rates, all-electric efficiency-only packages result in higher utility costs than

⁶ HPWH life based on average lifetime for storage tank water heaters.



similar designs with natural gas appliances. In both these cases PV is evaluated in CBECC-Res according to the California Flexible Installation (CFI).

- **PV-Plus:** The current CEC proposal for minimum PV system sizing under the 2019 code requires a PV system large enough to offset the estimated electricity usage in a mixed-fuel building. If all-electric designs were also required to offset the total electricity use, they would be forced to purchase and install much larger PV systems, effectively penalizing all-electric designs. This package is designed to yield a minimum PV system size consistent with the PV-Plus package in the CALGreen Cost-Effectiveness study (DEG, 2016), also the same methodology used in the California Energy Commission's proposed Solar PV Ordinance (CEC, 2017). PV systems are sized to offset approximately 80% of estimated annual electricity consumption in a gas/electric home. This results in PV systems sized to offset less than 80% (33%-73%) of the total building electricity use in the all-electric design, but relies on a PV system size that is the same, independent of fuel mix. It is important to note that the system sizes in this report are examples only; all projects must independently evaluate the actual electricity use and appropriate PV system size to comply with code and meet the customer's long-term objectives.
- **Zero-Electric:** Exceed Title 24, Part 6 through building energy efficiency and install a PV system sized to offset 100% of estimated building site electricity use (total kWh), including appliances and plug loads. For the all-electric case, this system size is typically slightly larger than sizing the PV system to offset 100% of the TDV energy use, based on 2016 TDV.

In some instances, particularly in the hot valley and cold climate zones with the zero-electric package, there may not be sufficient unshaded roof space for the required PV capacity. For these cases exceptions will need to be developed similar to what the CEC is proposing for the 2019 Title 24, Part 6 Standards.

2.6 Cost-Effectiveness

This analysis uses a customer-based approach to evaluating cost effectiveness consistent with the methodology applied in the main CALGreen Cost-Effectiveness Study (DEG, 2016).

The current residential utility rates at the time of the analysis were used to calculate utility costs and determine cost effectiveness for the proposed packages. Annual utility costs were calculated using hourly electricity and gas output from CBECC-Res and applying the utility tariffs summarized in Table 5. Appendix D includes the utility rate schedules used for this study. The standard residential rate (E1 in PG&E territory, D in SCE territory, & DR in SDG&E) was applied to the base case and a time-of-use (TOU) rate was applied to all proposed cases (with PV systems).⁷ Any annual electricity production in excess of annual electricity consumption is credited to the utility account at the applicable wholesale rate based on the approved NEM2 tariffs for that utility. Minimum delivery bill and mandatory non-bypassable charges have been applied. Future changes to NEM tariffs including devaluation of solar production have not been evaluated since the proposed changes are still unknown. Net surplus compensation rates for each utility are as follows⁸:

- PG&E: \$0.0272 / kWh

⁷ Under NEM rulings by the CPUC (D-16-01-144, 1/28/16), all new PV customers shall be in an approved TOU rate structure. As of March 2016, all new PG&E net energy metering (NEM) customers are enrolled in a time-of-use rate.

(<http://www.pge.com/en/myhome/saveenergymoney/plans/tou/index.page?>).

⁸ Net surplus compensation rates for each utility are based on a 1-year average over the period October 2016 – September 2017.



- SCE: \$0.0256 / kWh
- SDG&E: \$0.0275 / kWh

Table 5: IOU Utility Tariffs used based on Climate Zone

Climate Zones	Electric / Gas Utility	Electricity (Standard)	Electricity (Time-of-use)	Natural Gas
1-5, 11-13, 16	PG&E	E1	E-TOU, Option A	G1
6, 8-10, 14, 15	SCE / SoCal Gas	D	TOU-D-T	GR
7	SDG&E	DR	DR-SES	GR

Propane costs used for the Standard Design basecase in the “No Natural Gas” scenario, were based on an average rate of \$2.12/gallon (equivalent to \$2.32/therm). This was calculated as the average weekly U.S. residential propane rate from January 2015 through January 2017 based on data from the U.S. Energy Information Administration⁹.

Cost effectiveness was evaluated for all sixteen climate zones and is presented according to lifecycle customer benefit-to-cost ratio. The benefit-to-cost ratio is a metric which represents the cost effectiveness of energy efficiency over a 30-year lifetime taking into account discounting of future savings and financing of incremental costs. A value of one (1.0) indicates the savings over the life of the measure are equivalent to the incremental cost of that measure. A value greater than one (1.0) represents a positive return on investment. The ratio is calculated as follows:

$$\text{Lifecycle Benefit Cost Ratio} = \frac{\text{Equation 1} \quad (\text{Annual utility cost savings} * \text{Lifecycle cost factor})}{(\text{First incremental cost} * \text{Financing factor})}$$

The lifecycle cost factor is 19.6 and was calculated using Equation 2 as follows. No utility rate escalation is assumed.

$$\text{Lifecycle Cost Factor} = \frac{1 - (1 + \text{disc})^{-n}}{\text{disc}} \quad \text{Equation 2}$$

Where:

- n = analysis and financing term of 30-years
- disc = real discount rate of 3%

The financing factor is calculated as follows:

$$\text{Financing Factor} = \frac{PV_{\text{Mortgage Increase}} - PV_{\text{Tax Savings}}}{L} \quad \text{Equation 3}$$

Where:

- L = first incremental cost (\$)
- $PV_{\text{Mortgage Increase}}$ = Present value of increased mortgage costs
- $PV_{\text{Tax Savings}}$ = Present value of tax savings from additional interest payments due to increased mortgage

⁹ http://www.eia.gov/dnav/pet/pet_pri_wfr_a_EPLLPA_PRS_dpgal_w.htm



$PV_{Mortgage\ Increase}$ is calculated using Equations 4 and 5.

$$P = L \frac{\left[\frac{c}{12} \left(1 + \frac{c}{12} \right)^{n*12} \right]}{\left[\left(1 + \frac{c}{12} \right)^{n*12} - 1 \right]} \quad \text{Equation 4}$$

$$PV_{Mortgage\ Increase} = P * 12 \frac{1 - (1 + disc)^{-n}}{disc} \quad \text{Equation 5}$$

Where:

- P = incremental monthly mortgage payment (\$)
- c = loan interest rate of 4.5%

$PV_{Tax\ Savings}$ is calculated using Equations 6 and 7.

$$\text{Annual Tax Savings} = \text{balance} * c * \text{taxrate} \quad \text{Equation 6}$$

$$PV_{Tax\ Savings} = \sum_{n=1}^{30} \text{Annual Tax Savings} * \frac{1}{(1 + disc)^n} \quad \text{Equation 7}$$

Where:

- taxrate = average tax rate of 20% (to account for tax savings due to loan interest deductions)
- balance = balance of incremental cost of mortgage at beginning of each year

The financing factor based on the above assumptions was 1.068 for this study.

Simple payback is also presented and is calculated using the equation below. Based on the terms described above the lifecycle cost-to-benefit ratio threshold of one is roughly equivalent to a simple payback of 18 years. Maintenance costs were not included because there are no incremental maintenance costs expected for any of these measures. There is no assumed maintenance on the envelope measures and for HVAC and DHW measures there should not be any additional maintenance cost for a more efficient version of the same system type as the baseline. Replacement costs for inverters were included for PV systems.

$$\text{Simple payback} = \text{First incremental cost} / \text{Annual customer utility cost savings} \quad \text{Equation 8}$$

2.7 Greenhouse Gas Emissions

Equivalent CO₂ emission savings were calculated using the following emission factors (Table 6). Electricity factors are specific to California electricity production.



Table 6: Equivalent CO₂ Emissions Factors

		<i>Source</i>
Electricity	0.724 lb. CO ₂ -e / kWh	U.S. Environmental Protection Agency's 2007 eGRID data. ¹⁰
Natural Gas	11.7 lb. CO ₂ -e / Therm	Emission rates for natural gas combustion as reported by the U.S. Environmental Protection Agency's GHG Equivalencies Calculator. ¹¹
Propane	139.05 lb. CO ₂ -e / MMBtu	Emission rates for propane combustion as reported by the U.S. Environmental Protection Agency's GHG Emissions Coefficients. ¹²

3 Results

A cost-effectiveness analysis evaluating two performance packages that include both efficiency measures and PV systems was completed for all sixteen climate zones.

3.1 *Single Family Results*

3.1.1 *Single Family Cost-Effectiveness Analysis*

A comparison of cost-effectiveness for the two PV performance packages (PV-Plus and Zero-Electric) and two scenarios in each climate zone is presented in Figure 1. Results are presented for the blended 2,430 ft² single family prototype, which is consistent with the main report for the gas/electric cases. Table 7 and Table 8 provide the results in tabular form along with energy and greenhouse gas (GHG) savings for each PV performance tier for the “No Natural Gas” and “Natural Gas Available” scenarios, respectively. The lifecycle benefit-to-cost (B/C) ratio threshold of 1.0 is roughly equivalent to a simple payback of 18 years. Gas savings are a result of the standard design including gas water heating (both scenarios) and gas clothes drying (“Natural Gas Available” scenario). Savings for the “No Natural Gas” cases are based upon fuel costs and GHG values for propane.

The PV system capacity for the PV-Plus packages range from 1.8 to 4.6 kW DC depending on climate. The required Zero-Electric PV capacity (to offset site electricity use) ranges from 3.8 kW DC in the mild climates (CZ7) to 6.9 kW DC in very cold climates (CZ16), based on the “Natural Gas Available” scenario. Zero-Electric PV sizes for the “No Natural Gas” cases are between 0.3 and 0.7 kW larger, depending on climate zone, due to higher energy use of the minimum efficiency HPWH.

The PV-Plus cases demonstrate cost-effectiveness with a B/C ratio ranging from 1.30 to 2.58. The Zero-Electric cases also all demonstrate cost-effectiveness with a B/C ratio ranging from 1.35 to 2.11. Cost-effectiveness for the “Natural Gas Available” cases are slightly better than the “No Natural Gas” cases in all climates. Greenhouse gas (GHG) reductions for the two PV packages average 58% and 100% for the PV-Plus and Zero-Electric cases, respectively.

¹⁰ <https://www.epa.gov/energy/ghg-equivalencies-calculator-calculations-and-references>

¹¹ <https://www.epa.gov/energy/greenhouse-gas-equivalencies-calculator>

¹² https://www.eia.gov/environment/emissions/co2_vol_mass.php



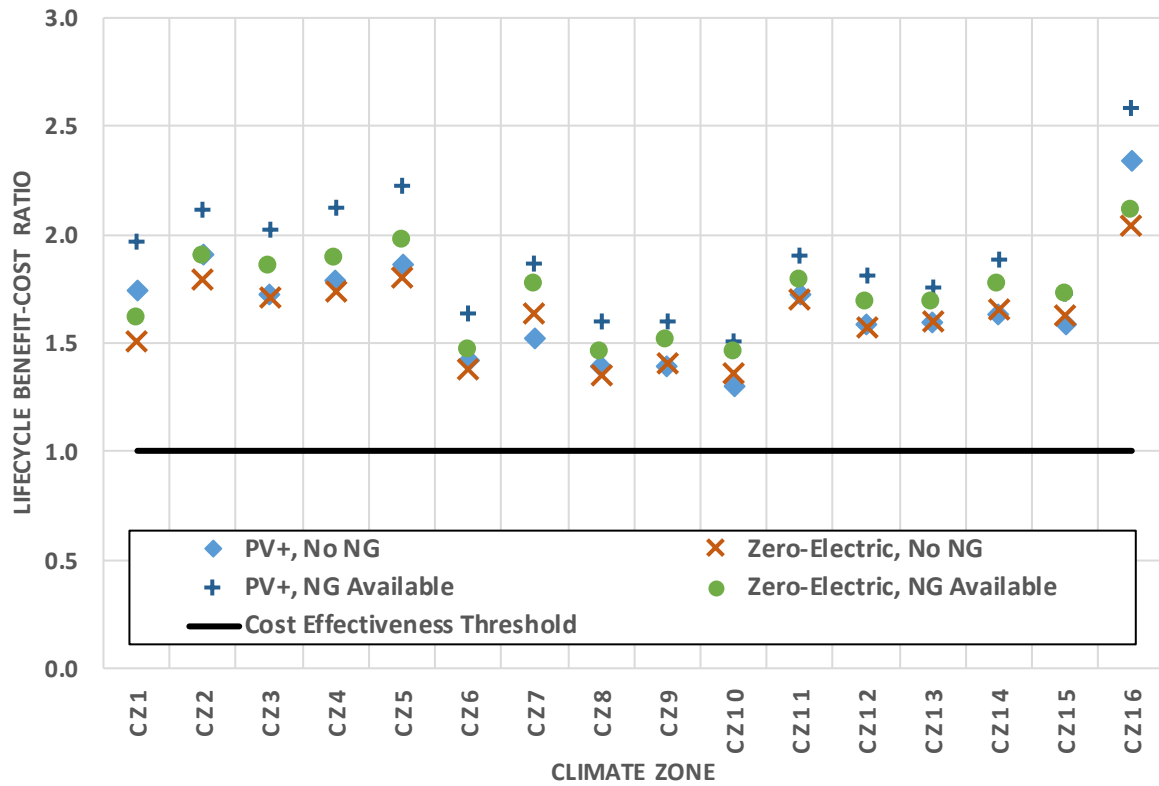


Figure 1: Single family all-electric cost-effectiveness comparison



Table 7: Single Family All-Electric PV-Plus Performance Package Cost-Effectiveness Results

Climate Zone	Compliance Margin	PV Capacity (kW)	Elec Savings (kWh)	Gas Savings (therms) ¹	GHG % Savings ²	Package Cost ³	Utility Cost Savings	Simple Payback	Lifecycle Benefit-to-Cost Ratio
No Natural Gas¹									
CZ1	34.0%	3.0	3,659	137.0	52.2%	\$13,052	\$1,234	10.6	1.74
CZ2	33.4%	2.5	3,405	122.9	55.8%	\$10,973	\$1,141	9.6	1.91
CZ3	23.6%	2.6	2,714	123.5	55.5%	\$10,178	\$953	10.7	1.72
CZ4	34.1%	2.3	2,404	117.6	48.3%	\$9,137	\$890	10.3	1.79
CZ5	24.4%	2.3	2,466	126.4	53.4%	\$9,137	\$925	9.9	1.86
CZ6	17.9%	2.5	2,568	112.2	57.0%	\$9,879	\$765	12.9	1.42
CZ7	17.5%	1.8	1,592	110.4	48.9%	\$7,837	\$650	12.1	1.52
CZ8	43.8%	2.6	2,726	107.5	59.8%	\$10,054	\$761	13.2	1.39
CZ9	43.6%	2.5	2,813	107.3	56.9%	\$9,846	\$745	13.2	1.39
CZ10	37.9%	2.5	2,918	106.5	55.9%	\$9,766	\$693	14.1	1.30
CZ11	37.2%	3.5	4,802	108.7	60.4%	\$13,326	\$1,247	10.7	1.72
CZ12	34.7%	2.9	3,305	114.3	54.0%	\$11,095	\$957	11.6	1.58
CZ13	33.8%	3.7	4,725	106.6	60.6%	\$13,834	\$1,199	11.5	1.59
CZ14	33.7%	2.5	3,673	110.0	50.3%	\$9,923	\$880	11.3	1.63
CZ15	33.3%	4.6	7,568	79.6	73.4%	\$16,858	\$1,451	11.6	1.58
CZ16	36.4%	2.5	3,683	136.0	43.8%	\$10,420	\$1,327	7.9	2.34
Natural Gas Available									
CZ1	40.7%	3.0	4,570	137.0	58.3%	\$11,994	\$1,282	9.4	1.96
CZ2	30.9%	2.5	3,971	122.9	59.8%	\$9,915	\$1,141	8.7	2.11
CZ3	22.5%	2.6	3,513	123.5	62.7%	\$9,120	\$1,005	9.1	2.02
CZ4	32.8%	2.3	3,149	117.6	54.3%	\$8,079	\$935	8.6	2.13
CZ5	22.8%	2.3	3,281	126.4	60.6%	\$8,079	\$977	8.3	2.22
CZ6	15.7%	2.5	3,264	112.2	63.9%	\$8,820	\$785	11.2	1.63
CZ7	12.4%	1.8	2,259	110.4	55.8%	\$6,779	\$690	9.8	1.87
CZ8	41.0%	2.6	3,383	107.5	66.6%	\$8,996	\$781	11.5	1.59
CZ9	42.6%	2.5	3,468	107.3	63.2%	\$8,788	\$764	11.5	1.60
CZ10	36.2%	2.5	3,572	106.5	61.8%	\$8,708	\$713	12.2	1.50
CZ11	37.2%	3.5	5,484	108.7	65.4%	\$12,268	\$1,272	9.6	1.90
CZ12	33.6%	2.9	4,027	114.3	59.7%	\$10,037	\$988	10.2	1.81
CZ13	33.1%	3.7	5,386	106.6	65.6%	\$12,776	\$1,221	10.5	1.75
CZ14	33.2%	2.5	4,384	110.0	55.2%	\$8,864	\$908	9.8	1.88
CZ15	33.1%	4.6	8,073	79.6	77.0%	\$15,800	\$1,484	10.6	1.72
CZ16	31.9%	2.5	4,220	136.0	46.0%	\$9,362	\$1,316	7.1	2.58

¹Savings for “No Natural Gas” case are propane savings from elimination of propane water heater. Gas savings are therms equivalent.

²Based on CA electricity production and equivalent CO₂ emission rates of 0.724 lbCO₂e/kWh, 11.7 lb-CO₂e/therm natural gas & 13.9 lb-CO₂e/therm propane.

³Includes ten percent markup for builder profit and overhead.



Table 8: Single Family All-Electric Zero Electric Performance Package Cost-Effectiveness Results

Climate Zone	Compliance Margin	PV Capacity (kW)	Elec Savings (kWh)	Gas Savings (therms) ¹	GHG % Savings ²	Package Cost ³	Utility Cost Savings	Simple Payback	Lifecycle Benefit-to-Cost Ratio
No Natural Gas¹									
CZ1	34.0%	7.3	9,417	137.0	100%	\$27,344	\$2,242	12.2	1.50
CZ2	33.4%	5.4	7,972	122.9	100%	\$20,612	\$2,005	10.3	1.79
CZ3	23.6%	5.1	6,789	123.5	100%	\$18,487	\$1,719	10.8	1.71
CZ4	34.1%	5.4	7,395	117.6	100%	\$19,440	\$1,834	10.6	1.73
CZ5	24.4%	4.8	6,739	126.4	100%	\$17,446	\$1,712	10.2	1.80
CZ6	17.9%	4.7	6,131	112.2	100%	\$17,191	\$1,285	13.4	1.37
CZ7	17.5%	4.2	5,464	110.4	100%	\$15,814	\$1,409	11.2	1.64
CZ8	43.8%	4.6	5,952	107.5	100%	\$16,701	\$1,229	13.6	1.35
CZ9	43.6%	4.7	6,504	107.3	100%	\$17,158	\$1,312	13.1	1.40
CZ10	37.9%	4.9	6,839	106.5	100%	\$17,742	\$1,316	13.5	1.36
CZ11	37.2%	6.3	9,313	108.7	100%	\$22,632	\$2,090	10.8	1.69
CZ12	34.7%	5.9	7,996	114.3	100%	\$21,066	\$1,802	11.7	1.57
CZ13	33.8%	6.5	9,122	106.6	100%	\$23,140	\$2,008	11.5	1.59
CZ14	33.7%	5.7	9,383	110.0	100%	\$20,558	\$1,854	11.1	1.65
CZ15	33.3%	6.6	10,862	79.6	100%	\$23,505	\$2,078	11.3	1.62
CZ16	36.4%	7.2	11,769	136.0	100%	\$26,041	\$2,889	9.0	2.04
Natural Gas Available									
CZ1	40.7%	6.6	9,417	137.0	100%	\$23,959	\$2,102	11.4	1.61
CZ2	30.9%	5.0	7,972	122.9	100%	\$18,224	\$1,880	9.7	1.89
CZ3	22.5%	4.6	6,789	123.5	100%	\$15,767	\$1,592	9.9	1.85
CZ4	32.8%	4.9	7,395	117.6	100%	\$16,720	\$1,715	9.8	1.88
CZ5	22.8%	4.3	6,739	126.4	100%	\$14,726	\$1,582	9.3	1.97
CZ6	15.7%	4.3	6,131	112.2	100%	\$14,803	\$1,180	12.5	1.46
CZ7	12.4%	3.8	5,464	110.4	100%	\$13,426	\$1,292	10.4	1.77
CZ8	41.0%	4.2	5,952	107.5	100%	\$14,314	\$1,133	12.6	1.45
CZ9	42.6%	4.3	6,504	107.3	100%	\$14,770	\$1,214	12.2	1.51
CZ10	36.2%	4.5	6,839	106.5	100%	\$15,355	\$1,219	12.6	1.46
CZ11	37.2%	5.9	9,313	108.7	100%	\$20,245	\$1,969	10.3	1.79
CZ12	33.6%	5.4	7,996	114.3	100%	\$18,346	\$1,686	10.9	1.69
CZ13	33.1%	6.1	9,122	106.6	100%	\$20,753	\$1,909	10.9	1.69
CZ14	33.2%	5.3	9,383	110.0	100%	\$18,170	\$1,752	10.4	1.77
CZ15	33.1%	6.3	10,862	79.6	100%	\$21,450	\$2,014	10.7	1.72
CZ16	31.9%	6.9	11,769	136.0	100%	\$23,986	\$2,751	8.7	2.11

¹Savings for “No Natural Gas” case are propane savings from elimination of propane water heater. Gas savings are therms equivalent.

²Based on CA electricity production and equivalent CO₂ emission rates of 0.724 lbCO₂e/kWh, 11.7 lb-CO₂e/therm natural gas & 13.9 lb-CO₂e/therm propane.

³Includes ten percent markup for builder profit and overhead.



3.1.2 Single Family Packages

PV-Plus & Zero-Electric: Cost-effective all-electric packages using both efficiency and PV to exceed the minimum requirements were identified in all 16 climate zones. Table 9 summarizes the cost-effective efficiency measures used in each climate zone. In most cases the measures in these packages reflect those in the mixed fuel PV performance packages. In Climate Zones 9 through 14, additional efficiency measures (shown as values in red in the table) were added to meet the 30% compliance margin target. The “Natural Gas Available” scenarios include the same efficiency measures with the addition of the high efficiency HPWH.

Table 9: Single Family All-Electric PV Packages: Cost-Effective Measures Summary

Climate Zone	PV Compliance Credit	QII	ACH50	Window U-value / SHGC	Door U-value	HPA	AH Fan W/cfm	HPWH Location ¹	HERS Verified HW Pipe Insul.
CZ1	Y	Y	3.0	.30/.50	0.20	Y		Gar	Y
CZ2	Y	Y		.30/.50	0.20	Y		CS	Y
CZ3	Y	Y		.30/.50	0.20			Gar	
CZ4	Y	Y		.30/.23				Gar	
CZ5	Y	Y		.30/.50				Gar	
CZ6	N/A	Y					0.30	Gar	
CZ7	N/A	Y		.30/.23	0.20		0.30	Gar	Y
CZ8	Y	Y						Gar	
CZ9	Y	Y		.30/.23	0.20			Gar	
CZ10	Y	Y			0.20			Gar	
CZ11	Y	Y		.30/.23	0.20		0.30	Gar	
CZ12	Y	Y			0.20			Gar	
CZ13	Y	Y		.30/.23	0.20			Gar	
CZ14	Y	Y			0.20		0.30	Gar	
CZ15	Y	Y					0.30	Gar	
CZ16	Y	Y	3.0	.30/.23	0.20		0.30	CS	

Values in red indicate a change between the gas/electric and all-electric results.

¹CS = conditioned space; Gar = garage.

3.2 Multifamily Results

3.2.1 Multifamily Cost-Effectiveness Analysis

A comparison of cost-effectiveness for the multifamily prototype is presented in Figure 2. Table 10 and

Table 11 provide the results in tabular form, along with energy and greenhouse gas savings for each PV performance tier for the “No Natural Gas” and “Natural Gas Available” scenarios, respectively. *All multifamily results are presented on a per dwelling unit basis.* The above-code compliance targets are more difficult to achieve with the multifamily prototype than single family. Water heating compliance margins are lower in the multifamily model due to higher standby losses and lower efficiencies resulting from modeling the multifamily HPWH in an outdoor closet instead of in the attached garage, as in the single family prototypes.

Cost-effectiveness results are presented for the two PV performance packages (PV-Plus and Zero-Electric) in each climate zone. The lifecycle B/C ratio threshold of 1.0 is roughly equivalent to a simple payback of 18 years. Table 10 and

Table 11 summarize the cost-effectiveness of the two PV performance packages including the PV capacity necessary to offset the site electricity use for each case. Gas savings are a result of the standard design



including gas water heating (both scenarios). Savings for the “No Natural Gas” cases are based upon fuel costs and GHG values for propane.

The PV capacity for the PV-Plus packages are sized using the same methodology as for the single family analysis and range from 1.3 to 2.1 kW DC depending on climate. The required Zero-Electric PV capacity per apartment ranges from 2.5 kW DC in the mild climates (CZ7) to 3.7 kW DC in colder climates (CZ1) for the “Natural Gas Available” scenario. For the multifamily prototype 8-unit apartment building, this is equivalent to 20 to 30 kW for the building. Zero-Electric PV sizes for the “No Natural Gas” cases are between 0.2 and 0.4 kW larger, depending on climate zone, due to higher energy use of the minimum efficiency HPWH.

The PV-Plus cases demonstrate cost-effectiveness with a B/C ratio ranging from 1.10 to 1.73. The Zero-Electric cases also all demonstrate cost-effectiveness with a B/C ratio ranging from 1.16 to 1.65. Cost-effectiveness for the “No Natural Gas” cases is better than or equal to the “Natural Gas Available” cases in most climates except in some mild climates and Climate Zone 15.

Greenhouse gas (GHG) reductions for the two PV packages average 54% and 100% for the PV-Plus and Zero-Electric cases, respectively.

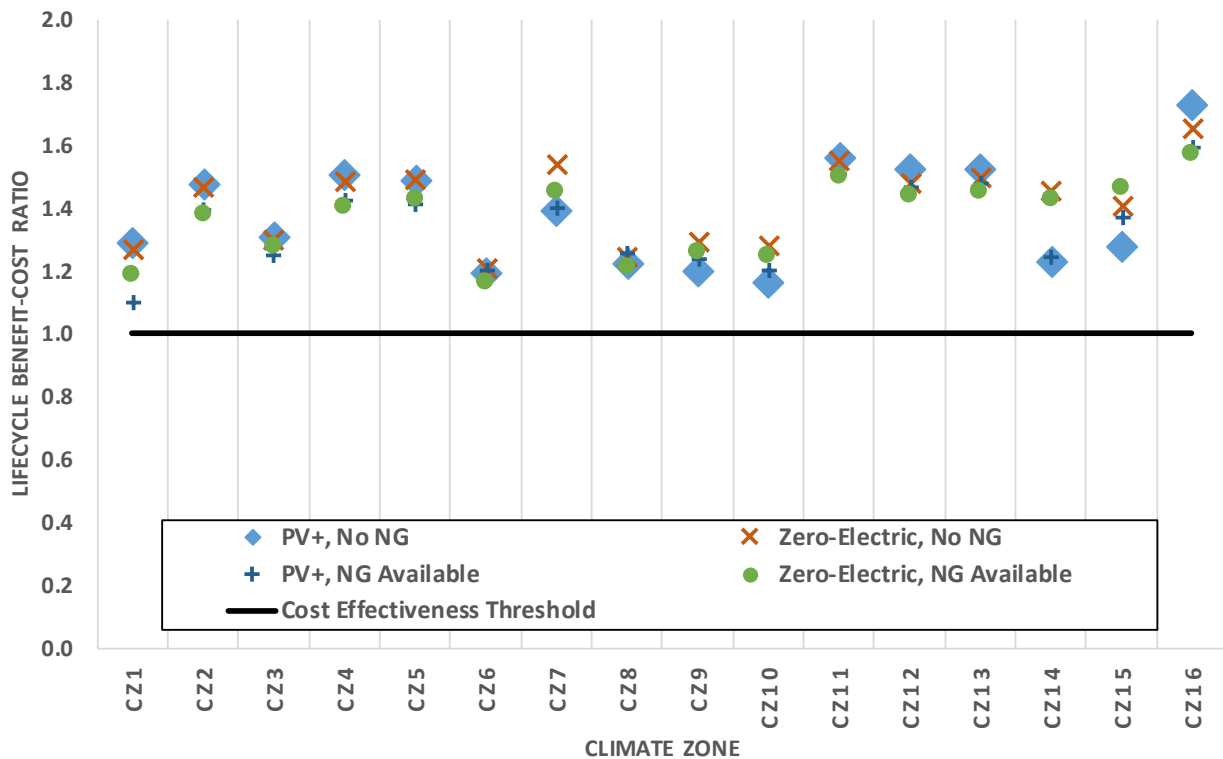


Figure 2: Multifamily all-electric cost-effectiveness comparison

Table 10: Multifamily All-Electric PV-Plus Performance Package Cost-Effectiveness Results

Climate Zone	Compliance Margin	PV Capacity (kW)	Elec Savings (kWh)	Gas Savings (therms) ¹	GHG % Savings ²	Package Cost ³	Utility Cost Savings	Simple Payback	Lifecycle Benefit-to-Cost Ratio
No Natural Gas¹									
CZ1	19.2%	1.6	998	96.4	43.2%	\$6,309	\$444	14.2	1.29
CZ2	24.7%	1.4	1,176	86.5	46.0%	\$5,686	\$457	12.4	1.47
CZ3	12.8%	1.5	1,140	86.9	49.0%	\$6,789	\$484	14.0	1.31
CZ4	33.8%	1.3	1,155	82.8	46.4%	\$5,374	\$441	12.2	1.50
CZ5	22.9%	1.4	1,327	89.0	53.0%	\$5,906	\$478	12.4	1.49
CZ6	25.4%	1.5	1,448	79.1	54.7%	\$5,997	\$390	15.4	1.19
CZ7	24.9%	1.3	1,210	77.9	51.3%	\$5,457	\$414	13.2	1.39
CZ8	36.7%	1.5	1,573	75.8	55.3%	\$5,997	\$400	15.0	1.23
CZ9	37.0%	1.4	1,488	75.7	51.7%	\$5,563	\$364	15.3	1.20
CZ10	36.6%	1.4	1,509	75.1	50.8%	\$5,563	\$353	15.8	1.16
CZ11	30.1%	1.7	1,998	76.5	52.8%	\$6,498	\$553	11.8	1.56
CZ12	33.4%	1.5	1,502	80.5	49.1%	\$5,875	\$488	12.0	1.53
CZ13	30.9%	1.8	2,109	75.1	54.5%	\$6,809	\$565	12.1	1.52
CZ14	30.4%	1.3	1,603	77.4	46.5%	\$5,251	\$352	14.9	1.23
CZ15	28.4%	2.1	3,255	56.2	62.7%	\$7,744	\$540	14.3	1.28
CZ16	25.4%	1.3	1,105	95.5	38.6%	\$5,137	\$484	10.6	1.73
Natural Gas Available									
CZ1	11.4%	1.6	1,527	96.4	52.2%	\$7,011	\$420	16.7	1.10
CZ2	16.1%	1.4	1,553	86.5	52.7%	\$5,838	\$443	13.2	1.39
CZ3	12.1%	1.5	1,758	86.9	60.9%	\$6,940	\$474	14.6	1.25
CZ4	27.8%	1.3	1,526	82.8	53.3%	\$5,526	\$429	12.9	1.43
CZ5	10.8%	1.4	1,732	89.0	60.7%	\$6,058	\$466	13.0	1.41
CZ6	19.1%	1.5	1,829	79.1	62.3%	\$6,149	\$402	15.3	1.20
CZ7	20.2%	1.3	1,606	77.9	59.5%	\$5,608	\$427	13.1	1.40
CZ8	35.6%	1.5	1,964	75.8	63.0%	\$6,149	\$420	14.6	1.25
CZ9	35.6%	1.4	1,886	75.7	59.3%	\$5,715	\$385	14.8	1.24
CZ10	34.3%	1.4	1,900	75.1	58.1%	\$5,715	\$374	15.3	1.20
CZ11	28.2%	1.7	2,366	76.5	58.8%	\$6,650	\$547	12.2	1.51
CZ12	30.7%	1.5	1,885	80.5	55.8%	\$6,026	\$481	12.5	1.47
CZ13	28.6%	1.8	2,482	75.1	60.7%	\$6,961	\$561	12.4	1.48
CZ14	27.9%	1.3	1,971	77.4	52.5%	\$5,403	\$367	14.7	1.25
CZ15	29.6%	2.1	3,654	56.2	68.8%	\$7,896	\$589	13.4	1.37
CZ16	16.9%	1.3	1,469	95.5	44.0%	\$5,289	\$460	11.5	1.60
¹ Savings for “No Natural Gas” case are propane savings from elimination of propane water heater. Gas savings are therms equivalent. ² Based on CA electricity production and equivalent CO ₂ emission rates of 0.724 lbCO ₂ e/kWh, 11.7 lb-CO ₂ e/therm natural gas & 13.9 lb-CO ₂ e/therm propane. ³ Includes ten percent markup for builder profit and overhead.									



Table 11: Multifamily All-Electric Zero Electric Performance Package Cost-Effectiveness Results

Climate Zone	Compliance Margin	PV Capacity (kW)	Elec Savings (kWh)	Gas Savings (therms) ¹	GHG % Savings ²	Package Cost ³	Utility Cost Savings	Simple Payback	Lifecycle Benefit-Cost Ratio
No Natural Gas¹									
CZ1	19.2%	4.1	4,355	96.4	100%	\$14,099	\$973	14.5	1.27
CZ2	24.7%	3.3	4,198	86.5	100%	\$11,606	\$926	12.5	1.47
CZ3	12.8%	3.2	3,789	86.9	100%	\$12,086	\$855	14.1	1.30
CZ4	33.8%	3.1	4,038	82.8	100%	\$10,983	\$888	12.4	1.48
CZ5	22.9%	2.9	3,783	89.0	100%	\$10,580	\$858	12.3	1.49
CZ6	25.4%	2.9	3,709	79.1	100%	\$10,360	\$683	15.2	1.21
CZ7	24.9%	2.7	3,556	77.9	100%	\$9,819	\$823	11.9	1.54
CZ8	36.7%	2.9	3,834	75.8	100%	\$10,360	\$702	14.8	1.24
CZ9	37.0%	2.9	4,017	75.7	100%	\$10,237	\$722	14.2	1.29
CZ10	36.6%	3.0	4,142	75.1	100%	\$10,548	\$735	14.3	1.28
CZ11	30.1%	3.5	4,895	76.5	100%	\$12,106	\$1,021	11.9	1.55
CZ12	33.4%	3.4	4,409	80.5	100%	\$11,795	\$949	12.4	1.48
CZ13	30.9%	3.6	4,878	75.1	100%	\$12,418	\$1,014	12.2	1.50
CZ14	30.4%	3.1	4,891	77.4	100%	\$10,860	\$863	12.6	1.46
CZ15	28.4%	3.6	5,727	56.2	100%	\$12,418	\$950	13.1	1.40
CZ16	25.4%	3.8	5,311	95.5	100%	\$12,927	\$1,164	11.1	1.65
Natural Gas Available									
CZ1	11.4%	3.7	4,355	96.4	100%	\$13,554	\$875	15.5	1.19
CZ2	16.1%	3.1	4,198	86.5	100%	\$11,135	\$839	13.3	1.38
CZ3	12.1%	2.8	3,789	86.9	100%	\$10,991	\$765	14.4	1.28
CZ4	27.8%	2.9	4,038	82.8	100%	\$10,511	\$805	13.1	1.41
CZ5	10.8%	2.6	3,783	89.0	100%	\$9,797	\$761	12.9	1.43
CZ6	19.1%	2.7	3,709	79.1	100%	\$9,888	\$627	15.8	1.16
CZ7	20.2%	2.5	3,556	77.9	100%	\$9,348	\$740	12.6	1.45
CZ8	35.6%	2.7	3,834	75.8	100%	\$9,888	\$652	15.2	1.21
CZ9	35.6%	2.7	4,017	75.7	100%	\$9,765	\$671	14.6	1.26
CZ10	34.3%	2.8	4,142	75.1	100%	\$10,077	\$686	14.7	1.25
CZ11	28.2%	3.3	4,895	76.5	100%	\$11,635	\$949	12.3	1.50
CZ12	30.7%	3.1	4,409	80.5	100%	\$11,012	\$866	12.7	1.44
CZ13	28.6%	3.4	4,878	75.1	100%	\$11,947	\$946	12.6	1.45
CZ14	27.9%	2.9	4,891	77.4	100%	\$10,389	\$809	12.8	1.43
CZ15	29.6%	3.3	5,727	56.2	100%	\$11,635	\$927	12.6	1.46
CZ16	16.9%	3.6	5,311	95.5	100%	\$12,455	\$1,067	11.7	1.57

¹ Savings for “No Natural Gas” case are propane savings from elimination of propane water heater. Gas savings are therms equivalent.

² Based on CA electricity production and equivalent CO₂ emission rates of 0.724 lbCO₂e/kWh, 11.7 lb-CO₂e/therm natural gas & 13.9 lb-CO₂e/therm propane.

³ Includes ten percent markup for builder profit and overhead.



3.2.2 Multifamily Packages

PV-Plus & Zero-Electric: Cost-effective packages using both efficiency and PV to exceed minimum requirements were identified in all 16 climate zones as demonstrated in Table 10 and

Table 11 above. Meeting higher compliance margin targets in all-electric buildings is more challenging in multifamily than in single family. The results from the CBECC-Res simulation software are very sensitive to the HPWH selection as well as the efficiency measures selected, particularly in milder climates.

Table 12 summarizes the cost-effective efficiency measures used in each climate zone. The “Natural Gas Available” scenarios include the same efficiency measures except where indicated with the addition of the high efficiency HPWH. Values in red reflect measures added to the all-electric packages to meet the performance targets.

In most climates the HPWH was located within the conditioned space because there is a net benefit in locating the HPWH inside as a result of lower water heating and space cooling energy use when compared to an externally located unit. In Climate Zone 3, the HPWH was evaluated in an exterior closet. As a heating dominated climate, with negligible amounts of cooling energy, the negative impact on space heating from moving the HPWH into conditioned space is greater than the water heating savings. While Climate Zone 16 is also heating dominated it has a summer cooling load and the winter temperatures are much more extreme resulting in a far higher penalty for leaving the HPWH outdoors. In Climate Zone 1 CBECC-Res predicts different trends for the “No Natural Gas” and “Natural Gas Available” cases. Water heating savings from moving the lower efficiency HPWH in the “No Natural Gas” scenario into conditioned space are greater than in the “Natural Gas Available” scenario. However, the impact on space heating in the former case is lower because the HPWH operates in electric resistance mode more of the time. This combination of effects results in the lower efficiency 2.0 Energy Factor HPWH (“No Natural Gas” scenario) optimally located in the conditioned space but the higher efficiency NEEA rated HPWH (“Natural Gas Available” scenario) optimally located outdoors.

Table 12: Multifamily All-Electric PV Packages: Cost-Effective Measures Summary

Climate Zone	PV Compliance Credit	QII	Window U-value / SHGC	Door U-value	High Performance Attic	AH Fan W/cfm	LLDCS	Refrigerant Charge	HPWH Location ¹	HW Comp. Dist.
CZ1	Y	Y	0.30/0.50	0.20		0.3			CS (No NG) Ext (NG Avail)	Y
CZ2	Y	Y	0.30/0.23	0.20		0.3			CS	Y
CZ3	Y	Y	0.30/0.50	0.20	R-13	0.3			Ext	Y
CZ4	Y	Y	0.30/0.23	0.20		0.3			CS	Y
CZ5	Y	Y	0.30/0.50	0.20		0.3	Y		CS	Y
CZ6	N/A	Y	0.30/0.23	0.20		0.3			CS	Y
CZ7	N/A	Y	0.30/0.23	0.20		0.3		Y	CS	Y
CZ8	Y	Y	0.30/0.23	0.20		0.3			CS	Y
CZ9	Y	Y	0.30/0.23	0.20		0.3			CS	
CZ10	Y	Y	0.30/0.23	0.20		0.3			CS	
CZ11	Y	Y	0.30/0.23	0.20		0.3			CS	
CZ12	Y	Y	0.30/0.23	0.20		0.3			CS	
CZ13	Y	Y	0.30/0.23	0.20		0.3			CS	
CZ14	Y	Y	0.30/0.23	0.20		0.3			CS	
CZ15	Y	Y	0.30/0.23	0.20		0.3			CS	
CZ16	Y	Y	0.30/0.23	0.20					CS	

Values in red indicate a change between the gas/electric and all-electric results.

¹CS = conditioned space; Ext = exterior closet.



4 Conclusions & Summary

This report evaluated the feasibility and cost-effectiveness of all-electric single family and low-rise multifamily residential new construction that exceeds the 2016 Building Energy Efficiency Standards through the installation of both efficiency measures and PV systems in all 16 California climate zones. The results of this evaluation provide local jurisdictions flexibility when adopting an energy efficiency ordinance ensuring that the requirement can be met either with a mixed-fuel design or an all-electric design. Two scenarios were evaluated. The “No Natural Gas” case does not trigger federal preemption issues, and represents options that local jurisdictions can adopt into a local ordinance. The “Natural Gas Available” scenario requires water heating equipment that is more efficient than federal standards, thus triggering federal preemption restrictions.

For this analysis, PG&E rates were used for gas and electricity in Climate Zones 1 through 5, 11 through 13, and 16. SCE electricity rates and Southern California Gas rates were used for Climate Zones 6, 8 through 10, 14, and 15. SDG&E rates were used for electricity and gas for Climate Zone 7.

Recommended Title 24 compliance margin targets were set based on results of the cost effectiveness analysis and match those recommended in the gas/electric analysis in most cases. When setting recommendations results from both the “Natural Gas Available” and “No Natural Gas” scenarios were reviewed to ensure that the targets could be met in either case. For single family homes 30% was achievable everywhere except Climate Zones 3, and 5-7; in those climates cost effective packages were found that achieve a 10%-20% compliance margin. Meeting higher compliance margin targets in all-electric buildings is more challenging in multifamily buildings than in single family. The results from the CBECC-Res simulation software are very sensitive to the HPWH selection as well as the efficiency measures selected, particularly in milder climates. Due to this the HPWH was located within the conditioned space in most climates. Table 13 and Table 14 summarize cost-effective ordinance criteria by climate zone for single family and multifamily buildings, respectively. The tables include the Title 24 compliance target needed to meet the criteria. Consistent with CALGreen voluntary tiers, the analysis assumes a pre-requisite for all packages includes HERS verification of Quality Insulation Installation (QII).

Table 13: Single Family Cost-Effective All-Electric Reach Code Package

Packages	Climate Zones	T-24 Compliance Target	QII	PVCC Allowed	PV
PV-Plus & Zero-Electric Packages	1, 2, 4, 8-16	30%	Yes	Yes	Yes
	3, 5	20%	Yes	Yes	Yes
	6-7	10%	Yes	N/A	Yes

Table 14: Multifamily Cost-Effective All-Electric Reach Code Package

Packages	Climate Zones	T-24 Compliance Target	QII	PVCC Allowed	PV
PV-Plus & Zero-Electric Packages	4,9-15	25%	Yes	Yes	Yes
	8	20%	Yes	Yes	Yes
	2,16	15%	Yes	Yes	Yes
	1,3,5	10%	Yes	Yes	Yes
	6-7	10%	Yes	n/a	Yes

Table 15 and Table 16 present a summary of the differences in the cost-effective packages for all-electric homes compared to those for gas/electric homes. Differences are highlighted in red. For single family, the



2016 compliance margin targets are the same as those for the gas/electric packages in all cases. The PV Compliance Credit (PVCC) may be used to meet these targets, except in Climate Zones 6 and 7, where the PVCC is not available.

With multifamily, the 2016 compliance margin targets are the same as those for the gas/electric packages except for Climate Zones 1, 2, 3, and 16 (see Table 16). In these four climate zones the predicted penalty in CBECC-Res for using a HPWH could not be fully offset with cost effective efficiency measures. The recommended compliance margin targets have been subsequently reduced by 5%-10%.

Table 15: Single Family PV Package Compliance Target Comparison

Climate Zone	Nat. Gas/Electric		All-Electric	
	Compliance Margin Target	PVCC Allowed	Compliance Margin Target	PVCC Allowed
CZ1	30%	Yes	30%	Yes
CZ2	30%	Yes	30%	Yes
CZ3	20%	Yes	20%	Yes
CZ4	30%	Yes	30%	Yes
CZ5	20%	Yes	20%	Yes
CZ6	10%	N/A	10%	N/A
CZ7	10%	N/A	10%	N/A
CZ8	30%	Yes	30%	Yes
CZ9	30%	Yes	30%	Yes
CZ10	30%	Yes	30%	Yes
CZ11	30%	Yes	30%	Yes
CZ12	30%	Yes	30%	Yes
CZ13	30%	Yes	30%	Yes
CZ14	30%	Yes	30%	Yes
CZ15	30%	Yes	30%	Yes
CZ16	30%	Yes	30%	Yes



Table 16: Multifamily PV Package Compliance Target Comparison

Climate Zone	Nat. Gas/Electric		All-Electric	
	Compliance Margin Target	PVCC Allowed	Compliance Margin Target	PVCC Allowed
CZ1	20%	Yes	10%	Yes
CZ2	20%	Yes	15%	Yes
CZ3	15%	Yes	10%	Yes
CZ4	25%	Yes	25%	Yes
CZ5	10%	Yes	10%	Yes
CZ6	10%	N/A	10%	N/A
CZ7	10%	N/A	10%	N/A
CZ8	20%	Yes	20%	Yes
CZ9	25%	Yes	25%	Yes
CZ10	25%	Yes	25%	Yes
CZ11	25%	Yes	25%	Yes
CZ12	25%	Yes	25%	Yes
CZ13	25%	Yes	25%	Yes
CZ14	25%	Yes	25%	Yes
CZ15	25%	Yes	25%	Yes
CZ16	25%	Yes	15%	Yes

Values in red indicate a change between the gas/electric and all-electric results.

In the gas/electric analysis, recommendations were made for both efficiency-only and PV performance packages. Based on current residential utility rates across all the California investor owned utilities, switching from gas to electric appliances results in higher annual utility costs for all-electric efficiency-only packages. It is also expected that the majority of projects complying with an all-electric above code local ordinance will also be incorporating PV. For this reason, only PV performance packages that incorporate both efficiency measures and PV were developed.

In addition to the PV-Plus performance package introduced in the gas/electric analysis, a Zero-Electric package was also found to be cost-effective for all-electric homes. This was evaluated in place of a Zero-TDV package. Zero-TDV was evaluated in the gas/electric analysis as a way to achieve zero net energy with mixed fuels; however, it was not found to be cost-effective. This approach is not favored by California policy in mixed fuel homes, because PV systems sized to offset both gas (natural gas or propane) and electricity TDV result in PV systems sized larger than the building electricity use. Generating more electricity than is used on site is not cost-effective to the owner under California Net Energy Metering policy and can violate utility net energy metering rules for the size of a PV system. The consumer is compensated by the utility for electricity generation in excess of annual consumption, but only at the wholesale rate, which is substantially lower than the retail rate. When all onsite energy use is supplied by electricity, excess annual generation may be minimal.

5 References

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Appendix A – Prescriptive Package

The following presents the residential prescriptive package as printed in the 2016 Building Energy Efficiency Standards (CEC, 2016b).

						Climate Zone															
						1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Building Envelope Insulation	Roofs/ Ceilings	Option A (meets §150.1(c)(9A))	Continuous Insulation Above Roof Rafter	Roofing Type	No Air Space ¹	NR	NR	NR	R 8	NR	NR	NR	R 8	R 8	R 8	R 8	R 8	R 8	R 8	R 8	
				With Air Space ²	NR	NR	NR	R 6	NR	NR	NR	R 6	R 6	R 6	R 6	R 6	R 6	R 6	R 6	R 6	
			Ceiling Insulation		R 38	R 38	R 30	R 38	R 30	R 30	R 30	R 38	R 38	R 38	R 38	R 38	R 38	R 38	R 38	R 38	
			Radiant Barrier		NR	REQ	REQ	REQ	REQ	REQ	REQ	REQ	REQ	REQ	REQ	REQ	REQ	REQ	REQ	NR	
		Option B (meets §150.1(c)(9A))	Below Roof Deck Insulation	Roofing Type	No Air Space	NR	NR	NR	R 18	NR	NR	NR	R 18	R 18	R 18	R 18	R 18	R 18	R 18	R 18	
				With Air	NR	NR	NR	R 13	NR	NR	NR	R 13	R 13	R 13	R 13	R 13	R 13	R 13	R 13	R 13	
			Ceiling Insulation		R 38	R 38	R 30	R 38	R 30	R 30	R 30	R 38	R 38	R 38	R 38	R 38	R 38	R 38	R 38	R 38	
			Radiant Barrier		NR	REQ	REQ	NR	REQ	REQ	REQ	REQ	NR	NR	NR	NR	NR	NR	NR	NR	NR
		Option C (meets	Ceiling Insulation		R 38	R 30	R 30	R 30	R 30	R 30	R 30	R 30	R 30	R 30	R 30	R 38	R 38	R 38	R 38	R 38	
			Radiant		NR	REQ	REQ	REQ	REQ	REQ	REQ	REQ	REQ	REQ	REQ	REQ	REQ	REQ	REQ	NR	



TABLE 150.1-A COMPONENT PACKAGE-A STANDARD BUILDING DESIGN (CONTINUED)

				Climate Zone															
				1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Building Envelope Insulation	Walls	Above Grade	Framed ⁴	U 0.051	U 0.051	U 0.051	U 0.051	U 0.051	U 0.065	U 0.065	U 0.051	U 0.051	U 0.051	U 0.051	U 0.051	U 0.051	U 0.051	U 0.051	U 0.051
			Mass Wall Interior ⁵	U 0.070 R 13	U 0.070 R 13	U 0.070 R 13	U 0.070 R 13	U 0.070 R 13	U 0.070 R 13	U 0.070 R 13	U 0.070 R 13	U 0.070 R 13	U 0.070 R 13	U 0.070 R 13	U 0.070 R 13	U 0.070 R 13	U 0.070 R 13	U 0.070 R 13	U 0.059 R 17
			Mass Wall Exterior ⁶	U 0.125 R 8.0	U 0.125 R 8.0	U 0.125 R 8.0	U 0.125 R 8.0	U 0.125 R 8.0	U 0.125 R 8.0	U 0.125 R 8.0	U 0.125 R 8.0	U 0.125 R 8.0	U 0.125 R 8.0	U 0.125 R 8.0	U 0.125 R 8.0	U 0.125 R 8.0	U 0.1025 R 8.0	U 0.125 R 8.0	U 0.070 R 13
		Below Grade	Below Grade Interior ⁷	U 0.070 R 13	U 0.070 R 13	U 0.070 R 13	U 0.070 R 13	U 0.070 R 13	U 0.070 R 13	U 0.070 R 13	U 0.070 R 13	U 0.070 R 13	U 0.070 R 13	U 0.070 R 13	U 0.070 R 13	U 0.070 R 13	U 0.070 R 13	U 0.070 R 13	U 0.066 R 15
			Below Grade Exterior	U 0.200 R 5.0	U 0.200 R 5.0	U 0.200 R 5.0	U 0.200 R 5.0	U 0.200 R 5.0	U 0.200 R 5.0	U 0.200 R 5.0	U 0.200 R 5.0	U 0.200 R 5.0	U 0.200 R 5.0	U 0.200 R 5.0	U 0.200 R 5.0	U 0.200 R 5.0	U 0.100 R 10	U 0.100 R 10	U 0.053 R 19
	Floors	Slab Perimeter		NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	U 0.58 R 7.0
		Raised		U 0.037 R 19	U 0.037 R 19	U 0.037 R 19	U 0.037 R 19	U 0.037 R 19	U 0.037 R 19	U 0.037 R 19	U 0.037 R 19	U 0.037 R 19	U 0.037 R 19	U 0.037 R 19	U 0.037 R 19	U 0.037 R 19	U 0.037 R 19	U 0.037 R 19	U 0.037 R 19
		Concrete Raised		U 0.092 R 8.0	U 0.092 R 8.0	U 0.269 R 0	U 0.269 R 0	U 0.269 R 0	U 0.269 R 0	U 0.269 R 0	U 0.269 R 0	U 0.269 R 0	U 0.269 R 0	U 0.092 R 8.0	U 0.138 R 4.0	U 0.092 R 8.0	U 0.092 R 8.0	U 0.138 R 4.0	U 0.092 R 8.0
Building Envelope	Roofing Products	Low-sloped	Aged Solar Reflectance	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	0.63	NR	0.63	NR
			Thermal Emittance	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	0.75	NR	0.75	NR
		Steep Sloped	Aged Solar Reflectance	NR	NR	NR	NR	NR	NR	NR	NR	NR	0.20	0.20	0.20	0.20	0.20	0.20	NR
			Thermal Emittance	NR	NR	NR	NR	NR	NR	NR	NR	NR	0.75	0.75	0.75	0.75	0.75	0.75	NR
Building Envelope	Fenestra	Maximum U-factor		0.32	0.32	0.32	0.32	0.32	0.32	0.32	0.32	0.32	0.32	0.32	0.32	0.32	0.32	0.32	0.32
		Maximum SHGC		NR	0.25	NR	0.25	NR	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
		Maximum Total Area		20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%



		Maximum West Facing Area	NR	5%	NR	5%	NR	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%
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TABLE 150.1-A COMPONENT PACKAGE-A STANDARD BUILDING DESIGN (CONTINUED)

				Climate Zone															
				1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
HVAC SYSTEM	Space Heating ¹¹	Electric-Resistance Allowed		No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No
		If gas, AFUE		MIN	MIN	MIN	MIN	MIN	MIN	MIN	MIN	MIN	MIN	MIN	MIN	MIN	MIN	MIN	MIN
		If Heat Pump, HSPF ⁹		MIN	MIN	MIN	MIN	MIN	MIN	MIN	MIN	MIN	MIN	MIN	MIN	MIN	MIN	MIN	MIN
	Space cooling	SEER		MIN	MIN	MIN	MIN	MIN	MIN	MIN	MIN	MIN	MIN	MIN	MIN	MIN	MIN	MIN	MIN
		Refrigerant Charge Verification or Fault Indicator Display		NR	REQ	NR	NR	NR	NR	NR	REQ	REQ	REQ	REQ	REQ	REQ	REQ	REQ	NR
		Whole House Fan ¹⁰		NR	NR	NR	NR	NR	NR	NR	REQ	REQ	REQ	REQ	REQ	REQ	REQ	NR	NR
	Central System Air Handlers	Central Fan Integrated Ventilation System Fan Efficacy		REQ	REQ	REQ	REQ	REQ	REQ	REQ	REQ	REQ	REQ	REQ	REQ	REQ	REQ	REQ	REQ
	Ducts ¹²	Roof/Ceiling Options A & B	Duct Insulation	R-8	R-8	R-6	R-8	R-6	R-6	R-6	R-8	R-8	R-8	R-8	R-8	R-8	R-8	R-8	R-8
			§150.1(c)9A	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
		Roof/Ceiling	Duct Insulation	R-6	R-6	R-6	R-6	R-6	R-6	R-6	R-6	R-6	R-6	R-6	R-6	R-6	R-6	R-6	R-6
			§150.1(c)9B	REQ	REQ	REQ	REQ	REQ	REQ	REQ	REQ	REQ	REQ	REQ	REQ	REQ	REQ	REQ	REQ
Water Heating	All Buildings			System Shall meet Section 150.1(c)8															



Footnote requirements to TABLE 150.1-A:¹³

1. Install the specified R-value with no air space present between the roofing and the roof deck.
2. Install the specified R-value with an air space present between the roofing and the roof deck. Such as standard installation of concrete or clay tile.
3. R-values shown for below roof deck insulation are for wood-frame construction with insulation installed between the framing members.
4. Assembly U-factors can be met with cavity insulation alone or with continuous insulation alone, or with both cavity and continuous insulation that results in an assembly U-factor equal to or less than the U-factor shown. Use Reference Joint Appendices JA4 Table 4.3.1, 4.3.1(a), or Table 4.3.4 to determine alternative insulation products to meet the required maximum U-factor.
5. Mass wall has a thermal heat capacity greater than or equal to 7.0 Btu/h-ft². "Interior" denotes insulation installed on the inside surface of the wall.
6. Mass wall has a thermal heat capacity greater than or equal to 7.0 Btu/h-ft². "Exterior" denotes insulation installed on the exterior surface of the wall.
7. Below grade "interior" denotes insulation installed on the inside surface of the wall.
8. Below grade "exterior" denotes insulation installed on the outside surface of the wall.
9. HSPF means "heating seasonal performance factor."
10. When whole house fans are required (REQ), only those whole house fans that are listed in the Appliance Efficiency Directory may be installed. Compliance requires installation of one or more WHFs whose total airflow CFM is capable of meeting or exceeding a minimum 1.5 cfm/square foot of conditioned floor area as specified by Section 150.1(c)12.
11. A supplemental heating unit may be installed in a space served directly or indirectly by a primary heating system, provided that the unit thermal capacity does not exceed 2 kilowatts or 7,000 Btu/hr and is controlled by a timelimiting device not exceeding 30 minutes.
12. For duct and air handler location: REQ denotes location in conditioned space. When the table indicates ducts and air handlers are in conditioned space, a HERS verification is required as specified by Reference Residential Appendix RA3.1.4.3.8.

¹³ CBECC-Res applies Option B to the Standard Design with ductwork located in the attic for single family and in conditioned space for multifamily buildings.



Appendix B – Measure Cost Details

Table 17: Measure Descriptions & Cost Assumptions

Measure	Performance Level	Incremental Cost		Source & Notes
		Single Family	MF-Per Unit	
QII	Yes	\$519	\$133	City of Palo Alto 2016 Reach Code Ordinance: http://www.cityofpaloalto.org/civicax/filebank/documents/52054
ACH50	3.0	\$379	N/A	NREL measure cost database (\$0.115/ft ² for sealing) + HERS Rater verification (\$100).
Wall Insulation	R-21	\$391	N/A	Relative to R-19. 2016 CASE Report: Residential High Performance Walls and QII, 2016-RES-ENV2-F.
Cool Roof	Aged Reflect = 0.20	\$523	\$131	\$0-\$0.50/ft ² of roof area per local industry expert at LBNL. Used average of \$0.25/ft ² .
Window U-Factor/SHGC	0.30/0.23	\$73	\$20	EnerComp (\$0.15/ft ² of window area).
Doors	0.20 U-factor	\$40	\$20	EnerComp (\$1.00/ft ² for exterior doors).
High Performance Attics (HPA)	R-13 under roof deck	\$878	\$219	For Climate Zones 1-3, & 5-7 only where HPA is not prescriptive. 2016 CASE Report: Residential Ducts in Conditioned Space/High Performance Attics, 2016-RES-ENV1-F.
Fan Efficacy	0.3 watts/cfm	\$143	\$104	HVAC contractor costs, MF reduction for smaller capacity.
Refrigerant Charge	HERS verified	N/A	\$75	Local HERS Rater.
Duct Insulation	R-8	\$164	N/A	For Climate Zones 3, 6, & 7 where not prescriptive. Cost is relative to R-6. 2016 CASE Report: Residential Ducts in Conditioned Space/High Performance Attics, 2016-RES-ENV1-F.
Low Leakage Ducts in Conditioned Space	25cfm leakage to outside	N/A	\$379	Only includes the cost for blower door testing (see ACH50 costs for SF above) since the basecase assume ductwork located in conditioned space and duct testing.
HERS Verification of Hot Water Pipe Insulation	HERS verified	\$146	N/A	Roughly equivalent to code requirements effective Jan. 2017. ten percent of \$3.87 per ft (2013 SF DHW CASE Report) for additional labor to pass HERS inspection. \$100 for HERS verification per local HERS Raters.
Hot Water Compact Distribution	HERS verified	N/A	\$112	Assume compact design already or easily achieved in MF units – no added cost. \$100 HERS verification fee per local HERS Rater. Pipe insulation cost per the pipe insulation measure assumptions.
Ducted Heat Pump Water Heater in Conditioned Space	Exhaust air ducted to the outdoors	N/A	\$500	Costs includes ducting kit and installation
PV System	System size varies	\$2.80/W DC	\$2.63/W DC	Source: Tracking the Sun IX. (https://emp.lbl.gov/sites/default/files/tracking_the_sun_ix_report.pdf). Single Family: Avg. system cost of \$4.00/watt in 2015 for residential new construction. Multifamily systems: an average residential and small commercial system costs @ \$3.25/watt was used. Systems are expected to be typically greater than 10 kW, although not as large as some commercial systems reported on in the database. In both cases, costs assume 30 percent for the solar investment tax credit. No NSHP incentive was used.
PV Inverter–Replacement	Micro inverter	\$0.40/W DC	\$0.40/W DC	Assumes inverter replacement at 20 years based on life of micro inverters. NREL cost study: \$0.29/W based on new construction. (http://www.nrel.gov/docs/fy15osti/64746.pdf). Add labor cost of \$275.



Appendix C – Efficiency Package Summaries

Table 18 and Table 19 summarize the measures selected to cost effectively meet the performance targets in the report. Values in red reflect measures added to the all-electric packages to meet the performance targets. Blank cells mean that values are the same as 2016 prescriptive values for that climate zone.

Table 18: Single Family PV Packages

Climate Zone	Compliance Margin Target	QII	ACH50	Window U-value / SHGC	Door U-value	HPA	AH Fan W/cfm	HPWH Location ¹	HW Pipe Insul.	PV Credit Size (kW)
CZ1	30%	Y	3	.30/.50	0.20	Y		Gar	PI	2.1
CZ2	30%	Y		.30/.50	0.20	Y		CS	PI	2.1
CZ3	20%	Y		.30/.50	0.20			Gar		2.0
CZ4	30%	Y		.30/.23				Gar		2.1
CZ5	20%	Y		.30/.50				Gar		2.0
CZ6	10%	Y					0.30	Gar		n/a
CZ7	10%	Y		.30/.23	0.20		0.30	Gar	PI	n/a
CZ8	30%	Y						Gar		2.1
CZ9	30%	Y		.30/.23	0.20			Gar		2.0
CZ10	30%	Y			0.20			Gar		2.1
CZ11	30%	Y		.30/.23	0.20		0.30	Gar		2.2
CZ12	30%	Y			0.20			Gar		2.1
CZ13	30%	Y		.30/.23	0.20			Gar		2.2
CZ14	30%	Y			0.20		0.30	Gar		2.2
CZ15	30%	Y					0.30	Gar		2.2
CZ16	30%	Y	3	.30/.23	0.20		0.30	CS		2.1

¹CS = conditioned space; Gar = garage.

Table 19: Multifamily PV Packages

Climate Zone	Compliance Margin Target	QII	Window U-value / SHGC	Door U-value	AH Fan W/cfm	Refrigerant Charge	HPWH Location ¹	HW Comp. Dist.	PV Credit Size (kW)
CZ1	20%	Y	0.30/0.50	0.20	0.3		CS (No NG) Ext (NG Avail)	Y	1.0
CZ2	20%	Y	0.30/0.23	0.20	0.3		CS	Y	1.0
CZ3	15%	Y	0.30/0.50	0.20	0.3		Ext	Y	1.0
CZ4	25%	Y	0.30/0.23	0.20	0.3		CS	Y	1.0
CZ5	10%	Y	0.30/0.50	0.20	0.3		CS	Y	1.0
CZ6	10%	Y	0.30/0.23	0.20	0.3		CS	Y	
CZ7	10%	Y	0.30/0.23	0.20	0.3	Y	CS	Y	
CZ8	20%	Y	0.30/0.23	0.20	0.3		CS	Y	1.0
CZ9	25%	Y	0.30/0.23	0.20	0.3		CS		1.0
CZ10	25%	Y	0.30/0.23	0.20	0.3		CS		1.0
CZ11	25%	Y	0.30/0.23	0.20	0.3		CS		1.0
CZ12	25%	Y	0.30/0.23	0.20	0.3		CS		1.0
CZ13	25%	Y	0.30/0.23	0.20	0.3		CS		1.0
CZ14	25%	Y	0.30/0.23	0.20	0.3		CS		1.0
CZ15	25%	Y	0.30/0.23	0.20	0.3		CS		1.0
CZ16	25%	Y	0.30/0.23	0.20			CS		1.0

¹CS = conditioned space; CS-Duct = ducted unit in conditioned space.



Appendix D – Utility Rate Tariffs

Following are the PG&E electricity, both standard and time-of-use, and natural gas tariffs applied in this study. The PG&E monthly gas rate in \$/therm was applied on a monthly basis for the 12-month period ending September 2017.



**Pacific Gas and
Electric Company**
U 39 San Francisco, California

Cancelling Revised Cal. P.U.C. Sheet No. 40030-E
Revised Cal. P.U.C. Sheet No. 38021-E

ELECTRIC SCHEDULE E-1 RESIDENTIAL SERVICES

Sheet 1

APPLICABILITY: This schedule is applicable to single-phase and polyphase residential service in single-family dwellings and in flats and apartments separately metered by PG&E; to single-phase and polyphase service in common areas in a multifamily complex (see Special Condition 8); and to all single-phase and polyphase farm service on the premises operated by the person whose residence is supplied through the same meter.

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

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

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

Customers receiving a medical baseline allowance shall pay for all usage in excess of 200 percent of baseline at a rate \$0.04000 per kWh less than the applicable rate for usage in excess of 200 percent of baseline. No portion of the rates paid by customers that receive a Medical Baseline allowance shall be used to pay the DWR Bond charge. For these customers, the Conservation Incentive Adjustment is calculated residually based on the total rate less the sum of: Transmission, Transmission Rate Adjustments, Reliability Services, Distribution, Generation, Public Purpose Programs, Nuclear Decommissioning, Competition Transition Charges (CTC), New System Generation Charges,¹ and Energy Cost Recovery Amount. Customers receiving a medical baseline allowance shall also receive a 50 percent discount on the delivery minimum bill amount shown below.

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

TOTAL RATES

Total Energy Rates (\$ per kWh)		
Baseline Usage	\$0.19979 (I)	
101% - 400% of Baseline	\$0.27612 (I)	(T)
High Usage Over 400% of Baseline	\$0.40139	(T)
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)	(\$17.40)	

¹ Per Decision 11-12-031, New System Generation Charges are effective 1/1/2012.

(Continued)

Advice 5011-E-A
Decision

Issued by
Robert S. Kenney
Vice President, Regulatory Affairs

Date Filed February 24, 2017
Effective March 1, 2017
Resolution





**Pacific Gas and
Electric Company**
U 39 San Francisco, California

Cancelling Revised Cal. P.U.C. Sheet No. 40052-E
Revised Cal. P.U.C. Sheet No. 38051-E

ELECTRIC SCHEDULE E-TOU
RESIDENTIAL TIME-OF-USE SERVICE

Sheet 2

RATES
(Cont'd.):

OPTION A TOTAL RATES

Total Energy Rates (\$ per kWh)	PEAK		OFF-PEAK	
<i>Summer</i>				
Total Usage	\$0.39336	(R)	\$0.31778	(R)
Baseline Credit (Applied to Baseline Usage Only)	(\$0.08830)	(I)	(\$0.08830)	(I)
<i>Winter</i>				
Total Usage	\$0.27539	(R)	\$0.26109	(R)
Baseline Credit (Applied to Baseline Usage Only)	(\$0.08830)	(I)	(\$0.08830)	(I)
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)	(\$17.40)			

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 Charges¹ based on kWh usage times the corresponding unbundled rate component per kWh, with any residual revenue assigned to Distribution.*

¹ Per Decision 11-12-031, New System Generation Charges are effective 1/1/2012.

* This same assignment of revenues applies to direct access and community choice aggregation customers.

(Continued)

Advice	5011-E-A	Issued by	Date Filed	February 24, 2017
Decision		Robert S. Kenney	Effective	March 1, 2017
		Vice President, Regulatory Affairs	Resolution	





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

Cancelling Revised Cal. P.U.C. Sheet No. 33319-G
Revised Cal. P.U.C. Sheet No. 33280-G

**GAS SCHEDULE G-1
RESIDENTIAL SERVICE**

Sheet 1

APPLICABILITY: This rate schedule* applies to natural gas service to Core End-Use Customers on PG&E's Transmission and/or Distribution Systems. To qualify, service must be to individually-metered single family premises for residential use, including those in a multifamily complex, and to separately-metered common areas in a multifamily complex where Schedules GM, GS, or GT are not applicable. Common area accounts that are separately metered by PG&E have an option of switching to a core commercial rate schedule. Common area accounts are those accounts that provide gas service to common use areas as defined in Rule 1.

TERRITORY: Schedule G-1 applies everywhere within PG&E's natural gas Service Territory.

RATES: Customers on this schedule pay a Procurement Charge and a Transportation Charge, per meter, as shown below. The Transportation Charge will be no less than the Minimum Transportation Charge, as follows:

	<u>Minimum Transportation Charge:**</u>	
	<u>Per Day</u>	
	\$0.09863	
	<u>Per Therm</u>	
	<u>Baseline</u>	<u>Excess</u>
<u>Procurement:</u>	\$0.39848 (R)	\$0.39848 (R)
<u>Transportation Charge:</u>	\$0.88798	\$1.42077
<u>Total:</u>	\$1.28646 (R)	\$1.81925 (R)

Public Purpose Program Surcharge:

Customers served under this schedule are subject to a gas Public Purpose Program (PPP) Surcharge under Schedule G-PPPS.

See Preliminary Statement, Part B for the Default Tariff Rate Components.

The Procurement Charge on this schedule is equivalent to the rate shown on informational Schedule G-CP—Gas Procurement Service to Core End-Use Customers.

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

BASELINE QUANTITIES (Therms Per Day Per Dwelling Unit)		
Baseline Territories***	Summer Effective Apr. 1, 2016	Winter Effective Nov. 1, 2015
P	0.46	2.15
Q	0.69	1.98
R	0.46	1.79
S	0.46	1.92
T	0.69	1.79
V	0.69	1.79
W	0.46	1.69
X	0.59	1.98
Y	0.85	2.55

* PG&E's gas tariffs are available online at www.pge.com.

** The Minimum Transportation charge does not apply to submetered tenants of master-metered customers served under gas rate Schedules GS and GT.

*** The applicable baseline territory is described in Preliminary Statement, Part A.

(Continued)

Advice	3836-G	Issued by	Date Filed	April 24, 2017
Decision	97-10-065 & 98-07-025	Robert S. Kenney	Effective	May 1, 2017
		Vice President, Regulatory Affairs	Resolution	



Pacific Gas and Electric Company

Residential Non-CARE and CARE Gas Tariff Rates
January 1, 2016, to Present
(\$/therm)^{1/}

Effective Date	Advice Letter Number	Minimum Transportation Charge ^{2/} (per day)	Procurement Charge	Transportation Charge ^{2/}	TOTAL Residential Non-CARE Schedules Charge ^{3/}
10/01/16	3760-G	\$0.09863	\$0.38660	\$0.96817 \$1.54907	\$1.35477 \$1.93567
11/01/16	3775-G	\$0.09863	\$0.45875	\$0.96817 \$1.54907	\$1.42692 \$2.00782
12/01/16	3785-G	\$0.09863	\$0.39428	\$0.96817 \$1.54907	\$1.36245 \$1.94335
01/01/17	3793-G	\$0.09863	\$0.45305	\$0.88798 \$1.42077	\$1.34103 \$1.87382
02/01/17	3800-G	\$0.09863	\$0.44251	\$0.88798 \$1.42077	\$1.33049 \$1.86328
03/01/17	3812-G	\$0.09863	\$0.40169	\$0.88798 \$1.42077	\$1.28967 \$1.82246
04/01/17	3827-G	\$0.09863	\$0.42225	\$0.88798 \$1.42077	\$1.31023 \$1.84302
05/01/17	3836-G	\$0.09863	\$0.39848	\$0.88798 \$1.42077	\$1.28646 \$1.81925
06/01/17	3844-G	\$0.09863	\$0.39102	\$0.88798 \$1.42077	\$1.27900 \$1.81179
07/01/17	3859-G	\$0.09863	\$0.31908	\$0.88566 \$1.41705	\$1.20472 \$1.73611
08/01/17	3870-G	\$0.09863	\$0.32821	\$0.88566 \$1.41705	\$1.21387 \$1.74526
09/01/17	3879-G	\$0.09863	\$0.27240 ^{7/}	\$0.88566 \$1.41705	\$1.15806 \$1.68945

^{1/} Unless otherwise noted

^{2/} Effective July 1, 2005, the Transportation Charge will be no less than the Minimum Transportation Charge of \$0.09863 (per day). Applicable to Rate Schedule G-1 only and does not apply to submetered tenants of master-metered customers served under gas Rate Schedule GS and GT.

^{3/} Schedule G-PPPS (Public Purpose Program Surcharge) needs to be added to the TOTAL Non-CARE Charge and TOTAL CARE Charge for bill calculation. See Schedule G-PPPS for details and exempt customers.

^{4/} CARE Schedules include California Solar Initiative (CSI) Exemption in accordance with Advice Letter 3257-G-A.

^{5/} Per dwelling unit per day (Multifamily Service)

^{6/} Per installed space per day (Mobilehome Park Service)

^{7/} This procurement rate includes a charge of \$0.02431 per therm to reflect account balance amortizations in accordance with Advice Letter 3157-G.

Seasons: Winter = Nov-Mar Summer = April-Oct



Following are the SCE electricity tariffs, both standard and time-of-use, and SoCalGas natural gas tariffs applied in this study.



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

Cancelling Revised Cal. PUC Sheet No. 61658-E
Revised Cal. PUC Sheet No. 60925-E

**Schedule D
DOMESTIC SERVICE**

Sheet 2

(Continued)

RATES

Delivery Service		Generation ²	
		UG***	DWREC ³
Total ¹			
Energy Charge- \$/kWh/Meter/Day			
Baseline Service			
Summer	0.05765 (R)	0.07477	0.00000
Winter	0.05765 (R)	0.07477	0.00000
Nonbaseline Service*			
101% - 400% of Baseline - Summer	0.17275 (R)	0.07477	0.00000
Winter	0.17275 (R)	0.07477	0.00000
High Usage Charge			
(Over 400% of Baseline) - Summer	0.23747 (R)	0.07477	0.00000
- Winter	0.23747 (R)	0.07477	0.00000
Basic Charge - \$/Meter/Day			
Single-Family Accommodation	0.031		
Multi-Family Accommodation	0.024		
Minimum Charge** - \$/Meter/Day			
Single-Family Accommodation	0.329		
Multi-Family Accommodation	0.329		
Minimum Charge (Medical Baseline)** - \$/Meter/Day			
Single-Family Accommodation	0.164		
Multi-Family Accommodation	0.164		
California Climate Credit ⁴	(31.00)		
Peak Time Rebate - \$/kWh		(0.75)	
Peak Time Rebate w/enabling technology - \$/kWh		(1.25)	

* Nonbaseline Service includes all kWh in excess of applicable Baseline allocations as described in Preliminary Statement, Part H, Baseline Service.

** The Minimum Charge is applicable when the Delivery Service Energy Charge, plus the applicable Basic Charge is less than the Minimum Charge.

*** The ongoing Competition Transition Charge (CTC) of \$(0.00034) per kWh is recovered in the UG component of Generation.

¹ Total = Total Delivery Service rates are applicable to Bundled Service, Direct Access (DA) and Community Choice Aggregation Service (CCA Service) Customers, except DA and CCA Service Customers are not subject to the DWRBC rate component of this Schedule but instead pay the DWRBC as provided by Schedule DA-CRS or Schedule CCA-CRS.

² Generation = The Generation rates are applicable only to Bundled Service Customers.

³ DWREC = Department of Water Resources (DWR) Energy Credit - For more information on the DWR Energy Credit, see the Billing Calculation Special Condition of this Schedule.

⁴ Applied on an equal basis, per household, semi-annually. See the Special Conditions of this Schedule for more information.

(Continued)

(To be inserted by utility)

Advice 3608-E
Decision _____

2017

Issued by

Caroline Choi
Senior Vice President

(To be inserted by Cal. PUC)

Date Filed May 25, 2017
Effective Jun 1, 2017
Resolution E-3930





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

Cancelling Revised
Revised

Cal. PUC Sheet No. 61672-E
Cal. PUC Sheet No. 60939-E

Schedule TOU-D-T
TIME-OF-USE TIERED DOMESTIC

Sheet 2

(Continued)

RATES

	Delivery Service Total ¹	Generation ²	
		UG***	DWREC ³
Energy Charge - \$/kWh/Meter/Day			
Summer Season - On-Peak			
Level I (up to 130% of Baseline)	0.12304 (R)	0.23031	0.00000
Level II (More than 130% of Baseline)	0.16121 (R)	0.23031	0.00000
Summer Season - Off-Peak			
Level I (up to 130% of Baseline)	0.12304 (R)	0.05736	0.00000
Level II (More than 130% of Baseline)	0.16121 (R)	0.05736	0.00000
Winter Season - On-Peak			
Level I (up to 130% of Baseline)	0.12304 (R)	0.11031	0.00000
Level II (More than 130% of Baseline)	0.16121 (R)	0.11031	0.00000
Winter Season - Off-Peak			
Level I (up to 130% of Baseline)	0.12304 (R)	0.05121	0.00000
Level II (More than 130% of Baseline)	0.16121 (R)	0.05121	0.00000
Basic Charge - \$/Meter/Day			
Single-Family Accommodation	0.031		
Multi-Family Accommodation	0.024		
Minimum Charge* - \$/Meter/Day			
Single-Family Accommodation	0.329		
Multi-Family Accommodation	0.329		
Minimum Charge (Medical Baseline)** - \$/Meter/Day			
Single-Family Accommodation	0.164		
Multi-Family Accommodation	0.164		
California Climate Credit ⁴	(31.00)		
California Alternate Rates for Energy Discount - %	100.00*		
Peak Time Rebate - \$/kWh		(0.75)	
Peak Time Rebate w/enabling technology - \$/kWh		(1.25)	

* The Minimum Charge is applicable when the Delivery Service Energy Charge, plus the applicable Basic Charge is less than the Minimum Charge.

** Represents 100% of the discount percentage as shown in the applicable Special Condition of this Schedule.

*** The ongoing Competition Transition Charge (CTC) of \$(0.00034) per kWh is recovered in the UG component of Generation.

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.

(Continued)

(To be inserted by utility)

Advice 3608-E
Decision _____

2C20

Issued by
Caroline Choi
Senior Vice President

(To be inserted by Cal. PUC)

Date Filed May 25, 2017
Effective Jun 1, 2017
Resolution E-3930



SOUTHERN CALIFORNIA GAS COMPANY Revised CAL. P.U.C. SHEET NO. 54294-G
LOS ANGELES, CALIFORNIA CANCELING Revised CAL. P.U.C. SHEET NO. 54268-G

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

Sheet 1

APPLICABILITY

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

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

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

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

TERRITORY

Applicable throughout the service territory.

RATES

	<u>GR</u>	<u>GR-C</u>	<u>GT-R</u>
<u>Customer Charge</u> , per meter per day:.....	16.438¢	16.438¢	16.438¢

For "Space Heating Only" customers, a daily Customer Charge applies during the winter period from November 1 through April 30 ^{1/} :	33.149¢	33.149¢	33.149¢
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Baseline Rate, per therm (baseline usage defined in Special Conditions 3 and 4):

<u>Procurement Charge</u> : ^{2/}	33.735¢	34.213¢	N/A
<u>Transmission Charge</u> : ^{3/}	51.195¢	51.195¢	51.220¢
<u>Total Baseline Charge</u> :	84.930¢	85.408¢	51.220¢

Non-Baseline Rate, per therm (usage in excess of baseline usage):

<u>Procurement Charge</u> : ^{2/}	33.735¢	34.213¢	N/A
<u>Transmission Charge</u> : ^{3/}	84.028¢	84.028¢	84.053¢
<u>Total Non-Baseline Charge</u> :	117.763¢	118.241¢	84.053¢

^{1/} For the summer period beginning May 1 through October 31, with some exceptions, usage will be accumulated to at least 20 Ccf (100 cubic feet) before billing.

(Footnotes continue next page.)

(Continued)

(TO BE INSERTED BY UTILITY)

ADVICE LETTER NO. 5185

DECISION NO.

ICS

ISSUED BY

Dan Skopec

Vice President

Regulatory Affairs

(TO BE INSERTED BY CAL. PUC)


DATE FILED Sep 8, 2017

EFFECTIVE Sep 10, 2017

RESOLUTION NO. G-3351



Following are the SDG&E electricity, both standard and time-of-use, and natural gas tariffs applied in this study.



San Diego Gas & Electric Company
San Diego, California

Revised Cal. P.U.C. Sheet No. 29081-E

Canceling Revised Cal. P.U.C. Sheet No. 28651-E

SCHEDULE DR

RESIDENTIAL SERVICE

(Includes Rates for DR-LI)

Sheet 1

APPLICABILITY

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

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

Customers on this schedule may also qualify for a semi-annual California Climate Credit \$(29.62) per Schedule GHG-ARR.

TERRITORY

Within the entire territory served by the Utility.

RATES

Total Rates:

Description - DR Rates	UDC Total Rate	DWR-BC Rate	EECC Rate + DWR Credit	Total Rate
Summer:				
Up to 130% of Baseline Energy (\$/kWh)	0.07716 I	0.00549	0.14106	0.22373 I
Above 130% of Baseline (\$/kWh)	0.25496 R	0.00549	0.14106	0.40153 R
Winter:				
Up to 130% of Baseline Energy (\$/kWh)	0.12807 I	0.00549	0.07196	0.20552 I
Above 130% of Baseline (\$/kWh)	0.29139 R	0.00549	0.07196	0.36884 R
Minimum Bill (\$/day)	0.329			0.329

Description -DR-LI Rates	UDC Total Rate	DWR-BC Rate	EECC Rate + DWR Credit	Total Rate	Total Effective N CARE Rate
Summer - CARE Rates:					
Up to 130% of Baseline Energy (\$/kWh)	0.07671 I	0.00000	0.14106	0.21777 I	0.13766
Above 130% of Baseline (\$/kWh)	0.25451 R	0.00000	0.14106	0.39557 R	0.25230
Winter - CARE Rates:					
Up to 130% of Baseline Energy (\$/kWh)	0.12760 I	0.00000	0.07196	0.19956 I	0.12614
Above 130% of Baseline (\$/kWh)	0.29092 R	0.00000	0.07196	0.36288 R	0.23126
Minimum Bill (\$/day)	0.164			0.164	0.164

(Continued)

1C13

Advice Ltr. No. 3055-E-A

Decision No. 15-07-001

Issued by

Dan Skopec

Vice President

Regulatory Affairs

Date Filed Aug 17, 2017

Effective Sep 1, 2017

Resolution No. 4870





San Diego Gas & Electric Company
San Diego, California

Revised Cal. P.U.C. Sheet No. 28663-E

Canceling Revised Cal. P.U.C. Sheet No. 28533-E

SCHEDULE DR-SES

Sheet 1

DOMESTIC TIME-OF-USE FOR HOUSEHOLDS WITH A SOLAR ENERGY SYSTEM

APPLICABILITY

Service under this schedule is available on a voluntary basis for individually metered residential customers with Solar Energy Systems. Service is limited to individually metered residential customers with a Solar Energy System with domestic service for lighting, heating, cooking, water heating, and power, or combination thereof, in single family dwellings and flats. Qualifying California Alternative Rates for Energy (CARE) customers are eligible for service on this schedule, as further described under Special Condition 8 of this schedule.

Customers on this schedule may also qualify for a semi-annual California Climate Credit \$(29.62) per Schedule GHG-ARR.

TERRITORY

Within the entire territory served by the Utility.

RATES

Total Rates:

Description – DR-SES Rates	UDC Total Rate	DWR-BC Rate	EECC Rate + DWR Credit	Total Rate
Energy Charges (\$/kWh)				
On-Peak – Summer	0.14184 I	0.00549	0.35896 I	0.50629 I
Semi-Peak – Summer	0.14184 I	0.00549	0.10375 I	0.25108 I
Off-Peak – Summer	0.14184 I	0.00549	0.07968 I	0.22721 I
Semi-Peak – Winter	0.14184 I	0.00549	0.08866 I	0.23619 I
Off-Peak – Winter	0.14184 I	0.00549	0.07438 I	0.22171 I
Minimum Bill (\$/day)	0.329			0.329

- (1) Total Rates consist of UDC, Schedule DWR-BC (Department of Water Resources Bond Charge), and Schedule EECC (Electric Energy Commodity Cost) rates, with the EECC rates reflecting a DWR Credit of \$0.00000 that customers receive on their monthly bills.
- (2) Total Rates presented are for customers that receive commodity supply and delivery service from Utility. Differences in total rates paid by Direct Access (DA) and Community Choice Aggregation (CCA) customers are identified in Schedule DA-CRS and CCA-CRS, respectively.
- (3) DWR-BC charges do not apply to CARE or Medical Baseline customers.

UDC Rates

Description-DR-SES	Transm	Distr	PPP	ND	CTC	LGC	RS	TRAC	UDC Total
Energy Charges (\$/kWh)									
On-Peak – Summer	0.03829	0.08677	0.01063	(0.00049)	0.00177 R	0.00268 I	0.00019	0.00000	0.14184 I
Semi-Peak – Summer	0.03829	0.08677	0.01063	(0.00049)	0.00177 R	0.00268 I	0.00019	0.00000	0.14184 I
Off-Peak – Summer	0.03829	0.08677	0.01063	(0.00049)	0.00177 R	0.00268 I	0.00019	0.00000	0.14184 I
Semi-Peak – Winter	0.03829	0.08677	0.01063	(0.00049)	0.00177 R	0.00268 I	0.00019	0.00000	0.14184 I
Off-Peak – Winter	0.03829	0.08677	0.01063	(0.00049)	0.00177 R	0.00268 I	0.00019	0.00000	0.14184 I
Minimum Bill (\$/day)		0.329							0.329

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1C8

Advice Ltr. No. 3034-E

Decision No. 16-12-053

Issued by
Dan Skopec
Vice President
Regulatory Affairs

Date Filed Jan 17, 2017

Effective Mar 1, 2017

Resolution No.





San Diego Gas & Electric Company
San Diego, California

Revised Cal. P.U.C. Sheet No. 22788-G

Canceling Revised Cal. P.U.C. Sheet No. 22775-G

SCHEDULE GR

Sheet 1

RESIDENTIAL NATURAL GAS SERVICE (Includes Rates for GR, GR-C, GTC/GTCA)

APPLICABILITY

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

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

The GTC/GTCA rate is applicable to intrastate gas transportation-only services to individually metered residential customers, as set forth in Special Condition 11.

Customers taking service under this schedule may be eligible for a 20% California Alternate Rate for Energy (CARE) program discount, reflected as a separate line item on the bill, if they qualify to receive service under the terms and conditions of Schedule G-CARE.

TERRITORY

Within the entire territory served natural gas by the utility.

RATES

	<u>GR</u>	<u>GR-C</u>	<u>GTC/GTCA^{1/}</u>
<u>Baseline Rate</u> , per therm (baseline usage defined in Special Conditions 3 and 4):			
Procurement Charge: ^{2/}	\$0.33755	\$0.33755 R	N/A
Transmission Charge:	\$0.91113	\$0.91113	\$0.91113
Total Baseline Charge:	\$1.24868	\$1.24868 R	\$0.91113
<u>Non-Baseline Rate</u> , per therm (usage in excess of baseline usage):			
Procurement Charge: ^{2/}	\$0.33755	\$0.33755 R	N/A
Transmission Charge:	\$1.09834	\$1.09834	\$1.09834
Total Non-Baseline Charge:	\$1.43589	\$1.43589 R	\$1.09834
<u>Minimum Bill</u> , per day: ^{3/}			
Non-CARE customers:	\$0.09863	\$0.09863	\$0.09863
CARE customers:	\$0.07890	\$0.07890	\$0.07890

^{1/} The rates for core transportation-only customers, with the exception of customers taking service under Schedule GT-NGV, include any FERC Settlement Proceeds Memorandum Account (FSPMA) credit adjustments.

^{2/} This charge is applicable to Utility Procurement Customers and includes the GPC and GPC-A Procurement Charges shown in Schedule GPC which are subject to change monthly as set forth in Special Condition 7.

^{3/} Effective starting May 1, 2017, the minimum bill is calculated as the minimum bill charge of \$0.09863 per day times the number of days in the billing cycle (approximately \$3 per month) with a 20% discount applied for CARE customer resulting in a minimum bill charge of \$0.07890 per day (approximately \$2.40 per month).

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1CS

Advice Ltr. No. 2608-G

Decision No.

Issued by
Dan Skopec
Vice President
Regulatory Affairs

Date Filed Sep 8, 2017

Effective Sep 10, 2017

Resolution No.

