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Title 24, Part 11
Local Energy Efficiency Ordinances

CALGreen Cost Effectiveness Study

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LEGAL NOTICE

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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.

This report presents the results from analysis of the feasibility and cost-effectiveness of requiring new low-rise single family and multifamily residential construction to exceed the 2016 Building Energy Efficiency Standards, which become effective January 1, 2017. The analysis includes scenarios of compliance packages options and cost effectiveness analysis for all sixteen California climate zones. Four levels of building energy performance were examined:

(1) exceeding the minimum requirements by at least 15%, consistent with the voluntary Tier 1 Performance Standard in Title 24, Part 11 (CALGreen),

(2) exceeding minimum requirement by at least 30%, consistent with the voluntary Tier 2 Performance Standard in CALGreen,

(3) meeting minimum Title 24 efficiency performance targets plus on-site renewable energy generation sufficient to achieve an Energy Design Rating of zero (TDV-Zero), consistent with the voluntary Zero Net Energy Design tier in CALGreen,

(4) meeting minimum Title 24 efficiency performance targets plus on-site renewable energy generation sized to offset a portion of the total TDV loads of the building without risking sizing of the PV system larger than the estimated electrical energy use of the building.

2 Methodology and Assumptions

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

	Single Family One-Story	Single Family Two-Story	Multifamily
Conditioned Floor Area	2,100 ft²	2,700 ft²	6,960 ft²: (4) 780 ft² & (4) 960 ft² 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%

Additionally, each prototype building has the following features:

- Slab-on-grade foundation
- Vented attic. High performance attic in climates where prescriptively assigned (CZ 4, 8-16) with insulation installed below roof deck. Refer to Table 150.1-A in Appendix A.
- Ductwork located in the attic for single family homes and in conditioned space for multifamily.
- Split-system gas furnace with air conditioner that meet the minimum federal guidelines for efficiency
- Tankless gas water heater that meets the minimum federal guidelines for efficiency; individual water heaters in each multifamily apartment.

Other features are defined consistent with the Standard Design in the Alternative Calculation Method Reference Manual (CEC, 2016d), designed to meet, but not exceed, the minimum requirements.

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 ft^2 house[1].

2.2 Efficiency Measures & Package Development

The CBECC-RES 2016.2.0 ALPHA2[2] (833) compliance simulation tool 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 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, prospective energy efficiency measures were identified and modeled in each of the prototypes to determine the projected energy (Therm and kWh) and compliance impacts. A large set of parametric runs[3] were conducted to develop packages of measures that exceed the minimum code performance level by 15% (CALGreen Tier 1), and 30% (Tier 2). The consultants authoring this study selected packages and measures based on decades of experience with residential architects, builders, and engineers along with general knowledge of the relative acceptance and preferences of many measures, as well as their incremental costs.

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[1] 2,430 ft^2 = 45% * 2,100 ft^2 + 55% * 2,700 ft^2

[2] On June 14, 2016 the CEC approved CBECC-Res 2016.2.0 Version of the software. The version used for this study is nearly identical to the approved version with the exception of minor changes that do not affect the cost effective analysis of the measures evaluated.

[3] Using the "quick" simulation speed option.

Evaluation results for the selected packages show that meeting the performance targets for both single family and multifamily prototypes is feasible in most climate zones. In climates where it was not feasible, targets were relaxed to an appropriate level. 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.

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

Quality Insulation Installation (QII): HERS rater verification of insulation quality 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)[4] 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-value 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 climates 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 Efficiency Furnace: Upgrade furnace to a condensing unit with an efficiency of 92% AFUE.

High Efficiency Air Conditioner: Upgrade air conditioner efficiency beyond federal efficiency minimum to either SEER 15 / EER 12.5 or SEER 16 / EER 13.

High Efficacy Fan: Upgrade the fan in the furnace or air handler using an electronically commutated motor (ECM) that meets an efficacy of 0.3 Watts / cfm or lower operating at full speed. 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.

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[4] 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 climates zones where this is not already required prescriptively.

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

High Efficiency Water Heater: Upgrade tankless water heater to a condensing unit with a rated Energy Factor (EF) of either 0.94 or 0.96.

Hot Water Pipe Insulation: Beginning in January 1, 2017 the 2016 California Plumbing Code will require 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.

PV Compliance Credit: 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 ft^2 of conditioned floor area and 1 kW DC per multifamily unit with no more than 1,000 ft^2 of conditioned floor area is required. For the single family 2,430 ft^2 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 ft^2 and therefore require a 1 kW system. The credit was developed to give builders an option with which to trade-off High Performance Attics and Walls, and to begin preparing for ZNE requirements.

Table 2 below summarizes the measures evaluated along with cost assumptions.

Table 2: Measure Descriptions & Cost Assumptions

Measure	Performance Level	Incremental Cost Single Family	Incremental Cost MF – Per Unit	Source & Notes
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/ft² for sealing) + HERS rater verification ($100).
Wall Insulation	R-21	$164	n/a	2016 CASE Report: Residential High Performance Walls and QII, 2016-RES-ENV2-F
Cool Roof	Aged Reflect = 0.20	$523	$131	$0-$0.50 / ft² of roof area per local industry expert at LBNL. Used average of $0.25/ft².
Window U-factor/ SHGC	0.30/0.23	$73	$20	EnerComp ($0.15/ft² of window area)
Doors	0.20 U-factor	$210	$140	NREL measure cost database ($3.50/ft²) for doors between house and garage. Double cost ($7/ft²) for front door assuming a premium product.
High Performance Attics (HPA)	R-15 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
Furnace	92%	$389	$351	Local HVAC contractor, MF reduction for smaller capacity.
Air Conditioning	15/12.5	$78	$46	Local HVAC contractor, MF reduction for smaller capacity.
	16/13	$839	$699	Average of local HVAC contractor & NREL database costs. MF reduction for smaller capacity.
Fan Efficacy	0.3 Watts/cfm	$143	$104	Local HVAC contractor, 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. 2016 CASE Report: Residential Ducts in Conditioned Space / High Performance Attics, 2016-RES-ENV1-F
Water heater	0.94 EF	$0	$0	Internet pricing and plumbing contractor input. Minimal incremental equip cost and lower cost to install PVC venting (condensing) vs stainless venting (standard). Slight premium going from 0.94 to 0.96.
	0.96 EF	$100	$100	
Hot water pipe insulation	HERS verified	$146	n/a	Roughly equivalent to code requirements effective Jan. 2017. 10% of $3.87 per ft (2013 SF DHW CASE study) 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.
PV	System size varies	$3.53 / kW DC	$3.21 / kW DC	Avg. system cost for systems < 10kW (for the last 12 months) of $5.29/Watt for single family (http://www.gosolarcalifornia.ca.gov/). For multi-family systems, an average of the < 10 kW and > 10kW system cost ($4.37/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 cost was reduced by $0.25/Watt for the NSHP incentive & 30% for the solar investment tax credit.

2.3 Efficiency Packages

Three efficiency packages were developed for each climate zone where feasible, as described below. Since the federal government does not allow local or state government agencies to require the use of federally-regulated equipment that exceeds the minimum standard requirement, this analysis includes at least one package for each climate zone that does not require installing equipment with higher efficiencies than federally mandated. In climates where the PV Compliance Credit (PVCC) is available (all climates except 6 and 7) a package that includes the PVCC in addition to efficiency measures was evaluated to achieve Tier 2 performance levels.

1) **Envelope**: These packages focus on building envelope measures but also include efficient hot water pipe distribution and cooling fan efficiency measures that don't trigger federal preemption issues.
2) **Equipment**: Use of HVAC and water heating equipment that are more efficient than federal standards combined with efficient envelope measures if necessary.
3) **PV Credit**: Utilize the PV compliance credit (PVCC) available in all climate zones except 6 and 7.

2.4 PV Performance Packages

Using the Tier 2 efficiency package (or Tier 1 in cases where reaching Tier 2 wasn't feasible), the PV system was evaluated and sized to offset TDV loads for the following two conditions:

1) **PV-Plus**: Install a PV system sized to offset a portion of the total household energy use based on TDV energy. PV sizing is consistent with the methodology included in the California Energy Commission's proposed Solar PV Ordinance being developed by the CEC, and PV sizing calculations were developed such that PV size is to be equivalent to offsetting approximately 80% of total estimated building electricity use for a gas/electric home built to the 2016 Title 24. Table 3 summarizes the prescriptive PV sizing based on Climate Zone and home size.
2) **TDV-Zero**: Install a PV system sized to offset 100% of building energy use based on TDV energy, including appliances and plug loads. This is consistent with the requirements of the CALGreen Zero Net Energy Design tier.

In both these cases PV is evaluated in CBECC-Res according to the California Flexible Installation (CFI).

Table 3: Minimum PV System Size (kW_{DC}) required to meet Solar PV Ordinance by Climate Zone

Conditioned Space (ft2)	CZ1	CZ2	CZ3	CZ4	CZ5	CZ6	CZ7	CZ8	CZ9	CZ10	CZ11	CZ12	CZ13	CZ14	CZ15	CZ16
Less than 1000	1.6	1.4	1.5	1.3	1.4	1.5	1.3	1.5	1.4	1.4	1.7	1.5	1.8	1.3	2.1	1.3
1000 - 1499	2.0	1.7	1.7	1.5	1.6	1.7	1.5	1.8	1.7	1.7	2.2	1.9	2.3	1.6	2.8	1.6
1500 - 1999	2.4	2.0	2.1	1.8	1.9	2.0	1.8	2.1	2.0	2.0	2.7	2.3	2.8	2.0	3.5	1.9
2000 - 2499	2.8	2.3	2.4	2.1	2.1	2.3	2.0	2.4	2.3	2.3	3.2	2.7	3.4	2.3	4.2	2.3
2500 - 2999	3.2	2.6	2.7	2.4	2.4	2.6	2.3	2.7	2.6	2.7	3.7	3.1	3.9	2.7	4.9	2.6
3000 - 3499	3.6	2.9	3.0	2.6	2.7	2.9	2.5	3.0	2.9	3.0	4.2	3.4	4.4	3.0	5.6	3.0
3500 - 3999	3.9	3.2	3.2	2.9	2.9	3.2	2.7	3.3	3.2	3.3	4.7	3.8	4.9	3.4	6.3	3.3
4000 - 4499	4.3	3.5	3.5	3.2	3.1	3.4	2.9	3.6	3.5	3.6	5.1	4.2	5.4	3.7	7.0	3.6

2.5 Cost Effectiveness

A customer based approach to evaluating cost effectiveness was used based on past experience with Reach Code adoption by local governments. The current residential utility rates at the time of the analysis were used to calculate utility costs for all cases 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 4. Appendix C 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 all cases without PV systems. The applicable residential time-of-use (TOU) rate was applied to all cases with PV systems. [5] 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 NEM tariffs for that utility. The net surplus compensation rates for the different utilities are as follows:

- PG&E: $0.043 / kWh
- SCE: $0.0298 / kWh[6]
- SDG&E: $0.0321 / kWh[7]

Table 4: 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

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 indicates the savings over the life of the measure are equivalent to the incremental cost of that measure. A value greater than one represents a positive return on investment. The ratio is calculated as follows:

Lifecycle Customer Benefit-Cost Ratio =

*(Annual utility cost savings * Lifecycle cost factor) / (First incremental cost * Financing factor)*

The lifecycle cost factor is 19.6 and includes the following assumptions:

- 30-year measure life & utility cost savings
- 3% real discount rate
- No utility rate escalation (conservative assumption)

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[5] 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?).

[6] SCE net surplus compensation rate based on 1-year average September 2015 – August 2016.

[7] SDG&E net surplus compensation rate based on 1-year average August 2015 – July 2016.

The financing factor is 1.068 and includes the following assumptions:

- 30-year financing term
- 4.5% loan interest rate
- 3% real discount rate
- 20% average tax rate (to account for tax savings due to loan interest deductions)

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.

Simple payback = First incremental cost / Annual customer utility cost savings

2.6 Greenhouse Gas Emissions

Equivalent CO_2 emission savings were calculated using the following emission factors. Electricity factors are specific to California electricity production.

Table 5: Equivalent CO_2 Emissions Factors

		Source
Electricity	0.724 lb. CO_2-e / kWh	U.S. Environmental Protection agency's 2007 eGRID data.[8]
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.[9]

[8] https://www.epa.gov/energy/ghg-equivalencies-calculator-calculations-and-references

[9] https://www.epa.gov/energy/greenhouse-gas-equivalencies-calculator

3 Results

Cost effective analysis including evaluating three efficiency packages and two PV performance packages was completed for all sixteen climate zones. Evaluations looked to identify cost effective Tier 1 and Tier 2 packages for both single family and multifamily prototypes at the CALGreen performance targets of 15% and 30%. When initial proposed packages were found to not be cost effective, multiple iterations were conducted to identify a cost effective package. In certain climates it was not feasible, and targets were subsequently relaxed to something more appropriate. In other climates no cost effective package could be identified. In almost every climate there was no cost effective way to achieve Tier 2 efficiency levels without the PV compliance credit, therefore all Tier 2 packages include PV. Because the PVCC is not available in climate zones 6 and 7, no Tier 2 packages were developed for those climates.

Since the results from this analysis are intended to support mandatory energy efficiency requirements, the authors intentionally selected proven cost-effective measures with wide market acceptance in typical residential construction. Achieving greater performance is feasible using advanced design strategies and measures.

3.1 Single Family Results

3.1.1 Single Family Cost Effectiveness Analysis

A comparison of cost effectiveness for each climate zone and five cases is presented in Figure 1. Table 6 and Table 7 provide the results in tabular form along with energy and greenhouse gas (GHG) savings for each efficiency and PV performance tier. Cost effectiveness results are presented for all three efficiency packages described previously (Envelope, Equipment, and PV Credit) as well as for the two PV performance packages (PV-Plus and TDV-Zero). A summary of measures included in each package is listed in Appendix B.1. The lifecycle benefit-to-cost ratio threshold of one is roughly equivalent to a simple payback of 18 years. Shaded rows in the tables reflect those cases which are not cost effective. While using high efficiency equipment is shown to result in the highest return on investment in many climates, it was necessary to find cost effective packages that do not require specification of equipment with efficiencies better than federally mandated values to avoid federal preemption prohibitions.

Tier 1 Envelope packages were found to be cost effective in climate zones 1 through 5 and 9 through 16. The Tier 1 threshold in climate zone 4 was reduced to 10% to meet the cost effectiveness criteria without installing equipment more efficient than federally mandated. No cost effective Tier 1 efficiency packages were identified in climate zones 6 through 8.

Table 7 presents results for the two PV performance packages including the PV capacity necessary to offset the specified TDV energy. The PV system capacity for the PV-Plus packages is sized based upon the values in Table 3 to provide approximately 80% of estimated annual kWh consumption. The required TDV-Zero PV capacity (as required to generate a TDV=0 compliance simulation result) ranges from 3.1 kW DC in the mild climates (CZ5 and 7) to 7.7 kW DC in hot climates (CZ15). In all cases the measures in these packages reflect those in the Tier 2 package, with the exception of climate zones 6 & 7 where they are based on the Tier 1 envelope package.

The PV-Plus cases demonstrate cost effectiveness with a benefit-to-cost ratio ranging from 1.08 to 1.49. Adding PV beyond the amount needed to offset electricity use reduces cost effectiveness in all cases. The Zero-TDV cases are cost effective in only four climate zones and benefit-cost ratios are consistently lower in all climates. This is impacted by the fact that the compliance model is based upon a home with natural gas space and water heating, thus when sizing PV to offset total house TDV, PV electricity generation is offsetting natural gas consumption. The customer is paid for excess electricity generation beyond what is consumed by the dwelling but only at the wholesale rate which is substantially lower than the retail rate.

Greenhouse gas (GHG) savings range from 4.1% to 12.7% for the envelope and equipment Tier 1 packages. Including the PV compliance credit increases GHG reductions to 39% on average. GHG reductions for the two PV packages average 50% and 77% for the PV-Plus and TDV-ZERO cases, respectively.

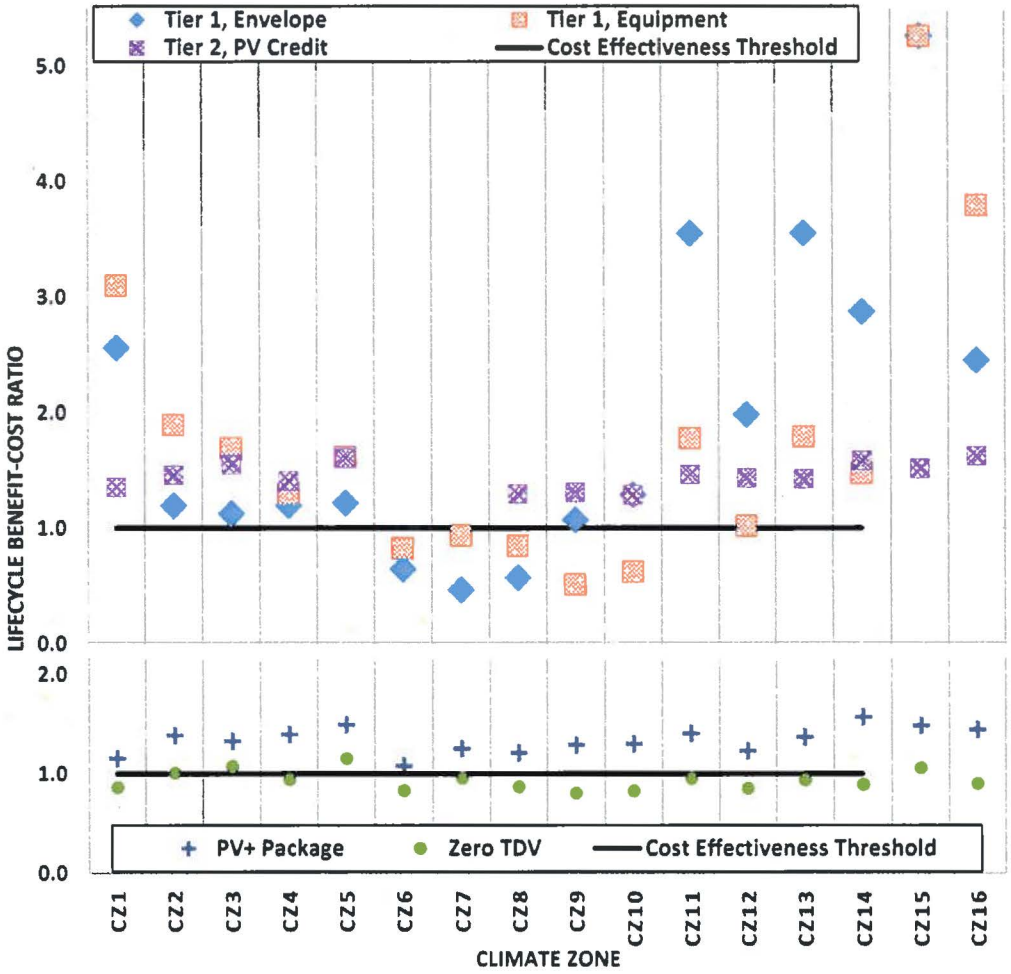

Figure 1: Single family cost effectiveness comparison

Table 6: Single Family Efficiency Package Cost Effectiveness Results[1]

Climate Zone	T-24 Comp. Margin	Elec Savings (kWh)	Gas Savings (therms)	% GHG Savings[2]	Package Cost[3]	Utility Cost Savings	Simple Payback	Lifecycle Benefit-Cost Ratio
Tier 1, Envelope Cases								
CZ1	16.1%	67	83.7	10.7%	$1,043	$146	7.2	2.56
CZ2	15.8%	146	49.1	8.2%	$1,617	$105	15.4	1.20
CZ3	15.5%	32	43.6	7.7%	$1,043	$64	16.3	1.13
CZ4	12.0%	114	18.8	4.1%	$808	$53	15.3	1.20
CZ5	15.2%	27	39.3	7.3%	$812	$54	15.1	1.22
CZ6	8.7%	20	17.1	3.6%	$571	$20	28.4	0.65
CZ7	7.0%	9	9.7	2.3%	$571	$15	39.3	0.47
CZ8	8.9%	37	10.2	2.6%	$571	$18	32.1	0.57
CZ9	17.2%	169	11.1	4.1%	$808	$47	17.2	1.07
CZ10	17.2%	213	12.9	4.7%	$808	$57	14.2	1.29
CZ11	16.9%	460	25.9	7.1%	$808	$156	5.2	3.55
CZ12	16.4%	222	24.2	5.4%	$808	$87	9.3	1.98
CZ13	17.4%	485	22.1	7.0%	$808	$157	5.2	3.56
CZ14	16.4%	441	24.4	6.9%	$808	$127	6.4	2.88
CZ15	15.2%	896	4.7	8.1%	$728	$209	3.5	5.26
CZ16	15.8%	296	80.4	9.8%	$1,456	$195	7.5	2.46
Tier 1, Equipment Cases								
CZ1	19.3%	47	101.7	12.7%	$999	$169	5.9	3.10
CZ2	16.8%	34	67.0	9.7%	$999	$103	9.7	1.89
CZ3	15.3%	23	45.4	8.0%	$681	$63	10.8	1.69
CZ4	17.0%	103	45.4	8.3%	$1,156	$82	14.2	1.30
CZ5	16.9%	22	46.0	8.4%	$681	$60	11.3	1.62
CZ6	15.5%	20	36.2	7.3%	$842	$38	22.2	0.83
CZ7	15.6%	9	25.7	5.8%	$681	$35	19.6	0.94
CZ8	17.4%	68	25.1	6.0%	$838	$39	21.6	0.85
CZ9	16.9%	159	12.2	4.2%	$1,650	$46	35.8	0.51
CZ10	16.6%	203	14.2	4.9%	$1,650	$56	29.4	0.62
CZ11	17.3%	473	26.0	7.2%	$1,650	$160	10.3	1.78
CZ12	16.0%	247	22.7	5.4%	$1,650	$92	18.0	1.02
CZ13	17.9%	507	21.5	7.1%	$1,650	$161	10.2	1.79
CZ14	17.1%	458	26.4	7.3%	$1,650	$133	12.4	1.48
CZ15	15.2%	896	4.7	8.1%	$728	$209	3.5	5.26
CZ16	17.6%	58	123.7	12.6%	$999	$207	4.8	3.80

Climate Zone	T-24 Comp. Margin	Elec Savings (kWh)	Gas Savings (therms)	% GHG Savings[2]	Package Cost[3]	Utility Cost Savings	Simple Payback	Lifecycle Benefit-Cost Ratio
Tier 2, Cases with PV Credit								
CZ1	32.2%	2,947	111.8	35.7%	$10,576	$781	13.5	1.36
CZ2	31.4%	3,227	132.7	46.9%	$10,158	$809	12.6	1.46
CZ3	21.8%	3,190	40.1	40.3%	$8,644	$731	11.8	1.55
CZ4	30.4%	3,353	21.8	36.6%	$8,801	$677	13.0	1.41
CZ5	22.0%	3,392	35.6	43.7%	$8,413	$737	11.4	1.61
CZ6	N/A - No PV Credit							
CZ7	N/A - No PV Credit							
CZ8	36.4%	3,290	10.2	44.0%	$8,721	$617	14.1	1.30
CZ9	35.0%	3,333	13.2	41.5%	$8,333	$595	14.0	1.31
CZ10	32.2%	3,517	15.4	42.3%	$8,721	$612	14.2	1.29
CZ11	31.2%	3,698	35.8	34.7%	$9,420	$752	12.5	1.47
CZ12	32.4%	3,386	27.9	33.8%	$8,721	$684	12.8	1.44
CZ13	31.3%	3,584	25.4	33.2%	$9,189	$715	12.9	1.43
CZ14	30.9%	4,366	26.4	39.4%	$9,265	$801	11.6	1.59
CZ15	32.2%	4,610	4.7	39.0%	$9,265	$767	12.1	1.52
CZ16	31.5%	3,881	80.4	31.8%	$9,606	$852	11.3	1.63

[1] Shaded rows reflect those cases which are not cost effective.

[2] Based on CA electricity production and equivalent CO_2 emission rates of 0.724 lbCO_2e / kWh & 11.7 lb-CO_2e / therm.

[3] Includes 10% markup for builder profit and overhead.

Table 7: Single Family PV Performance Package Cost Effectiveness Results[1]

Climate Zone	Compliance Margin	PV Capacity (kW)	Elec Savings (kWh)	Gas Savings (therms)	GHG % Savings[2]	Package Cost[3]	Utility Cost Savings	Simple Payback	Lifecycle Benefit-Cost Ratio
PV-Plus Package									
CZ1	32.2%	3.0	4,178	111.8	45.0%	$14,146	$889	15.9	1.15
CZ2	31.4%	2.5	3,798	132.7	51.9%	$11,575	$872	13.3	1.38
CZ3	21.8%	2.6	4,082	40.1	49.7%	$10,836	$784	13.8	1.33
CZ4	30.4%	2.3	3,619	21.8	39.2%	$9,441	$716	13.2	1.39
CZ5	22.0%	2.3	3,838	35.6	48.6%	$9,441	$768	12.3	1.49
CZ6	10.8%	2.5	3,912	17.1	48.9%	$10,294	$604	17.0	1.08
CZ7	10.6%	2.2	3,556	9.7	51.5%	$9,602	$655	14.7	1.25
CZ8	36.4%	2.6	4,026	10.2	53.4%	$10,525	$693	15.2	1.21
CZ9	35.0%	2.5	4,092	13.2	50.3%	$10,137	$713	14.2	1.29
CZ10	32.2%	2.5	4,202	15.4	50.0%	$10,351	$733	14.1	1.30
CZ11	31.2%	3.5	5,728	35.8	51.1%	$14,368	$1,097	13.1	1.40
CZ12	32.4%	2.9	4,673	27.9	45.2%	$11,903	$799	14.9	1.23
CZ13	31.3%	3.7	5,863	25.4	52.1%	$14,913	$1,111	13.4	1.37
CZ14	30.9%	2.5	4,941	26.4	44.1%	$10,507	$900	11.7	1.57
CZ15	32.2%	4.6	8,600	4.7	72.2%	$18,521	$1,497	12.4	1.48
CZ16	31.5%	2.5	4,501	80.4	35.6%	$11,022	$866	12.7	1.44
Zero-TDV Package									
CZ1	32.2%	4.8	6,560	111.8	62.9%	$21,054	$987	21.3	0.86
CZ2	31.4%	4.0	6,200	132.7	72.9%	$17,532	$960	18.3	1.01
CZ3	21.8%	3.5	5,557	40.1	65.2%	$14,465	$845	17.1	1.07
CZ4	30.4%	3.9	6,252	21.8	65.3%	$15,786	$808	19.5	0.94
CZ5	22.0%	3.2	5,411	35.6	65.9%	$13,070	$821	15.9	1.15
CZ6	10.8%	3.5	5,530	17.1	68.3%	$14,271	$644	22.2	0.83
CZ7	10.6%	3.1	5,083	9.7	72.4%	$13,221	$686	19.3	0.95
CZ8	36.4%	3.7	5,821	10.2	76.3%	$14,930	$705	21.2	0.87
CZ9	35.0%	4.3	7,090	13.2	85.4%	$17,258	$756	22.8	0.80
CZ10	32.2%	4.3	7,103	15.4	82.5%	$17,258	$776	22.2	0.83
CZ11	31.2%	6.1	9,908	35.8	85.0%	$24,555	$1,269	19.3	0.95
CZ12	32.4%	5.1	8,094	27.9	75.4%	$20,363	$944	21.6	0.85
CZ13	31.3%	6.4	10,075	25.4	87.1%	$25,488	$1,299	19.6	0.94
CZ14	30.9%	5.5	10,295	26.4	88.0%	$22,072	$1,068	20.7	0.89
CZ15	32.2%	7.7	13,811	4.7	115.5%	$30,610	$1,762	17.4	1.06
CZ16	31.5%	5.2	9,147	80.4	64.2%	$21,636	$1,061	20.4	0.90

[1] Shaded rows reflect those cases which are not cost effective.
[2] Based on CA electricity production and equivalent CO_2 emission rates of 0.724 lbCO_2e / kWh & 11.7 lb-CO_2e / therm.
[3] Includes 10% markup for builder profit and overhead.

3.1.2 Single Family Package Recommendations

Based on the single family cost effective analysis, two reach code packages were developed, an efficiency package and a PV package as described below. Table 8 and Table 9 summarize the measures used to cost effectively meet the performance targets for each package.

Tier 1 Efficiency only: Where cost effective packages were identified, the 15% compliance margin target, consistent with CALGreen Tier 1 were used. As stated earlier, a cost effective 15% package was not identified for climate zone 4, so a 10% compliance margin target was used. No cost effective efficiency only packages were identified for climate zones 6 through 8.

Table 8: Single Family Efficiency Only: Cost Effective Measures Summary

Climate Zone	Compliance Margin Target	QII	ACH50	Window U-value / SHGC	Door U-value	AH Fan W/cfm	HW Pipe Insul.
CZ1	15%	Y		.30/.50	0.20		Y
CZ2	15%	Y	3	.30/.23	0.20	0.30	Y
CZ3	15%	Y		.30/.50	0.20		Y
CZ4	10%	Y		.30/.23		0.30	
CZ5	15%	Y		.30/.50			Y
CZ6	No package						
CZ7	No package						
CZ8	No package						
CZ9	15%	Y		.30/.23		0.30	
CZ10	15%	Y		.30/.23		0.30	
CZ11	15%	Y		.30/.23		0.30	
CZ12	15%	Y		.30/.23		0.30	
CZ13	15%	Y		.30/.23		0.30	
CZ14	15%	Y		.30/.23		0.30	
CZ15	15%	Y				0.30	
CZ16	15%	Y	3	.30/.23	0.20	0.3	

PV-Plus: Cost effective packages with efficiency and PV were identified in all 16 climate zones, but the compliance margin targets were lowered to 20% for climates 3 and 5, and to 10% for 6 and 7. Table 9 summarizes the measures used in each climate zone to cost effectively meet the targets. It is assumed that the PV compliance credit can be used to meet all these targets, except in climate zones 6 and 7. It is also assumed that a PV system is installed per the methodology described in Table 3 and consistent with the CEC Solar PV Ordinance.

Table 9: Single Family PV-Plus: Cost Effective Measures Summary

Climate Zone	Compliance Margin Target	QII	ACH50	Window U-value / SHGC	Door U-value	HPA	AH Fan W/cfm	HW Pipe Insul.	PV Capacity (kW)
CZ1	30%	Y	3	.30/.50	0.20	Y		Y	3.0
CZ2	30%	Y		.30/.50	0.20	Y		Y	2.5
CZ3	20%	Y		.30/.50	0.20				2.6
CZ4	30%	Y		.30/.23					2.3
CZ5	20%	Y		.30/.50					2.3
CZ6	10%	Y					0.30		2.5
CZ7	10%	Y		.30/.23	0.20		0.30	Y	2.2
CZ8	30%	Y							2.6
CZ9	30%	Y							2.5
CZ10	30%	Y							2.5
CZ11	30%	Y		.30/.23	0.20				3.5
CZ12	30%	Y							2.9
CZ13	30%	Y		.30/.23					3.7
CZ14	30%	Y					0.30		2.5
CZ15	30%	Y					0.30		4.6
CZ16	30%	Y	3	.30/.23	0.20		0.30		2.5

3.2 Multifamily Results

It is generally more challenging to achieve equivalent savings targets for the multifamily cases than for the single family cases. With less exterior surface area per floor area the impact of envelope measures is diminished in multifamily buildings. The PV credit is also much smaller because it is offsetting only high performance walls; high performance attic is not applied to the multifamily prescriptive design because ducts are already assumed to be within conditioned space. Shaded rows in the tables below indicate cases that don't meet the 15% target for Tier 1 or don't have feasible Tier 2 packages.

3.2.1 Multifamily Cost Effectiveness Analysis

A comparison of cost effectiveness for the multi-family 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 the efficiency and PV performance tiers, respectively. *All multifamily results are presented on a per dwelling unit basis.* Cost effectiveness results are presented for all of the three efficiency packages described previously (envelope, equipment, and PV compliance credit) as well as for the two PV performance packages (PV-Plus and TDV-Zero). A summary of measures included in each package is listed in Appendix B.2. The lifecycle benefit-to-cost ratio threshold of one is roughly equivalent to a simple payback of 18 years. Shaded rows in the tables reflect those cases which aren't cost effective. While using high efficiency equipment is shown to result in an improved return on investment in many climates, it was necessary to find cost effective packages that do not require specification of equipment with efficiencies better than federally mandated values. It can be noted that since rental rates are determined primarily by location, tenants may not experience increased rents due to the cost of efficiency measures. If this is the case, the tenants have no costs and only the benefit of lower energy utility costs.

Tier 1, Envelope packages were found to be cost effective in climate zones 1, and 10 through 16, although the threshold for climate zone 10 was lowered to 10% to meet the cost effectiveness criteria. QII alone was found to be cost effective in climate zone 2 but a cost effective 10% package requires using the PV

compliance credit. No cost effective Tier 1, Envelope efficiency packages were identified in climate zones 3 through 9 without the addition of high efficiency equipment or PV.

Table 11 summarizes the cost effectiveness of the PV performance packages. PV capacity required to meet the required TDV energy offset for each case is also included. The PV capacity for the PV-Plus packages are sized the same as for the single family analysis and based upon the values in Table 3. The required TDV-Zero PV capacity per apartment ranges from 1.9 kW DC in the mild climates to 3.7 kW DC in hot climates (CZ15). For the multifamily prototype 8-unit apartment building, this is equivalent to 15.2 to 29.6 kW for the building. In all cases the measures in these packages reflect those in the Tier 2 package, with the exception of climate zones 6 & 7 where they are based on the Tier 1 envelope package.

The PV-Plus cases demonstrate cost effectiveness with a benefit-to-cost ratio ranging from 1.01 to 1. 66. Similar to the single family analysis, while PV is cost effective in offsetting electricity use, adding PV to meet a zero TDV design reduces cost effectiveness in all cases with only two climates having a value greater than 1.

Greenhouse gas (GHG) savings range from 2.2% to 8.6% for the envelope and equipment Tier 1 packages. Including the PV compliance credit increases GHG reductions to 34% on average. GHG reductions for the two PV packages average 49% and 78% for the PV-Plus and ZN-TDV cases, respectively.

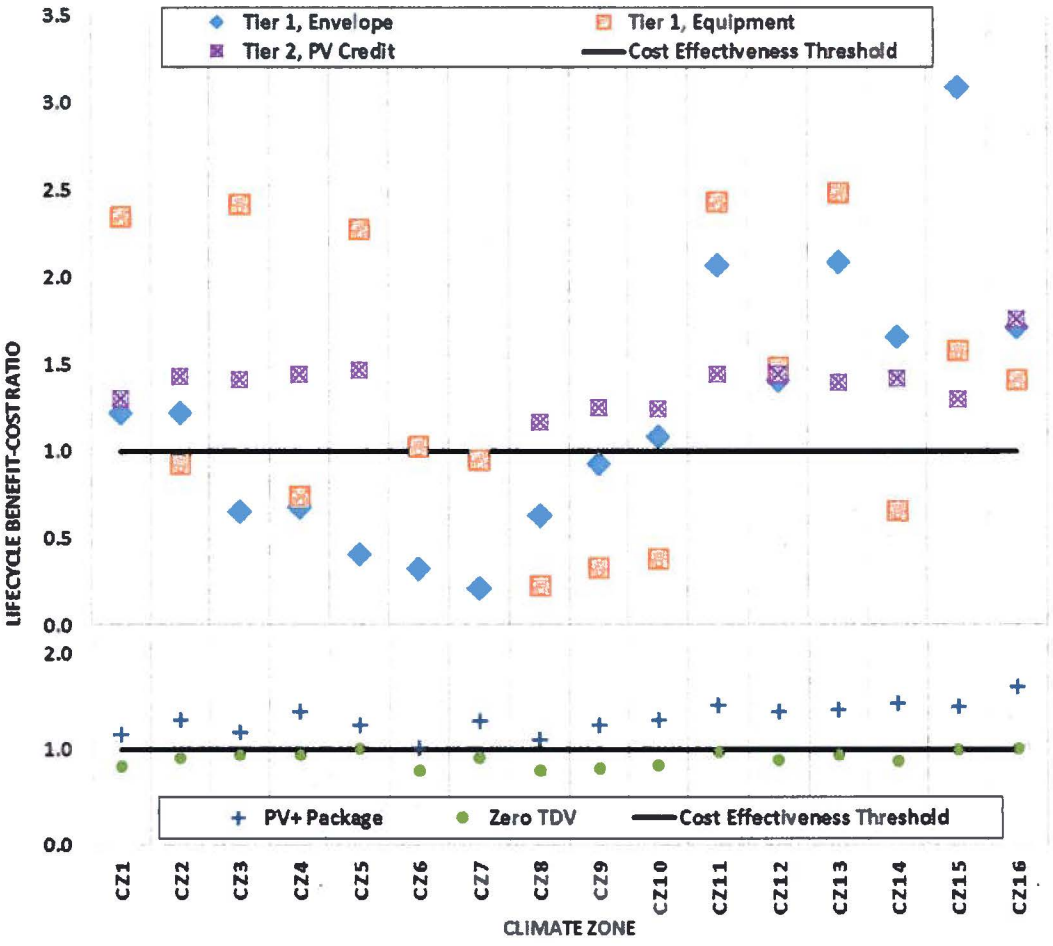

Figure 2: Multifamily cost effectiveness comparison

Table 10: Multifamily Efficiency Cost Effectiveness Results[1]

Climate Zone	T-24 Comp. Margin	Elec Savings (kWh)	Gas Savings (therms)	% GHG Savings[2]	Package Cost[3]	Utility Cost Savings	Simple Payback	Lifecycle Benefit-Cost Ratio
Tier 1, Envelope Cases								
CZ1	16.5%	31	28.0	8.0%	$559	$37	15.0	1.22
CZ2	4.8%	7	7.3	2.2%	$146	$10	15.0	1.22
CZ3	10.9%	-3	14.3	4.5%	$444	$16	28.1	0.65
CZ4	10.9%	45	4.6	2.3%	$364	$14	26.9	0.68
CZ5	10.2%	-4	13.3	4.2%	$641	$14	45.1	0.41
CZ6	11.7%	19	7.7	3.0%	$559	$10	55.7	0.33
CZ7	10.2%	10	4.3	1.7%	$641	$7	87.3	0.21
CZ8	10.5%	55	1.2	1.5%	$282	$10	29.0	0.63
CZ9	12.3%	79	2.0	2.2%	$282	$14	19.7	0.93
CZ10	10.1%	92	2.5	2.6%	$282	$17	16.9	1.08
CZ11	17.7%	186	13.2	6.5%	$436	$49	8.9	2.07
CZ12	17.1%	103	12.6	5.4%	$436	$33	13.1	1.41
CZ13	18.1%	200	11.3	6.3%	$436	$50	8.8	2.09
CZ14	17.8%	176	12.9	6.3%	$436	$39	11.1	1.66
CZ15	17.7%	426	0.6	6.8%	$436	$73	5.9	3.09
CZ16	16.3%	91	29.9	8.0%	$559	$52	10.7	1.71
Tier 1, Equipment Cases								
CZ1	16.7%	8	31.7	8.6%	$290	$37	7.8	2.35
CZ2	15.0%	7	27.3	8.0%	$642	$32	19.8	0.93
CZ3	12.4%	1	16.9	5.4%	$146	$19	7.6	2.42
CZ4	16.3%	11	25.5	8.0%	$765	$31	24.8	0.74
CZ5	11.8%	-3	16.6	5.3%	$146	$18	8.1	2.28
CZ6	12.1%	1	16.4	5.6%	$269	$15	17.8	1.03
CZ7	12.5%	-1	15.9	5.5%	$379	$20	19.3	0.95
CZ8	15.2%	83	1.2	2.1%	$1,133	$14	80.4	0.23
CZ9	15.7%	106	2.0	2.8%	$1,029	$19	55.4	0.33
CZ10	15.5%	124	2.5	3.2%	$1,029	$22	47.2	0.39
CZ11	16.5%	202	6.3	5.0%	$333	$44	7.5	2.43
CZ12	15.0%	109	6.1	3.6%	$333	$27	12.4	1.48
CZ13	15.4%	199	5.1	4.6%	$311	$42	7.4	2.48
CZ14	16.5%	201	6.1	4.9%	$1,029	$37	27.7	0.66
CZ15	20.4%	515	0.4	8.2%	$1,029	$89	11.6	1.58
CZ16	15.7%	86	29.8	7.9%	$668	$51	13.0	1.41

Climate Zone	T-24 Comp. Margin	Elec Savings (kWh)	Gas Savings (therms)	% GHG Savings[2]	Package Cost[3]	Utility Cost Savings	Simple Payback	Lifecycle Benefit-Cost Ratio
Tier 2, Cases with PV Credit								
CZ1	21.0%	1,370	28.0	30.2%	$4,085	$291	14.1	1.31
CZ2	20.4%	1,608	17.2	33.7%	$4,085	$318	12.8	1.43
CZ3	15.3%	1,585	14.1	35.7%	$4,085	$315	13.0	1.41
CZ4	26.9%	1,654	13.6	35.6%	$4,085	$321	12.7	1.44
CZ5	12.4%	1,677	13.3	37.7%	$4,085	$326	12.5	1.46
CZ6	N/A - No PV credit							
CZ7	N/A - No PV credit							
CZ8	21.0%	1,622	5.7	35.3%	$4,085	$260	15.7	1.17
CZ9	26.8%	1,719	4.0	35.4%	$3,963	$270	14.7	1.25
CZ10	26.2%	1,734	4.9	35.2%	$3,963	$269	14.7	1.25
CZ11	26.5%	1,778	13.2	32.6%	$3,963	$311	12.7	1.44
CZ12	26.5%	1,673	12.6	32.8%	$3,963	$312	12.7	1.44
CZ13	27.3%	1,746	11.3	31.8%	$3,963	$301	13.2	1.39
CZ14	26.0%	1,973	12.9	36.0%	$3,963	$307	12.9	1.42
CZ15	25.4%	2,100	0.6	33.0%	$3,963	$281	14.1	1.30
CZ16	25.7%	1,734	42.4	33.8%	$3,848	$369	10.4	1.76

[1] Shaded rows reflect those cases which are not cost effective.

[2] Based on CA electricity production and equivalent CO_2 emission rates of 0.724 lbCO_2e / kWh & 11.7 lb-CO_2e / therm.

[3] Includes 10% markup for builder profit and overhead.

Table 11: Multifamily PV Performance Cost Effectiveness Results[1]

Climate Zone	Compliance Margin	PV Capacity (kW)	Elec Savings (kWh)	Gas Savings (therms)	GHG % Savings[2]	Package Cost[3]	Utility Cost Savings	Simple Payback	Lifecycle Benefit-Cost Ratio
PV-Plus Package									
CZ1	21.0%	1.6	2,172	28.0	43.5%	$6,201	$393	15.8	1.16
CZ2	20.4%	1.4	2,234	17.2	44.9%	$5,496	$393	14.0	1.31
CZ3	15.3%	1.5	2,374	14.1	51.2%	$5,849	$377	15.5	1.18
CZ4	26.9%	1.3	2,137	13.6	44.8%	$5,143	$391	13.1	1.40
CZ5	12.4%	1.4	2,350	13.3	51.1%	$5,496	$375	14.7	1.25
CZ6	11.7%	1.5	2,388	7.7	52.5%	$5,849	$322	18.1	1.01
CZ7	10.2%	1.3	2,139	4.3	48.0%	$5,226	$369	14.2	1.30
CZ8	21.0%	1.5	2,413	5.7	51.6%	$5,849	$350	16.7	1.10
CZ9	26.8%	1.4	2,372	4.0	48.4%	$5,373	$369	14.6	1.26
CZ10	26.2%	1.4	2,386	4.9	47.9%	$5,373	$383	14.0	1.31
CZ11	26.5%	1.7	2,893	13.2	50.8%	$6,431	$514	12.5	1.47
CZ12	26.5%	1.5	2,457	12.6	46.5%	$5,726	$437	13.1	1.40
CZ13	27.3%	1.8	2,982	11.3	52.2%	$6,784	$525	12.9	1.42
CZ14	26.0%	1.3	2,512	12.9	44.9%	$5,021	$406	12.4	1.49
CZ15	25.4%	2.1	3,940	0.6	61.8%	$7,842	$618	12.7	1.45
CZ16	25.7%	1.3	2,244	42.4	40.9%	$4,906	$444	11.1	1.66
Zero-TDV Package									
CZ1	21.0%	2.5	3,415	28.0	64.2%	$9,476	$424	22.3	0.82
CZ2	20.4%	2.3	3,674	17.2	70.7%	$8,741	$433	20.2	0.91
CZ3	15.3%	2.0	3,233	14.1	68.1%	$7,767	$400	19.4	0.94
CZ4	26.9%	2.2	3,587	13.6	72.4%	$8,320	$429	19.4	0.95
CZ5	12.4%	1.9	3,189	13.3	67.8%	$7,254	$399	18.2	1.01
CZ6	11.7%	2.1	3,356	8.0	72.7%	$8,011	$341	23.5	0.78
CZ7	10.2%	2.1	3,383	4.0	75.0%	$7,903	$394	20.0	0.92
CZ8	21.0%	2.4	3,768	5.7	79.6%	$8,869	$379	23.4	0.78
CZ9	26.8%	2.5	4,124	4.0	83.1%	$9,154	$403	22.7	0.81
CZ10	26.2%	2.5	4,115	4.9	81.5%	$9,115	$415	22.0	0.84
CZ11	26.5%	3.0	4,979	13.2	84.9%	$11,052	$586	18.9	0.97
CZ12	26.5%	2.8	4,509	12.6	82.3%	$10,336	$503	20.6	0.89
CZ13	27.3%	3.2	5,129	11.3	87.6%	$11,681	$603	19.4	0.95
CZ14	26.0%	2.7	5,056	12.9	86.8%	$10,014	$482	20.8	0.88
CZ15	25.4%	3.7	6,571	0.6	102.9%	$13,389	$726	18.4	0.99
CZ16	25.7%	2.6	4,398	42.4	71.0%	$9,379	$514	18.2	1.01

[1] Shaded rows reflect those cases which are not cost effective.
[2] Based on CA electricity production and equivalent CO_2 emission rates of 0.724 lbCO_2e / kWh & 11.7 lb-CO_2e / therm.
[3] Includes 10% markup for builder profit and overhead.

3.2.2 Multifamily Package Recommendations

Based on the multifamily cost effective analysis, two reach code packages were developed, similar to the single family packages. Table 12 and Table 13 summarize the measures used to cost effectively meet the performance targets for each multifamily package.

Tier 1 Efficiency only: Where cost effective packages were identified, the 15% compliance margin target, consistent with CALGreen Tier 1 were used. As stated earlier, a cost effective 15% package was not identified for climate zone 10, so a 10% compliance margin target was used, and only QII was cost effective in climate zone 2. Additionally, no cost effective efficiency only packages were identified for climate zones 3 through 9.

Table 12: Multifamily Efficiency Only: Cost Effective Measures Summary

Climate Zone	Compliance Margin Target	QII	Window U-value / SHGC	Door U-value	AH Fan W/cfm	Refrigerant Charge	HW Comp. Dist.
CZ1	15%	Y	0.30/0.50	0.20	0.3		Y
CZ2	QII Only	Y					
CZ3	No package						
CZ4	No package						
CZ5	No package						
CZ6	No package						
CZ7	No package						
CZ8	No package						
CZ9	No package						
CZ10	10%	Y	0.30/0.23		0.3		
CZ11	15%	Y	0.30/0.23	0.20	0.3		
CZ12	15%	Y	0.30/0.23	0.20	0.3		
CZ13	15%	Y	0.30/0.23	0.20	0.3		
CZ14	15%	Y	0.30/0.23	0.20	0.3		
CZ15	15%	Y	0.30/0.23	0.20	0.3		
CZ16	15%	Y	0.30/0.23	0.20	0.3		Y

PV-Plus: Cost effective packages with efficiency and PV were identified in all 16 climate zones, but the compliance margin targets in all climates were lowered below 30% in all cases to be cost effective. Table 13 summarizes the compliance margin targets in each climate zone and the measures used to cost effectively meet the targets. As with the single family packages, with the exception of climate zones 6 and 7, it is assumed that the PV compliance credit can be used to meet these targets. It is also assumed that a PV system is installed per the methodology developed for the proposed Solar PV ordinance (Table 3).

Table 13: Multifamily PV-Plus: Cost Effective Measures Summary

Climate Zone	Compliance Margin Target	QII	Window U-value / SHGC	Door U-value	AH Fan W/cfm	HW Comp. Dist.	PV Capacity (kW)
CZ1	20%	Y	0.30/0.50	0.20	0.3	Y	1.6
CZ2	20%	Y	0.30/0.23	0.20	0.3	Y	1.4
CZ3	15%	Y	0.30/0.50	0.20	0.3	Y	1.5
CZ4	25%	Y	0.30/0.23	0.20	0.3	Y	1.3
CZ5	10%	Y	0.30/0.50	0.20	0.3	Y	1.4
CZ6	10%	Y	0.30/0.23	0.20			1.5
CZ7	10%	Y	0.30/0.23	0.20			1.3
CZ8	20%	Y	0.30/0.23	0.20	0.3	Y	1.5
CZ9	25%	Y	0.30/0.23	0.20	0.3		1.4
CZ10	25%	Y	0.30/0.23	0.20	0.3		1.4
CZ11	25%	Y	0.30/0.23	0.20	0.3		1.7
CZ12	25%	Y	0.30/0.23	0.20	0.3		1.5
CZ13	25%	Y	0.30/0.23	0.20	0.3		1.8
CZ14	25%	Y	0.30/0.23	0.20	0.3		1.3
CZ15	25%	Y	0.30/0.23	0.20	0.3		2.1
CZ16	25%	Y	0.30/0.23	0.20			1.3

4 Conclusions & Summary

This report evaluated the feasibility and cost effectiveness of "above code" ordinance performance tiers through the application of both efficiency measures and PV in all 16 California climates zones. 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.

The following describes the recommended performance levels for the above-code ordinance packages. The original intent was to develop packages that align with the tiers as defined in the 2016 CALGreen code. Based on the analysis results, performance thresholds were reduced in some climates and eliminated altogether in other climates. Identifying cost effective efficiency (only) packages was particularly challenging in multifamily buildings. Table 14 and Table 15 summarize recommended cost effective ordinance criteria by climate zone for single family and multifamily buildings, respectively. Where cost effective packages exist, there is both a Tier 1 efficiency only package and the efficiency with PV (PV-Plus) package. The tables include the Title 24 compliance target needed to meet the criteria for each package. Tier 1 compliance targets are compliance margins for efficiency measures only and are designed to be met without using the PV Compliance Credit. The PV-Plus compliance targets are for projects that include PV. The efficiency targets are set higher, but assume that the PV compliance credit (PVCC) is used to meet the performance targets. The efficiency targets are set lower for climate zones 6 and 7 because projects built in these climate zones are not eligible to take the PVCC.

Following is a summary of the differences between the two packages defined in this analysis and the tiers defined in CALGreen.

Tier 1 Packages: CALGreen defines Tier 1 as showing a 15% or greater Title 24 compliance margin compared to the Standard Design. The intent of the Efficiency tier in this study was to find cost effective packages of measures that meet the CALGreen Tier 1 criteria without mandating the installation of PV or high efficiency equipment that exceed federal minimum levels. To encourage adoption of efficiency measures in preparation for the 2019 Title-24 code, the authors recommend that PV not be allowed as a means to meet the Tier 1 compliance requirements. Based on the lifecycle benefit-to-cost ratio metric applied in this analysis, cost effectiveness results for the single family and low-rise multifamily homes show that there exist multiple cost effective packages to meet Tier 1. There are several climates where the compliance margin targets are lowered to maintain the cost effectiveness criteria and other climates where no cost effective efficiency packages were identified.

PV-Plus Packages: CALGreen defines both Tier 2 and ZNE Tier performance levels. The ZNE Tier requires that the building meet the required efficiency targets as defined in Section A4.203.1.2.3 of 2016 CALGreen and size a PV system to offset 100% of the TDV energy of the building (achieve an Energy Design Rating of 0). The results of this work, based on dwellings with gas and electricity, found that sizing the PV system to meet the ZNE Tier criteria was generally not cost effective or in some limited cases, marginally cost effective. Instead a PV and efficiency package (PV-Plus) was developed that limited the size of the PV system to no larger than the annual estimated electricity use of the building and combine it with efficiency measures that are cost effective in all climate zones. Lifecycle benefit-to-cost ratio for the PV-Plus cases for both the single family and multifamily prototypes are all above one. In cases where PV capacity in the PV-Plus package is less than the minimum to meet the PV compliance credit, it's recommended that jurisdictions allow the smaller PV capacity be installed and still qualify for the PVCC to avoid sizing the PV systems larger than the estimated electricity use.

Table 14: Single Family Reach Code Package Recommendations

Packages	Climate Zones	T-24 Compliance Target	PVCC Allowed	PV
Tier 1 Efficiency Only Package	1-3, 5, 9-16	15%	No	n/a
	4	10%	No	n/a
PV-Plus Package	1,2,4, 8-16	30%	Yes	Yes
	3,5	20%	Yes	Yes
	6-7	10%	n/a	Yes

Table 15: Multifamily Reach Code Package Recommendations

Packages	Climate Zones	T-24 Compliance Target	PVCC Allowed	PV
Tier 1 Efficiency Only Package	1, 11-16	15%	No	n/a
	10	10%	No	n/a
	2	QII	No	n/a
PV-Plus Package	4, 9-16	25%	Yes	Yes
	1-2, 8	20%	Yes	Yes
	3	15%	Yes	Yes
	5	10%	Yes	Yes
	6-7	10%	n/a	Yes

Consistent with CALGreen, a pre-requisite for all packages includes HERS verification of Quality Insulation Installation (QII).

The recommended packages do not include a TDV-Zero option because these packages were generally not found to be cost effective. Lifecycle benefit-to-cost ratios for the single family TDV-Zero packages are 0.78 to 1.07. Limited cost effectiveness is largely a result of oversizing the PV systems relative to the house electricity load. With mixed fuel homes, PV electricity generation offsets natural gas consumption when sizing relative to zero TDV. 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. Consideration of dwellings without gas was not in the scope of this study.

In conclusion, this report has identified cost effective options to meet above-code performance levels for dwellings using natural gas and electricity which can be adopted by cities and counties within investor-owned utility territories across California. Including PV to the level of offsetting electricity loads was found to be cost effective in all sixteen climate zones evaluated as summarized above.

5 References

CEC. 2016a. 2016 Alternative Calculation Method Approval Manual. CEC-400-2015-039-CMF. June 2015. California Energy Commission. http://www.energy.ca.gov/2015publications/CEC-400-2015-039/CEC-400-2015-039-CMF.pdf

CEC. 2016b. 2016 Building Energy Efficiency Standards for Residential and Nonresidential Buildings. CEC-400-2015-037-CMF. June 2015. California Energy Commission. http://www.energy.ca.gov/2015publications/CEC-400-2015-037/CEC-400-2015-037-CMF.pdf

CEC. 2016c. 2016 Reference Appendices. CEC-400-2015-038-CMF. June 2015. California Energy Commission. http://www.energy.ca.gov/2015publications/CEC-400-2015-038/CEC-400-2015-038-CMF.pdf

CEC. 2016d. 2016 Residential Alternative Calculation Method Reference Manual. CEC-400-2015-024-CMF-REV. June 2017. California Energy Commission. http://www.energy.ca.gov/2015publications/CEC-400-2015-024/CEC-400-2015-024-CMF-REV.pdf

Horii, B., E. Cutter, N. Kapur, J. Arent, and D. Conotyannis. 2014. "Time Dependent Valuation of Energy for Developing Building Energy Efficiency Standards." http://www.energy.ca.gov/title24/2016standards/prerulemaking/documents/2014-07-09_workshop/2017_TDV_Documents/

Appendix A – Prescriptive Package

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

TABLE 150.1-A COMPONENT PACKAGE-A STANDARD BUILDING DESIGN

						C													
						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	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	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	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 38	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	U0.269 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	Fenestration	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%

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:[10]

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-ft^2. "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-ft^2. "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.

[10] Single family buildings are modeled with Option B and multifamily buildings are modeled with Option C.

Appendix B.1 – Single Family Package Summaries

Table 16: Single Family Tier Packages

Climate Zone	QII	ACH50	Window U-value / SHGC	Door U-value	HPA	Furnace AFUE	AC SEER/EER	AH Fan W/cfm	DHW EF	HW Pipe Insul.	PV Credit Size (kW)	T-24 Comp. Margin
Tier 1, Envelope Cases												
CZ1	Y		.30/.50	0.20						Y		16.1%
CZ2	Y	3	.30/.23	0.20				0.30		Y		15.8%
CZ3	Y		.30/.50	0.20						Y		15.5%
CZ4	Y		.30/.23					0.30				12.0%
CZ5	Y		.30/.50							Y		15.2%
CZ6	Y											8.7%
CZ7	Y											7.0%
CZ8	Y											8.9%
CZ9	Y		.30/.23					0.30				17.2%
CZ10	Y		.30/.23					0.30				17.2%
CZ11	Y		.30/.23					0.30				16.9%
CZ12	Y		.30/.23					0.30				16.4%
CZ13	Y		.30/.23					0.30				17.4%
CZ14	Y		.30/.23					0.30				16.4%
CZ15	Y							0.30				15.2%
CZ16	Y	3	.30/.23	0.20				0.30				15.8%
Tier 1, Equipment Cases												
CZ1	Y					0.92						19.3%
CZ2	Y					0.92						16.8%
CZ3	Y								0.94			15.3%
CZ4	Y					0.92		0.30				17.0%
CZ5	Y								0.94			16.9%
CZ6	Y								0.94	Y		15.5%
CZ7	Y								0.94			15.6%
CZ8	Y							0.30	0.94			17.4%
CZ9	Y						15/12.5	0.30				16.9%
CZ10	Y						15/12.5	0.30				16.6%
CZ11	Y						15/12.5	0.30				17.3%
CZ12	Y						15/12.5	0.30				16.0%
CZ13	Y						15/12.5	0.30				17.9%
CZ14	Y						15/12.5	0.30				17.1%
CZ15	Y							0.30				15.2%
CZ16	Y					0.92						17.6%

Climate Zone	QII	ACH50	Window U-value / SHGC	Door U-value	HPA	Furnace AFUE	AC SEER/EER	AH Fan W/cfm	DHW EF	HW Pipe Insul.	PV Credit Size (kW)	T-24 Comp. Margin
Tier 2, Cases with PV Credit												
CZ1	Y	3	.30/.50	0.20	Y					Y	2.1	32.2%
CZ2	Y		.30/.50	0.20	Y					Y	2.1	31.4%
CZ3	Y		.30/.50	0.20							2.0	21.8%
CZ4	Y		.30/.23								2.1	30.4%
CZ5	Y		.30/.50								2.0	22.0%
CZ6	N/A – No PV Credit											
CZ7	N/A – No PV Credit											
CZ8	Y										2.1	36.4%
CZ9	Y										2.0	35.0%
CZ10	Y										2.1	32.2%
CZ11	Y		.30/.23	0.20							2.2	31.2%
CZ12	Y										2.1	32.4%
CZ13	Y		.30/.23								2.2	31.3%
CZ14	Y							0.30			2.2	30.9%
CZ15	Y							0.30			2.2	32.2%
CZ16	Y	3	.30/.23	0.20				0.30			2.1	31.5%

Appendix B.2 – Multifamily Package Summaries

Table 17: Multifamily Tier 1 Packages

Climate Zone	QII	Window U-value / SHGC	Door U-value	Furnace AFUE	AC SEER/EER	AH Fan W/cfm	Refrigerant Charge	DHW EF	HW Comp. Dist.	PV Credit Size (kW)	T-24 Comp. Margin
Tier 1, Envelope Cases											
CZ1	Y	0.30/0.50	0.20			0.3			Y		16.5%
CZ2	Y										4.8%
CZ3	Y	0.30/0.50	0.20						Y		10.9%
CZ4	Y	0.30/0.23				0.3	Y				10.9%
CZ5	Y	0.30/0.50	0.20			0.3	Y		Y		10.2%
CZ6	Y	0.30/0.23	0.20			0.3			Y		11.7%
CZ7	Y	0.30/0.23	0.20			0.3	Y		Y		10.2%
CZ8	Y	0.30/0.23				0.3					10.5%
CZ9	Y	0.30/0.23				0.3					12.3%
CZ10	Y	0.30/0.23				0.3					10.1%
CZ11	Y	0.30/0.23	0.20			0.3					17.7%
CZ12	Y	0.30/0.23	0.20			0.3					17.1%
CZ13	Y	0.30/0.23	0.20			0.3					18.1%
CZ14	Y	0.30/0.23	0.20			0.3					17.8%
CZ15	Y	0.30/0.23	0.20			0.3					17.7%
CZ16	Y	0.30/0.23	0.20			0.3			Y		16.3%
Tier 1, Equipment Cases											
CZ1	Y	0.30/0.50						94	Y		16.7%
CZ2	Y			92				96			15.0%
CZ3	Y							94			12.4%
CZ4	Y			92				96	Y		16.3%
CZ5	Y							94			11.8%
CZ6	Y							94	Y		12.1%
CZ7	Y							96	Y		12.5%
CZ8	Y	0.30/0.23			16/13	0.3	Y				15.2%
CZ9	Y				16/13	0.3					15.7%
CZ10	Y				16/13	0.3					15.5%
CZ11	Y	0.30/0.23			15/12.5	0.3					16.5%
CZ12	Y	0.30/0.23			15/12.5	0.3					15.0%
CZ13	Y				15/12.5	0.3					15.4%
CZ14	Y				16/13	0.3					16.5%
CZ15	Y				16/13	0.3					20.4%
CZ16	Y	0.30/0.23		92		0.3					15.7%

Climate Zone	QII	Window U-value / SHGC	Door U-value	Furnace AFUE	AC SEER/EER	AH Fan W/cfm	Refrigerant Charge	DHW EF	HW Comp. Dist.	PV Credit Size (kW)	T-24 Comp. Margin
Tier 2, Cases with PV Credit											
CZ1	Y	0.30/0.50	0.20			0.3			Y	1.0	21.0%
CZ2	Y	0.30/0.23	0.20			0.3			Y	1.0	20.4%
CZ3	Y	0.30/0.50	0.20			0.3			Y	1.0	15.3%
CZ4	Y	0.30/0.23	0.20			0.3			Y	1.0	26.9%
CZ5	Y	0.30/0.50	0.20			0.3			Y	1.0	12.4%
CZ6	N/A – No PV Credit										
CZ7	N/A – No PV Credit										
CZ8	Y	0.30/0.23	0.20			0.3			Y	1.0	21.0%
CZ9	Y	0.30/0.23	0.20			0.3				1.0	26.8%
CZ10	Y	0.30/0.23	0.20			0.3				1.0	26.2%
CZ11	Y	0.30/0.23	0.20			0.3				1.0	26.5%
CZ12	Y	0.30/0.23	0.20			0.3				1.0	26.5%
CZ13	Y	0.30/0.23	0.20			0.3				1.0	27.3%
CZ14	Y	0.30/0.23	0.20			0.3				1.0	26.0%
CZ15	Y	0.30/0.23	0.20			0.3				1.0	25.4%
CZ16	Y	0.30/0.23	0.20							1.0	25.7%

Appendix C - 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 March 2016.

Pacific Gas and Electric Company — Revised Cal. P.U.C. Sheet No. 36706-E
San Francisco, California — Cancelling Revised Cal. P.U.C. Sheet No. 36470-E
U 39

ELECTRIC SCHEDULE E-1 Sheet 1
RESIDENTIAL SERVICES

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

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

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

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

Customers receiving a medical baseline allowance shall pay for all usage 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	$0.18212
101% - 130% of Baseline	$0.24090 (I)
131% - 200% of Baseline	$0.24090 (R)
201% - 300% of Baseline	$0.39999 (I)
Over 300% of Baseline	$0.39999 (I)
Delivery Minimum Bill Amount ($ per meter per day)	$0.32854
California Climate Credit (per household, per semi-annual payment occurring in the April and October bill cycles)	($28.14)

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

(Continued)

Advice Letter No: 4810-E-A — Issued by: Steven Malnight, Senior Vice President, Regulatory Affairs — Date Filed: May 31, 2016
Decision No. 15-07-001 and E-4782 — Effective: June 1, 2016
1C8 — Resolution No.

Pacific Gas and Electric Company
San Francisco, California
U 39

Cancelling Revised Cal. P.U.C. Sheet No. 36713-E
Revised Cal. P.U.C. Sheet No. 36500-E

ELECTRIC SCHEDULE E-TOU Sheet 2
RESIDENTIAL TIME-OF-USE SERVICE

RATES
(Cont'd.):

OPTION A TOTAL RATES

Total Energy Rates ($ per kWh)	PEAK		OFF-PEAK	
Summer				
Total Usage	$0.40327	(I)	$0.32769	(I)
Baseline Credit (Applied to Baseline Usage Only)	($0.11709)	(R)	($0.11709)	(R)
Winter				
Total Usage	$0.28530	(I)	$0.27100	(I)
Baseline Credit (Applied to Baseline Usage Only)	($0.11709)	(R)	($0.11709)	(R)
Delivery Minimum Bill Amount ($ per meter per day)	$0.32854			
California Climate Credit (per household, per semi-annual payment occurring in the April and October bill cycles)	($28.14)			

Total bundled service charges shown on customer's bills are unbundled according to the component rates shown below. Where the delivery minimum bill amount applies, the customer's bill will equal the sum of (1) the delivery minimum bill amount plus (2) for bundled service, the generation rate times the number of kWh used. For revenue accounting purposes, the revenues from the delivery minimum bill amount will be assigned to the Transmission, Transmission Rate Adjustments, Reliability Services, Public Purpose Programs, Nuclear Decommissioning, Competition Transition Charges, Energy Cost Recovery Amount, DWR Bond, and New System Generation Charges[1] 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 Letter No: 4810-E-A
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Issued by
Steven Malnight
Senior Vice President
Regulatory Affairs

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2C9

Pacific Gas and Electric Company Revised Cal. P.U.C. Sheet No. 32682-G
San Francisco, California Cancelling Revised Cal. P.U.C. Sheet No. 32620-G
U 39

GAS SCHEDULE G-1 Sheet 1
RESIDENTIAL SERVICE

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:

	Per Day
Minimum Transportation Charge**	$0.09863

	Per Therm			
	Baseline		Excess	
Procurement	$0.20960	(R)	$0.20960	(R)
Transportation Charge	$0.81592		$1.30547	
Total	$1.02552	(R)	$1.51507	(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	0.69	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)

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1C8

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Senior Vice President
Regulatory Affairs

Date Filed May 24, 2016
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Resolution No.

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

EDISON

Southern California Edison — Revised Cal. PUC Sheet No. 59026-E
Rosemead, California (U 338-E) — Cancelling Revised Cal. PUC Sheet No. 58237-E

Schedule D — Sheet 2
DOMESTIC SERVICE

(Continued)

RATES

	Delivery Service Total[1]	Generation[2] UDC***	Generation[2] DWREC[3]
Energy Charge - $/kWh/Meter/Day			
Baseline Service			
Summer	0.09769 (I)	0.06918 (I)	(0.00022)
Winter	0.09769 (I)	0.06918 (I)	(0.00022)
Nonbaseline Service*			
101% - 200% of Baseline - Summer	0.15987 (I)	0.06918 (I)	(0.00022)
Winter	0.15987 (I)	0.06918 (I)	(0.00022)
Over 200% of Baseline - Summer	0.22309 (R)	0.06918 (I)	(0.00022)
Winter	0.22309 (R)	0.06918 (I)	(0.00022)
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]	(35.00)		
Peak Time Rebate - $/kWh		(0.75)	
Peak Time Rebate interuptible 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 $(0.00615) per kWh is recovered in the UDC 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 DWREC rate component of this Schedule but instead pay the DWREC 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 3401-E
Decision 16-03-030

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R. O. Nichols
Senior Vice President

(To be inserted by Cal. PUC)
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EDISON

Southern California Edison — Revised Cal. PUC Sheet No. 59059-E
Rosemead, California (U 338-E) — Cancelling Revised Cal. PUC Sheet No. 58249-E

Schedule TOU-D-T — Sheet 2
TIME-OF-USE TIERED DOMESTIC

(Continued)

RATES

	Delivery Service Total[1]	Generation[2] UD***	Generation[2] DWREC[3]
Energy Charge - $/kWh/Meter/Day			
Summer Season - On-Peak			
Level I (up to 130% of Baseline)	0.10523 (I)	0.21660 (R)	(0.00022)
Level II (More than 130% of Baseline)	0.18332 (R)	0.21660 (R)	(0.00022)
Summer Season - Off-Peak			
Level I (up to 130% of Baseline)	0.10523 (I)	0.05311 (I)	(0.00022)
Level II (More than 130% of Baseline)	0.18332 (R)	0.05311 (I)	(0.00022)
Winter Season - On-Peak			
Level I (up to 130% of Baseline)	0.10523 (I)	0.09660 (R)	(0.00022)
Level II (More than 130% of Baseline)	0.18332 (R)	0.09660 (R)	(0.00022)
Winter Season - Off-Peak			
Level I (up to 130% of Baseline)	0.10523 (I)	0.04749 (I)	(0.00022)
Level II (More than 130% of Baseline)	0.18332 (R)	0.04749 (I)	(0.00022)
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]	(35.00)		
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 $(0.00015) per kWh is recovered in the UD 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 DWREC rate component of this Schedule but instead pay the DWREC 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 3401-E
Decision 16-03-030

Issued by
R. O. Nichols
Senior Vice President

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SOUTHERN CALIFORNIA GAS COMPANY Revised CAL. P.U.C. SHEET NO. 52782-G
LOS ANGELES, CALIFORNIA CANCELING Revised CAL. P.U.C. SHEET NO. 52751-G

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

APPLICABILITY

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

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

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

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

TERRITORY

Applicable throughout the service territory.

RATES	GR	GR-C	GT-R	
Customer Charge, per meter per day:	16.438¢	16.438¢	16.438¢	
For "Space Heating Only" customers, a daily Customer Charge applies during the winter period from November 1 through April 30[1]:	33.149¢	33.149¢	33.149¢	
Baseline Rate, per therm (baseline usage defined in Special Conditions 3 and 4):				
Procurement Charge:	34.536¢	34.536¢	N/A	I
Transmission Charge:	56.280¢	56.280¢	55.758¢	
Total Baseline Charge:	90.816¢	90.816¢	55.758¢	I
Non-Baseline Rate, per therm (usage in excess of baseline usage):				
Procurement Charge:	34.536¢	34.536¢	N/A	I
Transmission Charge:	82.280¢	82.280¢	81.758¢	
Total Non-Baseline Charge:	116.816¢	116.816¢	81.758¢	I

[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. 4989
DECISION NO.
1G2

ISSUED BY
Dan Skopec
Vice President
Regulatory Affairs

(TO BE INSERTED BY CAL. PUC)
DATE FILED Jul 7, 2016
EFFECTIVE Jul 10, 2016
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. 27850-E
Canceling Revised Cal. P.U.C. Sheet No. 26948-E

SCHEDULE DR Sheet 1

RESIDENTIAL SERVICE
(Includes Rates for DR-LI)

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 $(17.44) 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							
Baseline Energy ($/kWh)	0.05420	I	0.00539	0.12955	0.18564	I	D
Above 130% of Baseline	0.25645	R	0.00539	0.12955	0.39149	R	
Winter							
Baseline Energy ($/kWh)	0.10255	I	0.00539	0.06604	0.17399	I	D
Above 130% of Baseline	0.25737	R	0.00539	0.06604	0.32880	R	
Minimum Bill ($/day)	0.329				0.329		

Description - DR-LI Rates	UDC Total Rate		DWR-BC Rate	EECC Rate + DWR Credit	Total Rate		
Summer – CARE Rates:							
Baseline Energy ($/kWh)	0.05225	I	0.00000	0.12955	0.18180	I	D
Above 130% of Baseline	0.25380	R	0.00000	0.12955	0.38335	R	
Winter – CARE Rates:							
Baseline Energy ($/kWh)	0.10001	I	0.00000	0.06604	0.16605	I	D
Above 130% of Baseline	0.25482	R	0.00000	0.06604	0.32086	R	
Minimum Bill ($/day)	0.184				0.184		

(Continued)

1C10
Issued by
Dan Skopec
Vice President
Regulatory Affairs

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Effective Jul 1, 2016
Resolution No. E-4787

Advice Ltr. No. 2861-E-A
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SDGE

San Diego Gas & Electric Company
San Diego, California

Revised Cal. P.U.C. Sheet No. 26962-E
Canceling Revised Cal. P.U.C. Sheet No. 26908-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 $(17.44) per Schedule GHG-ARR. I

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 ($/kWh)								
On-Peak - Summer	0.12835	I	0.00639	I	0.33023	R	0.46397	R
Semi-Peak - Summer	0.12835	I	0.00639	I	0.09630	R	0.22904	R
Off-Peak - Summer	0.12835	I	0.00639	I	0.07832	R	0.20706	R
Semi-Peak - Winter	0.12835	I	0.00639	I	0.08159	R	0.21633	R
Off-Peak - Winter	0.12835	I	0.00639	I	0.06826	R	0.20300	R
Minimum Bill ($/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 $(0.00021) 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	LOC	RS		TRAC		UDC Total	
Energy Charges ($/kWh)														
On-Peak - Summer	0.02943	I	0.08367	R	0.01241	I 0.00052	I 0.00160	I 0.00039	I 0.00013	R	0.00000	I	0.12835	I
Semi-Peak - Summer	0.02943	I	0.08367	R	0.01241	I 0.00052	I 0.00160	I 0.00039	I 0.00013	R	0.00000	I	0.12835	I
Off-Peak - Summer	0.02943	I	0.08367	R	0.01241	I 0.00052	I 0.00160	I 0.00039	I 0.00013	R	0.00000	I	0.12835	I
Semi-Peak - Winter	0.02943	I	0.08367	R	0.01241	I 0.00052	I 0.00160	I 0.00039	I 0.00013	R	0.00000	I	0.12835	I
Off-Peak - Winter	0.02943	I	0.08367	R	0.01241	I 0.00052	I 0.00160	I 0.00039	I 0.00013	R	0.00000	I	0.12835	I
Minimum Bill ($/day)			0.329										0.329	

(Continued)

1C9

Issued by
Dan Skopec
Vice President
Regulatory Affairs

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Effective Jan 1, 2016
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Advice Ltr. No. 2840-E
Decision No.

San Diego Gas & Electric Company
San Diego, California

Revised Cal. P.U.C. Sheet No. 21921-G
Canceling Revised Cal. P.U.C. Sheet No. 21808-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

	GR	GR-C	GTC/GTCA[1]
Baseline Rate, per therm (baseline usage defined in Special Conditions 3 and 4):			
Procurement Charge:[2]	$0.34561	$0.34561 I	N/A
Transmission Charge:	$0.90805	$0.90805	$0.90805
Total Baseline Charge:	$1.25366	$1.25366 I	$0.90805
Non-Baseline Rate, per therm (usage in excess of baseline usage):			
Procurement Charge:[2]	$0.34561	$0.34561 I	N/A
Transmission Charge:	$1.08354	$1.08354	$1.08354
Total Non-Baseline Charge:	$1.42915	$1.42915 I	$1.08354

[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.

(Continued)

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Vice President
Regulatory Affairs

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