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A STATEWIDE UTILITY PROGRAM

Title 24, Parts 6 and 11
Local Energy Efficiency Ordinances

2019 Cost-effectiveness Study: Low-Rise Residential Addendum – Cost Effectiveness Study for the City of Piedmont Requiring Photovoltaic (PV) Systems and Exterior Lighting Controls on Residential Additions

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LEGAL NOTICE

This report was prepared by Pacific Gas and Electric Company and funded by the California utility customers under the auspices of the California Public Utilities Commission.

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1 Introduction

This addendum presents results from analysis conducted in response to a request from the City of Piedmont to evaluate the cost effectiveness of requiring the installation of solar photovoltaic (PV) systems and outdoor lighting controls for additions that meet certain qualifications to single family residential buildings. The City has defined qualifying additions as those that include new upper levels or additions that increase the total existing roof area by 30 percent or more. The proposed ordinance would require the project install photosensor controls to all hard-wired exterior lighting fixtures, and install a PV system that meets the minimum prescriptive size requirements as defined in the 2019 Title 24, Part 6 code for new construction based on the total conditioned floor area of the home, including the addition.

This analysis builds upon the results of the 2019 Cost-effectiveness Study: Low-Rise Residential New Construction (Statewide Reach Codes Team, 2019) and the 2019 Cost-effectiveness Study: Existing Low-Rise Residential Building Efficiency Upgrade (Statewide Reach Codes Team, 2020) conducted for the California Statewide Codes and Standards Program, which evaluated new construction and retrofit upgrade packages across all 16 California climate zones.

2 Methodology and Assumptions

This analysis is based on the 1,665 square foot single family existing home prototype used for the 2019 statewide retrofit study. The prototype is mixed fuel with natural gas serving space and water heating, cooking and clothes drying end uses. Two building vintages were evaluated to determine sensitivity of existing building performance on cost-effectiveness of PV installation: a home built prior to 1978 (pre-1978) when the first Title-24 Part 6 energy standards went into effect, and a home built between 1992 and 2005 (1990s era). The building characteristics for each vintage were determined based on either prescriptive requirements from the Title 24 code that were in effect, or standard construction practice during that time period. Building characteristic details are provided in Appendix B.

Exterior Lighting Controls

Evaluation of the exterior lighting controls was completed on a per-fixture basis external to the energy model and assumes a screw-in photosensor control is installed in outdoor lighting luminaires. Energy savings of 12.1 kWh per year was used based on analysis done by the Consortium for Energy Efficiency, assuming LED lamps, 2.6 hours per day of operation, and photosensor controls reduce operating hours on average of 20 percent per day (CEE, 2014). Energy savings would be higher for incandescent or CFL luminaires.

An incremental cost of $10.50, based on a screw-in photosensor control, was obtained from an on-line product search of available products. A five year lifetime for this type of control was assumed.

Solar Photovoltaics (PV)

Two PV system capacities were evaluated to compare cost effectiveness sensitivity over the range of feasible systems that could be required as part of an ordinance. On the lower end a 1 kW_{DC} PV system was evaluated, and on the upper end, the smaller of a 2.5 kW system or a system that offsets 100 percent of the estimated electricity use. For the pre-1978 vintage home a 2.5 kW system was evaluated as it did not offset all the home's estimated electricity use. For the 1990s era home a 2.3 kW system resulted in net-zero electricity use on an annual basis. For the 1,665 square foot prototype, the prescriptive PV size would be 2.17 kW for Climate Zone 3, within the range of PV system sizes that were evaluated.

PV system first costs are from LBNL's Tracking the Sun 2019 Edition report (Barbose et al., 2019) and represent median installed costs prior to incentives for the first half of 2019 of $3.70/W-DC for residential systems. These costs were reduced by 14% for the solar investment tax credit, which is the average credit from the second half of 2020 through 2022. Inverter replacement cost of $0.14/W-DC present value includes replacements at year 11 at $0.15/W-DC (nominal) and at year 21 at $0.12/W-DC (nominal) per the 2019 PV CASE Report (California Energy Commission, 2017). System maintenance costs of $0.31/W-DC present value assume $0.02/W-DC (nominal) annually per the 2019 PV CASE Report (California Energy Commission, 2017). 10% overhead and profit added to all costs for a total present value cost of $3.99/W-DC.

It is assumed that the PV system is financed over a 30-year loan term at a rate of 5 percent.

Cost-Effectiveness

East Bay Community Energy (EBCE) time-of-use (TOU) tariffs were applied to calculate and compare cost-effectiveness. EBCE customers are required to enroll in a TOU rate when installing PV systems on their homes. Both TOU-B and TOU-C tariffs were evaluated. Beginning May 1, 2020, the TOU-B rate is no longer available to new EBCE customers but was evaluated for customers that may already be enrolled in a TOU rate prior to installing PV. The TOU-C tariff is the current default tariff when transitioning customers to a TOU rate. Utility rates are assumed to escalate over time, using the same assumptions applied in the statewide retrofit study which were based on research conducted by Energy and Environmental Economics (E3) in the 2019 study Residential Building Electrification in California study (Energy & Environmental Economics, 2019). Details on the utility tariffs is provided in Appendix A.

All other applicable assumptions from the residential new construction analysis were applied. Refer to the 2019 Cost-effectiveness Study: Existing Low-Rise Residential Building Efficiency Upgrade (Statewide Reach Codes Team, 2020) for further details. Key components of the methodology are repeated below.

Cost-effectiveness

This analysis uses two different metrics to assess cost-effectiveness. Both methodologies require estimating and quantifying the incremental costs and energy savings associated with energy efficiency measures as compared to the 2019 prescriptive Title 24 requirements. The main difference between the methodologies is the way they value energy and thus the cost savings of reduced or avoided energy use.

- **Utility Bill Impacts (On-Bill)**: Customer-based Lifecycle Cost (LCC) approach that values energy based upon estimated site energy usage and customer on-bill savings using electricity and natural gas utility rate schedules over a 30-year duration accounting for discount rate and energy inflation.
- **Time Dependent Valuation (TDV)**: Energy Commission LCC methodology, which is intended to capture the "societal value or cost" of energy use including long-term projected costs such as the cost of providing energy during peak periods of demand and other societal costs such as projected costs for carbon emissions, as well as grid transmission and distribution impacts. This metric values energy use differently depending on the fuel source (gas, electricity, and propane), time of day, and season. Electricity used (or saved) during peak periods has a much higher value than electricity used (or saved) during off-peak periods (Horii et al, 2014). This is the methodology used by the Energy Commission in evaluating cost-effectiveness for efficiency measures in Title 24, Part 6.

Results are presented as a lifecycle benefit-to-cost (B/C) ratio, a net present value (NPV) metric which represents the cost-effectiveness of a measure over a 30-year lifetime taking into account discounting of future savings and costs and financing of incremental first costs. A value of one indicates the NPV of the savings over the life of the measure is equivalent to the NPV of the lifetime incremental cost of that measure. A value greater than one represents a positive return on investment.

3 Results

Exterior Lighting Controls

Table 1 summarize results from the analysis for the Bright Choice rate options under both the TOU-B and TOU-C rate tariffs, assuming all energy savings from exterior lighting occurs during off-peak time periods. Cost-effectiveness would improve under the Renewable 100 EBCE rate option.

Table 1: Exterior Lighting Controls Cost Effectiveness Results (per Luminaire)

Climate Zone 3 EBCE/PG&E Bright Choice	Annual Energy Savings (kWh/yr)	First Incremental Cost ($)	Year 1 Utility Costs Savings	Average 5-yr Annual Utility Cost Savings	Simple Payback (yrs)	5-Year Lifecycle Benefit to Cost Ratio, no Financing
TOU-B	12.1	$10.50	$3.28	$3.19	3.20	1.52
TOU-C			$2.86	$2.78	3.67	1.32

Solar Photovoltaics (PV)

Table 2 and Table 3 summarize results from the analysis for the Bright Choice and Renewable 100 EBCE rate options under both the TOU-B and TOU-C rate tariffs. These two rates were evaluated to represent the range of costs a customer may experience based on their rate choice.

Table 2: Summary of Cost Effectiveness Results – Bright Choice Rate

Climate Zone 3 EBCE/PG&E Bright Choice	Annual Net kWh	First Incremental Cost ($)	PV of Lifetime Incremental Cost (2020 $)	Year 1 Utility Costs		PV of Lifetime Savings (2020 $)			Benefit to Cost Ratio (B/C)		
						On-Bill		TDV	On-Bill		TDV
				TOU-B	TOU-C	TOU-B	TOU-C		TOU-B	TOU-C	
1990s No PV	3,651	n/a	n/a	$982	$928	n/a	n/a	n/a	n/a	n/a	n/a
1990s 1kW	2,073	$3,500	$5,033	$563	$499	$9,923	$10,152	$6,455	**1.97**	**2.02**	1.28
1990s 2.3kW	0	$8,097	$11,642	$121	$126	$20,397	$18,994	$14,278	**1.75**	**1.63**	1.23
Pre 1978 No PV	4,018	n/a	n/a	$1,083	$1,047	n/a	n/a	n/a	n/a	n/a	n/a
Pre 1978 1kW	2,440	$3,500	$5,033	$664	$600	$9,926	$10,572	$6,458	**1.97**	**2.10**	1.28
Pre 1978 2.5kW	72	$8,750	$12,582	$132	$136	$22,528	$21,566	$15,402	**1.79**	**1.71**	1.22

Table 3: Summary of Cost Effectiveness Results – Renewable 100 Rate

Climate Zone 3 EBCE/PG&E Renewable 100	Annual Net kWh	First Incremental Cost ($)	PV of Lifetime Incremental Cost (2020 $)	Year 1 Utility Costs		PV of Lifetime Savings (2020 $)			Benefit to Cost Ratio (B/C)		
						On-Bill		TDV	On-Bill		TDV
				TOU-B	TOU-C	TOU-B	TOU-C		TOU-B	TOU-C	
1990s No PV	3,651	n/a	n/a	$1,025	$971	n/a	n/a	n/a	n/a	n/a	n/a
1990s 1kW	2,073	$3,500	$5,033	$588	$524	$10,359	$10,589	$6,455	**2.06**	**2.10**	1.28
1990s 2.3kW	0	$8,097	$11,642	$121	$126	$21,407	$20,004	$14,278	**1.84**	**1.72**	1.23
Pre 1978 No PV	4,018	n/a	n/a	$1,130	$1,094	n/a	n/a	n/a	n/a	n/a	n/a
Pre 1978 1kW	2,440	$3,500	$5,033	$693	$629	$10,362	$11,009	$6,458	**2.06**	**2.19**	1.28
Pre 1978 2.5kW	72	$8,750	$12,582	$133	$137	$23,619	$22,657	$15,402	**1.88**	**1.80**	1.22

4 Conclusions

Following are conclusions from this analysis.

- Installation of photosensor controls on LED exterior light fixtures is cost-effective with simple paybacks just over 3 years, less than the assumed lifetime of the screw-in photosensor control. Savings and cost-effectiveness would increase if CFL or incandescent luminaires are present. Customers on the Renewable 100 rate will experience slightly higher utility cost savings and improved cost effectiveness as well.
- Installing a PV system ranging in size from 1kW to 2.5kW was found to be cost-effective in all cases evaluated using both the On-Bill and TDV approaches and based on both TOU-B and TOU-C tariffs.
- Customers on the Renewable 100 rate will experience slightly higher utility cost savings and improved cost-effectiveness for a new PV system than customers on the Bright Choice rate.
- Existing customers on the TOU-B tariff will experience slightly higher utility cost savings and improved cost effectiveness than customers on the TOU-C rate for larger PV systems that offset all or most of the home electricity use. However, the TOU-B tariff is closed to new customers as of May 1, 2020.
- The vintage of the home has little impact on the cost effectiveness of PV, which supports an ordinance requiring PV systems for existing homes of any vintage and for additions.
- The smaller 1kW PV systems is more cost effective than the larger systems evaluated due to PG&E's minimum bill requirement which limits savings on the PG&E portion of the bill once annual costs are reduced to $120.
- The 2019 Title 24, Part 6 new construction prescriptive PV sizing requirement for Climate Zone 3 is 2.17 kW for a 1,665 square foot house. This is within the range of PV system capacities evaluated and found to be cost effective in this study, supporting an ordinance requiring PV sized according to 2019 new construction standards.

The Reach Codes Team recommends considering scenarios where the PV requirement should be waived or reduced, such as under the following conditions.

- Existing PV systems that exceed the capacity requirements of the proposed ordinance or meet a certain percentage of the requirement, such as 90%.
- Where production of electric energy from solar panels is technically infeasible due to lack of available space or shaded areas.
- Homes that can demonstrate that the required PV capacity exceeds the historical annual electricity use of the home.

5 References

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Appendix A – Utility Rate Tariffs

The following pages provide details on the EBCE & PG&E electricity tariffs applied in this study.

EBCE

Following are details on the EBCE generation rates that were applied in this study. Generation costs were calculated based on the rates without the system fees applied and the peak period. System fees were calculated separately as a volumetric charge based on annual net kWh and added to the generation costs and PG&E's distribution costs. 2018 vintage system fees were applied based on guidance from EBCE. Any excess production was credited based on the generation retail rates described below per EBCE's net metering agreement.

East Bay Community Energy Rate Sheets

Rates effective as of May 1, 2020

This rate sheet is for **2018** vintage year rates. See "How to Find Your Vintage Year" at ebce.org/rates to verify your vintage year.

Rate	Billing Determinant Name	Bright Choice Rate	Brilliant 100 Rate	Renewable 100 Rate	2018 Vintage System Fees	Total Bright Choice Rate	Total Brilliant 100 Rate	Total Renewable 100 Rate	May 2020 PG&E Generation Rate	Unit
ETOUB	Off-Peak Summer	0.08358	0.08537	0.09537	0.03399	0.11757	0.11936	0.12936	0.11936	kWh
ETOUB	Off-Peak Winter	0.06134	0.06279	0.07279	0.03399	0.09533	0.09678	0.10678	0.09678	kWh
ETOUB	Peak Summer	0.18509	0.18843	0.19843	0.03399	0.21908	0.22242	0.23242	0.22242	kWh
ETOUB	Peak Winter	0.07986	0.08159	0.09159	0.03399	0.11385	0.11558	0.12558	0.11558	kWh
ETOUC	Off-Peak Summer	0.07821	0.07992	0.08992	0.03399	0.11220	0.11391	0.12391	0.11391	kWh
ETOUC	Off-Peak Winter	0.06802	0.06957	0.07957	0.03399	0.10201	0.10356	0.11356	0.10356	kWh
ETOUC	Peak Summer	0.13085	0.13336	0.14336	0.03399	0.16484	0.16735	0.17735	0.16735	kWh
ETOUC	Peak Winter	0.08282	0.08460	0.09460	0.03399	0.11681	0.11859	0.12859	0.11859	kWh

PG&E

Following are details on the PG&E delivery rates that were applied for both TOU-B and TOU-C. Only distribution, transmission and other miscellaneous fees (highlighted in yellow below) were included in the PG&E cost estimates. For the TOU-C rate, baseline territory T was applied for the City of Piedmont.

TOU-B

TIME PERIODS FOR OPTION B: Times of the year and times of the day are defined as follows:

Summer (service from June 1 through September 30):

Peak: 4:00 p.m. to 9:00 p.m. Monday through Friday

Off-Peak: All other times including Holidays.

Winter (service from October 1 through May 31):

Peak: 4:00 p.m. to 9:00 p.m. Monday through Friday

Off-Peak: All other times including Holidays.

Holidays: "Holidays" for the purposes of this rate schedule are New Year's Day, President's Day, Memorial Day, Independence Day, Labor Day, Veterans Day, Thanksgiving Day, and Christmas Day. The dates will be those on which the holidays are legally observed.

UNBUNDLING OF OPTION B TOTAL RATES

Generation	PEAK		OFF-PEAK	
Summer (all usage)	$0.22242	(R)	$0.11936	(R)
Winter (all usage)	$0.11558	(R)	$0.09678	(R)
Distribution**				
Summer (all usage)	$0.11515	(I)	$0.11515	(I)
Winter (all usage)	$0.08452	(I)	$0.08452	(I)

Transmission* (all usage)	$0.03595	
Transmission Rate Adjustments* (all usage)	$0.00314	
Reliability Services* (all usage)	($0.00066)	
Public Purpose Programs (all usage)	$0.01296	(I)
Nuclear Decommissioning (all usage)	$0.00101	(I)
Competition Transition Charges (all usage)	$0.00096	(R)
Energy Cost Recovery Amount (all usage)	$0.00005	(I)
DWR Bond (all usage)	$0.00580	
New System Generation Charge (all usage)**	$0.00571	(I)

Delivery Minimum Bill Amount ($ per meter per day)	$0.32854

TOU-C

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

Summer (service from June 1 through September 30):

Peak:	4:00 p.m. to 9:00 p.m.	All days
Off-Peak:	All other times	

Winter (service from October 1 through May 31):

Peak:	4:00 p.m. to 9:00 p.m.	All days
Off-Peak:	All other times	

RATES: (Cont'd.)

UNBUNDLING OF E-TOU-C TOTAL RATES

Energy Rates by Component ($ per kWh)	PEAK		OFF-PEAK	
Generation:				
Summer (all usage)	$0.16735	(R)	$0.11391	(R)
Winter (all usage)	$0.11859	(R)	$0.10356	(R)
Distribution**:				
Summer (all usage)	$0.12767	(I)	$0.11767	(I)
Winter (all usage)	$0.07935	(I)	$0.07705	(I)

Conservation Incentive Adjustment (Baseline Usage)	($0.03294)	(I)
Conservation Incentive Adjustment (Over Baseline Usage)	$0.05339	(I)
Transmission* (all usage)	$0.03595	
Transmission Rate Adjustments* (all usage)	$0.00314	
Reliability Services* (all usage)	($0.00066)	
Public Purpose Programs (all usage)	$0.01296	(I)
Nuclear Decommissioning (all usage)	$0.00101	(I)
Competition Transition Charges (all usage)	$0.00096	(R)
Energy Cost Recovery Amount (all usage)	$0.00005	(I)
DWR Bond (all usage)	$0.00580	
New System Generation Charge (all usage)**	$0.00571	(I)

Delivery Minimum Bill Amount ($ per meter per day)	$0.32854

1. BASELINE (TIER 1) QUANTITIES: The following quantities of electricity are to be used to define usage eligible for the baseline credit (also see Rule 19 for additional allowances for medical needs):

BASELINE QUANTITIES (kWh PER DAY)

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

Appendix B – Building Characteristics

Table 4: Efficiency Characteristics for Two Vintage Cases

Building Component Efficiency Feature	Vintage Case	
	Pre-1978	1992-2005
Envelope		
Exterior Walls	2x4 16"oc wood frame, R-0	2x4 16"oc wood frame, R-13
Foundation Type & Insulation	Raised floor, R-0	Uninsulated slab
Ceiling Insulation & Attic Type	Vented attic, R-11 @ ceiling level	Vented attic, R-30 @ ceiling level
Roofing Material & Color	Asphalt shingles, dark	Asphalt shingles, dark
Radiant Barrier	No	No
Window Type: U-factor / SHGC[1]	Metal, single pane: 1.16 / 0.76	Vinyl, dual pane Low-E: 0.55 / 0.40
House Infiltration	15 ACH50	7 ACH50
HVAC Equipment[2]		
Heating Efficiency	78 AFUE	78 AFUE
Cooling Efficiency	10 SEER	13 SEER
Duct Location & Details	Attic, R-2.1, 30% leakage	Attic, R-4.2, 15% leakage
Whole Building Mechanical Ventilation	None	None
Water Heating Equipment[2]		
Water Heater Efficiency	0.575 Energy Factor	0.575 Energy Factor
Water Heater Tank	40gal uninsulated tank	40gal uninsulated tank
Pipe Insulation	None	None
Hot Water Fixtures	Standard, non-low flow	Standard, non-low flow