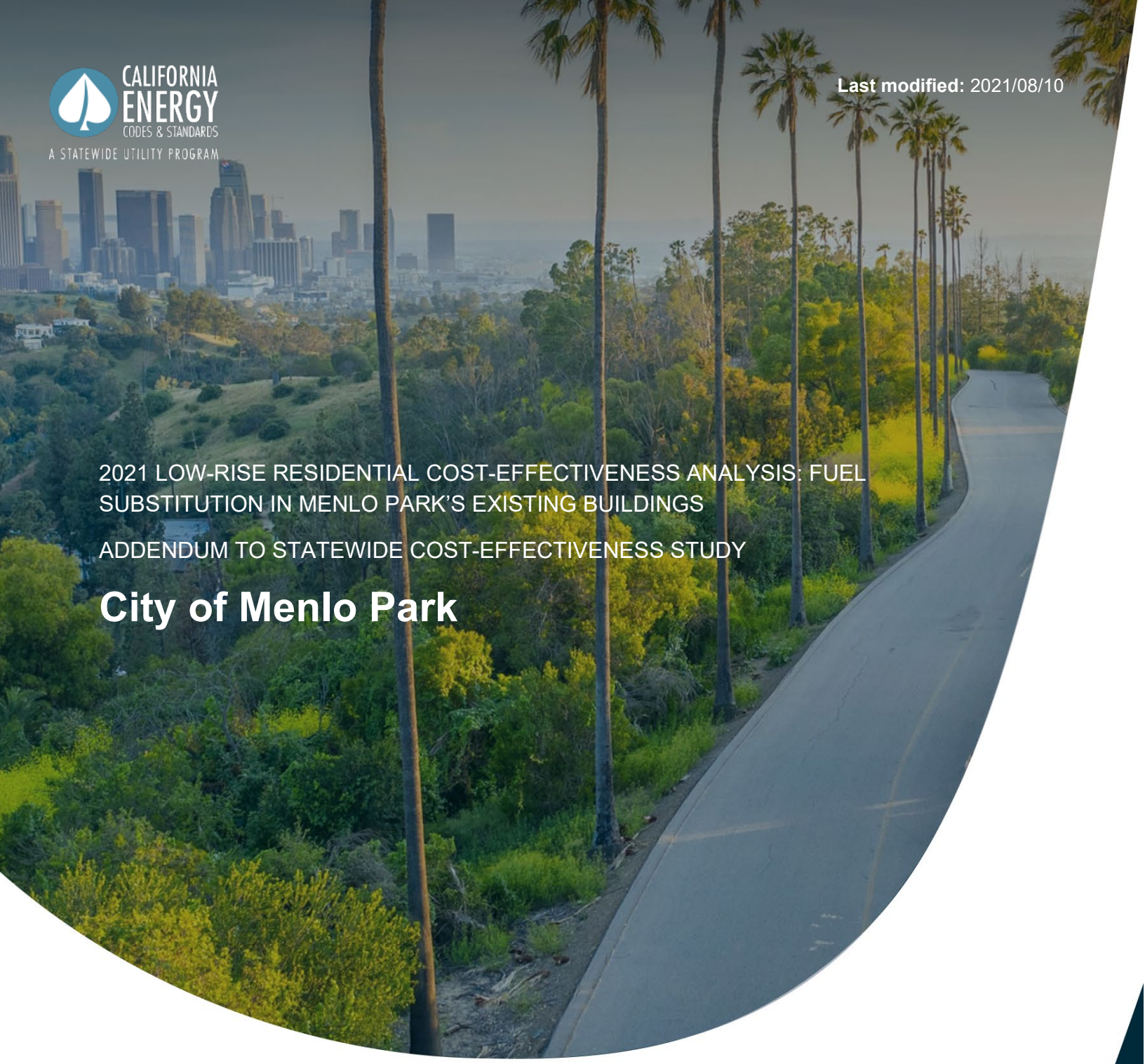

CALIFORNIA ENERGY CODES & STANDARDS
A STATEWIDE UTILITY PROGRAM

Last modified: 2021/08/10

2021 LOW-RISE RESIDENTIAL COST-EFFECTIVENESS ANALYSIS: FUEL SUBSTITUTION IN MENLO PARK'S EXISTING BUILDINGS

ADDENDUM TO STATEWIDE COST-EFFECTIVENESS STUDY

City of Menlo Park

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SDGE A Sempra Energy utility
SoCalGas A Sempra Energy utility
Southern California Edison An EDISON INTERNATIONAL Company
PG&E Pacific Gas and Electric Company

Acronym List

B/C – Benefit-to-Cost Ratio

BayREN – Bay Area Regional Energy Network

CBECC – California Building Energy Code Compliance

CBSC – California Building Standards Commission

CEC – California Energy Commission

CZ – Climate Zone

GHG – Greenhouse Gas

IOU – Investor-Owned Utility

PCE – Peninsula Clean Energy

POU – Publicly Owned Utility

PG&E – Pacific Gas & Electric (utility)

SCE – Southern California Edison (utility)

SCG – Southern California Gas (utility)

SDG&E – San Diego Gas & Electric (utility)

CPAU – City of Palo Alto Utilities

SMUD – Sacramento Municipal Utility District

LADWP – Los Angeles Department of Water and Power

kWh – Kilowatt Hour

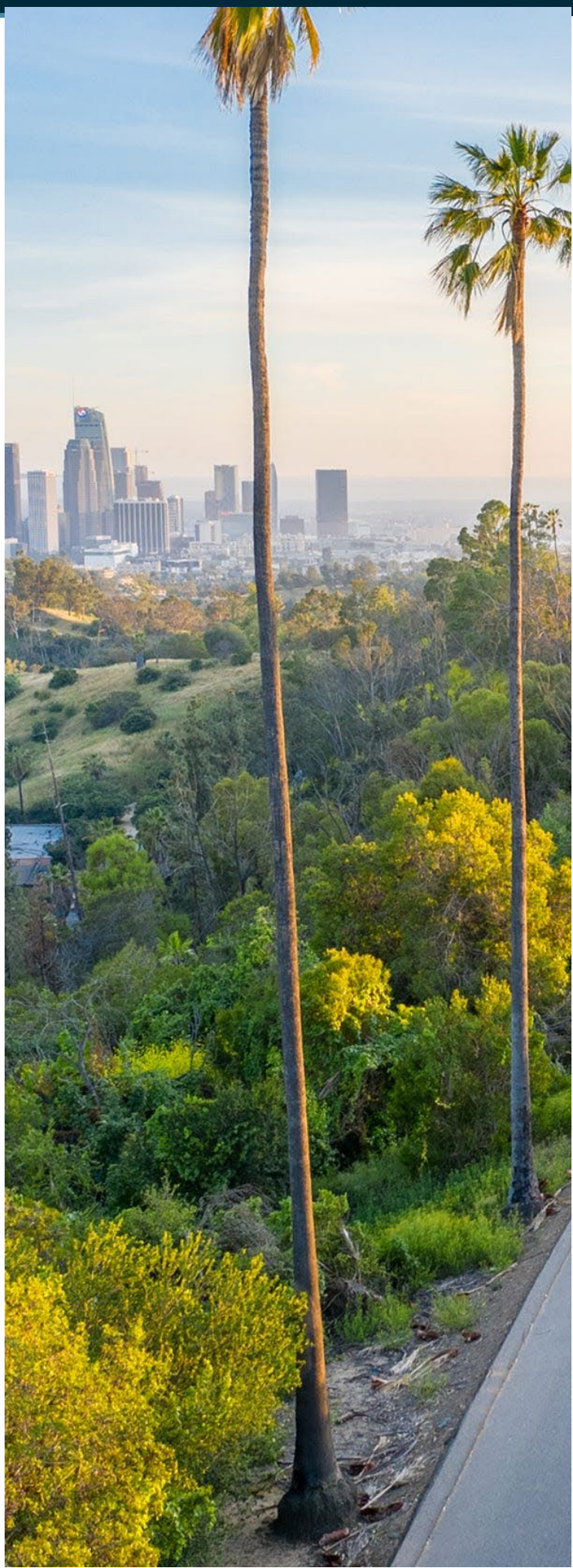
NPV – Net Present Value

PV - Solar Photovoltaic

TDV - Time Dependent Valuation

Title 24 – California Code of Regulations Title 24, Part 6

TOU – Time of Use



Summary of Revisions		
Date	**Description**	**Reference (page or section)**
4/22/2021	Original Release	NA
6/23/2021	Update to include multifamily analysis; include additional detail on incremental costs.	NA
7/8/2021	Update to PCE HPWH incentive, GHG savings, and 1992-2010 HP results. Add cost details on electric ready measures.	NA
8/10/2021	Added detail and clarification to narrative and tables. Updated cost-effectiveness results to include whole-home package and based on revised escalation rates.	NA

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1 Introduction

The California Codes and Standards Reach Codes program provides technical support to local governments considering adopting a local ordinance (reach code) intended to support meeting local and/or statewide energy and greenhouse gas reduction goals. The program facilitates adoption and implementation of the code when requested by local jurisdictions by providing resources such as cost-effectiveness studies, model language, sample findings, and other supporting documentation. Local jurisdictions that are considering adopting ordinances may contact the program for support through its website, LocalEnergyCodes.com.

The California Building Energy Efficiency Standards Title 24, Part 6 (Title 24) (California Energy Commission, 2018) is maintained and updated every three years by two state agencies: the California Energy Commission (the Energy Commission) and the Building Standards Commission (BSC). In addition to enforcing the code, local jurisdictions have the authority to adopt local energy efficiency ordinances—or reach codes—that exceed the minimum standards defined by Title 24 (as established by Public Resources Code Section 25402.1(h)2 and Section 10-106 of the Building Energy Efficiency Standards). Local jurisdictions that adopt energy conservation amendments or ordinances as the term is used in PRC 25402.1(h)2 must demonstrate that the requirements of the proposed ordinance are cost-effective according to the local jurisdiction criteria, and do not result in buildings consuming more energy than is permitted by Title 24. For energy conservation amendments, the jurisdiction must obtain approval from the Energy Commission and file the ordinance with the BSC for the ordinance to be legally enforceable.

This analysis is an update to the statewide cost-effectiveness study for existing building upgrades completed in March 2021 (Statewide Reach Code Team, 2021) which evaluates the feasibility and cost-effectiveness of retrofit measures in existing single family homes built before 2010. This report presents results from analysis conducted in response to a request from the City of Menlo Park to evaluate the fuel substitution measures with revisions that more accurately reflect local conditions. Cost-effectiveness is reported for California Climate Zone 3 based on Peninsula Clean Energy (PCE) electric tariffs for both single family and low-rise multifamily buildings. This report was developed in coordination with the California Statewide Investor Owned Utilities (IOUs) Codes and Standards Program, key consultants, and engaged cities—collectively known as the Reach Code Team.

The Department of Energy (DOE) sets minimum efficiency standards for equipment and appliances that are federally regulated under the National Appliance Energy Conservation Act, including heating, cooling, and water heating equipment (E-CFR, 2020). Since state and local governments are prohibited from adopting higher minimum efficiencies than the federal standards require, the focus of this study is to identify and evaluate cost-effective packages that do not include high efficiency heating, cooling, and water heating equipment. High efficiency appliances are often the easiest and most affordable measures to increase energy performance. While federal preemption limits reach code mandatory requirements for covered appliances, in practice, builders may install any package of compliant measures to achieve the performance requirements.

2 Methodology and Assumptions

The same methodology used in the statewide analysis (Statewide Reach Code Team, 2021) is applied to this analysis with the following exceptions:

- Local PCE electric utility tariffs are used in place of PG&E tariffs.
- PCE and BayREN incentives are considered.
- A single family 2,700 square foot home is used in place of the 1,665 square foot home applied in the statewide study. This larger home better reflects the Menlo Park building stock, which has a median single-family square footage of 2,240 and an average of 2,426.
- A two-story multifamily apartment building was also evaluated. The eight-unit building has four one-bedroom 780 square foot units and four two-bedroom 960 square foot units.
- Only the fuel substitution measures are evaluated.
- Two additional measures are evaluated showing the energy impact of converting a gas dryer and gas range/oven to electric resistance appliances.

Key components of the methodology are repeated below. Refer to the statewide study for further details.

2.1 Measures and Costs

In addition to the fuel substitution measures for space heating and water heating the Statewide Reach Code Team also evaluated fuel substitution for clothes drying and cooking. Standard and high efficiency heat pumps were considered in this analysis. For space conditioning, the study assumes that an existing AC and natural gas furnace is replaced with a heat pump. It is assumed there is no incremental labor except in providing new 240 V electrical service to the air handler location. In mild climates, where AC may not be installed, there will be additional costs for installing an outdoor unit, refrigerant lines, and condensate drain pan, though these costs and associated analyses were not examined in this study. A 21 SEER, 11 HSPF variable capacity heat pump was modeled for the high efficiency space conditioning heat pump.

The heat pump water heater (HPWH) measures are based on replacement of a natural gas storage water heater with a HPWH, assuming the existing water heater is located in the garage for single family buildings and an exterior closet for multifamily buildings. Costs include all material and installation labor including providing new 240 V electrical service to the water heater location.

Incremental costs for these fuel substitution measures are presented in Table 1, Table 2, and Table 3. All equipment is assumed to be replaced at end-of-life and incremental costs are relative to comparable gas equipment. The lifetime for the heat pump, furnace, and air conditioner are based on the Database for Energy Efficient Resources (DEER) (California Public Utilities Commission, 2021). In DEER heat pump and air conditioner measures are assigned an effective useful lifetime (EUL) of 15 years and a furnace an EUL of 20 years. The heating and cooling system components are typically replaced at the same time when one reaches the end of its life and the other is near it. Therefore, it is assumed that both the furnace and air conditioner are replaced at the same time at year 17.5, halfway between 15 and 20 years. Future replacement costs for the heat pumps are reduced by 20% to account for cost reductions as a result of a maturing market. The HVAC single family costs reflect a 3-ton heat pump or air conditioner and a 60,000 Btu/h furnace. The multifamily costs are slightly lower as they reflect a 2-ton heat pump or air conditioner and a 40,000 Btu/h furnace. Incremental costs for electric ready measures are presented in Table 4.

Table 1: HVAC Measure Cost Assumptions – Electric Replacements

	Single Family (3-ton HP/AC, 60kBtu/h furnace)			Multifamily (2-ton HP/AC, 40kBtu/h furnace)			Notes
	Gas Furnace /AC	14 SEER Heat Pump	21 SEER Heat Pump	Gas Furnace /AC	14 SEER Heat Pump	21 SEER Heat Pump	
First Cost	$8,738	$9,101	$11,247	$8,545	$8,731	$10,725	Equipment costs from on-line sources and HVAC contractors. Other supply and labor costs from 2019 report on residential building electrification in California (Energy & Environmental Economics, 2019). First cost includes disposal, electrical upgrade, and labor costs.
Replacement Cost (Future Value)	$8,738	$6,729	$8,445	$8,545	$6,433	$8,028	Future total replacement costs for the heat pumps are reduced by 20% to account for cost reductions because of a maturing market and electrical upgrade costs are removed.
Replacement Cost (Present Value)	$5,209	$4,319	$5,421	$5,094	$4,129	$5,153	Based on 17.5-year lifetime for gas furnace/AC, 15-year lifetime for heat pumps, 3% discount rate.
Remaining Value at Year 30	($1,029)	$0	$0	($1,006)	$0	$0	Residual value of the gas furnace/AC to account for the remaining life at end of 30-year analysis period.
Total Lifecycle Cost	$12,918	$13,419	$16,667	$12,633	$12,859	$15,878	
Incremental Cost	**-**	**$501**	**$3,749**	**-**	**$227**	**$3,245**	

Table 2: Water Heating Measure Cost Assumptions – Electric Replacements

	Single Family & Multifamily			Notes
	Gas Storage Water Heater	2.0 UEF HPWH[1]	NEEA Tier 3 HPWH	
First Cost	$1,600	$4,018	$4,155	First cost based on 2018-2020 costs from SMUD incentive program for NEEA Tier 3 HPWH (Sacramento Municipal Utility District, 2020). 2.0 UEF first cost assumes 90% of equipment cost compared to NEEA Tier 3 unit based on on-line product research. Includes equipment cost, electrical upgrade, permitting, and labor.
Replacement Cost (Future Value)	$1,600	$1,874	$1,943	Future replacement cost assumes the same labor for the gas and HPWH case. HPWH replacement equipment costs are reduced by 50% to account for cost reductions because of a maturing market.
Replacement Cost (Present Value)	$1,027	$1,203	$1,247	Based on 15-year lifetime and 3% discount rate.
Remaining Value at Year 30	$0	$0	$0	
Total Lifecycle Cost	$2,627	$5,221	$5,402	
Incremental Cost	**-**	**$2,594**	**$2,775**	

Note 1: The 2.0 Uniform Energy Factor (UEF) represents the minimum federal efficiency standards. However, efficiency standards have not kept pace with equipment efficiency improvements and do not represent the lowest efficiency HPWHs available in California. The UEF=2.0 results likely underestimate the on-bill performance of a market baseline heat pump water heater.

Table 3: Cooking and Clothes Dryer Measure Cost Assumptions – Electric Replacements

	Single Family & Multifamily				Notes
	Gas Range	Electric Resistance Range	Gas Dryer	Electric Resistance Dryer	
First Cost	$1,510	$2,118	$1,805	$2,118	Costs from E3 study for Climate Zone 3 (Energy & Environmental Economics, 2019). No incremental replacement costs assumed.
Incremental Cost	**-**	**$608**		**$313**	

Table 4: Electric Ready Cost Assumptions

	Incremental Cost	Notes
Appliance pre-wire	$455 per appliance. $910 total for space and water heating	$125 parts, $330 labor. (Energy & Environmental Economics, 2019).
Main service panel upgrade	$3,181	Upgrade 100A to 200A (TRC, 2016)

A PV system is evaluated in combination with select fuel substitution measures. The PV system size presented in Table 5 was based on the sizing methodology of the 2019 new construction standards in Climate Zone 3. It was

evaluated in CBECC-Res according to the California Flexible Installation (CFI) assumptions. Table 5 also presents incremental costs.

Table 5: PV System Capacity & Costs

	PV Size	Total Lifecycle Cost	Notes
Single Family	2.82 kW-DC	$3.18/kW-DC ($8,953 total)	First costs are from LBNL's Tracking the Sun 2019 costs (Barbose, 2019) and represent costs for the first half of 2019 of $3.70/WDC for residential systems and $3.10/WDC for small commercial systems. These costs were reduced by 26% for the solar ITC, which is the average credit over years 2021-2022. Inverter replacement cost of $0.14/WDC present value includes replacements at year 11 at $0.15/WDC (nominal) and at year 21 at $0.12/WDC (nominal) per the 2019 PV CASE Report (California Energy Commission, 2017). System maintenance costs of $0.31/WDC present value assume $0.02/WDC (nominal) annually per the 2019 PV CASE Report (California Energy Commission, 2017).
Multifamily	13.33 kW-DC total (1.67 kW-DC per dwelling unit)	$2.74/kW-DC ($4,559 per dwelling unit)	

2.2 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 impacts using electricity and natural gas utility rate schedules over a 30-year duration accounting for discount rate (three percent real 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 uses 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, Cutter, Kapur, Arent, & Conotyannis, 2014). This is the methodology used by the Energy Commission in evaluating cost-effectiveness for efficiency measures in Title 24, Part 6. Analysis based on both 2019 and 2022 TDV is presented in this report.

On-Bill analysis was completed using the utility rates described in Table 6. PCE's TOU-C rate is similar to PG&E's TOU-C rate except with a lower generation rate and additional credit for solar PV generation. Rates reflect PCE's most recent updates on April 1, 2021 and PG&E's March 1, 2021 updates. Monthly net energy production is credited at $0.01/kWh in addition to the retail rate. See 5.1 Utility Tariff Details in the Appendix for details.

Table 6: Utility Tariffs Applied in Analysis

Electricity	Natural Gas
PCE TOU-C	PG&E G-1

Source: Utility websites, see 5.1 Utility Tariff Details in the Appendix for details on the tariffs applied.

Utility rates are assumed to escalate over time based on assumptions from the CPUC's 2021 En Banc hearing and associated white paper on electric rates (California Public Utilities Commission, 2021) as well as escalation rates embedded in the California Energy Commission's 2022 TDV multipliers. Escalation of electric utility rates for PCE was not available and the assumptions used in this analysis are based on California statewide estimates or those for PG&E (the CPUC report provides electricity escalation rates separately for each of the IOUs). These escalation rates do not include recent and unapproved General Rate Case filings in Q3 2021. See Table 7 for the rates used in this analysis. The CPUC data was used for escalation through 2030 after which time the TDV rates were applied.

Table 7: Annual Real Utility Escalation Rate Assumptions

Year	Natural Gas	Electricity
2022	4.6%	1.80%
2023	4.6%	1.80%
2024	4.6%	1.80%
2025	4.6%	1.80%
2026	4.6%	1.80%
2027	4.6%	1.80%
2028	4.6%	1.80%
2029	4.6%	1.80%
2030	4.6%	1.80%
2031	2.0%	0.6%
2032	2.4%	0.6%
2033	2.1%	0.6%
2034	1.9%	0.6%
2035	1.9%	0.6%
2036	1.8%	0.6%
2037	1.7%	0.6%
2038	1.6%	0.6%
2039	2.1%	0.6%
2040	1.6%	0.6%
2041	2.2%	0.6%
2042	2.2%	0.6%
2043	2.3%	0.6%
2044	2.4%	0.6%
2045	2.5%	0.6%
2046	1.5%	0.6%
2047	1.3%	0.6%
2048	1.6%	0.6%
2049	1.3%	0.6%
2050	1.5%	0.6%
2051	1.8%	0.6%

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 considering 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 and Discussion

Table 8 through Table 12 summarize cost-effectiveness of the fuel substitution measures evaluated. Cost-effectiveness analysis was evaluated using both On-Bill and TDV cost-effectiveness criteria. Site energy savings, cost savings, measure cost, and cost-effectiveness including lifecycle B/C ratio and NPV of savings are provided. Where measures are dependent on building vintage (envelope efficiency measures), cost-effectiveness is reported for each vintage. The electric clothes dryer and electric cooking measure results do not differ by vintage.

Greenhouse gas (GHG) savings in lb CO_2e do not represent PCE values, but rather those for PG&E based on the automatically generated outputs of CBECC-Res. It is likely that higher GHG savings are achievable from an increased penetration of renewable energy supply, such as that provided by PCE.

3.1 On-Bill Cost-Effectiveness

The fuel substitution measures are not cost-effective on their own based on the On-Bill approach, with the exception of the SEER 21 heat pump in the pre-1978 vintage single family home. When coupled with PV both the heat pump at HVAC replacement and HPWH at water heater replacement are cost-effective across all vintages. PCE[1] and BayREN[2] each offer a $1,000 incentive for a combined $2,000 incentive for installing a HPWH with a Uniform Energy Factor (UEF) of 3.1 or greater that replaces a gas water heater. These incentives reduce the first incremental cost substantially, enough to make this measure cost-effective across the three vintages for both single family and multifamily building types. Because the incentives only apply to HPWHs with UEFs higher than the federal minimum standard, the cost-effectiveness results for single family cannot be used as the basis of an ordinance. Higher efficiency HPWHs can be installed as an option to an ordinance that is based on minimum efficiency equipment.

BayREN also offers a $1,000 incentive for a space conditioning heat pump with a minimum SEER of 17 and HSPF of 9.4. This incentive improves cost-effectiveness for the high efficiency heat pump measure, enough to result in a positive On-Bill NPV over the lifetime for the single family home pre-1978 and 1978-1991 vintages.

The electric dryer and range measures are not cost-effective on their own. They may be cost-effective if evaluated as a package with PV measures or if incentives were available.

An all-electric package was evaluated for the single family 1978-1991 vintage prototype (Table 10). When PV is included, the package has a positive On-Bill NPV, but without PV it is not cost-effective.

For multifamily buildings, this study assumed the water heater is located in an outdoor closet. Performance of a HPWH will be slightly better if the existing water heater is located inside the unit (in conditioned space) but would create potential sound and comfort issues. Cost to install a HPWH inside the apartment would also be higher and most likely require ducting to properly vent the unit.

3.2 TDV Cost-Effectiveness

Cost-effectiveness improves for the fuel substitution measures based on the 2019 and 2022 TDV metric and all the measures except for the high efficiency heat pump for multifamily and the electric clothes dryer and range/oven are cost-effective based on 2022 TDV. The measures are cost-effective under 2019 TDV when combined with a PV system. PV systems are more cost-effective On-Bill than with the TDV metrics, but the PV packages are all cost-effective based on all metrics. The all-electric single family package is cost-effective based on 2022 TDV both with and without PV. It is only cost-effective under 2019 TDV with PV.

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[1] PCE incentive is currently $1,500 but will be reduced later in 2021 to $1,000. https://www.peninsulacleanenergy.com/heat-pump-water-heater/

[2] https://bayrenresidential.org/sites/default/files/2021-01/BayREN_Home+_Measures_10292020.pdf

Table 8: Single Family Equipment Fuel Substitution Cost-Effectiveness Results – No Incentives

Measure	Vintage	30-year Measure Cost	Annual Electricity Savings (kWh)	Annual Gas Savings (therm)	PG&E Annual GHG Savings (lb CO_2e)	Utility Cost Savings		30-year Customer On-Bill		30-year 2019 TDV		30-year 2022 TDV	
						Year 1	Avg Annual	B/C Ratio	NPV	B/C Ratio	NPV	B/C Ratio	NPV
Heat Pump at HVAC Replacement	Pre-1978	$501	-4,528	451	2,409	-$377	-$57	0.00	-$2,271	0	-$5,462	9.30	$4,160
	1978-1991		-3,173	309	1,606	-$295	-$72	0.00	-$2,710	0	-$2,318	5.68	$2,348
	1992-2010		-2,722	265	1,398	-$262	-$71	0.00	-$2,683	0	-$1,109	4.96	$1,984
SEER 21 Heat Pump at HVAC Replacement	Pre-1978	$3,749	-3,261	451	2,977	-$30	$211	1.56	$2,273	0.92	-$312	3.17	$8,152
	1978-1991		-2,337	309	1,984	-$66	$105	0.77	-$913	0.52	-$1,788	1.96	$3,617
	1992-2010		-2,011	265	1,713	-$67	$79	0.59	-$1,678	0.78	-$825	1.60	$2,244
Heat Pump at HVAC Replacement + 2.82 kW_{DC} PV	Pre-1978	$9,454	-27	451	2,702	$786	$842	2.42	$14,803	1.33	$3,111	2.00	$9,478
	1978-1991		1,328	309	1,899	$868	$826	2.37	$14,339	1.66	$6,222	1.81	$7,637
	1992-2010		1,779	265	1,691	$901	$828	2.38	$14,382	1.79	$7,455	1.77	$7,292
2.0 UEF HPWH[1] at Water Heater Replacement	Pre-1978	$2,594	-1,588	179	1,358	-$114	$0	0.00	-$2,901	0	-$4,546	1.20	$522
	1978-1991		-1,593	181	1,369	-125	-11	0.00	-$3,231	0	-$4,486	1.20	$517
	1992-2010		-1,594	181	1,372	-128	-15	0.00	-$3,334	0	-$4,458	1.18	$466
NEEA Tier 3 HPWH at Replacement	Pre-1978	$2,775	-1,146	177	1,491	$5	$90	0.87	-$387	0.22	-$2,168	1.87	$2,419
	1978-1991		-1,152	179	1,505	-$6	$79	0.77	-$706	0.23	-$2,140	1.87	$2,424
	1992-2010		-1,155	180	1,510	-$9	$76	0.74	-$808	0.24	-$2,116	1.85	$2,359
2.0 UEF HPWH[1] at Water Heater Replacement + 2.82 kW_{DC} PV	Pre-1978	$11,546	2,913	179	1,651	$1,057	$904	2.12	$14,333	1.36	$4,167	1.52	$6,017
	1978-1991		2,908	181	1,662	$1,046	$893	2.09	$13,995	1.37	$4,218	1.52	$6,003
	1992-2010		2,907	181	1,666	$1,042	$889	2.09	$13,893	1.37	$4,246	1.52	$5,956
2.82 kW_{DC} PV + Electric Ready	Pre-1978	$13,044	4,501	0	293	$1,161	$897	1.86	$12,419	1.34	$4,375	1.09	$1,156
	1978-1991		4,485		292	$1,093	$844	1.75	$10,837	1.33	$4,365	1.08	$1,100
	1992-2010		4,400		287	$1,069	$826	1.71	$10,299	1.33	$4,365	1.07	$848
Electric Clothes Dryer	All	$313	-891	33	118	-$182	-$124	0.00	-$4,058	0	-$3,770	0	-$2,242
Electric Range/Oven	All	$608	-295	14	59	-$55	-$35	0.00	-$1,746	0	-$1,692	0	-$1,229

Note 1: The 2.0 Uniform Energy Factor (UEF) represents the minimum federal efficiency standards. However, efficiency standards have not kept pace with equipment efficiency improvements and do not represent the lowest efficiency HPWHs available in California. The UEF=2.0 results likely underestimate the on-bill performance of a market baseline heat pump water heater.

Note 2: Values shaded in **red** indicate option is not cost-effective with B/C ratio less than 1. Values shaded in **green** indicate option is cost-effective with B/C ratio greater than or equal to 1. Cells with "n/a" reflect cases where cost-effectiveness was not evaluated.

Table 9: Single Family On-Bill Cost-Effectiveness Comparison with Incentives

Measure	Vintage	Gross 30-year Measure Cost	PCE/ BayREN Incentive	Net Measure Cost	Year 1 Utility Cost Savings	No Incentive, over 30 years		With Incentive, over 30 years	
						On-Bill B/C Ratio	On-Bill NPV	On-Bill B/C Ratio	On-Bill NPV
SEER 21 Heat Pump at HVAC Replacement	Pre-1978	$3,749	$1,000	$2,749	-$30	1.56	$2,273	2.16	$3,396
	1978-1991				-$66	0.77	-$913	1.07	$209
	1992-2010				-$67	0.59	-$1,678	0.81	-$555
NEEA Tier 3 HPWH at Replacement	Pre-1978	$2,775	$2,000	$775	$5	0.87	-$387	3.20	$1,859
	1978-1991				-$6	0.77	-$706	2.83	$1,540
	1992-2010				-$9	0.74	-$808	2.71	$1,438

Note: Values shaded in **red** indicate option is not cost-effective with B/C ratio less than 1. Values shaded in **green** indicate option is cost-effective with B/C ratio greater than or equal to 1. Cells with "n/a" reflect cases where cost-effectiveness was not evaluated.

Table 10: Single Family All-Electric Home Cost-Effectiveness Results – No Incentives

Measure	Vintage	30-year Measure Cost	Annual Electricity Savings (kWh)	Annual Gas Savings (therm)	PG&E Annual GHG Savings (lb CO_2e)	Utility Cost Savings		30-year Customer On-Bill		30-year 2019 TDV		30-year 2022 TDV	
						Year 1	Avg Annual	B/C Ratio	NPV	B/C Ratio	NPV	B/C Ratio	NPV
All-Electric Package	1978-1991	$7,445	-4,717	543	3,816	-368	-33	0.00	-$9,173	0.01	-$7,600	1.71	$5,255
All-Electric Package w/ PV	1978-1991	$16,398	-216	543	4,110	811	878	1.46	$8,259	1.08	$1,346	1.67	$10,970

Table 11: Multifamily Equipment Fuel Substitution Cost-Effectiveness Results Per Dwelling Unit – No Incentives

Measure	Vintage	30-year Measure Cost	Annual Electricity Savings (kWh)	Annual Gas Savings (therm)	PG&E Annual GHG Savings (lb CO_2e)	Utility Cost Savings		30-year Customer On-Bill		30-year 2019 TDV		30-year 2022 TDV	
						Year 1	Avg Annual	B/C Ratio	NPV	B/C Ratio	NPV	B/C Ratio	NPV
Heat Pump at HVAC Replacement	Pre-1978	$227	-615	61	2,508	-$71	-$28	0	-$1,091	0	-$851	2.60	$363
	1978-1991		-402	40	1,585	-$47	-$19	0	-$833	0	-$678	1.53	$119
	1992-2010		-337	34	1,378	-$39	-$16	0	-$726	0	-$590	1.40	$91
SEER 21 Heat Pump at HVAC Replacement	Pre-1978	$3,245	-453	61	3,084	-$26	$7	0.06	-$3,317	0.20	-$2,585	0.60	-$1,311
	1978-1991		-294	40	1,972	-$17	$4	0.03	-$3,401	0.14	-$2,782	0.41	-$1,900
	1992-2010		-254	34	1,683	-$16	$2	0.02	-$3,459	0.02	-$3,191	0.33	-$2,184
Heat Pump at HVAC Replacement + 1.67 kW_{DC} PV	Pre-1978	$4,785	2,044	61	3,894	$616	$503	2.86	$9,808	2.03	$4,909	1.88	$4,224
	1978-1991		2,257	40	2,971	$640	$511	2.91	$10,060	2.06	$5,075	1.83	$3,974
	1992-2010		2,322	34	2,764	$598	$477	2.71	$9,026	2.08	$5,163	1.82	$3,941
2.0 UEF HPWH[1] at Water Heater Replacement	Pre-1978	$2,594	-1,037	141	8,868	-$74	$0	0	-$2,882	0	-$3,042	1.29	$753
	1978-1991		-1,037	141	8,868	-$74	$0	0	-$2,891	0	-$3,042	1.29	$753
	1992-2010		-1,037	141	8,868	-$74	$0	0	-$2,891	0	-$3,042	1.29	$753
NEEA Tier 3 HPWH at Replacement	Pre-1978	$2,775	-842	141	9,561	-$20	$42	0.41	-$1,826	0.29	-$1,961	1.57	$1,591
	1978-1991		-842	141	9,561	-$20	$42	0.41	-$1,835	0.29	-$1,961	1.57	$1,591
	1992-2010		-842	141	9,561	-$20	$42	0.41	-$1,835	0.29	-$1,961	1.57	$1,591
2.0 UEF HPWH[1] at Water Heater Replacement + 1.67 kW_{DC} PV	Pre-1978	$7,152	1,623	141	10,254	$621	$537	2.03	$8,188	1.41	$2,905	1.67	$4,806
	1978-1991		1,623	141	10,254	$620	$537	2.03	$8,176	1.41	$2,902	1.67	$4,803
	1992-2010		1,623	141	10,254	$620	$536	2.03	$8,171	1.41	$2,899	1.67	$4,797
1.67 kW_{DC} PV + Electric Ready	Pre-1978	$8,650	2,660	0	1,386	$608	$470	1.46	$4,470	1.19	$1,650	0.97	-$239
	1978-1991		2,655		1,384	$600	$463	1.44	$4,276	1.18	$1,573	0.97	-$257
	1992-2010		2,578		1,343	$578	$447	1.39	$3,778	1.16	$1,392	0.94	-$493
Electric Clothes Dryer	All	$313	-671	25	898	-$148	-$104	0	-$3,471	0	-$2,888	0	-$1,764
Electric Range/Oven	All	$608	-232	11	395	-$48	-$32	0	-$1,652	0	-$1,737	0	-$1,073

Note 1: The 2.0 Uniform Energy Factor (UEF) represents the minimum federal efficiency standards. However, efficiency standards have not kept pace with equipment efficiency improvements and do not represent the lowest efficiency HPWHs available in California. The UEF=2.0 results likely underestimate the on-bill performance of a market baseline heat pump water heater.

Note 2: Values shaded in **red** indicate option is not cost-effective with B/C ratio less than 1. Values shaded in **green** indicate option is cost-effective with B/C ratio greater than or equal to 1. Cells with "n/a" reflect cases where cost-effectiveness was not evaluated.

Table 12: Multifamily On-Bill Cost-Effectiveness Comparison with Incentives

Measure	Vintage	Gross 30-year Measure Cost	PCE/ BayREN Incentive	Net Measure Cost	Year 1 Utility Cost Savings	No Incentive, over 30 years		With Incentive, over 30 years	
						On-Bill B/C Ratio	On-Bill NPV	On-Bill B/C Ratio	On-Bill NPV
SEER 21 Heat Pump at HVAC Replacement	Pre-1978	$3,245	$1,000	$2,245	-$26	0.06	-$3,317	0.08	-$2,194
	1978-1991				-$17	0.03	-$3,401	0.05	-$2,278
	1992-2010				-$16	0.02	-$3,459	0.02	-$2,336
NEEA Tier 3 HPWH at Replacement	Pre-1978	$2,775	$2,000	$775	-$20	0.41	-$1,826	1.50	$420
	1978-1991				-$20	0.41	-$1,835	1.49	$411
	1992-2010				-$20	0.41	-$1,835	1.49	$411

Note: Values shaded in **red** indicate option is not cost-effective with B/C ratio less than 1. Values shaded in **green** indicate option is cost-effective with B/C ratio greater than or equal to 1. Cells with "n/a" reflect cases where cost-effectiveness was not evaluated.

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5 Appendices

5.1 Utility Tariff Details

5.1.1 PCE

Following are the PCE electricity tariffs applied in this study. The “Rate with PG&E Surchages” was used in place of PG&E’s generation rate. PG&E’s net energy metering (NEM) rules are applied. Additionally, monthly net energy production is credited at $0.01/kWh in addition to the retail rate at the hour of generation.

RESIDENTIAL CUSTOMER RATES

Rates Effective April 1, 2021

PENINSULA CLEAN ENERGY

RATE SCHEDULE	SCHEDULE TIMES	ENERGY CHARGE $/kWh		
		GENERATION RATE	RATE WITH PG&E SURCHARGES[1]	3.1.21 PG&E GENERATION RATE
E-TOU-C (PG&E equivalent: E-TOU-C)				
SUMMER - June 1 through September 30				
PEAK	4 pm to 9 pm every day	$ 0.10773	$ 0.15577	$ 0.16397
OFF-PEAK	All other hours	$ 0.05696	$ 0.10500	$ 0.11053
WINTER - October 1 through May 31				
PEAK	4 pm to 9 pm every day	$ 0.06141	$ 0.10945	$ 0.11521
OFF-PEAK	All other hours	$ 0.04713	$ 0.09517	$ 0.10018

5.1.2 PG&E

Following are the PG&E electricity tariffs applied in this study for non-generation rates. The electricity baseline territory used for Climate Zone 3 is T.

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

RATES: (Cont'd.)

UNBUNDLING OF E-TOU-C TOTAL RATES

Energy Rates by Component ($ per kWh)	PEAK		OFF-PEAK	
Generation:				
Summer (all usage)	$0.16397	(I)	$0.11053	(I)
Winter (all usage)	$0.11521	(I)	$0.10018	(I)
Distribution:**				
Summer (all usage)	$0.14292	(I)	$0.13292	(I)
Winter (all usage)	$0.09459	(I)	$0.09229	(I)

Conservation Incentive Adjustment (Baseline Usage)	($0.02659)	(R)
Conservation Incentive Adjustment (Over Baseline Usage)	$0.04925	(I)
Transmission* (all usage)	$0.03704	
Transmission Rate Adjustments* (all usage)	($0.00248)	(R)
Reliability Services* (all usage)	$0.00017	
Public Purpose Programs (all usage)	$0.01575	(I)
Nuclear Decommissioning (all usage)	$0.00093	
Competition Transition Charges (all usage)	$0.00004	
Energy Cost Recovery Amount (all usage)	$0.00032	
Wildfire Fund Charge (all usage)	$0.00580	
New System Generation Charge (all usage)**	$0.00442	

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

(Continued)

Advice	6090-E-A	*Issued by*	*Submitted*	February 26, 2021
Decision		***Robert S. Kenney***	*Effective*	March 1, 2021
		Vice President, Regulatory Affairs	*Resolution*	

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

SPECIAL CONDITIONS:

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

BASELINE QUANTITIES (kWh PER DAY)

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

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

Summer (service from June 1 through September 30):

Peak: 4:00 p.m. to 9:00 p.m. All days

Off-Peak: All other times

Winter (service from October 1 through May 31):

Peak: 4:00 p.m. to 9:00 p.m. All days

Off-Peak: All other times

* The applicable baseline territory is described in Part A of the Preliminary Statement

(Continued)

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

The following provide details on the PG&E 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 2021 according to the rates shown in Table 13. The natural gas baseline territory used for Climate Zone 3 is T.

Table 13: PG&E Monthly Gas Rate ($/therm)

Month	Procurement Charge	Transportation Charge		Total Charge	
		Baseline	Excess	Baseline	Excess
Jan 2021	$0.49332	$1.09586	$1.53752	$1.58918	$2.03084
Feb 2021	$0.49073	$1.09586	$1.53752	$1.58659	$2.02825
Mar 2021	$0.42316	$1.19868	$1.68034	$1.62184	$2.1035
Apr 2020	$0.23856	$1.13126	$1.64861	$1.36982	$1.88717
May 2020	$0.23187	$1.13126	$1.64861	$1.36313	$1.88048
June 2020	$0.24614	$1.13126	$1.64861	$1.3774	$1.89475
July 2020	$0.23892	$1.13126	$1.64861	$1.37018	$1.88753
Aug 2020	$0.28328	$1.13126	$1.64861	$1.41454	$1.93189
Sept 2020	$0.41891	$1.13126	$1.64861	$1.55017	$2.06752
Oct 2020	$0.38068	$1.13416	$1.65280	$1.51484	$2.03348
Nov 2020	$0.46046	$1.13416	$1.65280	$1.59462	$2.11326
Dec 2020	$0.48474	$1.13416	$1.65280	$1.6189	$2.13754

GAS SCHEDULE G-1 Sheet 2
RESIDENTIAL SERVICE

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

BASELINE QUANTITIES (Therms Per Day Per Dwelling Unit)

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

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

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