CALIFORNIA ENERGY CODES & STANDARDS
A STATEWIDE UTILITY PROGRAM

2019 Cost-Effectiveness Study:
2020 Analysis of Residential Construction Cost Effectiveness – City of Glendale

Last Modified: 2021-03-10

Prepared by:
Frontier Energy, Inc.
Misti Bruceri & Associates, LLC

Prepared for:
Kelly Cunningham
Codes and Standards Program
Pacific Gas and Electric Company

SDGE A Sempra Energy utility
SoCalGas A Sempra Energy utility
Southern California Edison Energy for What's Ahead
Pacific Gas and Electric Company

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.

Neither PG&E nor any of its employees makes any warranty, express or implied; or assumes any legal liability or responsibility for the accuracy, completeness or usefulness of any data, information, method, product, policy, or process disclosed in this document; or represents that its use will not infringe any privately-owned rights including, but not limited to, patents, trademarks, or copyrights.

Acronym List

2020 PV$	Present value costs in 2020
B/C	Benefit-to-Cost Ratio
BSC	Building Standards Commission
CALGreen	California Green Building Standards Code (California Code of Regulations Title 24, Part 11)
CFM	Cubic Feet per Minute
CZ	California Climate Zone
HERS	Home Energy Rating System Rater
HPWH	Heat Pump Water Heater
IOU	Investor-Owned Utility
kWh	Kilowatt Hour
kW_{DC}	Kilowatt Direct Current. Nominal rated power of a photovoltaic system
LCC	Lifecycle Cost
NEM	Net Energy Metering
NPV	Net Present Value
PG&E	Pacific Gas and Electric Company
PV	Photovoltaic
SHGC	Solar Heat Gain Coefficient
CASE	Codes and Standards Enhancement
TDV	Time Dependent Valuation
Therm	Unit for quantity of heat that equals 100,000 British thermal units
Title 24	California Code of Regulations Title 24, Part 6

TABLE OF CONTENTS

LIST OF TABLES

List of Figures

NO TABLE OF FIGURES ENTRIES FOUND.

1 Introduction

The California Codes and Standards Reach Codes program provides technical support to local governments considering adopting a local ordinance (reach code) intended to support meeting local and/or statewide energy and greenhouse gas (GHG) reduction goals. The program facilitates adoption and implementation of the code when requested by local jurisdictions by providing resources such as cost-effectiveness studies, model language, sample findings, and other supporting documentation. 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, or Title 24, Part 6 (Title 24) (California Energy Commission, 2018a) is maintained and updated every three years by two state agencies: the California Energy Commission (Energy Commission) and the Building Standards Commission (BSC). In addition to enforcing the code, local jurisdictions have the authority to adopt local energy efficiency ordinances—or reach codes—that exceed the minimum standards defined by Title 24 (as established by Public Resources Code Section 25402.1(h)2 and Section 10-106 of the Building Energy Efficiency Standards). Local jurisdictions must demonstrate that the requirements of the proposed ordinance are cost-effective and result in buildings consuming less energy than is permitted by Title 24. In addition, the jurisdiction must obtain approval from the Energy Commission and file the ordinance with the BSC for the ordinance to be legally enforceable.

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

This analysis was conducted for the City of Glendale to present results from the Reach Code Team residential statewide analyses for Climate Zone 9 using Glendale Water and Power (GWP) electric rates. The evaluation covers the following residential new construction building types: single family, low-rise multifamily (1 to 3 habitable stories), mid-rise multifamily (4 to 7 habitable stories), and high-rise multifamily (8 and above habitable stories). It also covers energy retrofits for single family existing homes. This analysis builds upon the results of the statewide reports which evaluated all sixteen California climate zones.

2 Methodology and Assumptions

The same methodology used in the statewide analyses was applied to this analysis except local GWP electric utility tariffs were used in place of SCE tariffs. Refer to the following statewide studies for further details:

- *2019 Cost-Effectiveness Study: Low-Rise Residential New Construction* (Statewide Reach Code Team, 2019)
- *2019 Mid-Rise New Construction Reach Code Cost-Effectiveness Study* (Statewide Reach Code Team, 2020)
- *2019 Cost-Effectiveness Study: 2020 Analysis of High-Rise Residential New Construction* (Statewide Reach Code Team, 2021a)
- *2019 Cost-Effectiveness Study: Existing Single Family Residential Building Upgrades* (Statewide Reach Code Team, 2021b)

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 impacts 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 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 et al, 2014). This is the methodology used by the Energy Commission in evaluating cost-effectiveness for efficiency measures in Title 24, Part 6. 2019 TDV is used for all analyses presented in this report. Additionally, 2022 TDV is used for the high-rise multifamily new construction and existing single family upgrades.[1]

On-Bill analysis was completed using the utility rates described in Table 1. GWP and SoCalGas residential rates are used for the single family and low-rise multifamily buildings and the in-unit portion of the mid-rise and high-rise multifamily buildings. Central water heating in the mid-rise and high-rise multifamily buildings is metered separately and therefore was evaluated under GWP's commercial electric rate and SoCalGas' multifamily service.

GWP L-1-A and L-1-D are volumetric rates with three tiers. They are identical except that L-1-D allows for customer owned generation under the Net Energy Metering (NEM) Resolution which allows for energy generated and sent to the grid to be credited at the retail rate. At the end of the 12-month period if the customer is a net electricity generator, the customer is compensated for excess kilowatt-hours at the feed-in-tariff price. In this analysis the Statewide Reach Code Team used the Q1 2021 feed-in-tariff price of $0.05753 per kWh.

L-1-D is used when onsite photovoltaics (PV) are included in the building design. In multifamily buildings the Statewide Reach Code Team assumed either virtual NEM is available or individual PV systems are connected to each residential electric meter. In the latter case no additional metering costs were considered.

[1] The 2022 TDV was not available at the time the low-rise and mid-rise residential new construction statewide analyses were conducted.

The central electric water heating in the mid-rise and high-rise buildings uses greater than 5,000 kWh monthly and therefore qualifies for the LD-2-A rate, which includes demand in addition to volumetric charges. The designs are evaluated under both the LD-2-A and the L-2-A rate to demonstrate the impact of the demand charge on total costs. L-2-A is also applied to the central gas water heating cases for the electric load which is primarily represented by hot water recirculation pumping.

See Appendix A – Utility Tariff Details for details on the tariffs applied.

Table 1: Utility Tariffs Applied Based on Case

Case	Electricity (GWP)	Natural Gas (SoCalGas)
Residential Dwelling Unit Energy	L-1-A L-1-D (with PV)	GR
Central Water Heating (for mid-rise and high-rise buildings only)	L-2-A and LD-2-A	GM-E

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

Utility rates are assumed to escalate over time, using assumptions from research conducted by Energy and Environmental Economics (E3) in the 2019 study Residential Building Electrification in California (Energy & Environmental Economics, 2019). Escalation of electric utility rates for GWP was not available and the assumptions used in this analysis are based on those from the statewide studies (Statewide Reach Code Team, 2019). Natural gas escalation between 2019 and 2022 is based on the currently filed General Rate Cases (GRCs) for SoCalGas. Consistent with the E3 study, gas rates are assumed to escalate at four percent per year above inflation from 2023 through 2025, which reflects historical rate increases between 2013 and 2018. Escalation of electricity rates from 2019 through 2025 is assumed to be two percent per year above inflation, based on electric utility estimates. After 2025, escalation rates for both natural gas and electric rates are assumed to drop to a more conservative one percent escalation per year above inflation for long-term rate trajectories beginning in 2026 through 2050. See Appendix A – Utility Tariff Details for additional details.

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.

2.1 Single Family and Low-Rise Multifamily New Construction

Three to four packages were evaluated for each prototype, as described below.

1. **Efficiency – Non-Preempted**: This package uses only efficiency measures that do not trigger federal preemption issues including envelope, and water heating and duct distribution efficiency measures.
2. **Efficiency – Equipment, Preempted**: This package shows an alternative design that applies HVAC and water heating equipment that are more efficient than federal standards. The Reach Code Team considers this more reflective of how builders meet above code requirements in practice. Note that this is a representative package only and may not be used to demonstrate cost-effectiveness for the purpose of an ordinance.
3. **Efficiency & PV**: Using the Efficiency – Non-Preempted Package as a starting point, PV capacity is added to offset most of the estimated electricity use. This only applies to the all-electric case, since for the mixed fuel cases, 100 percent of the projected electricity use is already being offset as required by 2019 Title 24.
4. **Efficiency & PV/Battery**: Using the Efficiency & PV Package as a starting point, PV capacity is added as well as a battery storage system.

In comparing mixed fuel and all-electric cases, three scenarios were evaluated for each prototype:

1. **2019 Code Compliant**: Compares a 2019 code compliant all-electric home with a 2019 code compliant mixed fuel home.
2. **Efficiency & PV Package**: Compares an all-electric home with efficiency and PV sized to 90 percent of the annual electricity use to a 2019 code compliant mixed fuel home. The first cost savings in the code

compliant all-electric house is invested in above code efficiency and PV reflective of the Efficiency & PV packages described above.

3. **Neutral Cost Package**: Compares an all-electric home with PV beyond code minimum with a 2019 code compliant mixed fuel home. The PV system for the all-electric case is sized to result in a zero lifetime incremental cost relative to a mixed fuel home.

Refer to the *2019 Cost-Effectiveness Study: Low-Rise Residential New Construction* report (Statewide Reach Code Team, 2019) for further details on building prototypes used and efficiency measures evaluated.

2.2 Mid-Rise and High-Rise Multifamily New Construction

Four packages were evaluated as described below.

1. **Efficiency – Mixed-Fuel**: This package applies efficiency measures that don't trigger federal preemption including envelope, water heating distribution, and duct distribution efficiency measures.
2. **Efficiency – All Electric**: This package applies efficiency measures that don't trigger federal preemption in addition to converting any natural gas appliances to electric appliances. For the residential spaces, only water heating is converted from natural gas to electric.
3. **Efficiency & PV – Mixed-Fuel**: Beginning with the Efficiency Package, PV was added to offset a portion of the apartment estimated electricity use.
4. **Efficiency & PV – All Electric**: Beginning with the Efficiency Package, PV was added to offset a portion of the apartment estimated electricity use.

Refer to the statewide mid-rise and high-rise studies (Statewide Reach Code Team, 2020) and (Statewide Reach Code Team, 2021a) for further details on building prototypes used and efficiency measures evaluated.

2.3 Single Family Existing Buildings

The primary objective of the evaluation is to identify cost-effective energy upgrade measures and packages for existing single family buildings to support the design of local ordinances requiring upgrades, which may be triggered by different events, such as at the time of a significant remodel or addition. Cost-effectiveness analysis was completed based on the single family existing homes prototype and designs representing building features commonly used during three vintage periods.

Refer to the *2019 Cost-Effectiveness Study: Existing Single Family Residential Building Upgrades* (Statewide Reach Code Team, 2021b) for further details on building assumptions used and efficiency measures evaluated.

3 Results and Discussion

3.1 Single Family and Low-Rise Multifamily New Construction

This analysis found cost-effective, non-preempted packages for both single family and low-rise multifamily buildings, under both mixed fuel and all-electric cases. The results of this analysis can be used by the City of Glendale to support the adoption of reach codes.

For the efficiency-only packages, measures were refined to ensure that the non-preempted package was cost-effective based on one of the two metrics applied in this study: TDV or On-Bill. The preempted equipment package, which the Reach Code Team considers to be a package of upgrades most reflective of what builders commonly apply to exceed code requirements, was designed to be cost-effective based on the On-Bill cost-effectiveness approach. The packages presented are representative examples of designs and measures that can be used to meet the requirements. In practice, a builder can use any combination of non-preempted or preempted compliant measures to meet the requirements.

Table 2 summarizes recommended target EDR reductions by case. Results are presented as EDR Margin instead of compliance margin. EDR is the metric used to determine code compliance for residential buildings in the 2019 cycle. Target EDR Margin is based on taking the calculated EDR Margin for the case and rounding down to the next half of a whole number. The maximum Target EDR Margin for the Efficiency Package is defined based on the EDR Margin of the non-preempted package. Although the equipment, preempted package often results in better performance, it may not be used as the basis for a local ordinance.

Table 2: Summary of Target Total EDR Reductions for Climate Zone 9

Climate Zone	Mixed Fuel		All-Electric		
	Efficiency	Efficiency & PV/Battery	Efficiency	Efficiency & PV	Efficiency & PV/Battery
Single Family	2.5	8.5	2.5	11.5	21.0
Low-Rise Multifamily	1.5	9.5	1.5	11.0	23.0

Table 3 and Table 4 present total energy cost savings over the 30-year analysis period and B/C ratios for single family and low-rise multifamily homes, respectively. All packages are cost-effective based on the On-Bill approach except for the Efficiency Non-Preempted and Efficiency & PV/Battery packages. All packages are cost-effective based on TDV.

Table 3: Single Family City of Glendale Climate Zone 9 Cost-Effectiveness Results Summary

Climate Zone 9 GWP/SoCalGas Single Family		Annual Net kWh	Annual therms	EDR Margin[4]	Average Annual Utility Cost Savings (2020 PV$)	First Incremental Cost ($)		Lifetime Incremental Cost (2020 PV$)		B/C Ratio	
						On-Bill	TDV	On-Bill	TDV	On-Bill	TDV
Mixed Fuel[1]	Code Compliant	0	229	n/a	n/a	n/a		n/a		n/a	n/a
	Efficiency-Non-Preempted	0	216	2.5	$14	$871		$912		0.47	1.97
	Efficiency-Equipment	0	201	2.5	$30	$445		$574		1.55	3.66
	Efficiency & PV/Battery	(14)	216	8.5	$17	$4,111		$4,785		0.10	1.48
All-Electric[2]	Code Compliant	2,801	0	n/a	n/a	n/a		n/a		n/a	n/a
	Efficiency-Non-Preempted	2,645	0	2.5	$20	$1,101		$1,180		0.51	1.96
	Efficiency-Equipment	2,460	0	3.0	$42	$629		$846		1.50	3.69
	Efficiency & PV	745	0	11.5	$246	$4,863		$5,778		1.28	1.64
	Efficiency & PV/Battery	(9)	0	21.0	$334	$9,579		$11,454		0.87	1.53
Mixed Fuel to All-Electric[3]	Code Compliant	2,801	0	0.0	($37)	($6,171)	($12,257)	($5,349)	($11,872)	4.86	2.90
	Efficiency & PV	745	0	11.5	$209	($1,308)	($7,394)	$429	($6,094)	15	>1
	Neutral Cost	594	0	10.0	$226	($1,786)	($7,872)	$0	($6,513)	>1	>1

[1] All reductions and incremental costs relative to the **mixed fuel** code compliant home.
[2] All reductions and incremental costs relative to the **all-electric** code compliant home.
[3] All reductions and incremental costs relative to the **mixed fuel** code compliant home except the EDR Margins are relative to the Standard Design for each case which is the **all-electric** code compliant home. Incremental costs for these packages reflect the costs used in the On-Bill cost-effectiveness methodology. Costs differ for the TDV methodology due to differences in the site gas infrastructure costs.
[4] This represents the Efficiency EDR Margin for the Efficiency-Non-Preempted and Efficiency-Equipment packages and Total EDR Margin for the Efficiency & PV, Efficiency & PV/Battery, and Neutral Cost packages.

Table 4: Low-Rise Multifamily City of Glendale Climate Zone 9 Cost-Effectiveness Results Summary

Climate Zone 9 GWP/SoCalGas Multifamily		Annual Net kWh	Annual therms	EDR Margin[4]	Average Annual Utility Cost Savings (2020 PV$)	First Incremental Cost ($)		Lifetime Incremental Cost (2020 PV$)		B/C Ratio	
						On-Bill	TDV	On-Bill	TDV	On-Bill	TDV
Mixed Fuel[1]	Code Compliant	0	111	n/a	n/a	n/a		n/a		n/a	n/a
	Efficiency-Non-Preempted	0	109	1.5	$2	$140		$136		0.54	3.35
	Efficiency-Equipment	0	101	2.5	$11	$204		$274		1.18	2.87
	Efficiency & PV/Battery	(7)	109	9.5	$4	$1,892		$2,234		0.05	1.49
All-Electric[2]	Code Compliant	1,468	0	n/a	n/a	n/a		n/a		n/a	n/a
	Efficiency-Non-Preempted	1,414	0	1.5	$7	$216		$231		0.85	2.70
	Efficiency-Equipment	1,334	0	1.5	$15	$270		$361		1.28	2.26
	Efficiency & PV	441	0	11.0	$118	$1,813		$2,232		1.59	1.91
	Efficiency & PV/Battery	(7)	0	23.0	$170	$4,287		$5,236		0.97	1.67
Mixed Fuel to All-Electric[3]	Code Compliant	1,468	0	0.0	($0.12)	($3,361)	($6,684)	($2,337)	($5,899)	673	2.55
	Efficiency & PV	55	0	11.0	$118	($1,548)	($4,872)	($104)	($3,667)	>1	>1
	Neutral Cost	331	0	11.0	$130	($1,495)	($4,819)	$0	($3,561)	>1	>1

[1] All reductions and incremental costs relative to the **mixed fuel** code compliant home.
[2] All reductions and incremental costs relative to the **all-electric** code compliant home.
[3] All reductions and incremental costs relative to the **mixed fuel** code compliant home except the EDR Margins are relative to the Standard Design for each case which is the **all-electric** code compliant home. Incremental costs for these packages reflect the cots used in the On-Bill cost-effectiveness methodology. Costs differ for the TDV methodology due to differences in the site gas infrastructure costs.
[4] This represents the Efficiency EDR Margin for the Efficiency-Non-Preempted and Efficiency-Equipment packages and Total EDR Margin for the Efficiency & PV, Efficiency & PV/Battery, and Neutral Cost packages.

3.2 Mid-Rise and High-Rise Multifamily New Construction

This analysis found cost-effective, non-preempted packages for mid-rise multifamily buildings under both mixed-fuel and all-electric cases. The results of this analysis can be used by the City of Glendale to support the adoption of reach codes. The packages presented are representative examples of designs and measures that can be used to meet the requirements. In practice, a builder can use any combination of non-preempted or preempted compliant measures to meet the requirements.

This analysis evaluated a package of efficiency measures applied to a mixed-fuel design and a similar package for an all-electric design. PV was also evaluated in conjunction with the efficiency packages. The base case prototype model assumes individual heat pumps for space heating and all-electric appliances in the dwelling units; therefore, the central domestic hot water system is the only equipment serving the dwelling unit spaces that was electrified in the all-electric design.

The Statewide Reach Codes Team evaluated two configurations for electric HPWHs. The clustered design uses residential integrated storage HPWHs to serve more than one dwelling unit and was evaluated for both the mid-rise and high-rise prototypes. A central HPWH with recirculation which meets the 2019 Title 24 prescriptive approach for central heat pump water heating systems was also evaluated for the high-rise prototype (California Energy Commission, 2019b).

Table 5 and Table 6 present results for the mid-rise and high-rise buildings, respectively. The results show cost-effectiveness for Efficiency Only and Efficiency plus PV packages (assuming a PV system sized based on 0.1 kW_{DC} per dwelling unit). Both mixed-fuel and all-electric results are relative to a mixed-fuel 2019 Title 24 prescriptive baseline (with gas water heating and heat pump space heating). B/C ratios for all packages are presented according to both the On-Bill and TDV methodologies.

The compliance margins for the mixed-fuel cases range from 6.5 to 7.6 percent, which meet the CALGreen Tier 1 energy performance requirement for high-rise residential buildings of 5 percent. The mixed fuel packages are cost effective based on TDV and On-Bill methodologies, both with and without PV.

The all-electric packages were evaluated differently for the mid-rise and high-rise prototypes due to timing between the release of enhanced HPWH modeling capabilities in the CBECC-Com compliance software relative to completion of the two reports. The clustered HPWH design was evaluated for both buildings while the central recirculation design was only evaluated for high-rise.[2] The clustered design is cost effective On-Bill for both mid-rise and high-rise buildings using GWP's L-2-A small business electric tariff. If the project is not eligible for this tariff and instead falls under the LD-2-A medium business tariff, none of the evaluated HPWH scenarios are cost effective. While the volumetric charge under LD-2-A is lower than under L-2-A, the LD-2-A includes demand charges that result in higher overall electric utility costs. The central recirculation HPWH design in the high-rise building is not cost-effective under either L-2-A or LD-2-A tariffs. Adding PV to the all-electric packages improves cost effectiveness slightly and is cost-effective when evaluated under the L-2-A tariff, but still not cost-effective under the LD-2-A tariff.

All cases are cost effective based on TDV except for the central recirculation HPWH in the high-rise building under 2019 TDV.

[2] For further details refer to the statewide reports (Statewide Reach Code Team, 2020) (Statewide Reach Code Team, 2021a).

Table 5: Mid-Rise Multifamily Results (Per Dwelling Unit)[1]

Case	PV[2]	Total Electric Savings (kWh)	Total Gas Savings (therm)	Comp. Margin	Lifetime Incremental Cost (2020 PV$)	On-Bill (L-2-A[3])			On-Bill (LD-2-A[3])			2019 TDV	
						Avg. Annual Utility Cost Savings (2020 PV$)	B/C Ratio	NPV	Avg. Annual Utility Cost Savings (2020 PV$)	B/C Ratio	NPV	B/C Ratio	NPV
Mixed Fuel	n/a	83	0	6.5%	$144	$12	2.4	$204	n/a			3.1	$297
	0.1 kW	246	0	6.5%	$460	$33	2.2	$532				2.4	$631
All-Electric Clustered	n/a	(633)	104	3.8%	($561)	$22	>1	$1,211	($55)	0.3	($1,089)	>1	$1,300
	0.1 kW	(469)	104	3.8%	($244)	$43	>1	$1,538	($34)	0.2	($762)	>1	$1,634

[1] Values in red indicate B/C ratios less than 1.
[2] PV capacity per dwelling unit in kW_{DC}.
[3]Results are presented comparing two commercial electric tariffs for the central water heating system. Gas and dwelling unit electric tariffs are the same under both scenarios.

Table 6: High-Rise Multifamily Results (Per Dwelling Unit)[1]

Case	PV[2]	Total Electric Savings (kWh)	Total Gas Savings (therm)	Comp. Margin	Lifetime Incremental Cost (2020 PV$)	On-Bill (L-2-A[3])			On-Bill (LD-2-A[3])			2019 TDV		2022 TDV	
						Avg. Annual Utility Cost Savings (2020 PV$)	B/C Ratio	NPV	Avg. Annual Utility Cost Savings (2020 PV$)	B/C Ratio	NPV	B/C Ratio	NPV	B/C Ratio	NPV
Mixed Fuel	n/a	125	0	7.6%	$144	$18	3.8	$398	n/a			4.2	$461	3.9	$413
	0.1 kW	303	0	7.6%	$460	$43	2.8	$836				2.8	$807	2.5	$697
All-Electric Clustered	n/a	(503)	76	1.9%	($715)	$12	>1	$1,085	($53)	0.4	($878)	>1	$1,062	>1	$2,202
	0.1 kW	(325)	76	3.4%	($399)	$37	>1	$1,524	($28)	0.5	($440)	>1	$1,407	>1	$2,486
All-Electric Central	n/a	(428)	76	4.2%	$702	$22	0.9	($35)	$4	0.2	($588)	0.9	($64)	2.7	$1,217
	0.1 kW	(250)	76	5.8%	$1,018	$47	1.4	$403	$29	0.9	($150)	1.3	$281	2.5	$1,501

[1] Values in red indicate B/C ratios less than 1.
[2] PV capacity per dwelling unit in kW_{DC}.
[3]Results are presented comparing two commercial electric tariffs for the central water heating system. Gas and dwelling unit electric tariffs are the same under both scenarios.

3.3 Single Family Existing Buildings

Table 7 through Table 10 summarize cost-effectiveness of the efficiency measures and packages 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. Some measure results do not differ by vintage such as LED lamp replacement and water heating upgrades.

3.3.1 On-Bill Cost Effectiveness

Efficiency measures that are cost-effective On-Bill include attic insulation in the pre-1978 vintage home and duct sealing, new ducts, and cool roof (at time of roof replacement) in the two older vintages. Some of the envelope packages combining attic insulation and duct measures are also cost-effective On-Bill in the two older vintages. The water heating and LED lighting measures are cost-effective in all cases.

Adding a PV system is cost-effective in all cases based on the On-Bill approach. However, when this is coupled with a battery storage system it is no longer cost-effective.

The fuel substitution measures are not cost-effective on their own based on the On-Bill approach. However, when they are coupled with PV both the heat pump at HVAC replacement and HPWH at water heater replacement are cost-effective across all vintages.

3.3.2 TDV Cost Effectiveness

Cost effectiveness improves for most measures based on the 2019 and 2022 TDV metric. Additional measures or measures in additional home vintages become cost-effective based on 2019 and 2022 TDV including attic insulation, duct sealing, cool roof (at time of roof replacement), wall insulation, envelope and duct packages, heat pump at HVAC replacement, and HPWH at water heater replacement. PV system installation is more cost-effective On-Bill using GWP rates than with the TDV metrics but is still cost-effective in all cases. Cost effectiveness improves with TDV when a battery system is coupled with PV.

Table 7: Single Family Efficiency Upgrade Cost-Effectiveness Results – Climate Zone 9

Measure	Vintage	Measure Cost (2020 PV$)	Electricity Savings (kWh)	Gas Savings (therms)	Utility Cost Savings		Customer On-Bill		2019 TDV		2022 TDV	
					Year 1	Avg Annual	B/C Ratio	NPV	B/C Ratio	NPV	B/C Ratio	NPV
R-49 Attic Insulation	Pre-1978	$3,332	840	19	$210	$168	1.35	$1,306	2.22	$4,054	2.04	$3,463
	1978-1991	$2,874	455	9	$112	$90	0.84	-$530	1.36	$1,021	1.21	$603
	1992-2010	$2,333	115	3	$27	$22	0.31	-$1,432	0.73	-$507	0.66	-$631
Reduced Infiltration	Pre-1978	$1,474	25	6	$13	$11	0.20	-$1,331	0.55	-$665	0.44	-$826
	1978-1991		12	3	$7	$6	0.11	-$1,480	0.29	-$1,042	0.35	-$956
	1992-2010		7	2	$4	$3	0.06	-$1,551	0.26	-$1,094	0.21	-$1,169
Duct Sealing	Pre-1978	$683	544	11	$138	$110	4.32	$2,543	10.65	$6,593	8.86	$5,372
	1978-1991	$683	322	6	$79	$63	2.48	$1,137	6.75	$3,929	5.26	$2,909
	1992-2010	$423	54	2	$13	$10	0.66	-$162	2.38	$582	1.76	$320
New Ducts	Pre-1978	$3,986	1,018	21	$256	$205	1.37	$1,675	3.28	$9,068	2.79	$7,144
	1978-1991		764	13	$188	$150	1.01	$38	2.55	$6,165	2.17	$4,670
	1992-2010		198	5	$47	$38	0.25	-$3,337	0.86	-$573	0.64	-$1,437
Cool Roof	Pre-1978	$778	396	-3	$85	$67	2.30	$1,136	4.13	$2,437	3.75	$2,137
	1978-1991		284	-2	$61	$48	1.64	$559	2.91	$1,486	2.68	$1,305
	1992-2010		128	-2	$24	$18	0.63	-$320	1.63	$490	1.29	$225
Wall Insulation	Pre-1978	$3,360	170	21	$63	$52	0.42	-$2,205	1.02	$62	0.88	-$393
Windows	Pre-1978	$9,810	1,141	0	$252	$199	0.54	-$5,038	0.94	-$621	0.82	-$1,719
	1978-1991		929	0	$203	$160	0.44	-$6,203	0.78	-$2,122	0.70	-$2,897
LED lamp vs CFL	All	$2.26	1.2	0	$0.24	$0.19	2.50	$3.38	n/a	n/a	n/a	n/a
Exterior photosensor	All	$42.58	12.1	0	$2.39	$1.89	1.33	$14.06	n/a	n/a	n/a	n/a

[1] Values in red and grey shaded rows indicate option is not cost-effective with B/C ratio less than 1. Cells with "n/a" reflect lighting and water heating efficiency measures and packages that did not look at TDV cost effectiveness or GHG impacts.

Table 8: Single Family Efficiency Packages Cost-Effectiveness Results – Climate Zone 9

Measure	Vintage	Measure Cost (2020 PV$)	Electricity Savings (kWh)	Gas Savings (therms)	Utility Cost Savings		Customer On-Bill		2019 TDV		2022 TDV	
					Year 1	Avg Annual	B/C Ratio	NPV	B/C Ratio	NPV	B/C Ratio	NPV
R49 Attic & Air Sealing Package	Pre-1978	$4,806	864	25	$222	$178	0.99	-$42	1.70	$3,358	1.54	$2,580
	1978-1991	$4,348	464	13	$119	$95	0.59	-$2,025	1.06	$244	0.94	-$243
	1992-2010	$3,807	121	6	$31	$25	0.20	-$2,985	0.55	-$1,494	0.46	-$1,808
R49 Attic & Duct Sealing Package	Pre-1978	$4,015	1,294	28	$324	$259	1.73	$3,276	3.45	$9,841	2.96	$7,887
	1978-1991	$3,557	735	14	$181	$145	1.09	$350	2.26	$4,497	1.89	$3,163
	1992-2010	$2,756	165	5	$39	$31	0.37	-$1,615	1.03	$58	0.81	-$438
R49 Attic, Air Sealing & Duct Sealing Package	Pre-1978	$5,489	1,303	34	$332	$266	1.30	$1,831	2.70	$9,352	2.31	$7,188
	1978-1991	$5,031	739	17	$186	$149	0.79	-$1,181	1.72	$3,599	1.43	$2,167
	1992-2010	$4,230	171	7	$43	$35	0.25	-$3,174	0.72	-$1,062	0.56	-$1,647
R49 Attic, Air Sealing & New Ducts Package	Pre-1978	$8,792	1,747	42	$441	$354	1.08	$746	2.34	$11,812	2.00	$8,828
	1978-1991	$8,334	1,153	24	$285	$228	0.73	-$2,506	1.71	$5,939	1.44	$3,657
	1992-2010	$7,793	305	11	$74	$59	0.22	-$6,428	0.68	-$2,306	0.54	-$3,378
Advanced Envelope Package	Pre-1978	$18,659	2,105	62	$537	$432	0.62	-$7,989	1.32	$5,955	1.15	$2,881
Water Heating Package	All Vintages	$208	n/a	n/a	$29	$318	1.36	$84	n/a	n/a	n/a	n/a

[1] Values in red and grey shaded rows indicate option is not cost-effective with B/C ratio less than 1. Cells with "n/a" reflect lighting and water heating efficiency measures and packages that did not look at TDV cost effectiveness or GHG impacts.

Table 9: Single Family PV & Battery Cost-Effectiveness Results – Climate Zone 9

Measure	Vintage	Measure Cost (2020 PV$)	Electricity Savings (kWh)	Gas Savings (therms)	Utility Cost Savings		Customer On-Bill		2019 TDV		2022 TDV	
					Year 1	Avg Annual	B/C Ratio	NPV	B/C Ratio	NPV	B/C Ratio	NPV
Prescriptive 2.38 kW_{DC} PV System	Pre-1978	$7,570	4,154	0	$743	$586	2.10	$9,211	1.99	$7,507	1.87	$6,599
	1978-1991				$720	$568	2.04	$8,684	1.99	$7,475	1.87	$6,568
	1992-2010				$653	$515	1.85	$7,092	1.98	$7,440	1.86	$6,513
2.38 kW_{DC} PV & 10kWh Battery	Pre-1978	$19,512	4,006	0	$718	$566	0.81	-$4,016	1.09	$1,674	0.94	-$1,201
	1978-1991				$696	$550	0.78	-$4,521	1.11	$2,118	0.98	-$478
	1992-2010				$632	$498	0.71	-$6,054	1.00	$15	1.02	$482

[1] Values in red and grey shaded rows indicate option is not cost-effective with B/C ratio less than 1. Cells with "n/a" reflect lighting and water heating efficiency measures and packages that did not look at TDV cost effectiveness or GHG impacts.

Table 10: Single Family Equipment Fuel Substitution Cost-Effectiveness Results – Climate Zone 9

Measure	Vintage	Measure Cost (2020 PV$)	Electricity Savings (kWh)	Gas Savings (therms)	Utility Cost Savings		Customer On-Bill		2019 TDV		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	$1,555	-921	86	-$55	-$32	0.00	-$2,556	0.00	-$1,956	0.37	-$976
	1978-1991		-638	57	-$39	-$23	0.00	-$2,298	0.00	-$1,915	0.16	-$1,310
	1992-2010		-405	51	-$2	$5	0.10	-$1,444	0.99	-$20	1.26	$412
High-Effic. Heat Pump at HVAC Replacement	Pre-1978	$4,024	-601	86	$15	$23	0.16	-$3,481	0.66	-$1,357	0.77	-$922
	1978-1991		-389	57	$13	$18	0.13	-$3,634	0.52	-$1,915	0.57	-$1,734
	1992-2010		-239	51	$30	$30	0.22	-$3,261	0.83	-$697	0.85	-$622
Heat Pump at HVAC Replacement + 2.38 kW_{DC} PV	Pre-1978	$9,125	3,233	86	$670	$540	1.63	$6,233	1.61	$5,571	1.62	$5,629
	1978-1991		3,516	57	$658	$527	1.59	$5,838	1.61	$5,574	1.58	$5,257
	1992-2010		3,763	58	$669	$536	1.61	$6,103	1.82	$7,441	1.76	$6,931
HPWH at Water Heater Replacement	Pre-1978	$2,594	-913	150	-$1	$17	0.18	-$2,368	0.37	-$1,626	1.83	$2,142
	1978-1991		-921	150	-$1	$18	0.18	-$2,363	0.36	-$1,672	1.82	$2,121
	1992-2010		-932	150	$4	$22	0.22	-$2,242	0.38	-$1,612	1.82	$2,136
NEEA Tier 3 HPWH at Replacement	Pre-1978	$2,775	-744	150	$30	$42	0.41	-$1,818	0.70	-$819	2.01	$2,816
	1978-1991		-755	150	$30	$42	0.41	-$1,827	0.68	-$888	2.09	$3,018
	1992-2010		-764	150	$34	$45	0.44	-$1,726	0.72	-$767	2.01	$2,802
HPWH at Water Heater Replacement + 2.38 kW_{DC} PV	Pre-1978	$10,163	3,242	150	$767	$624	1.66	$7,463	1.60	$6,077	1.88	$8,931
	1978-1991		3,233	150	$749	$610	1.62	$7,030	1.59	$6,005	1.87	$8,879
	1992-2010		3,222	150	$690	$563	1.50	$5,631	1.59	$6,030	1.87	$8,842
2.38 kW_{DC} PV + Pre-wire & panel upgrade	Pre-1978	$11,661	4,154	0	$743	$586	1.36	$4,618	1.29	$3,416	1.22	$2,508
	1978-1991		4,154	0	$720	$568	1.32	$4,090	1.29	$3,384	1.21	$2,477
	1992-2005		4,154	0	$653	$515	1.19	$2,498	1.29	$3,349	1.21	$2,422

[1] Values in red and grey shaded rows indicate option is not cost-effective with B/C ratio less than 1. Cells with "n/a" reflect lighting and water heating efficiency measures and packages that did not look at TDV cost effectiveness or GHG impacts.

4 References

Statewide CASE Team. (2020). *Multifamily Indoor Air Quality Draft CASE Report. .* Retrieved from https://title24stakeholders.com/wp-content/uploads/2018/10/MF-IAQ_Draft-CASE-Report_Statewide-CASE-Team.pdf

Statewide Reach Code Team. (2019). *Title 24, Parts 6 and 11 Local Energy Efficiency Ordinances. 2019 Cost-effectiveness Study: Low-rise Residential New Construction.* Last modified August 1, 2019. Retrieved from https://localenergycodes.com/download/800/file_path/fieldList/2019%20Res%20NC%20Reach%20Codes

Statewide Reach Code Team. (2020). *Title 24, Parts 6 and 11 Local Energy Efficiency Ordinances. 2019 Mid-Rise New Construction Reach Code Cost-Effectiveness Study.* Last modified June 22, 2020. Retrieved from https://localenergycodes.com/download/492/file_path/fieldList/2019%20Mid-rise%20NC%20Cost-Eff%20Report.pdf

Statewide Reach Code Team. (2021a). *2019 Cost-Effectiveness Study: 2020 Analysis of High-Rise Residential New Construction.*

Statewide Reach Code Team. (2021b). *2019 Cost-Effectiveness Study: Existing Single Family Residential Building Upgrades.*

5 Appendices

5.1 Appendix A – Utility Tariff Details

5.1.1 Glendale Water and Power

Following are the GWP electricity tariffs applied in this study.

Glendale Water and Power L-1-A Residential Electric Rate:

Customer Charge - per meter per day	$0.4400
Energy Charges - per kWh	
July through October (High Season)	
First 10kWh per day	$0.1620
Next 10kWh per day	$0.2008
Remaining kWh	$0.2398
November through June (Low Season)	
First 10kWh per day	$0.1358
Next 10kWh per day	$0.1682
Remaining kWh	$0.2075

Glendale Water and Power L-2-A Small Business Electric Rate:

Customer Charge - per meter per day	$0.6200
Energy Charges	
July through October (High Season)	$0.1841
Any Time	
November through June (Low Season)	$0.1595
Any Time	

Glendale Water and Power LD-2-A Medium Business Electric Rate:

Customer Charge - per meter per day	$2.5000
Energy Charges - per kWh	
July through October (High Season)	
Any Time	$0.1243
Demand - Per kW (maximum kW reading for last 12 months) per day	$0.6000
November through June (Low Season)	
Any Time	$0.1189
Demand - Per kW (maximum kW reading for last 12 months) per day	$0.4200

The Net Energy Metering (NEM) Resolution allows for energy generated and sent to the grid by customer owned generation to be credited at the retail rate. At the end of the 12-month period if the customer is a net electricity generator, the customer is compensated for excess kilowatt-hours at the feed-in-tariff price. In this analysis the Statewide Reach Code Team used the Q1 2021 feed-in tariff price of $0.05753/kWh.

Glendale Water and Power Feed-In Tariff Rates:

Feed-In Tariff Offer Price City of Glendale Water & Power (GWP)		
Quarter	**Effective Date**	**Price**
Q1 2021	1/1/2021	$57.53 per MWh for peak deliveries
		$56.50 per MWh for off-peak deliveries

5.1.2 SoCalGas

Following are the SoCalGas natural gas tariffs applied in this study. For Climate Zone 9 the baseline territory is 1.

The SoCalGas monthly gas rate in $/therm was applied on a monthly basis for the 12-month period ending January 2021 according to the rates shown in Table 11. Historical natural gas rate data was only available for SoCalGas' procurement charges.[3] To estimate total costs by month, the baseline and excess transmission charges were assumed to be consistent and applied for the entire year based on January 2021 costs.

[3] The SoCalGas procurement and transmission charges were obtained from the following site: https://www.socalgas.com/for-your-business/energy-market-services/gas-prices

Table 11: SoCalGas Monthly Gas Rate ($/therm) for GR and GM Tariff

Month	Procurement Charge	Transmission Charge		Total Charge	
		Baseline	Excess	Baseline	Excess
Jan 2021	0.39764	0.82358	1.21382	1.22122	1.61146
Feb 2020	0.36766	0.82358	1.21382	1.19124	1.58148
Mar 2020	0.22108	0.82358	1.21382	1.04466	1.4349
Apr 2020	0.20307	0.82358	1.21382	1.02665	1.41689
May 2020	0.25654	0.82358	1.21382	1.08012	1.47036
June 2020	0.2758	0.82358	1.21382	1.09938	1.48962
July 2020	0.26816	0.82358	1.21382	1.09174	1.48198
Aug 2020	0.26239	0.82358	1.21382	1.08597	1.47621
Sept 2020	0.25498	0.82358	1.21382	1.07856	1.4688
Oct 2020	0.25268	0.82358	1.21382	1.07626	1.4665
Nov 2020	0.3432	0.82358	1.21382	1.16678	1.55702
Dec 2020	0.36159	0.82358	1.21382	1.18517	1.57541

Source: SoCalGas.

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¢

Schedule No. GM Sheet 2
MULTI-FAMILY SERVICE
(Includes GM-E, GM-C, GM-EC, GM-CC, GT-ME, GT-MC and all GMB Rates)
(Continued)

APPLICABILITY (Continued)

Multi-family Accommodations built prior to December 15, 1981 and currently served under this schedule may also be eligible for service under Schedule No. GS. If an eligible Multi-family Accommodation served under this schedule converts to an applicable submetered tariff, the tenant rental charges shall be revised for the duration of the lease to reflect removal of the energy related charges.

Eligibility for service hereunder is subject to verification by the Utility.

TERRITORY

Applicable throughout the service territory.

RATES

	GM/GT-M	GMB/GT-MB
Customer Charge, per meter, per day:	16.438¢	$16.357
For "Space Heating Only" customers, a daily Customer Charge applies during the winter period from November 1 through April 30[/]:	33.149¢	

SOUTHERN CALIFORNIA GAS COMPANY Revised CAL. P.U.C. SHEET NO. 55620-G
LOS ANGELES, CALIFORNIA CANCELING Revised CAL. P.U.C. SHEET NO. 42978-G

Schedule No. GR Sheet 3
RESIDENTIAL SERVICE
(Includes GR, GR-C and GT-R Rates)
(Continued)

SPECIAL CONDITIONS (Continued)

3. Baseline Usage: The following quantities of gas used in individually metered residences not in a Multi-family Accommodation complex are to be billed at the Baseline rates. Usage in excess of applicable baseline allowances will be billed at the Non-Baseline rates. L

Per Residence	Daily Therm Allowance for Climate Zones*		
	1	2	3
Summer (May 1-Oct. 31)	0.473	0.473	0.473
Winter (Nov. 1-Apr. 30)	1.691	1.823	2.950

L

In Multi-family Accommodation complexes where individual dwelling units receive Individually Metered Service and where other residential services are provided from a separately metered central source, the applicable basic baseline allowance for each such individually metered dwelling unit, subject to verification, will be as follows:

Codes	Per Residence	Daily Therm Allowance for Climate Zones*		
		1	2	3
1	Space heating only			
	Summer	0.000	0.000	0.000
	Winter	1.210	1.343	2.470
2	Water heating and cooking	0.477	0.477	0.477
3	Cooking, water heating and space heating			
	Summer	0.473	0.473	0.473
	Winter	1.691	1.823	2.950
4	Cooking and space heating			
	Summer	0.088	0.088	0.088
	Winter	1.299	1.432	2.559
5	Cooking only	0.089	0.089	0.089
6	Water heating only	0.388	0.388	0.388
7	Water heating and space heating			
	Summer	0.385	0.385	0.385
	Winter	1.601	1.734	2.861

* Climate Zones are described in the Preliminary Statement.

L

(Continued)

(TO BE INSERTED BY UTILITY)
ADVICE LETTER NO. 5377
DECISION NO. 15-10-032
3C6

ISSUED BY
Dan Skopec
Vice President
Regulatory Affairs

(TO BE INSERTED BY CAL. PUC)
SUBMITTED Oct 31, 2018
EFFECTIVE Nov 30, 2018
RESOLUTION NO.

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

Schedule No. GM Sheet 5
MULTI-FAMILY SERVICE
(Includes GM-E, GM-C, GM-EC, GM-CC, GT-ME, GT-MC and all GMB Rates)
(Continued)

SPECIAL CONDITIONS (Continued)

3. (Continued)

Codes	Per Residence	Daily Therm Allowance for Climate Zones* 1	2	3
1	Space heating only			
	Summer	0.000	0.000	0.000
	Winter	1.210	1.343	2.470
2	Water heating and cooking	0.477	0.477	0.477
3	Cooking, water heating and space heating			
	Summer	0.473	0.473	0.473
	Winter	1.691	1.823	2.950
4	Cooking and space heating			
	Summer	0.088	0.088	0.088
	Winter	1.299	1.432	2.559
5	Cooking only	0.089	0.089	0.089
6	Water heating only	0.388	0.388	0.388
7	Water heating and space heating			
	Summer	0.385	0.385	0.385
	Winter	1.601	1.734	2.861

* Climate Zones are described in the Preliminary Statement.

4. Medical Baseline: Upon completion of an application and verification by a state-licensed physician, nurse practitioner, physician's assistant, or osteopath (Form No. 4859-E), an additional Baseline allowance of 0.822 therms per day will be provided for paraplegic, quadriplegic, or hemiplegic persons, those afflicted with multiple sclerosis or scleroderma, or persons being treated for a life threatening illness or who have a compromised immune system. T N

   Where it is established that the energy required for a Life-Support Device, as defined in Rule No. 1, exceeds 0.822 therms per day, an additional uniform daily Baseline allowance will be provided. The amount of the additional allowance will be determined by the Utility from load and operating time data of the Life-Support Device.

5. Space Heating Only: Applies to customers who are using gas primarily for space heating, as determined by survey or under the presumption that customers who use less than 11 Ccf per month during each of the regular billing periods ending in August and September qualify for Heat Only billing.

(Continued)

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

ISSUED BY
Dan Skopec
Vice President

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