CALIFORNIA ENERGY CODES & STANDARDS
A STATEWIDE UTILITY PROGRAM

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2022 CODE CYCLE:

Custom Cost Effectiveness Analysis: City of Burbank

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Acronym List

B/C – Benefit-to-Cost Ratio

BWP – Burbank Water and Power

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

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)

kWh – Kilowatt Hour

NPV – Net Present Value

PV - Solar Photovoltaic

TDV - Time Dependent Valuation

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

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1 Introduction

The California Codes and Standards (C&S) 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 efficiency 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.

The California Building Energy Efficiency Standards Title 24, Part 6 (Title 24) (CEC, 2019) 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 must demonstrate that the requirements of the proposed ordinance are cost-effective and do not result in buildings consuming more energy than is permitted by Title 24. In addition, the jurisdiction must obtain approval from the Energy Commission and file the ordinance with the BSC for the ordinance to be legally enforceable.

This report is an addendum to the *2022 Single Family New Construction Cost-effectiveness Study* modified to accurately represent the City of Burbank, California. The study analyzes cost-effectiveness of measures and measure packages that exceed the minimum state requirements, the 2022 Building Energy Efficiency Standards, effective January 1, 2023, in newly constructed 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 Codes Team.

The prototype building designs analyzed in this study are newly constructed:

- Single Family Home
- Detached Accessory Dwelling Unit (ADU)

The methodology, prototype characteristics, and measure packages are retained from the main studies referenced above except for the energy costs are calculated using local Burbank Water and Power (BWP) utility rates. Measure packages include combinations of energy efficiency, electrification, solar photovoltaics (PV), and battery storage with results evaluated for California Climate Zone 9.

This report presents measures or measure packages that local jurisdictions may consider adopting to achieve energy savings and emissions reductions beyond what will be accomplished by enforcing minimum state requirements, the 2022 Building Energy Efficiency Standards (Title 24, Part 6), effective January 1, 2023.

Local jurisdictions may also adopt ordinances that amend different Parts of the California Building Standards Code or may elect to amend other state or municipal codes. The decision regarding which code to amend will determine the specific requirements that must be followed for an ordinance to be legally enforceable. Although a cost-effectiveness study is only required to amend Part 6 of the CA Building Code, it is important to understand the economic impacts of any policy decision. This study documents the estimated costs, benefits, energy impacts and greenhouse gas emission reductions that may result from implementing an ordinance based on the results to help residents, local leadership, and other stakeholders make informed policy decisions.

Model ordinance language and other resources are posted on the C&S Reach Codes Program website at LocalEnergyCodes.com. Local jurisdictions that are considering adopting an ordinance may contact the program for further technical support at info@localenergycodes.com.

2 Methodology and Assumptions

The Reach Codes Team analyzed two residential prototype designs to represent a variety of common building types using the cost-effectiveness methodology detailed in this section below. The general methodology is consistent with analyses of other prototypes, whereas some specifics such as utility rate selection are customized for the City of Burbank rates.

2.1 Reach Codes

This section describes the approach to calculating cost-effectiveness including benefits, costs, metrics, and utility rate selection.

2.1.1 Benefits

This analysis used both on-bill and time dependent valuation (TDV) of energy-based approaches to evaluate cost-effectiveness. Both on-bill and TDV require estimating and quantifying the energy savings and costs associated with energy measures. The primary difference between on-bill and TDV is how energy is valued:

- On-Bill: Customer-based lifecycle cost 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 for residential and 15 years for nonresidential designs, accounting for a three percent discount rate and energy cost inflation per Appendix 7.2.3.
- TDV: TDV was developed by the Energy Commission to reflect the time dependent value of energy including long-term projected costs of energy such as the cost of providing energy during peak periods of demand and other societal costs including projected costs for carbon emissions and grid transmission 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.

The Reach Codes Team performed energy simulations using the most recent software available for 2022 Title 24 code compliance analysis, CBECC-Res v1.0.

2.1.2 Costs

The Reach Codes Team assessed the incremental costs and savings of the energy packages over the lifecycle of 30 years for the single family and ADU buildings. Incremental costs represent the equipment, installation, replacements, and maintenance costs of the proposed measure relative to the 2019 Title 24 Standards minimum requirements or standard industry practices. The Reach Codes Team obtained measure costs from manufacturer distributors, contractors, literature review, and online sources such as Home Depot and RS Means. Taxes and contractor markups were added as appropriate. Maintenance and replacement costs are included.

2.1.3 Metrics

Cost-effectiveness is presented using net present value (NPV) and benefit-to-cost (B/C) ratio metrics.

- NPV: The Reach Codes Team uses net savings (NPV benefits minus NPV costs) as the cost-effectiveness metric. If the net savings of a measure or package is positive, it is considered cost effective. Negative net savings represent net costs to the consumer. A measure that has negative energy cost benefits (energy cost increase) can still be cost effective if the costs to implement the measure are even more negative (i.e., construction and maintenance cost savings).
- B/C Ratio: Ratio of the present value of all benefits to the present value of all costs over 30 years (NPV benefits divided by NPV costs). The criteria for cost-effectiveness is a B/C greater than 1.0. A value of one

indicates the savings over the life of the measure are equivalent to the incremental cost of that measure. A value greater than one represents a positive return on investment.

Improving the energy performance of a building often requires an initial investment. In most cases the benefit is represented by annual on-bill utility or TDV savings, and the cost by incremental first cost and replacement costs. However, some packages result in initial construction cost savings (negative incremental cost), and either energy cost savings (positive benefits), or increased energy costs (negative benefits). In cases where both construction costs and energy-related savings are negative, the construction cost savings are treated as the benefit while the increased energy costs are the cost. In cases where a measure or package is cost-effective immediately (i.e., upfront construction cost savings and lifetime energy cost savings), B/C ratio cost-effectiveness is represented by ">1". Because of these situations, NPV savings are also reported, which, in these cases, are positive values.

2.1.4 Utility Rates

In coordination with the City of Burbank, the Reach Codes Team determined appropriate tariffs for each package, summarized in Table 1, based on the annual load profile of the prototype and the corresponding package, and the most prevalent rate for each building type.

For a more detailed breakdown of the rates selected refer to Appendix 7.2 Utility Rate Schedules.

Table 1. Utility Tariffs in City of Burbank

Electric / Gas Utility	Electricity	Natural Gas
Residential (Single Family and Detached ADU)		
Burbank Water and Power / SoCalGas	Residential Service (Basic)	G1

Utility rates are assumed to escalate over time, using assumptions detailed in Appendix 7.2. Please see the main *2022 Single Family New Construction Reach Code Cost Effectiveness Studies* for further details on methodology.

2.2 Greenhouse Gas Emissions

The analysis uses the greenhouse gas (GHG) emissions estimates built-in to CBECC-Res. There are 8760 hourly multipliers accounting for time dependent energy use and carbon emissions based on source emissions, including renewable portfolio standard projections. Natural gas fugitive emissions, which are shown to be substantial, are not included. There are two strings of multipliers—one for Northern California climate zones, and another for Southern California climate zones.[1].

[1] CBECC-Res multipliers are the same for CZs 1-5 and 11-13 (presumed to be Northern California), while there is another set of multipliers for CZs 6-10 and 14-16 (assumed to be Southern California).

3 Prototype Designs and Measure Packages

3.1 Residential Occupancies

Table 2 describes the basic characteristics of each residential prototype design. The prototypes have equal geometry on all walls, windows and roof to be orientation neutral.

Table 2: Residential Prototype Characteristics

Characteristic	Single Family One-Story	Single Family Two-Story	ADU
Conditioned Floor Area	2,100 ft^2	2,700 ft^2	625 ft^2
Num. of Stories	1	2	1
Num. of Bedrooms	3	3	1
Window-to-Floor Area Ratio	20%	20%	20%

The Reach Codes Team evaluated three packages for mixed fuel homes and five packages for all-electric homes for each prototype, as described below.

1. All-Electric Code Minimum: This package meets all the prescriptive requirements of the 2022 Title 24 Code. For the ADU, the prescriptive minimum package did not comply with code and efficiency measures were added to meet minimum compliance requirements.
2. Efficiency Only: This package uses only efficiency measures that don't trigger federal preemption issues including envelope and water heating or duct distribution efficiency measures.
3. Efficiency + NEEA (Preempted): This package was evaluated for the all-electric homes only and shows an alternative design that applies water heating equipment that is more efficient than federal standards meeting the NEEA Tier 3 rating. The Reach Codes Team considers this more reflective of how builders meet above code requirements in practice.
4. Efficiency + PV: Using the Efficiency Package as a starting point, PV capacity was added to offset most of the estimated electricity use.
5. Efficiency + PV + Battery: Using the Efficiency & PV Package as a starting point, a battery system was added. For mixed-fuel homes the package of efficiency measures differed from the Efficiency Package to arrive at a cost effective solution.

4 Results

Results are presented as per the prototype-specific Measure Packages described in Section 3. Overarching factors impacting the results include:

- Designation of a **'benefit'** or a **'cost'** varies with the scenarios because both energy savings, and incremental construction costs may be negative depending on the package. Typically, utility bill savings are categorized as a 'benefit' while incremental construction costs are treated as 'costs.' In cases where both construction costs are negative and utility bill savings are negative, the construction cost savings are treated as the 'benefit' while the utility bill negative savings are the 'cost.'
- All-electric packages will have lower **GHG emissions** than equivalent mixed-fuel packages in all cases, due to the clean power sources currently available from California's power providers.
- The Reach Codes Team coordinated with the City of Burbank to select the most prevalent tariffs for each prototype given the annual energy demand profile. The Reach Codes Team **did not compare a variety of tariffs** to determine their impact on cost-effectiveness although utility rate changes or updates can effect on-bill cost-effectiveness results.

4.1 Residential Occupancies

Table 3 and Table 4 show results for the single family and ADU prototypes, respectively, for all the evaluated packages. All packages are cost-effective based on TDV except for the mixed fuel Efficiency Only package for the ADU. All of the all-electric packages are On-Bill cost-effective with the exception of the Efficiency + PV + Battery cases.

Table 3. Single Family Cost-Effectiveness Summary

Case	Efficiency EDR2 Margin	Annual Elec Savings (kWh)	Annual Gas Savings (therms)	Average Annual GHG Reductions (metric tons)	Utility Cost Savings		Incremental Cost		On-Bill		TDV	
					First Year	Lifecycle (2022$)	First Year	Lifecycle (2022$)	B/C Ratio	NPV	B/C Ratio	NPV
All-Electric												
Code Minimum	1.2	-1,513	85	0.3	($55)	($115)	($5,288)	($5,234)	45.4	$5,119	3.3	$3,179
Efficiency Only	4.6	-1,336	85	0.3	($31)	$457	($4,093)	($3,893)	>1	$4,350	102.1	$3,357
Efficiency + NEEA	6.3	-1,198	85	0.3	($13)	$887	($4,093)	($3,893)	>1	$4,780	>1	$4,073
Efficiency + PV	4.6	922	85	0.4	$255	$7,148	($478)	$942	7.6	$6,207	8.7	$6,238
Efficiency + PV + Battery	9.9	791	85	0.9	$239	$6,770	$5,011	$12,487	0.5	($5,716)	1.9	$10,710
Mixed Fuel												
Efficiency Only	3.6	147	4	0.0	$24	$599	$1,194	$1,341	0.4	($743)	1.2	$250
Efficiency + PV	3.6	922	4	0.1	$119	$2,822	$2,435	$3,001	0.9	($179)	1.5	$1,229
Efficiency + PV + Battery	8.6	839	3	0.5	$107	$2,548	$7,509	$14,094	0.2	($11,546)	1.5	$5,914

Table 4. ADU Cost-Effectiveness Summary

Case	Efficiency EDR2 Margin	Annual Elec Savings (kWh)	Annual Gas Savings (therms)	Average Annual GHG Reductions (metric tons)	Utility Cost Savings		Incremental Cost		On-Bill		TDV	
					First Year	Lifecycle (2022$)	First Year	Lifecycle (2022$)	B/C Ratio	NPV	B/C Ratio	NPV
All-Electric												
Code Minimum	0.6	-901	38	0.1	($77)	($1,222)	($3,216)	($2,908)	2.4	$1,686	1.6	$896
Efficiency Only	3.7	-837	38	0.1	($66)	($955)	($3,003)	($1,455)	1.5	$501	1.1	$53
Efficiency + NEEA	5.4	-747	38	0.1	($50)	($581)	($3,003)	($1,455)	2.5	$875	1.5	$367
Efficiency + PV	3.7	3,506	38	0.3	$508	$12,466	$3,949	$7,842	1.6	$4,624	1.9	$6,334
Efficiency + PV + Battery	8.8	3,490	38	0.7	$506	$12,421	$9,510	$19,483	0.6	($7,062)	1.5	$9,406
Mixed Fuel												
Efficiency Only	3.7	36	3	0.0	$11	$303	$256	$1,502	0.2	($1,199)	0.5	($780)
Efficiency + PV	3.7	3,506	3	0.2	$442	$10,363	$5,810	$8,929	1.2	$1,434	1.5	$4,195
Efficiency + PV + Battery	8.9	3,512	3	0.5	$442	$10,370	$11,361	$20,556	0.5	($10,187)	1.4	$6,682

5 Summary

The Reach Codes Team developed packages of energy efficiency measures as well as packages combining energy efficiency with solar PV generation, simulated them in building modeling software, and gathered costs to determine the cost-effectiveness of multiple scenarios. The Reach Codes Team coordinated with multiple utilities, cities, and building community experts to develop a set of assumptions considered reasonable in the current market. Changing assumptions, such as the period of analysis, measure selection, cost assumptions, energy escalation rates, or utility tariffs are likely to change results.

Table 5 (all-electric) and Table 6 (mixed fuel) summarize results for each prototype and depict the efficiency EDR2 compliance margins achieved for each climate zone and package. Because local reach codes must both exceed the Energy Commission performance budget (i.e., have a positive compliance margin) and be cost-effective, the Reach Codes Team highlighted cells meeting these two requirements to help clarify the upper boundary for potential reach code policies. All results presented in this study have a positive compliance margin.

- Cells highlighted in **green** depict a positive compliance margin and cost-effective results using both On-Bill and TDV approaches.
- Cells highlighted in **yellow** depict a positive compliance and cost-effective results using either the On-Bill or TDV approach.
- Cells **not highlighted** depict a package that was not cost effective using either the On-Bill or TDV approach.

The Reach Codes Team found all-electric code compliant new construction to be feasible and cost effective based on TDV and Burbank electricity rates for both the single family and ADU prototypes. While the code compliant all-electric building had higher first year utility costs, the additional cost was small. Combining higher capacity PV systems and all-electric construction does reduce utility costs.

For a reach code that allows for mixed fuel buildings the mixed fuel efficiency, PV, and battery package was found to be cost effective based on TDV for both prototypes with EDR2 margins between 8.6 and 8.9.

Table 5: Summary of All-Electric Efficiency EDR2 Margins and Cost-Effectiveness

Single Family				ADU			
Code Min	EE	EE+PV	EE+PV/Batt	Code Min	EE	EE+PV	EE+PV/Batt
1.2	4.6	4.6	9.9	0.6	3.7	3.7	8.8

Table 6: Summary of Mixed Fuel Efficiency EDR2 Margins and Cost-Effectiveness

Single Family			ADU		
EE	EE+PV	EE+PV/Batt	EE	EE+PV	EE+PV/Batt
3.6	3.6	8.6	3.7	3.7	8.9

6 References

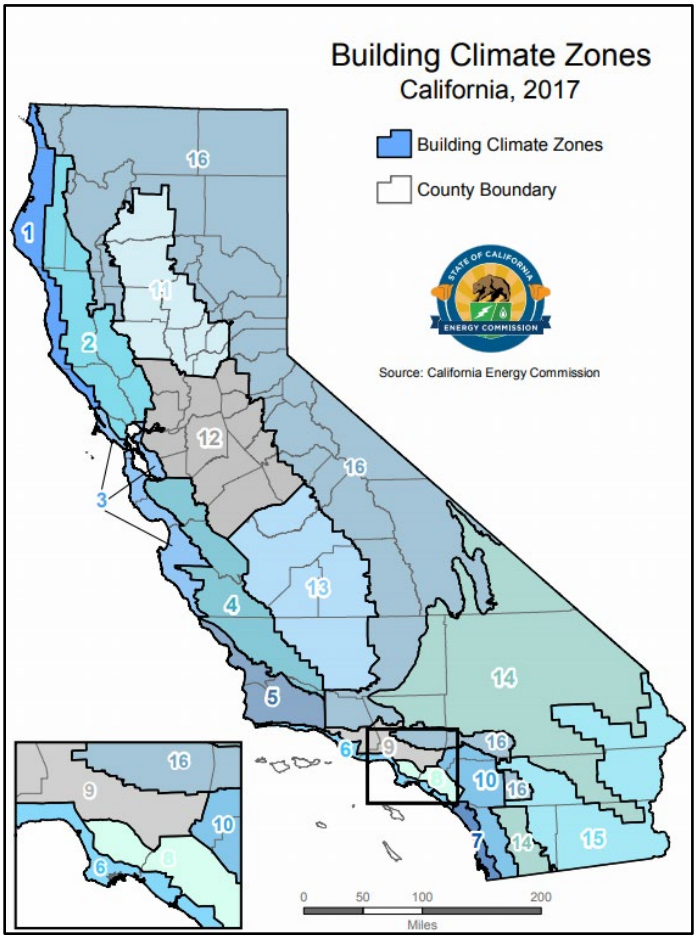
California Public Utilities Commission. (2021a). *Utility Costs and Affordability of the Grid of the Future: An Evaluation of Electric Costs, Rates, and Equity Issues Pursuant to P.U. Code Section 913.1.* Retrieved from https://www.cpuc.ca.gov/-/media/cpuc-website/divisions/office-of-governmental-affairs-division/reports/2021/senate-bill-695-report-2021-and-en-banc-whitepaper_final_04302021.pdf

7 Appendices

7.1 Map of California Climate Zones

Climate zone geographical boundaries are depicted in Figure 1. The map in Figure 1 along with a zip-code search directory is available at: https://ww2.energy.ca.gov/maps/renewable/building_climate_zones.html

Figure 1. Map of California climate zones.



7.2 Utility Rate Schedules

The Reach Codes Team used the City of Burbank tariffs detailed below to determine the On-Bill savings for each package.

7.2.1 Burbank Water and Power

7.2.1.1 Residential

Following in are the City of Burbank electricity tariffs applied in this study.[2] The Basic Residential Service Rate was applied to all of the scenarios based on the Composite Energy Rate and the medium size service charge. For homes with on-site solar generation and where the customer is a net generator of electricity, excess production was compensated at the net surplus compensation rate of $0.0455/kWh.

Residential Service

Description		Amount	Unit/Time
Basic Service Rate			
1. Customer Service Charge		$9.76	Meter
2. Service Size Charge	**Small**	$1.48	Meter
	Medium	$3.00	Meter
	Large	$8.99	Meter
	Definitions: **Small:** Service location with two (2) or more meters per service drop and does not meet definition of Large; typically Multifamily Residential **Medium:** Service location with one (1) meter per service drop and does not meet definition of Large; typically Single Family Residential **Large:** Service with panel size greater than 200A		
3. Energy Charge	**First 300 kWh**	$0.0429	kWh
	All additional kWh	$0.0622	kWh
4. Energy Cost Adjustment Charge (ECAC)	**First 300 kWh**	$0.0798	kWh
	All additional kWh	$0.1159	kWh
5. Composite Energy Rate (Comprised of Energy charge and ECAC and may differ from billed rate due to rounding)	**First 300 kWh**	$0.1227	kWh
	All additional kWh	$0.1781	kWh
	Each of the rates above shall be increased or decreased according to Section 13.		
6. Minimum Charge	**Small**	$11.24	Month
	Medium	$12.76	Month
	Large	$18.75	Month

[2] https://www.burbankwaterandpower.com/electric/rates-and-charges

7.2.2 SCG

Refer to the statewide study 2022 Single Family New Construction Cost-effectiveness Study for details on the gas rates applied.

7.2.3 Fuel Escalation Rates

7.2.3.1 Residential Occupancies

The average annual escalation rates in Table 7: Real Utility Rate Escalation Rate Assumptions were used in this study. The electricity and natural gas rates are based on assumptions from the CPUC 2021 En Banc hearings on utility costs through 2030 (California Public Utilities Commission, 2021a). Escalation rates through the remainder of the 30-year evaluation period are based on the escalation rate assumptions within the 2022 TDV factors. No data was available to estimate electricity escalation rates for BWP, therefore electricity escalation rates for SCE and statewide natural gas escalation rates were applied.

Table 7: Real Utility Rate Escalation Rate Assumptions

Year	Statewide Natural Gas Average Rate (%/year, real)	SCE Electric Average Rate (%/year, real)
2023	4.6%	1.6%
2024	4.6%	1.6%
2025	4.6%	1.6%
2026	4.6%	1.6%
2027	4.6%	1.6%
2028	4.6%	1.6%
2029	4.6%	1.6%
2030	4.6%	1.6%
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%
2052	1.8%	0.6%

Get In Touch

The adoption of reach codes can differentiate jurisdictions as efficiency leaders and help accelerate the adoption of new equipment, technologies, code compliance, and energy savings strategies.

As part of the Statewide Codes & Standards Program, the Reach Codes Subprogram is a resource available to any local jurisdiction located throughout the state of California.

Our experts develop robust toolkits as well as provide specific technical assistance to local jurisdictions (cities and counties) considering adopting energy reach codes. These include cost-effectiveness research and analysis, model ordinance language and other code development and implementation tools, and specific technical assistance throughout the code adoption process.

If you are interested in finding out more about local energy reach codes, the Reach Codes Team stands ready to assist jurisdictions at any stage of a reach code project.

Visit LocalEnergyCodes.com to access our resources and sign up for newsletters

Contact info@localenergycodes.com for no-charge assistance from expert Reach Code advisors

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1 Introduction

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This report is an addendum to the *2022 Multifamily New Construction Cost-effectiveness Study* modified to accurately represent the City of Burbank, California. The study analyzes cost-effectiveness of measures and measure packages that exceed the minimum state requirements, the 2022 Building Energy Efficiency Standards, effective January 1, 2023, in newly constructed 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 Codes Team.

Two multifamily prototypes were evaluated in this study. A 3-story loaded corridor and a 5-story mixed use prototype, which combined are estimated to represent 91 percent of new multifamily construction in California. The methodology, prototype characteristics, and measure packages are retained from the main studies referenced above except for the energy costs are calculated using local Burbank Public Utilities rates. Measure packages include combinations of energy efficiency, electrification, solar photovoltaics (PV), and battery storage with results evaluated for California Climate Zone 9.

This report presents measures or measure packages that local jurisdictions may consider adopting to achieve energy savings and emissions reductions beyond what will be accomplished by enforcing minimum state requirements, the 2022 Building Energy Efficiency Standards (Title 24, Part 6), effective January 1, 2023.

Local jurisdictions may also adopt ordinances that amend different Parts of the California Building Standards Code or may elect to amend other state or municipal codes. The decision regarding which code to amend will determine the specific requirements that must be followed for an ordinance to be legally enforceable. Although a cost-effectiveness study is only required to amend Part 6 of the CA Building Code, it is important to understand the economic impacts of any policy decision. This study documents the estimated costs, benefits, energy impacts and greenhouse gas emission reductions that may result from implementing an ordinance based on the results to help residents, local leadership, and other stakeholders make informed policy decisions.

Model ordinance language and other resources are posted on the C&S Reach Codes Program website at LocalEnergyCodes.com. Local jurisdictions that are considering adopting an ordinance may contact the program for further technical support at info@localenergycodes.com.

2 Methodology and Assumptions

The Reach Codes Team analyzed the 3-story and 5-story prototypes as requested by the City of Burbank. The analysis uses cost-effectiveness methodology detailed in this section below. The general methodology is consistent with other reach code analysis, whereas some specifics such as utility rate selection are customized for Burbank Public Utilities rates.

2.1 Reach Codes

This section describes the approach to calculating cost-effectiveness including benefits, costs, metrics, and utility rate selection.

2.1.1 Benefits

This analysis used both on-bill and time dependent valuation (TDV) of energy-based approaches to evaluate cost-effectiveness. Both on-bill and TDV require estimating and quantifying the energy savings and costs associated with energy measures. The primary difference between on-bill and TDV is how energy is valued:

- On-Bill: Customer-based lifecycle cost 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 for residential and 15 years for nonresidential designs, accounting for a three percent discount rate and energy cost inflation per Appendix 7.2.3.
- TDV: TDV was developed by the Energy Commission to reflect the time dependent value of energy including long-term projected costs of energy such as the cost of providing energy during peak periods of demand and other societal costs including projected costs for carbon emissions and grid transmission 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.

The Reach Codes Team performed energy simulations using the most recent software available for 2022 Title 24 code compliance analysis, CBECC 2022.2.0.

2.1.2 Costs

The Reach Codes Team assessed the incremental costs and savings of the energy packages over the lifecycle of 30 years for the multifamily buildings. Incremental costs represent the equipment, installation, replacements, and maintenance costs of the proposed measure relative to the 2022 Title 24 Standards minimum requirements or standard industry practices. The Reach Codes Team obtained measure costs from manufacturer distributors, contractors, literature review, and online sources such as Home Depot and RS Means. Taxes and contractor markups were added as appropriate. Maintenance and replacement costs are included.

2.1.3 Metrics

Cost-effectiveness is presented using net present value (NPV) and benefit-to-cost (B/C) ratio metrics.

- NPV: The Reach Codes Team uses net savings (NPV benefits minus NPV costs) as the cost-effectiveness metric. If the net savings of a measure or package is positive, it is considered cost effective. Negative net savings represent net costs to the consumer. A measure that has negative energy cost benefits (energy cost increase) can still be cost effective if the costs to implement the measure are even more negative (i.e., construction and maintenance cost savings).
- B/C Ratio: Ratio of the present value of all benefits to the present value of all costs over 30 years (NPV benefits divided by NPV costs). The criteria for cost-effectiveness is a B/C greater than 1.0. A value of one

indicates the savings over the life of the measure are equivalent to the incremental cost of that measure. A value greater than one represents a positive return on investment.

Improving the energy performance of a building often requires an initial investment. In most cases the benefit is represented by annual on-bill utility or TDV savings, and the cost by incremental first cost and replacement costs. However, some packages result in initial construction cost savings (negative incremental cost), and either energy cost savings (positive benefits), or increased energy costs (negative benefits). In cases where both construction costs and energy-related savings are negative, the construction cost savings are treated as the benefit while the increased energy costs are the cost. In cases where a measure or package is cost-effective immediately (i.e., upfront construction cost savings and lifetime energy cost savings), B/C ratio cost-effectiveness is represented by ">1". Because of these situations, NPV savings are also reported, which, in these cases, are positive values.

2.1.4 Utility Rates

In coordination with the City of Burbank, the Reach Codes Team determined appropriate tariffs for each package, summarized in Table 1, based on the annual load profile of the prototype and the corresponding package, and the most prevalent rate for each building type.

For SCG in-unit gas was evaluated under the G1 rate and central gas for water heating was evaluated under the relevant master metered gas tariff, GM. Electricity use for central water heating was evaluated using the residential rates. The water heating utility bill was calculated separately from the in-unit electricity bill. Photovoltaic (PV) and battery energy storage benefits were applied assuming virtual net energy metering (VNEM). PV was first assigned to the central water heating meter to offset 100 percent of the electricity use. The remaining PV and all of the battery impacts were then split evenly across the apartment meters.

The multifamily prototypes include common area spaces that serve the residents (lobby, leasing office, corridors, etc.). Most of the energy use for these spaces could not be separated from that for the dwelling units within the CBECC model. As a result, average per dwelling unit hourly energy use was calculated to include both the dwelling unit and common space energy use.

For a more detailed breakdown of the rates selected refer to Appendix 7.2 Utility Rate Schedules.

Table 1. Burbank Public Utilities Tariffs

Electric / Gas Utility	Electricity	Natural Gas
Residential Multifamily		
Burbank Water and Power / SoCalGas	Residential Service (Basic)	G1 / GM

Utility rates are assumed to escalate over time, using assumptions detailed in Appendix 7.2. Please see the main *2022 Multifamily New Construction Reach Code Cost Effectiveness Studies* for further details on methodology.

2.2 Greenhouse Gas Emissions

The analysis uses the greenhouse gas (GHG) emissions estimates built-in to CBECC. There are 8760 hourly multipliers accounting for time dependent energy use and carbon emissions based on source emissions, including renewable portfolio standard projections. Natural gas fugitive emissions, which are shown to be substantial, are not included.

There are two strings of multipliers—one for Northern California climate zones, and another for Southern California climate zones.[1]

[1] CBECC multipliers are the same for CZs 1-5 and 11-13 (presumed to be Northern California), while there is another set of multipliers for CZs 6-10 and 14-16 (assumed to be Southern California).

3 Prototype Designs and Measure Packages

3.1 Residential Occupancies

The Energy Commission defines building prototypes which it uses to evaluate the cost-effectiveness of proposed changes to Title 24 requirements. There are 4 multifamily prototypes used in code development: a 2-story garden style, a 3-story loaded corridor, a 5-story mixed use and a 10-story mixed use. Based on work completed for the 2022 Title 24 code development, the 3-story and the 5-story represent 33 percent and 58 percent, respectively, of new multifamily construction in California. As a result, these two prototypes are used in this analysis. Additional details on all four prototypes can be found in the Multifamily Prototypes Report (TRC, 2019). Table 2 describes the basic characteristics of each prototype.

Table 2: Residential Prototype Characteristics

Characteristic	3-Story Loaded Corridor	5-Story Mixed Use
Conditioned Floor Area	39,372 ft^2	113,100 ft^2 total: 33,660 ft^2 nonresidential 79,440 ft^2 residential
Num. of Stories	3	6 Stories total: 1 story parking garage (below grade) 1 story of nonresidential space 4 stories of residential space
Num. of Bedrooms	(6) Studio (12) 1-bed (12) 2-bed (6) 3-bed	(8) studios (40) 1-bed units (32) 2-bed units (8) 3-bed units
Window-to-Wall Area Ratio	25%	25%
Wall Type	Wood framed	Wood frame over a first-floor concrete podium
Roof Type	Flat roof	Flat roof
Foundation	Slab-on-grade	Concrete podium with underground parking

3.1 Measure Packages

The Reach Codes Team evaluated two packages for mixed fuel homes and two packages for all-electric homes for each prototype and climate zone, as described below.

1. All-Electric Prescriptive Code: This package meets all the prescriptive requirements of the 2022 Energy Code.
2. All-Electric Prescriptive Code + PV: Using the code minimum package as a starting point, PV capacity was added to offset 100 percent of the estimated annual electricity use.
3. Mixed Fuel Efficiency Only: This package uses only efficiency measures that do not trigger federal preemption including envelope and duct distribution efficiency measures.
4. Mixed Fuel Efficiency + PV + Battery: Using the Efficiency Package as a starting point, PV capacity was added to offset 100 percent of the estimated annual electricity use. A battery system was also added. This package only applies to the 3-story prototype. The 5-story prototype includes a battery system in the baseline per the 2022 prescriptive requirements.
5. Mixed Fuel Efficiency + PV: Using the Efficiency Package as a starting point, PV capacity was added to offset 100 percent of the estimated annual electricity use. This package only applies to the 5-story prototype.

4 Results

Cost-effectiveness results are presented per prototype and measure packages described in Section 3.1. The TDV and On-Bill based cost-effectiveness results are presented in terms of B/C ratio and NPV. Energy savings, compliance margin, utility bill savings, and incremental costs are also shown.

In the following figures, green highlighting indicates that the case is cost-effective with a B/C ratio greater than or equal to 1 and a NPV greater than or equal to 0. Red highlighting indicates the case is not cost-effective.

Compliance margins are presented as percentages both for the efficiency TDV and the source energy metrics. A compliance margin that is equal to or greater than 0 indicates the case is code compliant.

4.1 Residential Occupancies

Table 3 and Table 4 show results for the 3-story and 5-story multifamily prototypes respectively. All of the packages are cost-effective based on TDV. All of the all-electric packages are On-Bill cost-effective for both 3-story and 5-story multifamily prototypes. Only the 5-story mixed fuel efficiency + PV package is On-Bill cost-effective.

Table 3: 3-Story Multifamily Cost-Effectiveness Results per Dwelling Unit

Case	Efficiency TDV Comp Margin	Source Comp Margin	Annual Elec Savings (kWh)	Annual Gas Savings (therms)	Utility Cost Savings		Incremental Cost		On-Bill		TDV	
					First Year	Lifecycle (2022$)	First Year	Lifecycle (2022$)	B/C Ratio	NPV	B/C Ratio	NPV
All-Electric												
Code Minimum	13%	5%	-698	96	$45	$2,101	$697	$1,029	2.0	$1,072	8.0	$2,355
Efficiency + PV	13%	15%	1,204	96	$278	$7,515	$2,335	$3,160	2.4	$4,355	3.9	$7,131
Mixed Fuel												
Efficiency Only	1%	0%	28	0	$3	$79	$146	$156	0.5	($76)	1.6	$88
Efficiency + PV + Battery	1%	17%	1,129	0	$139	$3,212	$3,129	$5,017	0.6	($1,805)	1.4	$1,918

Table 4: 5-Story Multifamily Cost-Effectiveness Results per Dwelling Unit

Case	Efficiency TDV Comp Margin	Source Comp Margin	Annual Elec Savings (kWh)	Annual Gas Savings (therms)	Utility Cost Savings		Incremental Cost		On-Bill		TDV	
					First Year	Lifecycle (2022$)	First Year	Lifecycle (2022$)	B/C Ratio	NPV	B/C Ratio	NPV
All-Electric												
Code Minimum	7%	4%	-725	100	$46	$2,160	$608	$1,185	1.8	$975	2.4	$1,586
Efficiency + PV	7%	12%	60	100	$142	$4,393	$1,307	$2,093	2.1	$2,299	3.0	$4,091
Mixed Fuel												
Efficiency Only	1%	0%	28	0	$3	$81	$142	$149	0.5	($68)	1.7	$100
Efficiency + PV	1%	1%	99	0	$12	$282	$204	$230	1.2	$52	2.4	$326

5 Summary

The Reach Codes Team developed packages of energy efficiency measures as well as packages combining energy efficiency with solar PV generation, simulated them in building modeling software, and gathered costs to determine the cost-effectiveness of multiple scenarios. The Reach Codes Team coordinated with multiple utilities, cities, and building community experts to develop a set of assumptions considered reasonable in the current market. Changing assumptions, such as the period of analysis, measure selection, cost assumptions, energy escalation rates, or utility tariffs are likely to change results.

Table 5 summarizes results for each prototype and depicts the efficiency compliance margins achieved for each package. Because local reach codes must both exceed the Energy Commission performance budget (i.e., have a positive compliance margin) and be cost-effective, the Reach Codes Team highlighted cells meeting these two requirements to help clarify the upper boundary for potential reach code policies. All results presented in this study have a positive compliance margin.

- Cells highlighted in **green** depict a positive compliance margin and cost-effective results using both On-Bill and TDV approaches.
- Cells highlighted in **yellow** depict a positive compliance and cost-effective results using either the On-Bill or TDV approach.
- Cells **not highlighted** depict a package that was not cost effective using either the On-Bill or TDV approach.

The Reach Codes Team found all-electric code compliant new construction to be feasible and cost effective based on TDV and Burbank electricity rates for the 3 and 5-story multifamily prototype. Combining higher capacity PV systems and all-electric construction does reduce utility costs, increasing utility savings.

For a reach code that allows for mixed fuel buildings the mixed fuel efficiency, PV, and battery package was found to be cost effective based on TDV for the 3 and 5-story multifamily prototype only with a compliance margin of 1%.

Table 5: Summary of Efficiency TDV Compliance Margins and Cost-Effectiveness

3-Story				5-Story			
All-Electric Prescriptive Code	All-Electric + PV	Mixed Fuel Efficiency	Mixed Fuel Efficiency + PV + Battery	All-Electric Prescriptive Code	All-Electric + PV	Mixed Fuel Efficiency	Mixed Fuel Efficiency + PV
13%	13%	1%	1%	7%	7%	1%	1%

6 References

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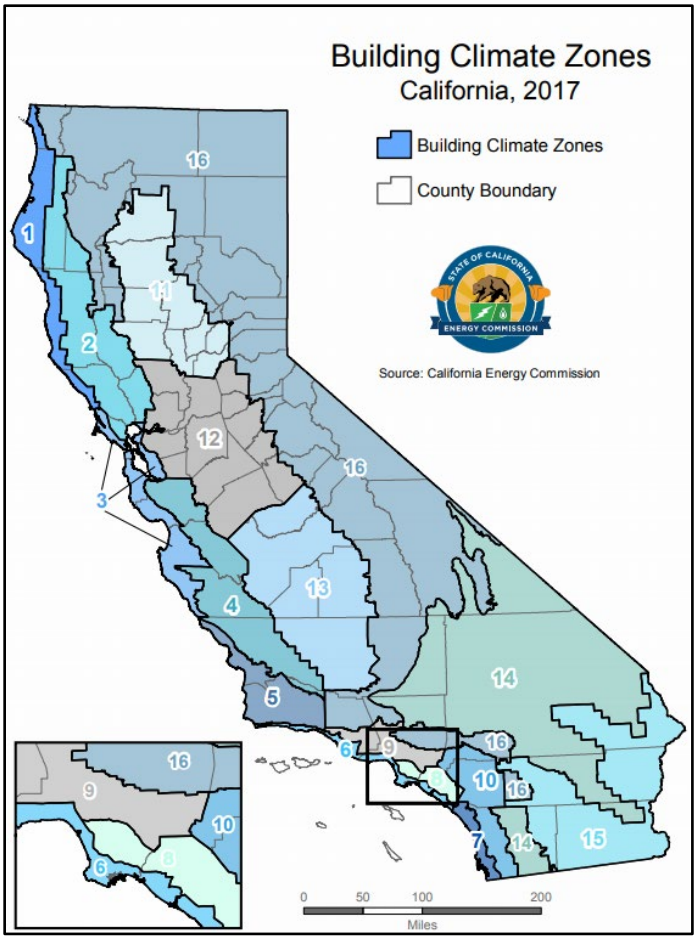
7 Appendices

7.1 Map of California Climate Zones

Climate zone geographical boundaries are depicted in Figure 1. The map in Figure 1 along with a zip-code search directory is available at: https://ww2.energy.ca.gov/maps/renewable/building_climate_zones.html

Figure 1. Map of California climate zones.



7.2 Utility Rate Schedules

The Reach Codes Team used Burbank Water and Power tariffs detailed below to determine the On-Bill savings for each package.

7.2.1 Burbank Water and Power

7.2.1.1 Residential

Following in are the Burbank Water and Power electricity tariffs applied in this study.[2] The Basic Residential Service Rate was applied to all of the scenarios based on the Composite Energy Rate and the medium size service charge. For homes with on-site solar generation and where the customer is a net generator of electricity, excess production was compensated at the net surplus compensation rate of $0.0455/kWh.

Residential Service

Description		Amount	Unit/Time
Basic Service Rate			
1. Customer Service Charge		$9.76	Meter
2. Service Size Charge	**Small**	$1.48	Meter
	Medium	$3.00	Meter
	Large	$8.99	Meter
	Definitions: **Small:** Service location with two (2) or more meters per service drop and does not meet definition of Large; typically Multifamily Residential **Medium:** Service location with one (1) meter per service drop and does not meet definition of Large; typically Single Family Residential **Large:** Service with panel size greater than 200A		
3. Energy Charge	**First 300 kWh**	$0.0429	kWh
	All additional kWh	$0.0622	kWh
4. Energy Cost Adjustment Charge (ECAC)	**First 300 kWh**	$0.0798	kWh
	All additional kWh	$0.1159	kWh
5. Composite Energy Rate (Comprised of Energy charge and ECAC and may differ from billed rate due to rounding)	**First 300 kWh**	$0.1227	kWh
	All additional kWh	$0.1781	kWh
	Each of the rates above shall be increased or decreased according to Section 13.		
6. Minimum Charge	**Small**	$11.24	Month
	Medium	$12.76	Month
	Large	$18.75	Month

[2] https://www.burbankwaterandpower.com/electric/rates-and-charges

7.2.2 SCG

Refer to the statewide study 2022 Multifamily New Construction Cost-effectiveness Study for details on the gas rates applied.

7.2.3 Fuel Escalation Rates

7.2.3.1 Residential Occupancies

The average annual escalation rates reported in Table 6 were used in this study. The electricity and natural gas rates are based on assumptions from the CPUC 2021 En Banc hearings on utility costs through 2030 (California Public Utilities Commission, 2021a). Escalation rates through the remainder of the 30-year evaluation period are based on the escalation rate assumptions within the 2022 TDV factors. No data was available to estimate electricity escalation rates for Burbank Water & Power therefore electricity escalation rates for SCE and statewide natural gas escalation rates were applied.

Table 6: Real Utility Rate Escalation Rate Assumptions

Year	Statewide Natural Gas Average Rate (%/year, real)	SCE Electric Average Rate (%/year, real)
2023	4.6%	1.6%
2024	4.6%	1.6%
2025	4.6%	1.6%
2026	4.6%	1.6%
2027	4.6%	1.6%
2028	4.6%	1.6%
2029	4.6%	1.6%
2030	4.6%	1.6%
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%
2052	1.8%	0.6%

Get In Touch

The adoption of reach codes can differentiate jurisdictions as efficiency leaders and help accelerate the adoption of new equipment, technologies, code compliance, and energy savings strategies.

As part of the Statewide Codes & Standards Program, the Reach Codes Subprogram is a resource available to any local jurisdiction located throughout the state of California.

Our experts develop robust toolkits as well as provide specific technical assistance to local jurisdictions (cities and counties) considering adopting energy reach codes. These include cost-effectiveness research and analysis, model ordinance language and other code development and implementation tools, and specific technical assistance throughout the code adoption process.

If you are interested in finding out more about local energy reach codes, the Reach Codes Team stands ready to assist jurisdictions at any stage of a reach code project.

Visit LocalEnergyCodes.com to access our resources and sign up for newsletters

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CALIFORNIA ENERGY CODES & STANDARDS
A STATEWIDE UTILITY PROGRAM

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2022 CODE CYCLE:

NRNC Custom Cost Effectiveness Analysis: City of Burbank

Prepared by:
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Prepared for:
Jay Madden, Codes and Standards Program, Southern California Edison

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Acronym List

B/C – Benefit-to-Cost Ratio

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

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

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

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1 Introduction

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The prototype building designs analyzed in this study are newly constructed:

- Medium Office
- Medium Retail
- Quick-Service Restaurant
- Small Hotel

The Reach Code Team performed cost-effectiveness analysis based on the prescriptive 2022 Title 24 code requirements:

- For the retail building type, the prescriptive code minimum is all-electric. Fuel substitution packages revert to mixed-fuel appliances.
- For all other building types, the prescriptive code minimum is mixed-fuel. Fuel substitution packages switch to all-electric appliances.

The methodology, prototype characteristics, and measure packages are retained from the main studies referenced above except for the energy costs are calculated using local City of Burbank utility rates. Measure packages include combinations of energy efficiency, electrification, solar photovoltaics (PV) with results evaluated for California Climate Zone 9.

This report presents measures or measure packages that local jurisdictions may consider adopting to achieve energy savings and emissions reductions beyond what will be accomplished by enforcing minimum state requirements, the 2022 Building Energy Efficiency Standards (Title 24, Part 6), effective January 1, 2023.

Local jurisdictions may also adopt ordinances that amend different Parts of the California Building Standards Code or may elect to amend other state or municipal codes. The decision regarding which code to amend will determine the specific requirements that must be followed for an ordinance to be legally enforceable. Although a cost-effectiveness study is only required to amend Part 6 of the CA Building Code, it is important to understand the economic impacts of any policy decision. This study documents the estimated costs, benefits, energy impacts and greenhouse gas emission

reductions that may result from implementing an ordinance based on the results to help residents, local leadership, and other stakeholders make informed policy decisions.

Model ordinance language and other resources are posted on the C&S Reach Codes Program website at LocalEnergyCodes.com. Local jurisdictions that are considering adopting an ordinance may contact the program for further technical support at info@localenergycodes.com.

2 Methodology and Assumptions

The Reach Codes Team analyzed four nonresidential prototypes to represent a variety of common building types using the cost-effectiveness methodology detailed in this section below. The general methodology is consistent with analyses of other prototypes, whereas some specifics such as utility rate selection are customized for the City of Burbank rates.

2.1 Reach Codes

This section describes the approach to calculating cost-effectiveness including benefits, costs, metrics, and utility rate selection.

2.1.1 Benefits

This analysis used both on-bill and time dependent valuation (TDV) of energy-based approaches to evaluate cost-effectiveness. Both on-bill and TDV require estimating and quantifying the energy savings and costs associated with energy measures. The primary difference between on-bill and TDV is how energy is valued:

- On-Bill: Customer-based lifecycle cost 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 for residential and 15 years for nonresidential designs, accounting for a three percent discount rate and energy cost inflation per Appendix 7.2.3.
- TDV: TDV was developed by the Energy Commission to reflect the time dependent value of energy including long-term projected costs of energy such as the cost of providing energy during peak periods of demand and other societal costs including projected costs for carbon emissions and grid transmission 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. This refers to the "Total TDV" that includes all the energy end uses such as space-conditioning, mechanical ventilation, service water heating indoor lighting, photovoltaic (PV) and battery storage systems, and covered process loads.

The Reach Codes Team performed energy simulations using the most recent software available (June 8, 2022) for 2022 Title 24 code compliance analysis, California's Building Energy Code Compliance Software CBECC 2022.1.0 (1250).

2.1.2 Costs

The Reach Codes Team assessed the incremental costs and savings of the energy packages over the lifecycle of 15 years for the nonresidential buildings. Incremental costs represent the equipment, installation, replacements, and maintenance costs of the proposed measure relative to the 2022 Title 24 Standards minimum requirements or standard industry practices. The Reach Code Team obtained baseline and measure costs from manufacturer distributors, contractors, literature review, and online sources such as RS Means.

2.1.3 Metrics

Cost-effectiveness is presented using net present value (NPV) and benefit-to-cost (B/C) ratio metrics.

- NPV: The Reach Codes Team uses net savings (NPV benefits minus NPV costs) as the cost-effectiveness metric. If the net savings of a measure or package is positive, it is considered cost effective. Negative net savings represent net costs to the consumer. A measure that has negative energy cost benefits (energy cost increase) can still be cost effective if the costs to implement the measure are even more negative (i.e., construction and maintenance cost savings).
- B/C Ratio: Ratio of the present value of all benefits to the present value of all costs over 15 years (NPV benefits divided by NPV costs). The criteria for cost-effectiveness is a B/C greater than 1.0. A value of one

indicates the savings over the life of the measure are equivalent to the incremental cost of that measure. A value greater than one represents a positive return on investment.

Improving the energy performance of a building often requires an initial investment. In most cases the benefit is represented by annual on-bill utility or TDV savings, and the cost by incremental first cost and replacement costs. However, some packages result in initial construction cost savings (negative incremental cost), and either energy cost savings (positive benefits), or increased energy costs (negative benefits). In cases where both construction costs and energy-related savings are negative, the construction cost savings are treated as the benefit while the increased energy costs are the cost. In cases where a measure or package is cost-effective immediately (i.e., upfront construction cost savings and lifetime energy cost savings), B/C ratio cost-effectiveness is represented by ">1". Because of these situations, NPV savings are also reported, which, in these cases, are positive values.

2.1.4 Utility Rates

In coordination with the City of Burbank, the Reach Codes Team determined appropriate tariffs for each package, summarized in Table 1, based on the annual load profile of the prototype and the corresponding package, and the most prevalent rate for each building type.

For a more detailed breakdown of the rates selected refer to Appendix 7.2 Utility Rate Schedules.

Table 1. Utility Tariffs in City of Burbank

Electric / Gas Utility	Electricity	Natural Gas
Nonresidential Buildings		
City of Burbank / SCG	D	G-10 (GN -10)

Utility rates are assumed to escalate over time, using assumptions detailed in Appendix 9.2 of the main report. Please see the main *2022 Nonresidential New Construction Reach Code Cost Effectiveness Study* for further details on methodology.

2.2 Greenhouse Gas Emissions

The analysis uses the greenhouse gas (GHG) emissions estimates built-in to CBECC software. There are 8,760 hourly multipliers accounting for time dependent energy use and carbon emissions based on source emissions, including RPS projections. There are 32 strings of multipliers, with a different string for each California CZ and each fuel type (metric tons of CO_2 per kWh for electricity and metric tons of CO_2 per therm for natural gas).

2.3 Nonresidential Occupancies

Table 2 describes the basic characteristics of each nonresidential prototype design.

Table 2: Nonresidential Prototype Characteristics

	Medium Office	Medium Retail	Quick-Service Restaurant	Small Hotel
Conditioned floor area (ft²)	53,628	24,563	2,501	42,554 (77 guest rooms)
Number of stories	3	1	1	4
Window-to-Wall Area ratio	0.33	0.07	0.11	0.14
Window U-factor/SHGC	U-factor: CZ 1-8, 10, 16 – 0.36 CZ 9, 11-15 – 0.34 SHGC: CZ 1-8, 10, 16 – 0.25 CZ 9, 11-15 – 0.22	U-factor: CZ 1-8, 10, 16 – 0.36 CZ 9, 11-15 – 0.34 SHGC: CZ 1-8, 10, 16 – 0.25 CZ 9, 11-15 – 0.22	U-factor: CZ 1-8, 10, 16 – 0.36 CZ 9, 11-15 – 0.34 SHGC: CZ 1-8, 10, 16 – 0.25 CZ 9, 11-15 – 0.22	Nonresidential: U-factor: CZ 1-8,10,16 – 0.36 CZ 9, 11-15 –0.34 SHGC: CZ 1-8,10,16 – 0.25 CZ 9, 11-15 – 0.22 Guest Rooms: U-factor: 0.36 SHGC: 0.25
Solar PV size	123 kW – 204 kW Depending on CZ	64 kW – 87 kW Depending on CZ	None	17 kW – 25 kW Depending on CZ
Battery Storage	217 kWh – 360 kWh Depending on CZ	70 kWh – 94 kWh Depending on CZ	None	16 kWh – 24 kWh Depending on CZ
HVAC System	VAV reheat system with packaged rooftop units, gas boilers, VAV terminal units with hot water reheat	CZ 1 Heat recovery for Core Retail space only CZ 1, 16 < 65 kBtu/h: SZAC with gas furnace > 65 kBtu/h and < 240 kBtu/h: SZHP and gas furnace (i.e., dual fuel heat pump). VAV. > 240 kBtu/h: SZAC VAV with gas furnace CZ 2-15 < 65 kBtu/h: SZAC with gas furnace > 65 kBtu/h and < 240 kBtu/h: SZHP VAV > 240 kBtu/h: SZAC VAV with gas furnace	< 65 kBtu/h: SZAC + gas furnace > 65 kBtu/h: SZAC VAV	Nonresidential and Laundry: VAV reheat system with packaged rooftop units, gas boilers, VAV terminal units with hot water reheat Guest Rooms: SZAC with gas furnaces
SHW System	5-gallon electric resistance water heater	5-gallon electric resistance water heater	100-gallon gas water heater	Nonresidential: 30-gallon electric resistance water heater Laundry Room: 120-gal gas storage water heater Guest rooms: Central gas water heater, 250 gallons storage, recirculation loop

The Reach Codes Team evaluated mixed fuel efficiency and all-electric packages for each prototype and climate zone, as described below.

- **Mixed Fuel + Efficiency Measures**: Mixed-fuel prescriptive building per 2022 Title 24 requirements, including additional efficiency measures.
- **All-Electric Code Minimum Efficiency:** All-Electric building to minimum Title 24 prescriptive standards and federal minimum efficiency standards. This package has the same PV size as mixed-fuel prescriptive baseline.
- **All-Electric Energy Efficiency:** All-Electric building with added energy efficiency measures related to HVAC, SHW, lighting or envelope.
- **All-Electric Energy Efficiency + Load Flexibility:** All-Electric building with added energy efficiency and load flexibility measures.
- **All-Electric Energy Efficiency + Solar PV:** All-Electric building with added energy efficiency and additional Solar PV. The added PV size is larger than prescriptive 2022 Title 24 code requirements and accounts for roof space availability.

For Quick Service Restaurant (QSR), the Reach Code Team has analyzed two scenarios for All-Electric packages, one with electric cooking and the one with gas cooking (the latter of which is referred to as the "HS" package to reflect all-electric HVAC and SHW).

For Small Hotel, the Reach Code Team also analyzed an alternative scenario with PTHP instead of SZHP in All-Electric scenario. It is denoted by the "PTHP" in parenthesis in package name.

3 Results

Results are presented as per the prototype-specific Measure Packages described in Section 4. Overarching factors impacting the results include:

- Designation of a **'benefit'** or a **'cost'** varies with the scenarios because both energy savings, and incremental construction costs may be negative depending on the package. Typically, utility bill savings are categorized as a 'benefit' while incremental construction costs are treated as 'costs.' In cases where both construction costs are negative and utility bill savings are negative, the construction cost savings are treated as the 'benefit' while the utility bill negative savings are the 'cost.'
- Most all-electric packages will have lower **GHG emissions** than equivalent mixed-fuel packages in all cases, due to the clean power sources currently available from California's power providers.
- The Reach Codes Team coordinated with the City of Burbank to select the most prevalent tariffs for each prototype given the annual energy demand profile. The Reach Codes Team **did not compare a variety of tariffs** to determine their impact on cost-effectiveness although utility rate changes or updates can effect on-bill cost-effectiveness results.

3.1 Nonresidential Occupancies

Table 3 through Table 6 shows results for the four nonresidential prototypes for all the evaluated packages in climate zone 9 using Burbank rate.

- For the Medium Office:
  - The total compliance margin of the baseline building represents a near-net-zero energy building with a very low total TDV energy consumption (0.07 TDV kBtu/ft^2-yr). This small number is in the denominator of the package Total Compliance Margin calculations, resulting in large magnitude results. In these situations, the sign of the result is the best indicator of the compliance of a given package.
  - Specifically, the Mixed Fuel + Efficiency Measures and All-Electric Energy Efficiency and Load Flexibility packages complied for Medium Office.
- Across all prototypes, the Reach Code Team identified cost effective efficiency measures when added to the mixed-fuel code minimum package.
- The Team identified On-bill cost effective packages for all All-Electric packages in Medium Office and All-Electric packages with added efficiency in Medium Retail with Burbank rates. The Team could not identify any On-bill cost effective packages for Quick Service Restaurant. For Small Hotel, the Team identified cost effective All-Electric packages except for All-Electric Code Minimum Efficiency package.

Table 3. Medium Office Cost-Effectiveness Summary

Package	Annual Elec Savings (kWh)	Annual Gas Savings (therms)	Annual GHG savings (tons)	Eff TDV Margin	Total Compliance Margin	Source kBtu Margin	Upfront Incremental Package Cost	Lifecycle Energy Cost Savings	Lifecycle $-TDV Savings	B/C Ratio (On-bill)	B/C Ratio (TDV)	NPV (On-bill)	NPV (TDV)
Mixed-Fuel + Efficiency Measures	10,560	(46)	0.9	4%	7674%	9%	$715	$23,195	$24,992	32.4	35.0	$22,480	$24,277
All Electric Code Minimum Efficiency	(23,780)	1,119	(0.3)	-8%	-12217%	-2%	($39,415)	($5,413)	($39,789)	7.3	1.0	$34,002	($373)
All Electric Energy Efficiency	(14,205)	1,119	0.6	-3%	-4992%	7%	($38,700)	$16,302	($16,257)	>1	2.4	$55,003	$22,443
All-Electric Energy Efficiency and Load Flexibility	(6,098)	1,119	2.9	3%	5033%	27%	($38,700)	$47,451	$16,391	>1	>1	$86,151	$55,091

Table 4. Medium Retail Cost-Effectiveness Summary

Package	Annual Elec Savings (kWh)	Annual Gas Savings (therms)	Annual GHG savings (tons)	Eff TDV Margin	Total Compliance Margin	Source kBtu Margin	Upfront Incremental Package Cost	Lifecycle Energy Cost Savings	Lifecycle $-TDV Savings	B/C Ratio (On-bill)	B/C Ratio (TDV)	NPV (On-bill)	NPV (TDV)
Mixed Fuel Code Minimum	226	(495)	(2.1)	-3%	-6%	-13%	$9,020	($21,996)	($12,981)	-2.4	-1.4	($31,016)	($22,000)
Mixed-Fuel + Efficiency Measures	22,532	(583)	0.9	11%	21%	5%	$21,820	$22,858	$48,072	1.0	2.2	$1,038	$26,252
All Electric Energy Efficiency	21,278	0	3.3	14%	27%	20%	$12,800	$47,218	$60,736	3.7	4.7	$34,418	$47,936

Table 5. Quick-Service Restaurant Cost-Effectiveness Summary

Package	Annual Elec Savings (kWh)	Annual Gas Savings (therms)	Annual GHG savings (tons)	Eff TDV Margin	Total Compliance Margin	Source kBtu Margin	Upfront Incremental Package Cost	Lifecycle Energy Cost Savings	Lifecycle $-TDV Savings	B/C Ratio (On-bill)	B/C Ratio (TDV)	NPV (On-bill)	NPV (TDV)
Mixed-Fuel + Efficiency Measures	3,764	444	3.1	11%	11%	18%	$16,150	$18,632	$21,426	1.2	1.3	$2,482	$5,276
All Electric HS Energy Code Minimum Efficiency	(29,886)	2,233	6.2	-14%	-14%	48%	$22,106	($11,139)	($26,069)	-0.5	-1.2	($33,245)	($48,176)
All-Electric HS Energy Efficiency	(20,124)	2,233	8.2	0%	0%	56%	$38,256	$9,779	$820	0.3	0.0	($28,477)	($37,436)
All-Electric HS Energy Efficiency + Load Flexibility	(20,702)	2,233	9.0	2%	2%	59%	$43,666	$7,433	$3,539	0.2	0.1	($36,233)	($40,126)
All-Electric HS Energy Efficiency + Solar PV	11,939	2,233	9.8	0%	34%	62%	$88,664	$66,544	$62,638	0.8	0.7	($22,120)	($26,025)
All Electric Code Minimum Efficiency	(126,307)	9,687	28.7	-11%	-11%	48%	$148,937	($79,510)	($113,479)	-0.5	-0.8	($228,447)	($262,415)
All Electric Energy Efficiency	(115,801)	9,687	30.9	4%	4%	57%	$165,086	($57,510)	($84,863)	-0.3	-0.5	($222,597)	($249,950)
All-Electric Energy Efficiency + Load Flexibility	(116,494)	9,687	31.7	5%	5%	60%	$170,496	($57,973)	($82,432)	-0.3	-0.5	($228,469)	($252,929)

Table 6. Small Hotel Cost-Effectiveness Summary

Package	Annual Elec Savings (kWh)	Annual Gas Savings (therms)	Annual GHG savings (tons)	Eff TDV Margin	Total Compliance Margin	Source kBtu Margin	Upfront Incremental Package Cost	Lifecycle Energy Cost Savings	Lifecycle $-TDV Savings	B/C Ratio (On-bill)	B/C Ratio (TDV)	NPV (On-bill)	NPV (TDV)
Mixed Fuel + Efficiency Measures	9,535	1,661	10.5	13.5%	16%	17%	$21,214	$63,118	$82,450	3.0	3.9	$41,905	$61,236
All Electric Code Minimum Efficiency	(170,301)	10,246	41.7	0.3%	0%	51%	($178,858)	($187,002)	($47,270)	1.0	3.8	($8,144)	$131,587
All Electric Energy Efficiency	(145,720)	10,246	43.5	10.1%	12%	54%	($157,644)	($120,316)	$13,998	1.3	>1	$37,327	$171,642
All Electric Energy Efficiency + Solar PV	(53,022)	10,246	47.4	10.1%	44%	60%	($11,515)	$65,706	$187,360	>1	>1	$77,221	$198,876
All Electric Code Minimum Efficiency (PTHP)	(170,479)	10,246	41.6	0.4%	0%	51%	($650,843)	($187,563)	($46,533)	3.5	14.0	$463,280	$604,309

4 Summary

The Reach Codes Team developed packages of energy efficiency measures as well as packages combining energy efficiency with solar PV generation, simulated them in building modeling software, and gathered costs to determine the cost-effectiveness of multiple scenarios. The Reach Codes Team coordinated with multiple utilities, cities, and building community experts to develop a set of assumptions considered reasonable in the current market. Changing assumptions, such as the period of analysis, measure selection, cost assumptions, energy escalation rates, or utility tariffs are likely to change results.

The combined result of cost effectiveness and code compliance across all packages are detailed in Table 7 through Table 10 below. The tables are formatted to show:

- "Both" with **green** highlight – for scenarios that are cost effective on both metrics and have positive compliance margin across all three compliance metrics.
- "TDV/On-Bill" with **yellow** highlight – for scenarios that are cost effective on either one of the metrics and has positive compliance margin across all three compliance metrics.
- "Comp" with **gray** highlight – for scenarios that are not cost effective on either metric but have positive compliance margin across all three compliance metrics.
- "-" with no color highlight – for scenarios that do not comply across any one code compliance metric and may or may not be cost effective.

The package names in table results columns are as follows:

- Mixed fuel – EE: Mixed Fuel + Efficiency Measures
- All-Electric – Code Min: All-Electric Code Minimum Efficiency
- All-Electric – EE: All-Electric Energy Efficiency
- All-Electric – EE+ LF: All-Electric Energy Efficiency and Load Flexibility
- All-Electric – EE + PV: All-Electric Energy Efficiency and Solar PV

The QSR has two electrification scenarios, with and without cooking appliance electrification, which is denoted by "HS" prefix.
The Small Hotel has an extra package that evaluates a different HVAC type in the All-Electric Code Minimum Efficiency package, a Packaged Terminal Heat Pump (PTHP) instead of a Single Zone Heat Pump.

Table 7. Summary of Medium Office Packages

CZ	Utility	Mixed Fuel	All-Electric		
		EE	Code Min	EE	EE + LF
CZ09	Burbank	Both	-	-	Both

Table 8. Summary of Medium Retail Packages

CZ	Utility	Mixed Fuel		All-electric
		Code Min	EE	EE
CZ09	Burbank	-	Both	Both

Table 9. Summary of Quick Service Restaurant Packages

CZ	Utility	Mixed Fuel	All-electric			All-electric "HS" (HVAC+SHW)			
		EE	Code Min	EE	EE + LF	Code Min	EE	EE + LF	EE + PV
CZ09	LA	Both	-	Comp	Comp	-	Comp	Comp	Comp

Table 10. Summary of Small Hotel Packages

CZ	Utility	Mixed Fuel	All-Electric				All-Electric
		EE	Code Min	EE	EE + LF	EE + PV	Code Min (PTHP)
CZ09	LA	Both	TDV	Both	Both	Both	Both

LEGEND KEY

Both	Compliant & c/e on both metrics
On-bill/TDV	Compliant & c/e on one metric
Comp	Compliant not c/e
-	Not compliant

The Reach Codes Team found All-Electric code compliant new construction to be feasible and cost effective based on TDV and Burbank electricity rates for all four nonresidential prototypes.

Results support reach code adoption for energy efficiency measures over mixed fuel nonresidential building types for all four prototypes in climate zone 9. For Medium Retail, the mixed-fuel code-minimum package is neither cost-effective nor code compliant.

The All-Electric packages indicate capability of achieving the greatest greenhouse savings as compared to mixed-fuel buildings:

- Medium Office All-Electric packages are cost effective, but only the All-Electric with added efficiency and load flexibility package is code compliant due to the use of electric resistance VAV reheat systems. The most likely All-Electric replacement for a central has boiler serving a variable air volume reheat system would be a central heat pump boiler; however, this system cannot be modeled in CBECC at the time of the writing of this report. As such, the Reach Code Team is treating this analysis as temporary until a compliance pathway is established for a central heat pump boiler in the Energy Code and results can be updated accordingly. This modeling capability is anticipated in early 2023 according to discussions with the CBECC software development team, and the cost-effectiveness analysis should become available in the first half of 2023. Heat pump systems are multiple times more efficient, but may also be multiple times more costly, than the electric resistance reheat systems currently analyzed.
- The Reach Codes Team found All-Electric Medium Retail to be cost effective based on Burbank electricity rates in climate zone 9 with added efficiency measures.
- For Quick-Service Restaurant, the Team could not identify any On-bill cost effective packages, but all-electric packages are code compliant with added efficiency and/or load flexibility measures and or PV measures (with/without cooking electrification), and hence can be pursued for reach code.
- For Small Hotel, all-electric packages are code compliant, and On-bill cost effective except for All-Electric Code Minimum Efficiency package.

5 References

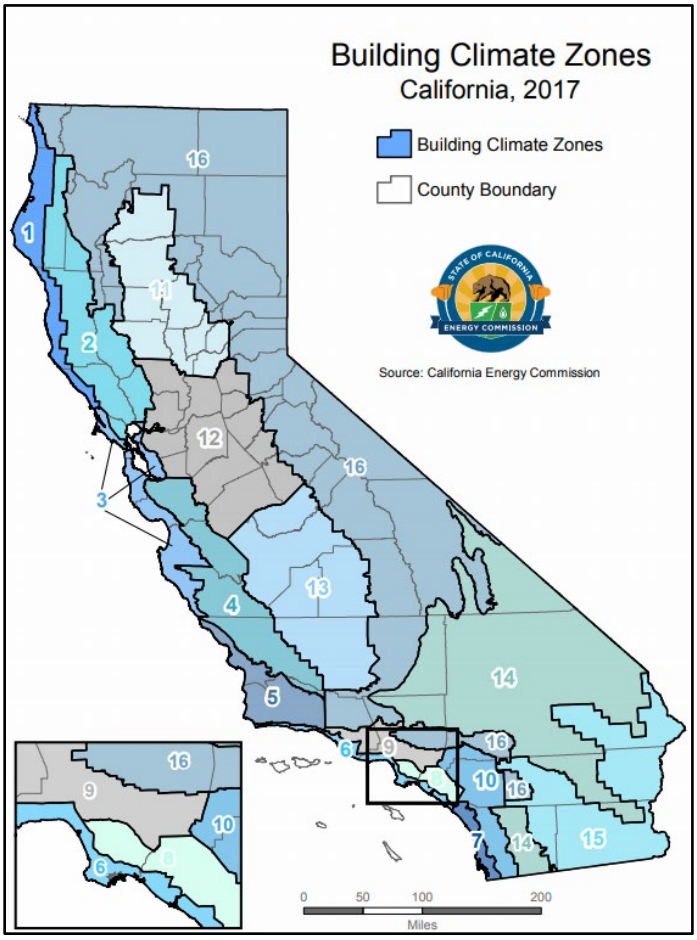
California Public Utilities Commission. (2021a). *Utility Costs and Affordability of the Grid of the Future: An Evaluation of Electric Costs, Rates, and Equity Issues Pursuant to P.U. Code Section 913.1.* Retrieved from https://www.cpuc.ca.gov/-/media/cpuc-website/divisions/office-of-governmental-affairs-division/reports/2021/senate-bill-695-report-2021-and-en-banc-whitepaper_final_04302021.pdf

6 Appendices

6.1 Map of California Climate Zones

Climate zone geographical boundaries are depicted in Figure 1. The map in Figure 1 along with a zip-code search directory is available at: https://ww2.energy.ca.gov/maps/renewable/building_climate_zones.html

Figure 1. Map of California climate zones.



6.2 Utility Rate Schedules

The Reach Codes Team used the City of Burbank tariffs detailed below to determine the On-Bill savings for each package.

6.2.1 City of Burbank

6.2.1.1 Nonresidential

Following are the City of Burbank electricity tariffs applied in this study. Rate D is applied based on the demands.

https://www.burbankwaterandpower.com/images/administrative/downloads/FY22-23_AdoptedFeeSchedule.pdf

SECTION 3. SCHEDULE D: MEDIUM GENERAL SERVICE 20 kVA to 250 kVA
(Last Update 5/24/22, Resolution 22-29,321)

Description			Amount	Unit/Time
(A)	Basic Service Rate			
	(1)	Customer Service Charge		
		(a) 1-phase	$12.68	Meter
		(b) 3-phase	$19.00	Meter
	(2)	Demand Charge		
		(a) Minimum	$104.49	Month
		(b) All kVA of Billing Demand	$11.72	kVA
	(3)	Energy Charge (Includes ECAC charge)		
		(a) Summer On-Peak	$0.2295	kWh
		(b) Summer Mid-Peak	$0.1434	kWh
		(c) Summer Off-Peak	$0.1147	kWh
		(d) Winter Mid-Peak	$0.1434	kWh
		(e) Winter Off-Peak	$0.1147	kWh

Definitions:

Summer: June 1 through October 31
On-Peak: 4pm to 7pm on weekdays , except holidays
Mid-Peak: 8am to 4pm, 7pm to 11pm on weekdays, except holidays
Off-Peak: All hours on weekends and holidays, 11pm to 8am on weekdays, except holidays

Non-Summer: November 1 through May 31
Mid-Peak: 8am to 11pm on weekdays, except holidays
Off-Peak: All hours on weekends and holidays, 11pm to 8am on weekdays, except holidays

Description	Amount	Unit/Time

Holidays are New Year's Day (January 1), President's Day (third Monday in February), Memorial Day (last Monday in May), Independence Day (July 4), Labor Day (first Monday in September), Veteran's Day (November 11), Thanksgiving Day (fourth Thursday in November, and Christmas (December 25).

When any holiday listed above falls on Sunday, the following Monday will be recognized as an off-peak period. No change will be made for holidays falling on Saturday.

(4) Minimum Charge

(a)	1-phase	$117.17	Month
(b)	3-phase	$123.49	Month

The minimum charge shall be the sum of the Customer Service Charge plus the Minimum Demand Charge.

6.2.1.2 SCG

SOUTHERN CALIFORNIA GAS COMPANY Revised CAL. P.U.C. SHEET NO. 46445-G
LOS ANGELES, CALIFORNIA CANCELING Revised CAL. P.U.C. SHEET NO. 46215-G
43002-G

Schedule No. G-10 Sheet 1
CORE COMMERCIAL AND INDUSTRIAL SERVICE
(Includes GN-10, GN-10C and GT-10 Rates)

APPLICABILITY

Applicable to core non-residential natural gas service, including both procurement service (GN rates) and transportation-only service (GT rates) including Core Aggregation Transportation (CAT). This schedule is also available to residential customers with separately metered service to common facilities (swimming pools, recreation rooms, saunas, spas, etc.) only and otherwise eligible for service under rates designated for GM-C, GM-CC, GM-BC, GM-BCC, GT-MC or GT-MBC, as appropriate, if so elected by the customer. Also applicable to service not provided under any other rate schedule. Pursuant to D.02-08-065, this schedule is not available to those electric generation, refinery, and enhanced oil recovery customers that are defined as ineligible for core service in Rule No. 23.B.

The California Alternate Rates for Energy (CARE) discount of 20%, reflected as a separate line item on the bill, is applicable to Nonprofit Group Living Facilities and Qualified Agricultural Employee Housing Facilities (migrant farmworker housing centers, privately owned employee housing, and agricultural employee housing operated by nonprofit entities) that meet the requirements for the CARE as set forth in Schedule No. G-CARE.

TERRITORY

Applicable throughout the service territory.

RATES

Customer Charge

Per meter, per day:

All customers except "Space Heating Only"	49.315¢
"Space Heating Only" customers:	
Beginning Dec. 1 through Mar. 31	$1.48760
Beginning Apr. 1 through Nov. 30	None

(Continued)

(TO BE INSERTED BY UTILITY)
ADVICE LETTER NO. 4152
DECISION NO. 98-07-068
1C11

ISSUED BY
Lee Schavrien
Senior Vice President
Regulatory Affairs

(TO BE INSERTED BY CAL. PUC)
DATE FILED Sep 30, 2010
EFFECTIVE Oct 1, 2010
RESOLUTION NO.

SOUTHERN CALIFORNIA GAS COMPANY Revised CAL. P.U.C. SHEET NO. 60204-G
LOS ANGELES, CALIFORNIA CANCELING Revised CAL. P.U.C. SHEET NO. 60169-G

Schedule No. G-10 Sheet 2
CORE COMMERCIAL AND INDUSTRIAL SERVICE
(Includes GN-10, GN-10C and GT-10 Rates)
(Continued)

RATES (Continued)

All Procurement, Transmission, and Commodity Charges are billed per therm.

			Tier I[1/]	Tier II[1/]	Tier III[1/]	
GN-10:[4/]	Applicable to natural gas procurement service to non-residential core customers, including service not provided under any other rate schedule.					
	Procurement Charge:[2/]	G-CPNR	64.959¢	64.959¢	64.959¢	R,R,R
	Transmission Charge:	GPT-10	106.047¢	60.635¢	30.186¢	
	Commodity Charge:	GN-10	171.006¢	125.594¢	95.145¢	R,R,R
GN-10C[4/]:	Core procurement service for previous non-residential transportation-only customers returning to core procurement service, including CAT customers with annual consumption over 50,000 therms, as further defined in Schedule No. G-CP.					
	Procurement Charge:[2/]	G-CPNRC	72.898¢	72.898¢	72.898¢	
	Transmission Charge:	GPT-10	106.047¢	60.635¢	30.186¢	
	Commodity Charge:	GN-10C	178.945¢	133.533¢	103.084¢	
GT-10[4/]:	Applicable to non-residential transportation-only service including CAT service, as set forth in Special Condition 13.					
	Transmission Charge:	GT-10	106.047¢[3/]	60.635¢[3/]	30.186¢[3/]	

[1/] Tier I rates are applicable for the first 250 therms used per month. Tier II rates are applicable for usage above Tier I quantities and up through 4,167 therms per month. Tier III rates are applicable for all usage above 4,167 therms per month. Under this schedule, the winter season shall be defined as December 1 through March 31 and the summer season as April 1 through November 30.

[2/] This charge is applicable for service to Utility Procurement Customers as shown in Schedule No. G-CP, in the manner approved by D.96-08-037, and subject to change monthly, as set forth in Special Condition 5.

[3/] These charges are equal to the core commodity rate less the following two components as approved in D.97-04-082: (1) the weighted average cost of gas; and (2) the core brokerage fee.

(Footnotes continue next page.)

(Continued)

(TO BE INSERTED BY UTILITY)
ADVICE LETTER NO. 6051
DECISION NO. 98-07-068
2C8

ISSUED BY
Dan Skopec
Senior Vice President
Regulatory Affairs

(TO BE INSERTED BY CAL. PUC)
SUBMITTED Oct 31, 2022
EFFECTIVE Nov 1, 2022
RESOLUTION NO.

6.2.2 Fuel Escalation Rates

6.2.2.1 Nonresidential Occupancies

Table 11 below demonstrate the escalation rates used for nonresidential buildings.

Table 11: Real Utility Rate Escalation Rate Assumptions

	Source	Statewide Electric Nonresidential Average Rate (%/year, real)	Statewide Natural Gas Nonresidential Core Rate (%/year, real)
2023	E3 2019	1.0%	4.0%
2024	2022 TDV	1.0%	7.7%
2025	2022 TDV	1.0%	5.5%
2026	2022 TDV	1.0%	5.6%
2027	2022 TDV	1.0%	5.6%
2028	2022 TDV	1.0%	5.7%
2029	2022 TDV	1.0%	5.7%
2030	2022 TDV	1.0%	5.8%
2031	2022 TDV	0.6%	3.3%
2032	2022 TDV	0.6%	3.6%
2033	2022 TDV	0.6%	3.4%
2034	2022 TDV	0.6%	3.4%
2035	2022 TDV	0.6%	3.2%
2036	2022 TDV	0.6%	3.2%
2037	2022 TDV	0.6%	3.1%

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