CALIFORNIA ENERGY CODES & STANDARDS
A STATEWIDE UTILITY PROGRAM

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2022 CODE CYCLE:

Cost Effectiveness Analysis: 5-Story Multifamily New Construction Update

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Acronym List

B/C – Benefit-to-Cost Ratio

CASE – Codes and Standards Enhancement

CBECC - California Building Energy Code Compliance

CBSC - California Building Standards Commission

CEC - California Energy Commission

CPAU – City of Palo Alto Utilities

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)

SSF – Solar Savings Fraction

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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Summary of Revisions

Date	Description	Reference (page or section)
6/20/2023	Original Release	-
10/24/24	Abbreviated report with updated 5-story packages, DHW costs, HPWH system design, increased solar thermal package, and software update to CBECC 2022.3.1	-

1 Introduction

This abbreviated report is an addendum to the statewide 2022 Cost-Effectiveness Study for Multifamily New Construction report that documents cost-effective combinations of measures that exceed the minimum state requirements, the 2022 Building Energy Efficiency Standards, effective January 1, 2023, for newly constructed multifamily buildings. This report was developed in coordination with the California Statewide Investor-Owned Utilities (CA IOUs) Codes and Standards Program, key consultants, and engaged cities, which are collectively known as the Reach Codes Team. The CA IOU Codes and Standards Program is comprised of IOUs representatives from Pacific Gas and Electric (PG&E), Southern California Edison (SCE), and San Diego Gas and Electric (SDG&E).

The focus of this update is to provide an additional package for the 5-story mixed use multifamily building type in the most recent CBECC software version in support of the single source margin reach code strategy. The package includes a combination of efficiency measures and an increase in the capacity of the solar thermal water heating system. In addition, this study uses updated water heater costs and heat pump water heater (HPWH) system design from the 2025 Multifamily Domestic Hot Water CASE study (Statewide CASE Team, 2023).

2 Methodology and Assumptions

The focus of this update is to provide additional packages for the 5-story multifamily building type in the most recent CBECC software version in support of the single source margin reach code strategy. The general methodology is consistent with the statewide study with the following updates:

1. Updated analysis focused on the 5-story prototype only.
2. Energy models were updated using CBECC 2022.3.1.
3. An additional mixed fuel package with an increased solar thermal system capacity resulting in 0.35 solar savings fraction (SSF) in climate zones (CZ) 1-9 and 0.50 SSF in CZ 10-16.
4. Updated water heater costs and HPWH system design consistent with the 2025 Multifamily Domestic Hot Water CASE study (Statewide CASE Team, 2023).

2.1 Reach Codes

This section describes the approach to calculate cost-effectiveness including benefits, costs, and metrics.

2.1.1 Benefits

This analysis used a time dependent valuation (TDV) of energy-based approach to evaluate cost-effectiveness. TDV requires estimating and quantifying energy savings and costs associated with energy measures.

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.

Utility costs and On-Bill cost-effectiveness were not evaluated for this update.

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, replacement, 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 where appropriate.

Table 1 includes the costs for the updated measures including the updated HPWH system to align with the 2025 Multifamily DHW CASE study and the upsized solar thermal system to 0.35 SSF and 0.50 SSF for CZ 1-9 and CZ 10-16 respectively.

Table 1: Measure Costs

Measure	Climate Zones	Performance Level	Incremental Cost per Dwelling Unit	Source & Notes
HPWH	1-9	2 Large-capacity CO_2 refrigerant Mitsubishi Heat2O	$809	2025 Multifamily Domestic Hot Water CASE study (Statewide CASE Team, 2023)
	10-16		$421	
Solar Thermal System	1-9	0.35 SSF	$774	Storage tank size design aligns with the 2022 Multifamily Domestic Hot Water CASE study (Statewide CASE Team, 2020). Solar thermal system cost methodology aligns with the original 2022 Multifamily Reach Code Report but is scaled up for the upsized solar thermal system (Statewide Reach Codes Team, 2023).
	10-16	0.50 SSF	$942	

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 criterion 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 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.

3 Prototype Designs and Measure Packages

3.1 Multifamily Prototype Buildings

The focus of this update is on the 5-story mixed use prototype described in Table 2 below. For more details on the building prototype selection methodology, please refer to the 2022 Multifamily New Construction Cost-Effectiveness Study (Statewide Reach Codes Team, 2023).

Table 2: Prototype Characteristics

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

3.2 Measure Packages

The Reach Codes Team evaluated an updated all-electric and mixed fuel package for the 5-story prototype, as described below.

1. All-Electric Prescriptive Code: This package meets all the prescriptive requirements of the 2022 Energy Code. In this update, 2 large-capacity CO_2 refrigerant Mitsubishi Heat2O HPWHs were used instead of the Sanden HPWH used in the initial report.
2. Mixed Fuel Efficiency + Solar Thermal: Using the Efficiency Package from the main study as a starting point, an upsized solar thermal system was added with efficiencies of 0.35 SSF for CZ1-9 and 0.50 SSF for CZ 10-16. This is an increase from the prescriptive solar thermal requirements of 0.20 SSF in CZ 1-9 and 0.35 SSF in CZ 10-16.

4 Results

Cost-effectiveness results are presented for measure packages described in Section 3.2. The TDV based cost-effectiveness results are presented in terms of B/C ratio and NPV. Energy savings, compliance margin, 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 an 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.

Table 3 and Table 4 show results for the all-electric package and the mixed fuel package respectively. In the all-electric package for CZ 1 and 16, there are significant cost savings. This is because the base case for CZ 1 and 16 is an electric heat pump with natural gas backup, so the large negative cost reflects the avoided first costs of installing a gas furnace as compared to a heat pump.

Table 3: All-Electric 5-Story Multifamily Cost-Effectiveness Results per Dwelling Unit

Climate Zone	Electric/ Gas Utility	Efficiency TDV Comp Margin	Source Comp Margin	Annual Elec Savings (kWh)	Annual Gas Savings (therms)	Incremental Cost		TDV	
						First Year	Lifecycle (2022$)	B/C Ratio	NPV
CZ01	PGE	15%	21%	-1,024	139	($5,820)	($6,292)	>1	$9,525
CZ02	PGE	10%	14%	-799	112	($573)	$681	4.0	$1,917
CZ03	PGE	11%	16%	-787	111	($573)	$681	3.9	$1,903
CZ04	PGE	9%	15%	-754	105	($573)	$681	3.6	$1,678
CZ04	CPAU	9%	15%	-754	105	($546)	$707	3.4	$1,651
CZ05	PGE	11%	15%	-785	109	($573)	$681	3.7	$1,759
CZ05	PGE/SCG	11%	15%	-785	109	($573)	$681	3.7	$1,759
CZ06	SCE/SCG	8%	17%	-695	96	($573)	$681	2.8	$1,155
CZ07	SDGE	10%	23%	-689	99	($573)	$681	3.1	$1,392
CZ08	SCE/SCG	7%	12%	-672	92	($573)	$681	2.7	$1,115
CZ09	SCE/SCG	6%	10%	-683	92	($573)	$681	2.7	$1,117
CZ10	SCE/SCG	6%	10%	-683	77	($843)	$293	6.5	$1,440
CZ10	SDGE	6%	10%	-683	77	($843)	$293	6.5	$1,440
CZ11	PGE	7%	12%	-723	85	($843)	$293	7.9	$1,793
CZ12	PGE	8%	16%	-743	89	($843)	$293	8.8	$2,030
CZ12	SMUD/PGE	8%	16%	-743	89	($843)	$293	8.8	$2,030
CZ13	PGE	6%	11%	-697	81	($843)	$293	7.2	$1,623
CZ14	SCE/SCG	5%	7%	-735	77	($843)	$293	5.6	$1,192
CZ14	SDGE	5%	7%	-735	77	($843)	$293	5.6	$1,192
CZ15	SCE/SCG	2%	1%	-576	59	($843)	$293	3.3	$601
CZ16	PGE	9%	25%	-1,322	141	($6,090)	($6,679)	>1	$8,886

Table 4: Mixed Fuel + Efficiency + Solar Thermal 5-Story Multifamily Cost-Effectiveness Results per Dwelling Unit

Climate Zone	Electric/ Gas Utility	Efficiency TDV Comp Margin	Source Comp Margin	Annual Elec Savings (kWh)	Annual Gas Savings (therms)	Incremental Cost		TDV	
						First Year	Lifecycle (2022$)	B/C Ratio	NPV
CZ01	PGE	4%	8%	2	16	$712	$899	1.0	$13
CZ02	PGE	4%	8%	10	14	$669	$855	1.2	$159
CZ03	PGE	5%	10%	4	16	$669	$855	1.2	$142
CZ04	PGE	4%	11%	10	16	$669	$855	1.3	$263
CZ04	CPAU	4%	11%	10	16	$669	$855	1.3	$263
CZ05	PGE	5%	11%	3	17	$669	$855	1.2	$164
CZ05	PGE/SCG	5%	11%	3	17	$669	$855	1.2	$164
CZ06	SCE/SCG	4%	13%	9	15	$669	$855	1.2	$138
CZ07	SDGE	5%	13%	6	16	$669	$855	1.1	$135
CZ08	SCE/SCG	4%	11%	21	14	$669	$855	1.2	$156
CZ09	SCE/SCG	4%	12%	25	14	$679	$872	1.2	$196
CZ10	SCE/SCG	6%	16%	81	18	$839	$1,073	1.5	$598
CZ10	SDGE	6%	16%	81	18	$839	$1,073	1.5	$598
CZ11	PGE	6%	12%	103	16	$839	$1,073	1.6	$716
CZ12	PGE	6%	13%	97	16	$974	$1,294	1.5	$681
CZ12	SMUD/PGE	6%	13%	97	16	$974	$1,294	1.5	$681
CZ13	PGE	6%	13%	117	16	$839	$1,073	1.7	$822
CZ14	SCE/SCG	7%	17%	94	18	$839	$1,073	1.7	$763
CZ14	SDGE	7%	17%	94	18	$839	$1,073	1.7	$763
CZ15	SCE/SCG	7%	20%	211	17	$839	$1,073	2.1	$1,292
CZ16	PGE	7%	11%	72	21	$1,318	$1,545	1.1	$135

5 Summary

The Reach Codes Team developed packages of energy efficiency measures as well as packages combining energy efficiency with solar thermal systems, 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, or energy escalation rates are likely to change results.

Table 5 summarizes results and depicts the source energy 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 TDV cost-effective.
- Cells **not highlighted** depict a package that was not TDV cost effective.

The Reach Codes Team concluded the following from the results of this study.

- All-electric package continues to be cost-effective with TDV in the updated 2022.3.1 CBECC software.
- The mixed fuel package with efficiency measures and increased solar thermal systems are cost-effective in all climate zones and demonstrates comparable compliance margins to the all-electric case.

Table 5: Summary of Source Energy Compliance Margins and Cost-Effectiveness for the 5-Story Prototype

Climate Zone	Electric/ Gas Utility	All-Electric	Mixed Fuel + Efficiency + Solar Thermal
CZ01	PGE	21%	8%
CZ02	PGE	14%	8%
CZ03	PGE	16%	10%
CZ04	PGE	15%	11%
CZ04	CPAU	15%	11%
CZ05	PGE	15%	11%
CZ05	PGE/SCG	15%	11%
CZ06	SCE/SCG	17%	13%
CZ07	SDGE	23%	13%
CZ08	SCE/SCG	12%	11%
CZ09	SCE/SCG	10%	12%
CZ10	SCE/SCG	10%	16%
CZ10	SDGE	10%	16%
CZ11	PGE	12%	12%
CZ12	PGE	16%	13%
CZ12	SMUD/PGE	16%	13%
CZ13	PGE	11%	13%
CZ14	SCE/SCG	7%	17%
CZ14	SDGE	7%	17%
CZ15	SCE/SCG	1%	20%
CZ16	PGE	25%	11%

6 References

Statewide CASE Team. (2020). *2022 Multifamily Domestic Hot Water.* Codes and Standards Enhancement (CASE) Initiative.

Statewide CASE Team. (2023). *2025 Multifamily Domestic Hot Water.* Codes and Standards Enhancement (CASE) Initiative.

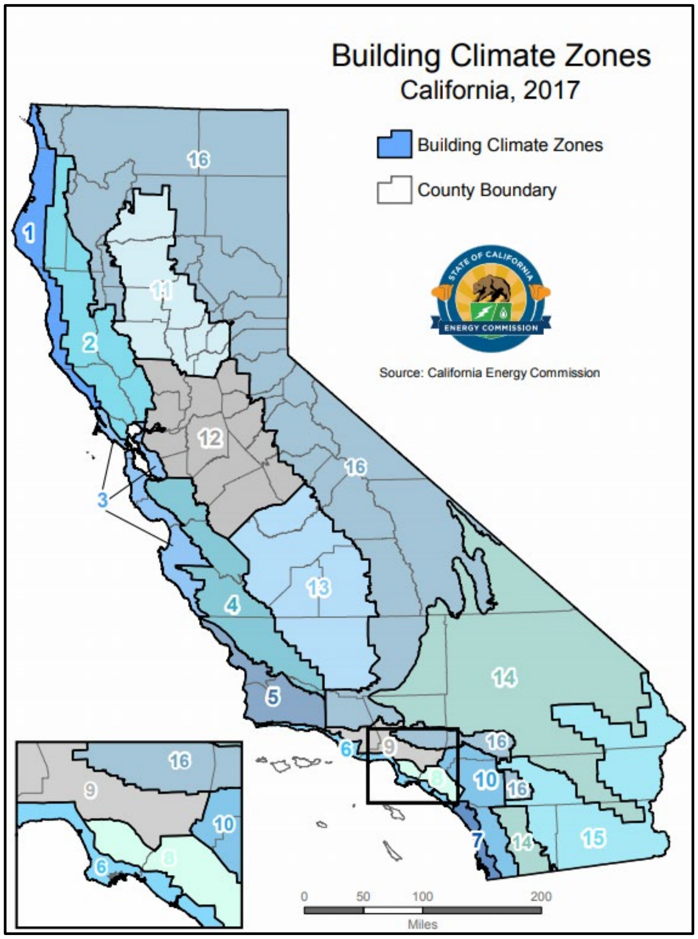
Statewide Reach Codes Team. (2023). *2022 Cost-Effectiveness Study: Multifamily New Construction.*

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.



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.

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