

Single Family New Construction Cost-Effectiveness Study

Building Energy Efficiency Standards: January 1, 2023

[Complete Report](#)

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.

This newly updated cost-effectiveness study on single family new construction documents cost-effectiveness analysis results for traditional detached single family and detached accessory dwelling unit (ADU) building types. A key change from the prior study is the use of the newly adopted Net Billing Tariff (NBT) in the analyses, instead of the previous Net Metering 2 (NEM2) tariff. This change, adopted by the California Public Utilities Commission (CPUC) on April 15, 2023, impacts rates for IOU customers with PV, and thus impacts cost effectiveness. Other changes related to costs and code compliance were incorporated and are detailed throughout the report.

This analysis follows the same structure as the original study, evaluating mixed fuel and all-electric construction packages in all sixteen California climate zones (CZs), including combinations of envelope efficiency measures, equipment efficiency measures (including federally preempted equipment), on-site renewable energy, and battery energy storage. The report utilizes utility tariffs from each investor-owned utility (IOU) and two publicly owned utilities (POUs) based on the climate zones served by the respective utility. The report also defines the metrics used in the analysis, such as On-Bill and TDV (Time-Dependent Valuation) for evaluating cost effectiveness, as well as various EDRs (Energy Design Ratings) for measuring code compliance.

Prototypes:

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	4	1
Window-to-Floor Area Ratio	20%	20%	19.2%

Climate Zones: All 16

Measure Packages

The Reach Codes Team evaluated two packages for mixed fuel homes and five packages for all-electric homes for each prototype and climate zone:

1. **All-Electric Code Minimum:** This package applied the prescriptive requirements of the 2022 Title 24 Code and replaced gas equipment with minimum efficiency electric equipment.
2. **Efficiency Only, all-electric:** This package used only efficiency measures that don't trigger federal preemption issues including envelope, water heating distribution, and duct distribution efficiency measures. For ADUs, this also included ductless variable capacity heat pumps (VCHPs). This package was evaluated for the all-electric homes only.
3. **Efficiency + High Efficiency (Preempted) Equipment, all-electric and mixed fuel:** This package builds off the Efficiency Only package, adding water heating and space conditioning equipment that is more efficient than federal standards. This package was evaluated to compare compliance results against the other non-preempted packages; however, cost-effectiveness was not evaluated for this package since it cannot serve as the basis for adoption of a local ordinance.
4. **Efficiency + PV, all-electric:** This package also builds on the Efficiency Only package, excluding preempted equipment. Instead, PV capacity was added to offset all of the estimated annual electricity use. This package was evaluated for the all-electric homes only.
5. **Efficiency + PV + Battery, all-electric and mixed fuel:** Using the Efficiency + PV package as a starting point for the all-electric analysis, a battery system was added. For mixed fuel homes the package of efficiency measures differed from the all-electric homes in some climate zones to arrive at a cost-effective solution.

Study Results

Table 1 (Single Family) and Table 2 (ADU) summarize results for each prototype and depict the EDR1 compliance margins achieved for each climate zone and package. Because local reach codes must both exceed the energy code (i.e., have a positive compliance margin in the performance approach) 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.
- Cells highlighted in **grey** depict the high efficiency equipment packages where cost-effectiveness was not evaluated.

Table 1. Summary of Single Family EDR1 Margins and Cost-Effectiveness

Climate Zone	Electric /Gas Utility	All-Electric					Mixed Fuel	
		Code Minimum	Efficiency	Efficiency + High Efficiency Equipment	Efficiency + PV	Efficiency + PV + Battery	Efficiency + High Efficiency Equipment	Efficiency + PV + Battery
CZ01	PGE	25.8	29.1	31.4	32.6	41.4	14.8	22.6
CZ02	PGE	14.0	16.3	18.0	18.9	28.3	9.1	14.1
CZ03	PGE	9.1	10.6	12.2	13.1	24.2	3.6	12.8
CZ04	PGE	8.8	10.4	11.9	12.8	24.6	3.8	13.2
CZ04	CPAU	8.8	10.4	11.9	12.8	24.6	3.8	13.2
CZ05	PGE	6.5	7.9	10.2	10.8	23.3	5.2	14.8
CZ05	PGE/SCG	6.5	7.9	10.2	10.8	23.3	5.2	14.8
CZ06	SCE/SCG	4.2	5.3	6.6	8.4	24.6	4.0	18.3
CZ07	SDGE	2.8	3.6	4.8	6.9	23.6	3.2	18.7
CZ08	SCE/SCG	2.1	2.9	4.2	5.6	21.3	2.7	17.1
CZ09	SCE/SCG	3.6	4.4	5.7	7.1	21.8	3.2	16.2
CZ10	SCE/SCG	4.8	5.8	7.2	8.5	21.9	3.9	14.4
CZ10	SDGE	4.8	5.8	7.2	8.5	21.9	3.9	14.4
CZ11	PGE	11.4	13.4	15.0	15.6	24.5	7.7	12.9
CZ12	PGE	11.5	13.3	14.8	15.5	25.2	7.2	13.2
CZ12	SMUD/PGE	11.5	13.3	14.8	15.5	25.2	7.2	13.2
CZ13	PGE	8.3	10.3	11.9	12.3	22.3	4.1	12.3
CZ14	SCE/SCG	8.8	11.5	13.2	14.3	24.7	4.6	13.4
CZ14	SDGE	8.8	11.5	13.2	14.3	24.7	4.6	13.4
CZ15	SCE/SCG	0.9	2.4	3.7	3.8	15.7	3.5	13.5
CZ16	PG&E	21.3	25.6	27.0	29.1	37.5	16.3	20.4

Table 2. Summary of ADU EDR1 Margins and Cost-Effectiveness

Climate Zone	Electric /Gas Utility	All-Electric					Mixed Fuel	
		Code Minimum	Efficiency	Efficiency + High Efficiency Equipment	Efficiency + PV	Efficiency + PV + Battery	Efficiency + High Efficiency Equipment	Efficiency + PV + Battery
CZ01	PGE	11.9	15.7	18.5	19.3	33.7	2.9	18.5
CZ02	PGE	5.7	7.9	9.7	10.8	25.6	-4.7	16.6
CZ03	PGE	2.9	4.0	5.9	7.1	23.2	4.0	11.8
CZ04	PGE	2.4	3.9	5.5	6.8	23.6	4.2	13.3
CZ04	CPAU	2.4	3.9	5.5	6.8	23.6	4.2	13.3
CZ05	PGE	1.8	2.9	4.8	6.4	24.0	-12.1	16.9
CZ05	PGE/SCG	1.8	2.9	4.8	6.4	24.0	-12.1	16.9
CZ06	SCE/SCG	0.5	1.3	2.6	5.0	25.7	-15.6	19.8
CZ07	SDGE	0.1	0.9	2.1	5.0	26.4	-16.5	20.3
CZ08	SCE/SCG	0.1	0.7	1.8	4.2	25.1	-15.3	20.4
CZ09	SCE	0.4	1.1	2.3	4.5	25.0	-14.4	19.6
CZ10	SCE/SCG	1.0	2.0	3.5	5.4	25.3	-11.9	19.0
CZ10	SDGE	1.0	2.0	3.5	5.4	25.3	-11.9	19.0
CZ11	PGE	4.6	7.0	8.6	9.6	25.1	-3.5	17.6
CZ12	PGE	4.6	6.6	8.3	9.3	24.5	-5.6	16.7
CZ12	SMUD/PGE	4.6	6.6	8.3	9.3	24.5	-5.6	16.7
CZ13	PGE	3.1	5.5	6.9	7.8	25.2	4.4	14.5
CZ14	SCE/SCG	3.5	6.3	8.0	9.6	26.9	5.1	14.5
CZ14	SDGE	3.5	6.3	8.0	9.6	26.9	5.1	14.5
CZ15	SCE/SCG	0.0	2.2	2.6	4.4	25.3	-9.3	19.2
CZ16	PG&E	11.2	14.7	15.7	18.3	33.7	2.9	18.3

Key Takeaways and Recommendations

Conclusions:

- All-electric buildings have lower GHG emissions than mixed fuel buildings, due to the clean power sources currently available from California’s power providers as well as accounting for increased penetration of renewables in the future. Almost all the all-electric packages evaluated resulted in greater GHG emission savings than the mixed fuel packages, with the exception of the mixed fuel package with battery storage in climate zones with low heating loads.
- The Reach Codes Team found code-compliant all-electric new construction to be feasible and cost-effective based on TDV for single family homes in all cases except Climate Zone 16.

- All-electric single family new construction was On-Bill cost-effective in all cases except Climate Zones 1, 3, 14, and 16.
- The all-electric ADU home was cost-effective based on TDV in all cases except in Climate Zones 3, 4, 13, and 14 where the higher cost of installing a ducted heat pump water heater (HPWH) instead of the prescriptively required gas tankless water heater exceed the resulting energy cost savings.
- Few cases were cost-effective On-Bill for the ADU.
- All-electric code minimum construction results in an increase in first year utility costs relative to a mixed fuel home, except for CPAU and SMUD where electricity rates are much lower than for the investor-owned utilities (IOUs). The addition of efficiency and other measures to an all-electric home reduces utility costs relative to a mixed fuel home in all cases.
- Under the Net Billing Tariff (NBT), utility cost savings for increasing PV system size beyond code minimum are substantially less than what they were under prior net energy metering rules (NEM 2.0); however, savings are sufficient to be On-Bill cost-effective in all climate zones for the all-electric single family home.
- Applying California Alternate Rates for Energy (CARE) rates in the IOU territories improves On-Bill cost-effectiveness for all-electric buildings, as compared to the same case under standard rates, due to higher utility cost savings compared to a code compliant mixed fuel building also on a CARE rate. This is due to the CARE discount on electricity being higher than that on gas.
- If gas tariffs are assumed to increase substantially over time, in line with the escalation assumption from the 2025 LSC development, all-electric new construction was found to be On-Bill cost-effective in almost all scenarios over the 30-year analysis period. There is much uncertainty surrounding future gas and electricity tariffs, both regarding near term IOU decision-making as well as longer-term industry trends.

Recommendations:

- A reach code with a single performance target based on source energy (EDR1) can be structured to strongly encourage electrification. This approach requires equivalent performance for all buildings and allows mixed fuel buildings which minimizes the risk of violating federal preemption.
- The 2022 Title 24 code's new source energy metric combined with the heat pump baseline encourages all-electric construction, providing an incentive that allows for some amount of prescriptively required building efficiency to be traded off while still being code compliant. The Reach Codes Team recommends that jurisdictions adopting a reach code for single family buildings also include an efficiency requirement with EDR1 margins at minimum consistent with the all-electric code minimum package results in Table 1.
- The code compliance margins for the ADU all-electric code minimum package are lower than for the single-family prototype; code compliance and cost-effectiveness can be more challenging for smaller

dwelling units. As a result, the Reach Codes Team does not recommend EDR1 targets above those reported for the all-electric Code Minimum package in Table 2.

Conclusion

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 (GHG) reduction goals. The program facilitates adoption and implementation of the code when requested by local jurisdictions by providing resources such as cost-effectiveness studies, model language, sample findings, and other supporting documentation.

Local jurisdictions 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. For example, jurisdictions may amend Part 11 instead of Part 6 of the CA Building Code requiring review and approval by the Building Standards Commission (BSC) but not the California Energy Commission (Energy Commission). Reach codes that amend Part 6 of the CA Building Code and require energy performance beyond state code minimums must demonstrate the proposed changes are cost-effective and obtain approval from the Energy Commission. Although a cost-effectiveness study is only required to amend Part 6 of the CA Building Code, this study provides valuable context for jurisdictions pursuing other ordinance paths 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](https://www.localenergycodes.com). Local jurisdictions that are considering adopting an ordinance may contact the program for further technical support at info@localenergycodes.com. In addition, jurisdictions in a CCA territory with rates or rate structures that are significantly different than IOU rates may email the program at info@localenergycodes.com to request a custom analysis.

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