


# Nonresidential New Construction Cost-effectiveness Study

Building Energy Efficiency Standards: January 1, 2023

[Complete Report](#)

This study documents cost-effective combinations of measures that exceed the minimum state requirements, the 2022 California Building Energy Efficiency Standards Title 24, Part 6 (Title 24) (CEC 2022), effective January 1, 2023, for newly constructed nonresidential buildings. The full report documents a variety of above-code electrification, energy efficiency, load flexibility, and solar photovoltaic (PV) packages applied to a set of four nonresidential building prototypes: Medium Office, Standalone Retail, Quick-Service Restaurant, and Small Hotel. This analysis used both On-Bill and time dependent valuation (TDV) of energy-based approaches to evaluate cost-effectiveness for all 16 Climate Zones (CZs). The full report contains detailed definitions for On-Bill, TDV, compliance metrics and the specific measures being analyzed.

## Prototypes:

	 Medium Office	 Medium Retail	 Quick-Service Restaurant	 Small Hotel
Conditioned floor area (ft <sup>2</sup> )	53,628	24,563	2,501	42,554*
Number of stories	3	1	1	4
Window-to-Wall Area ratio	0.33	0.07	0.11	0.14

\*(77 guest rooms) (Nonresidential area: 15,282 (36%))

Climate Zones: All 16

Measures



**Fuel Switching**

- Heat pump or electric space heating or gas furnace
- Heat pump or electric water heaters
- Electric cooking
- Electric clothes dryer
- Electrical panel capacity
- Natural gas infrastructure



**Energy Efficiency**

- Envelope
- Mechanical equipment (HVAC and SHW)
- Lighting



**Load Flexibility**

- Peak Load shedding
- Load shift



**Additional solar PV and/or battery storage**

- Additional solar PV for all-electric scenarios for QSR and Small Hotel prototypes

- **Mixed Fuel Code Minimum:** Mixed-fuel prescriptive building per 2022 Title 24 requirements.
- **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.

## Study Results

Table 1 offers an overview of the findings as well as reach code pathway considerations for every prototype. Subsequent sections provide a snapshot of the findings for each prototype as well as an estimation of greenhouse gas (GHG) savings per prototype.

**Table 1. Reach Code Pathway Considerations for All Prototypes**

Prototype	Compliance and Cost-Effectiveness Results Summary	Energy Efficiency	Electric-Preferred	All-Electric	All-Electric + Efficiency
<b>Medium Office</b>	The Team could not identify any all-electric package that complies with all three compliance metrics, with the Efficiency TDV Compliance margin being the most challenging.  Future iterations of this study will re-evaluate the Medium Office with a central heat pump boiler, an anticipated compliance software capability in early 2023, instead of electric resistance VAVs.	To Be Determined*	All CZs.	To Be Determined*  Future iterations of this study will re-evaluate this prototype	To Be Determined*
<b>Medium Retail</b>	The Team identified cost-effective and code compliant packages of all-electric + energy efficiency measures across most CZs. <u>Mixed-fuel</u> + efficiency was not code compliant in most CZs.	CZs 1-10 and 12-14. Compliance thresholds would be set at values found cost-effective for all-electric + EE.	CZs 7 and 9.	CZs 1-10, 12-14.	CZs 1-10, 12-14.
<b>Quick-Service Restaurant</b>	Code compliance results support reach code adoption for all-electric space conditioning and service water heating when including added measures for CZs 1 and 3-7, others are likely to be compliant with future modeling input updates. Cost-effectiveness is achieved or <i>nearly</i> achieved (Net Present Value is greater than -\$350/month) On-Bill in all CZs.  Cooking electrification does not impact code compliance but is not cost-effective against a mixed-fuel baseline.	CZs 1-7, 13.	CZs 1-7, 13.	Exempt commercial kitchen appliances. CZs 1, 3-7.  Most remaining CZs have a nearly cost-effective and/or nearly compliant pathway.	CZs 1, 3-7.
<b>Small Hotel</b>	Results support Electric-Preferred reach code for all CZs. The all-electric packages are <i>near</i> compliant and TDV cost-effective for most CZs when including energy efficiency measures and additional solar PV. They are <i>likely</i> to be compliant with future modeling iterations.  Future iterations of this study will re-evaluate the nonresidential areas of the hotel with a central heat pump boiler, as mentioned for the Medium Office, which can potentially improve code compliance.	To Be Determined*	All CZs	To Be Determined*  Future iterations of this study will re-evaluate this prototype	To Be Determined*

\*Modeling constraints impacted achievable compliance margins for all-electric packages.

### Medium Office

All-electric packages are cost-effective with energy efficiency and load flexibility measures in many climate zones, but do not achieve code compliance across all three metrics—with efficiency TDV margin being the most challenging. Results will be updated in the first half of 2023 when central heat pump boilers can be simulated in CBECC. Efficiency measures yield some On-Bill cost-effective all-electric packages in milder climate zones. Adding load flexibility measures increases the cost-effectiveness to most climates. The approaches offer significant GHG savings in most CZs as illustrated in Table 2.

**Table 2. Percentage GHG Savings for Medium Office Prototype**

CZ	Mixed Fuel	All-electric		
	EE	Code Min	EE	EE + LF
cz01	0%	3%	4%	12%
cz02	1%	0%	1%	8%
cz03	1%	0%	1%	8%
cz04	2%	-1%	1%	7%
cz05	1%	0%	2%	9%
cz06	2%	0%	2%	8%
cz07	3%	0%	3%	8%
cz08	3%	0%	2%	8%
cz09	2%	-1%	2%	7%
cz10	2%	-2%	0%	6%
cz11	1%	-3%	-1%	5%
cz12	1%	-2%	-1%	5%
cz13	2%	-3%	-1%	4%
cz14	2%	-4%	-2%	5%
cz15	3%	-1%	2%	7%
cz16	1%	1%	2%	7%

### Medium Retail



All-electric packages are cost-effective in all climate zones with added efficiency measures over all-electric baseline. Proposed mixed-fuel packages are cost-effective too with added efficiency measures in most climate zones. This is primarily driven by cost-equivalency in the all-electric package compared to a mixed-fuel package. GHG savings are available from the all-electric packages in all CZs, as illustrated in Table 3.

**Table 3. Percentage GHG Savings for Medium Retail Prototype**

CZ	Mixed Fuel		All-electric
	EE	Code Min	EE
cz01	-4%	-2%	9%
cz02	-21%	-13%	10%
cz03	-18%	-8%	11%
cz04	-14%	-5%	10%
cz05	-15%	-5%	12%
cz06	-7%	4%	13%
cz07	-5%	7%	14%
cz08	-7%	4%	12%
cz09	-8%	3%	13%
cz10	-12%	-9%	3%
cz11	-23%	-21%	2%
cz12	-19%	-11%	9%
cz13	-17%	-8%	10%
cz14	-15%	-5%	10%
cz15	-3%	0%	3%
cz16	-34%	-33%	2%



### Quick-Service Restaurant

The all-electric package with and without cooking electrification is cost-effective in City of Palo Alto Utilities (CPAU) and Sacramento Municipal Utility District (SMUD) only, On-Bill. The all-electric HVAC and SHW package (without electric cooking equipment) with added efficiency measures is On-Bill cost-effective in CZs 1, 3-5 and 12. Adding efficiency and solar PV is On-Bill cost-effective in CZs 1-5, 11-13, and 16. Substantial GHG savings are available from all-electric packages in all CZs, as illustrated in Table 4.

**Table 4. Percentage GHG Savings for Quick-Service Restaurant Prototype**

CZ	Mixed Fuel	All-electric "HS" (HVAC+SHW)				All-electric	
	EE	Code Min	EE	EE + LF	EE + PV	Code Min	EE
cz01	10%	21%	26%	28%	27%	47%	52%
cz02	7%	16%	19%	21%	21%	45%	49%
cz03	8%	14%	20%	22%	22%	45%	51%
cz04	7%	12%	17%	19%	19%	43%	49%
cz05	8%	14%	20%	22%	22%	45%	51%
cz06	7%	9%	15%	16%	17%	43%	48%
cz07	6%	8%	14%	15%	16%	43%	48%
cz08	4%	9%	12%	13%	14%	43%	46%
cz09	5%	9%	12%	13%	15%	43%	46%
cz10	5%	10%	13%	14%	15%	42%	46%
cz11	6%	13%	17%	18%	18%	43%	46%
cz12	6%	14%	17%	18%	19%	44%	48%
cz13	6%	12%	15%	16%	17%	43%	46%
cz14	6%	13%	16%	17%	18%	42%	46%
cz15	4%	7%	9%	11%	12%	40%	42%
cz16	8%	18%	23%	24%	24%	44%	49%

### Small Hotel



The all-electric hotel has tremendous cost savings compared to a mixed-fuel package, primarily due to the avoidance of gas infrastructure to each guest room. All-electric packages achieve TDV cost-effectiveness in all CZs except 16. On-Bill cost-effectiveness is limited to CZs 2-5, 12 and 15 with single zone ducted heat pumps, but nearly all CZs with a packaged terminal heat pump. As with the Quick-Serve Restaurant prototype, Table 5 shows the GHG savings are substantial with the all-electric packages for all CZs.

**Table 5. Percentage GHG Savings for Small Hotel Prototype**

CZ	Mixed Fuel	All-electric			All-electric
	EE	Code Min	EE	EE + PV	Code Min (PTHP)
cz01	13%	47%	48%	50%	47%
cz02	11%	42%	44%	47%	43%
cz03	12%	43%	45%	48%	43%
cz04	11%	41%	44%	46%	42%
cz05	11%	43%	45%	48%	43%
cz06	10%	41%	43%	46%	41%
cz07	10%	41%	43%	47%	41%
cz08	10%	40%	42%	46%	40%
cz09	10%	40%	42%	46%	40%
cz10	11%	37%	39%	43%	37%
cz11	12%	39%	41%	43%	39%
cz12	12%	38%	41%	43%	39%
cz13	11%	37%	39%	42%	37%
cz14	12%	38%	40%	44%	38%
cz15	10%	33%	35%	40%	33%
cz16	13%	43%	46%	48%	45%



This study has identified a set of reach code pathways for all climate zones, and jurisdictions have broad discretion on how to interpret the study's findings. Jurisdictions can adopt reach codes requiring energy efficiency via a Title 24 Part 6 local amendment, or electrification via a Title 24 Part 11 (or municipal code) amendment, or both. Jurisdictions may choose to exempt specific building systems from certain reach codes pathways.

## Get in touch

Get in touch with the Reach Code Team



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