CALIFORNIA ENERGY CODES & STANDARDS
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2019 Reach Code Cost-Effectiveness Analysis
Full-Service and Quick-Service Restaurants

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Acronym/Abbreviation List

AC – Air-Conditioning (unit)

ASHRAE – Society of Heating, Refrigerating and Air-Conditioning E

B/C – Benefit-to-Cost (ratio)

CBECC - California Building Energy Code Compliance

BSC - California Building Standards Commission

CEC - California Energy Commission

CHP – Commercial Heat Pump

CPAU – City of Palo Alto Utilities (utility)

CZ – Climate Zone

DEER - Database for Energy Efficiency Resources

DOE – United States Department of Energy

DX – Direct Expansion

E3 - Energy and Environmental Economics

ft^2 – Square Foot

ft^3 – Cubic Feet Per Minute

FSR – Full-Service Restaurant

gal – Gallon

gph – Gallons Per Hour

GHG - Greenhouse Gas

HVAC - Heating, Ventilation, and Air-Conditioning (equipment)

IOU – Investor-Owned Utility

kBtu – kilo British Thermal Unit

kBtu/hr – kilo British Thermal Unit Per Hour

kW – Kilowatt

kWh – Kilowatt-Hour

LADWP – Los Angeles Department of Water and Power (utility)

mtons – Metric Tons

NPV – Net Present Value

POU – Publicly-Owned Utility

PG&E – Pacific Gas & Electric (utility)

PV – Photovoltaic (solar)

QSR – Quick-Service Restaurant

SCE – Southern California Edison (utility)

SHW – Service hot water

SoCalGas – Southern California Gas (utility)

SDG&E – San Diego Gas & Electric (utility)

SMUD – Sacramento Municipal Utility District (utility)

TDV – Time Dependent Valuation

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

W – Watt(s)

Wdc – Direct Current Watt(s)

VAV – Variable Air Volume

Summary of Revisions		
Date	Description	Reference (page or section)
X/2022	Original Release	NA

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1 Introduction

The California Building Energy Efficiency Standards Title 24, Part 6 (Title 24)((CEC) California Energy Commission 2019) is maintained and updated every three years by two state agencies: the California Energy Commission (CEC) 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 Title 24, Part 6). 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 CEC and file the ordinance with the BSC for the ordinance to be legally enforceable.

This report documents cost-effective combinations of measures that exceed the minimum state requirements, the 2019 Building Energy Efficiency Standards, effective January 1, 2020, for design 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 Code Team.

The Reach Code Team published nonresidential new construction studies in 2019 that documented the cost effectiveness of energy measure packages of Medium Office, Medium Retail, and Small Hotel prototypes. (Statewide Utility Team 2020) Based on stakeholder requests, this report extends that analysis to two other new construction prototypes: quick-service and full-service restaurants (QSR and FSR, respectively). Measures include energy efficiency, electrification, solar photovoltaics (PV), and battery storage.

The United States Department of Energy (DOE) sets minimum efficiency standards for equipment and appliances that are federally regulated under the National Appliance Energy Conservation Act, including heating, cooling, and water heating equipment. (E-CFR 2020) Since state and local governments are prohibited from adopting higher minimum efficiencies than the federal standards require, the focus of this study is to identify and evaluate cost-effective packages that do not include high-efficiency (HE) heating, cooling, and water heating equipment. However, because federal appliance standards do not cover some of the appliances in the quick-service restaurant (QSR) and full-service restaurant (FSR) models, HE models are not preempted and are included in the study. HE appliances are often the easiest and most affordable measures to increase energy performance. While federal preemption limits reach code mandatory requirements for covered appliances, in practice, builders may install any package of compliant measures to achieve the performance requirements.

2 Methodology and Assumptions

The Reach Code Team analyzed the two prototypes using the methodology described in this section.

2.1 Cost Effectiveness

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

2.1.1 Benefits

Across all prototypes, this analysis used both *on-bill* and *time dependent valuation* (TDV) of energy-based approaches to evaluate cost effectiveness. Both approaches involve quantifying the energy savings and costs associated with energy measures, with the primary difference being how energy is valued:

- **On-bill:** Customer-based lifecycle cost approach that values energy based upon estimated customer on-bill impacts over a 15-year duration using electricity and natural gas utility rates, accounting for a three percent discount rate and energy cost inflation per Appendix 7.2.
- **TDV:** TDV was developed by the CEC to reflect the time dependent value of energy including long-term projected costs of energy. This includes costs of electricity supply during periods of peak demand, as well as projected costs for carbon emissions. Electricity used (or saved) during peak periods has a much higher value than electricity used (or saved) during off-peak periods. This metric values energy usage differently depending on the fuel source (electricity, natural gas, and propane), time of day, and time of year.

The Reach Code Team performed energy simulations using the most recent software available for 2019 Title 24 code compliance analysis, California Building Energy Code Compliance for Commercial Buildings (CBECC-Com) 2019.1.3. The Reach Code Team also tested the 2022 weather files and 2022 TDV multipliers using a research version of CBECC-Com 2022 software for most results to understand potential impacts on cost effectiveness, with results located in Section 7.5. This study will be updated when the compliance version of CBECC-Com 2022 becomes available in the first half of 2022.

2.1.2 Costs

The Reach Code Team assessed the incremental costs and savings of the energy packages over 15 years for each restaurant prototype. 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 Code 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.

The Reach Code Team leveraged cost data from 2022 Title 24 Codes and Standards Enhancement (CASE) work[1] and received additional cost estimates from a San Francisco Bay Area mechanical

[1] CASE efforts include detailed itemized costs for a wide range of HVAC and SHW systems, and from a variety of resources. Visit https://title24stakeholders.com/ for more information.

contractor for the heating, ventilation, and air conditioning (HVAC) and service water heating (SWH) systems for all packages. The Reach Code Team determined cost estimates for kitchen appliances from online retailers, using the average costs from three different appliance retailers for the analysis. The Reach Code Team adjusted material and labor costs for each climate zone (CZ) based on weighting factors from RSMeans.

2.1.3 Metrics

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

- **NPV:** The Reach Code 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 savings represent net costs. A measure that has negative energy cost benefits (i.e., the energy cost increases) 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:** The 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 criterion for cost effectiveness is a B/C ratio greater than 1.0. A value of 1.0 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 incremental construction cost 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 rate specialists at each IOU, and the publicly available information for several publicly-owned utilities (POUs), the Reach Code Team determined appropriate utility rates for each prototype and package (see Appendix 7.2 for details). The utility tariffs were determined based on the annual load profile of each prototype and the corresponding package, the most prevalent rate in each territory, and information that the rate offering was not planned to be phased out. For some prototypes there are multiple options for rates because of the varying load profiles of mixed-fuel buildings versus all-electric (AE) buildings. If more than one rate schedule is applicable for a particular load profile, the Reach Code Team did not attempt to compare or test a variety of tariffs to determine their impact on cost effectiveness. Utility rates were applied to each CZ based on the predominant IOU serving the population of each zone according to Figure 1.

A time-of-use (TOU) rate was applied to all cases. In addition to energy consumption charges, there are kW demand charges for monthly peak loads. Utilities calculate the peak load by the highest kW of the 15-minute interval readings in the month. However, the energy modeling software produces results on hourly intervals; therefore, the Reach Code Team calculated the demand charges by multiplying the highest load of all hourly loads in a month with the corresponding demand charge per kW. For cases with PV

generation, the approved NEM2 (Net Energy Metering) tariffs were applied along with minimum daily use billing and mandatory non-bypassable charges. For the PV cases, annual electric production was always less than annual electricity consumption; therefore, no credits for surplus generation were necessary.

Figure 1. Utility Tariffs used based on CZ

CZ	Electric/Gas Utility	Electricity (TOU)	Natural Gas
IOUs			
1-5,11-13,16	Pacific Gas and Electric Company (PG&E)	B-1 / B-10	G-NR1
5	PG&E/Southern California Gas Company (SoCalGas)	B-1 / B-10	G-10 (GN-10)
6, 8-10, 14, 15	Southern California Edison (SCE)/SoCalGas	TOU-GS-1 / TOU-GS-2 / TOU-GS-3	G-10 (GN-10)
7, 10, 14	San Diego Gas & Electric Company (SDG&E)	TOU-A+EECC / AL-TOU+EECC	GN-3
POUs			
4	City of Palo Alto (CPAU)	E-2/E-4 TOU	G-2
12	Sacramento Municipal Utility District (SMUD)/PG&E	GSN/GSS	G-NR1
6, 8, 9, 16	Los Angeles Department of Water and Power (LADWP)/SoCalGas	A-1 / A-2	G-10 (GN-10)

Utility rates are assumed to escalate over time using assumptions from research conducted by Energy and Environmental Economics (E3) in the 2019 study *Residential Building Electrification in California* (Energy & Environmental Economics 2019) and escalation rates used in the development of the 2022 TDV multipliers for the 2022 Building Energy Efficiency Standards (Energy & Environmental Economics 2021). See Appendix 7.2 Utility Rate Schedules for additional details.

2.2 Greenhouse Gas Emissions

The analysis uses the greenhouse gas (GHG) emission multipliers developed by E3 (E3 2021) to support development of compliance metrics for use in the 2022 California energy code. There are 8,760 hourly multipliers accounting for time dependent energy use and carbon emissions based on source emissions, including renewable portfolio standard projections. For the 2022 code cycle, the multipliers also incorporate GHG from methane and refrigerant leakage, which are two significant sources of GHG emissions. (NORESCO 2020) 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). The Reach Code Team used the 2022 multipliers to calculate emissions from both the 2019 and 2022 results.

3 Prototypes, Measure Packages, and Costs

This section describes the prototypes and analysis method. The Reach Code Team used modified versions of DOE building prototypes to evaluate cost effectiveness of measure packages after initializing the prototypes to comply with 2019 Title 24 new construction requirements. The Reach Code Team performed analyses beginning with DOE prototypes FSR and QSR. TRC designed all baseline prototypes to be mixed-fuel and have compliance margins as close to zero percent as possible to reflect a prescriptively compliant new construction building in each CZ.

The Reach Code Team analyzed two restaurant prototypes to discern the variance in analysis results depending on the type of restaurant: an FSR, representing fine dining serving American cuisine, and a QSR, representing a quick-service burger diner. Section 7.3 includes more details on restaurant types.

3.1 Prototype Characteristics

The Reach Code Team utilized DOE prototypes for the basic geometry of the FSR and QSR buildings, and applied prescriptive Title 24 new construction requirements, as summarized in Figure 2.

Figure 2. Restaurant Baseline Prototype Characteristics

		FSR	QSR
Conditioned floor area (ft^2)	Total	5,500	2,500
	Dining	*4,000*	*1,250*
	Kitchen	*1,500*	*1,250*
Number of stories		1	1
Wall assembly U-factor		0.069 (CZ1), 0.062 (CZ2, 4, 5, 8-16), 0.082 (CZ3)	
Roof assembly U-factor		0.034 (CZ1-5, 9-16), 0.049 (CZ6-8)	
Window-to-wall area ratio		0.17	0.14

3.2 Measure Definition and Costs

The Reach Code Team developed basis-of-designs (BODs) for kitchen process, HVAC (heating, ventilation, and air-conditioning), and SWH equipment for mixed-fuel and AE restaurants. The BODs served as the foundation for modeling inputs and cost assumptions for the cost-effectiveness analysis and is further detailed in Appendix 7.3, including details such as energy efficient appliance selection and kitchen exhaust hood design. None of the cooking appliances examined in this study are subject to federal energy efficiency requirements.

3.2.1 Cooking Appliances

For cooking appliances, the Reach Code Team focused on gas cooking appliances that require a Type I exhaust hood.[2] Compared to appliances needing a Type II exhaust hood, Type I appliances present

[2] Type I hoods are installed over cooking appliances, and they include listed grease filters, baffles, and a fire suppression system. Type II hood may nor may not have grease filters or baffles and is not designed to have a fire-suppression system. Compared to Type II hoods, Type I hoods have higher exhaust rate requirements and thus have a larger energy impact. Thus, Type I hoods require more design optimization and control.

challenges for electrification, and have large impacts on HVAC loads. Most appliances requiring Type II hoods, such as dishwashers, are already AE and require a smaller amount of exhaust air. The Reach Code Team determined the type and number of cooking appliances appropriate for the QSR and FSR based on data collected from more than 100 restaurants by PG&E and Frontier Energy (formerly Fisher-Nickel). (PG&E and Fisher-Nickel 2014) We selected specific models of cooking appliances and developed typical hourly energy load profiles for each appliance based on information collected through:

- Literature review, including Database for Energy Efficiency Resources (DEER) workpapers (DEER 2020), American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) RP 1362 (ASHRAE 2008), the IOU rebate product list (California Energy Wise 2020), Gas Technology Institute (GTI) and Fisher-Nickel (GTI and Fisher-Nickel 2013), and Energy Star® commercial kitchen product criteria;
- Interviews and BOD reviews with food service technology subject matter experts, including SCE, SoCalGas, SDG&E, and Frontier Energy (formerly Fisher-Nickel); and
- Market research, including product specification review.

The Reach Code Team developed two BODs for the QSR, a burger diner and a taqueria. The Reach Code Team verified that both are technically feasible, and the selected appliances in each package can achieve equivalent cooking capacity and cooking needs (see Appendix 7.3.1.3). Ultimately, the Reach Code Team tested only the burger diner for cost effectiveness analysis due to scope limitations, though cost-effectiveness results are not expected to be significantly different for the taqueria. The FSR BOD represents a fine dining restaurant serving American cuisine.

3.2.2 Exhaust and Ventilation

Both the QSR and FSR have wall-mounted canopy exhaust hoods that overhang appliances by six inches (in.) on each side, per ASHRAE 154. (ASHRAE 2020) The total exhaust rate is the maximum airflow allowed by 2019 Title 24 Table 140.9 for the appropriate equipment duty level. The larger system in the FSR includes demand-controlled kitchen ventilation (DCKV) per 2019 Title 24 prescriptive requirements.

For kitchen ventilation design, the Reach Code Team assumed makeup air was supplied via an outdoor air-makeup unit in the baseline (code minimum) packages. HVAC systems are sized to maintain space cooling and heating setpoints specified by the 2019 Title 24 Alternative Calculation Method Reference Manual.

3.2.3 Service Water Heating

For SWH design, the Reach Code Team reviewed a 2010 PG&E and Fisher-Nickel report and California Energy Wise design guide to determine the SWH design parameters and load profiles for both the QSR and FSR, and worked with commercial heat pump (CHP) water heater manufacturers to develop system designs. (Fisher-Nickel and PG&E 2010, California Energy Wise 2020)

3.2.4 All-Electric Design

The Reach Code Team compared the incremental differences in equipment selection, and associated costs, from a mixed-fuel baseline to AE restaurants for HVAC, SWH, kitchen process equipment, and

gas/electrical infrastructure. Figure 3 and Figure 4 show the costs for FSR and QSR, respectively, in CZ 12 as an example.

This analysis assumes that in an AE new construction scenario fuel gas would not be supplied to the site. Eliminating fuel gas in new construction saves costs associated with connecting a service line from the street main to the building, a gas meter, piping distribution within the building, plan review, and monthly connection charges by the utility. The Reach Code Team assumed 1.5-inch and 2-inch fuel gas pipes sized using Schedule 40 of the International Fuel Gas Code for QSR and FSR, respectively, for the plumbing distribution. Pipes were costed using an average of material and labor costs for steel and corrugated stainless-steel tubing material. The natural gas plan review cost is based on information received from CPAU. Meter costs are from PG&E and include both material and labor. The service extension costs are based on guidance from PG&E, who noted that the cost range is highly varied and that there is no *typical* cost, with costs being highly dependent on length of extension, terrain, whether the building is in a developed or undeveloped area, and number of buildings to be served. While an actual service extension cost is uncertain, the Reach Code Team believes the costs assumed in this analysis are within a reasonable range based on a sample range of costs provided by PG&E. These costs assume new construction in a previously developed area.

For replacement and maintenance costs, the Reach Code Team assumed the replacement of all cooking appliances at year ten. Based on interviews with subject matter experts, a typical mixed-fuel kitchen needs regular maintenance ten times a year, whereas an AE kitchen would require maintenance five times a year without the need for plumbing maintenance. We assumed each visit would cost $150.

Figure 3. New Construction FSR All-Electric Construction Costs, CZ12 Example

Mixed-Fuel Measure	Mixed-Fuel Cost	All-Electric measure	All-Electric Cost	All-Electric Incremental Cost
Mechanical Equipment				
HVAC: Packaged furnace, DX AC	$164,951	HVAC: Packaged heat pump	$161,040	$(3,911)
SWH: Gas storage water heater with recirculation loop - 400 kBtu/hr heater (2) - 200-gallon (gal) tank (1)	$38,088	SWH: Heat pump water heaters with storage tank with recirculation loop - Four Colmac CxV-5 (4) - 500 gal of primary storage (1) - 5 kW 120-gal electric resistance loop heater (1)	$146,864	$108,776
Kitchen Appliances				
Gas cooking appliances: - Underfired broiler (1) - French fryer (2) - Griddle, single sided (1) - Broiler, salamander (1) - Oven, convection double deck (1) - Oven, range (2) - Range, six open burners (2) - Range, stock pot (2)	$53,263	Electric cooking appliances: - Chain broiler (1) - French fryer (2) - Griddle, single sided (1) - Broiler, salamander (1) - Oven, convection double deck (1) - Oven, induction range (2) - Range, six burner induction cooktop (2) - Range, induction stock pot (2)	$101,638	$48,375
Infrastructure				
In-house gas plumbing	$7,873	In-house electrical upgrades for branch circuits	$2,626	$(5,247)
400 ampere (A) panel	$7,669	800 A panel	$15,338	$7,669
Natural gas plan review	$2,316	*Not applicable*	$0	$(2,316)
Gas service extension	$13,000	*Not applicable*	$0	$(13,000)
Gas meter	$3,000	*Not applicable*	$0	$(3,000)
Total	**$290,160**		**$427,506**	**$137,346**

Figure 4. New Construction QSR All-Electric Construction Costs, CZ12 Example

Mixed-fuel measure	Mixed-fuel cost	All-electric measure	All-electric cost	All-electric incremental cost
Mechanical Equipment				
HVAC: Packaged furnace, DX AC	$105,102	HVAC: Packaged heat pump	$115,127	$10,025
SWH: Gas storage water heater - 150,000 Btu/hr heater (1) - 100-gal tank (1)	$17,383	SWH: Heat pump water heaters with storage tank - AO Smith CHP 120 - Transfer fan + louvered door	$21,940	$4,557
Kitchen Appliances				
Gas cooking appliances: - French Fryer (4) - Griddle, single sided (2) - Half-size electric convection oven (1)	$21,649	Electric cooking appliances: - French fryer (4) - Griddle, single sided (2) - Half-size electric convection oven (1)	$43,534	$21,886
Infrastructure				
In-house gas plumbing	$2,998	In-house electrical upgrades for branch circuits	$1,919	$(1,080)
400 A panel	$7,669	800 A panel	$15,338	$7,669
Natural gas plan review	$2,316	*Not applicable*	$0	$(2,316)
Gas service extension	$13,000	*Not applicable*	$0	$(13,000)
Gas meter	$3,000	*Not applicable*	$0	$(3,000)
Total	**$173,117**		**$197,858**	**$24,741**

3.2.5 Efficiency

The Reach Code Team identified potential efficiency measures above the 2019 Title 24 code baseline to test for cost effectiveness. The measures were developed based on the Team's review of proposed 2022 Title 24 CASE nonresidential measures, as well as ASHRAE 90.1 and 189.1 Standards. The Reach Code Team developed the final measure list based on iterative modeling and discussions with designers and contractors.

3.2.5.1 Kitchen appliances

- **Energy efficient cooking appliances:** Specifies cooking appliances that meet ENERGY STAR specifications[3] or are qualified for IOU rebates[4], compared to mixed-fuel baseline appliances that are not ENERGY STAR or rebate-qualified. All-electric packages only contain ENERGY STAR or rebate-qualified cooking appliances, as these measures are not federally regulated and avoid preemption.

- **Kitchen of the Future (KOF)[5]:** Specifies a HE AE cooking appliance package to reduce space requirements, improve energy efficiency and reduce cooking time. The KOF involves careful design and selection of more advanced electric appliances that combine cooking processes. For example, combination and rapid cook ovens are used to replace broilers, convection ovens, range oven, and stock pot. Due to the appliances selected in BODs for each respective prototype, KOF principles are only applied to the FSR.

3.2.5.2 Envelope

- **Cool roof:** Specifies solar reflectance exceeding 2019 Title 24 roof solar reflectance requirements, representing the 2022 code requirements. The restaurant prototypes have steep-sloped roof.

  - CZs 2 and 4 through 16: The minimum aged solar reflectance is increased from 0.20 to 0.25, the minimum thermal emittance increased from 0.75 to 0.80, and the aged solar reflective index from 16 to 23.
  - CZs 1 and 3: No proposed steep-sloped roof measure.

    The 2022 High Performance Envelope CASE Report demonstrates similar cool roof opportunities available for low-sloped roofs (Title 24 Stakeholders 2020).
- **Modify fenestration solar heat gain coefficient (SHGC) and U-factor:** In all CZs, reduces the window SHGC from the prescriptive value of 0.25 to 0.20, and reduces the window U-factor from 0.36 to 0.31. No change to visible transmittance requirements.

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[3] EnergyStar commercial food service equipment. https://www.energystar.gov/products/commercial_food_service_equipment

[4] California Energy Wise summary of product qualified for IOU rebates. https://caenergywise.com/instant-rebates/#qualifying-products. Check the utility's website for more details.

[5] Kitchen of Future (KOF) concept was presented by Food Service Technology Center (FSTC) at Frontier Energy Inc. Presentation by Richard Young at ASHRAE Golden Gate Chapter Seminar on Building Decarbonization. The reach code team consulted FSTC for KOF equipment selection for this study. https://ggashrae.org/meetinginfo.php?id=165&ts=1598039593

3.2.5.3 Lighting

- **Reduced interior lighting power density (LPD):** Specifies the maximum allowable LPD values based on the 2022 Nonresidential Indoor Lighting CASE Report ((CEC) California Energy Commission 2021). Reduces the LPD requirement in the dining area from 0.55 watts (W) per ft2 (W/ft2) to 0.35 W/ft2. This measure only applies to dining and bar areas, which are only in the FSR and not the QSR.

3.2.5.4 HVAC

- **Efficiency in lower capacity HVAC units:** Increases operating efficiency of lower capacity HVAC units with cooling capacity greater than 33,000 Btu/hr in the QSR by applying the following:

  - Add an economizer.
  - Require a minimum of two stages of mechanical cooling capacity for direct expansion (DX) air-conditioning (AC) units.
  - Require a minimum fan speed ratio of 0.5.

  The 2019 Title 24 prescriptive requirements already specify economizer usage for units with a cooling capacity greater than 54,000 Btu/hr, and both two-stage cooling and a minimum fan speed ratio of 0.5 for units with a cooling capacity greater than 65,000 Btu/hr. This measure only applies to QSR because the HVAC units in FSR are too large for this measure to be applicable.

- **Transfer air for kitchens:** Decrease kitchen makeup air supply by adding the following:

  - Require at least 15 percent or 25 percent of replacement air come from transfer air in the dining space, for QSR and FSR respectively, that would otherwise be exhausted.
  - For QSR, implement a demand ventilation system for the kitchen.
- **Fan power budget:** Reduces supply and exhaust fan motor horsepower based on the proposed requirements of the 2022 CASE Report Air Distribution: High Performance Ducts and Fan Systems, which expands current requirements of 2019 Title 24 Section 140.4(c)1 (Energy Solutions 2020). Power budgets of each fan are dependent on the type of fan (supply or exhaust) and airflow.

3.2.5.5 Service hot water

- **Low-flow hot water dishwashing:** Specifies commercial dishwashers that use 20 percent less water than ENERGY STAR specifications and uses pre-rinse spray valves (PRSV) qualified for IOU rebates. In addition, the dishwasher includes heat recovery function such that it only needs connection to cold water and reduces hot water demand and sizes of the central service hot water (SHW) system. For QSRs, which typically specify a three-compartment sink for dishwashing, this measure would replace or add a dishwasher to reduce total hot water load. FSRs specify dishwashers as standard practice.

- **Reduce supply water temperature:** Reduces hot water demand and supply hot water temperature for the FSR, from 140ºF to 125ºF. These features are critical to enable AE heat pump water heater (HPWH) design to reduce upfront equipment cost and operational cost. This is a no-cost measure that is enabled by the use of the above-specified dishwasher. See details in Appendix 7.3.3 for details.

- **Low-flow water fixtures:** Specifies adding a 1.0 gallon per minute (gpm) faucet aerators to hand-washing sinks in the kitchen to reduce water usage. Title 20 requires kitchen sinks to have a flow rate of at most 1.8 gpm.

- **Low-demand electric SHW plant:** When all the measures above are applied to the FSR, the SHW equipment can be down-sized from four (4) Colmac CxV 5 to two (2) AO Smith CHP-120 due to a 27 percent reduction in daily hot water demand (see Figure 47 in Appendix 7.3.3). This results in upfront and operational cost savings and improved cost effectiveness for AE packages that include efficiency measures.

The incremental measure costs for these measures are in Figure 5.

Figure 5. Restaurant Efficiency Measure Incremental Costs

Measure Name	Incremental Cost Description	FSR	QSR
Energy efficient gas cooking appliances	Varies by appliance; only applicable in comparison to a mixed-fuel baseline	$48,376	$21,886
KOF electric cooking appliances	Only applicable for electric kitchen packages, and incremental cost in comparison to a mixed-fuel baseline	$71,018	n/a
Cool roof	$0.02/ft^2 of roof (Title 24 Stakeholders 2020)	$0 - $141 depending on CZ	$0 - $64 depending on CZ
Modify fenestration SHGC and U-factor	$4.24/ft^2 of window	$2,153	$1,188
Reduced LPD	-$1.36/ft^2 of floor area (Title 24 Stakeholders 2020)	$(5,420)	n/a
Efficiency in lower capacity HVAC units	$2,606/unit (Statewide Utility Team 2020, DMG n.d.).	n/a	$0 - $2,606 depending on CZ
Transfer air for kitchens	Cost is negligible as it only requires modification to control programming	$0	$0
Fan power budget	For constant volume HVAC units, $0.27/ft^2 of building floor area For variable volume HVAC units, $0.31/ft^2 of building floor area	$2,170	$1,112
Low-flow hot water dishwashing	For FSR: - HE door-type high temperature dishwasher: $5,056/unit - HE undercounter-type high temperature dishwasher: $4,460/unit - PRSV: $22 /unit For QSR:- HE door-type high temperature dishwasher: $7,633/unit - PRSV: $22/unit	$9,539	$7,656
Low flow fixtures	- Faucet Aerator: $8/unit - Five (5) kitchen hand-washing sinks in FSR and two (2) in QSR	$40	$16
Low-demand electric SHW plant (FSR only)	Reduced service hot water equipment cost, see Section 7.3.3 for details. - Two A.O. Smith HPWH and recirculation tank - Plumbing for central HPWH - Total $73,969, result in an incremental cost of $35,881 in comparison to a mixed-fuel baseline	$35,881	N/A

3.2.6 Solar PV

The Reach Code Team estimated 50% of the roof area is available to install PV and has solar access, with a capacity of 15 W/ft^2. This approach assumes that the other 50% of the roof is for skylights, mechanical equipment, and walking paths. Figure 6 and Figure 7 depict the portion of annual electricity consumption that is offset by PV for both mixed-fuel and AE buildings in the FSR and QSR, respectively. PV energy output is built into CBECC-Com and is based on the

National Renewable Energy Laboratory's (NREL) PVWatts calculator, which includes long-term performance degradation estimates.[6]

Figure 6. FSR - Annual Percent kWh Offset with 41.3 kW Array

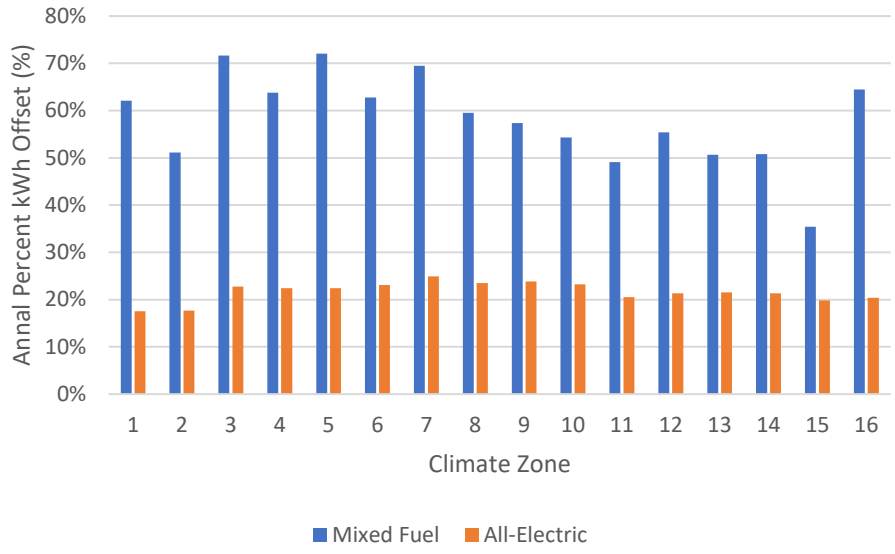
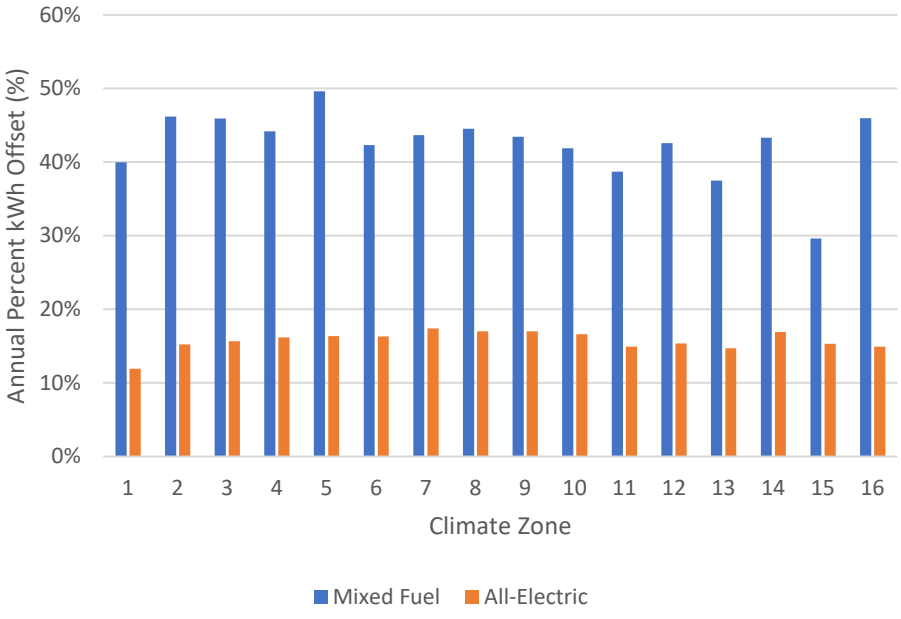


Figure 7. QSR: Annual Percent kWh Offset with 18.8 kW Array



[6] More information available at: https://pvwatts.nrel.gov/downloads/pvwattsv5.pdf

The PV costs include first cost to purchase and install the system, inverter replacement costs, and annual maintenance costs, summarized in Figure 8. Upfront solar PV system costs are reduced by the federal income tax credit (ITC) of approximately 26% due to a phased reduction in the credit through the year 2022.[7]

Figure 8. Restaurant Solar PV Costs

	Unit Cost	FSR	QSR	Useful Life (years)	Source
Solar PV system installation	$1.86/direct current W (Wdc)	$76.560	$34,880	30	NREL Q1 ((NREL) National Renewable Energy Laboratory 2018)
Inverter replacement	$0.15/Wdc	$6,190	$2,820	10	E3 Rooftop Solar PV System Report (E3 2020)
Annual maintenance costs	$0.02/Wdc	$826	$376	1	
Total	$2.03/Wdc	$83,576	$38,076		

3.2.7 Battery Storage

This measure includes installation of batteries to allow energy generated through PV to be stored and used later, providing utility cost benefits. The Reach Code Team assessed the impact of battery sizes and control algorithms on TDV savings. The battery size is optimized for each prototype to offset the majority of the peak period load (i.e., 4:00 PM – 9:00 PM). The Reach Code Team used the *ranked day demand response* control method, which assumes batteries are charged anytime PV generation is greater than the building load but discharges to the electric grid beginning on the highest priced hour of the day. This control algorithm uses the relative ranking of the highest TDV for a day to determine its rank instead of a specific TDV value as threshold.

This control option is *not* reflective of the current products on the market and represents an ideally controlled condition where there is real-time electricity pricing, and was selected because it would optimize cost-effectiveness. While the analysis uses this control strategy, the proposed requirement would not mandate the control strategy used in practice. CBECC-Com has approximations of performance characteristics changes due to environmental conditions, charge/discharge rates, and degradation with age and use.

The Reach Code Team used costs of $1,000 per kWh based on preliminary findings from concurrent research by the Statewide Utilities Codes and Standards Program, using data from the Self Generation Incentive Program. (Self Generation Incentive Program 2020) Batteries are eligible for the ITC if they are installed at the same time as the renewable generation source and

[7] The federal credit drops to 22% in 2023 before dropping permanently to 10% for commercial projects in 2024. More information on federal Investment Tax Credits available at: https://www.seia.org/initiatives/solar-investment-tax-credit-itc; https://www.seia.org/sites/default/files/2021-01/SEIA-ITC-Factsheet-2021-Jan.pdf

at least 75% of the energy used to charge the battery comes from a renewable source. Thus, the Reach Code Team also applied a 26% cost reduction to battery costs to reflect the ITC.

3.3 Measure Packages

For restaurants, the Reach Code Team analyzed the packages outlined below. As part of an effort to improve cost effectiveness, the Reach Code Team modeled a hybrid package that is AE except for a gas water heater, because an AE water heating system represented a significant portion of the incremental cost of the AE design (reference Figure 3 and Figure 4).

The Reach Code Team examined the following building packages:

- Restaurant Baseline Package (MF Code): Mixed-fuel prescriptively built building.
- Mixed Fuel Packages
  - Mixed-Fuel + Efficiency (MF Eff): Mixed-fuel appliances, including only efficiency measures.
  - Mixed-Fuel + Efficiency + HE Cooking (MF Eff HE): Mixed-fuel appliances, including efficiency measures and high efficiency (HE) gas cooking appliances.
  - Mixed-Fuel + Efficiency + HE Cooking + Solar PV and Battery (MF Eff HE PVB): Mixed-fuel appliances, including efficiency measures, HE gas cooking appliances, solar PV array and battery.
- Electrification Packages
  - All-Electric HVAC + Efficiency (AE Eff HVAC): All-electric HVAC only, including efficiency measures and baseline gas water heater and gas cooking.
  - All-Electric HVAC and SHW + Efficiency (AE Eff HVAC SHW): All-electric HVAC and SHW only, including efficiency measures and baseline gas cooking
  - All-Electric (AE HE): All-electric prescriptively built HVAC and SHW, including electric appliances that meet federal minimum efficiency criteria, as well as electrical upgrades. HE electric cooking appliances, such as induction cooktops are included in the package.
  - All-Electric + Efficiency (AE Eff HE): All-electric HVAC and SHW, including efficiency measures and HE electric cooking.
  - All-Electric + KOF + Efficiency (AE Eff KOF): All-electric HVAC and SHW, including efficiency measures and Kitchen of Future electric cooking. KOF only applies to FSR.
  - All-Electric + Efficiency + Solar PV and Battery (AE Eff HE PVB): All-electric HVAC and SHW, including efficiency measures, HE electric cooking (KOF in FSR), and a solar PV array and battery.
  - Hybrid + Efficiency + HE Cooking + Solar PV and Battery (HB Eff HE PVB): All-electric HVAC, baseline gas storage water heater, efficiency measures, HE electric cooking (KOF in FSR), and a solar PV array and battery.

4 Results

Results for the prototype-specific measure packages described in Section 3 are presented below.

The TDV and on-bill based cost-effectiveness results are presented in terms of B/C ratio and NPV savings. What constitutes 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, on-bill savings are categorized as a benefit while incremental construction costs are treated as costs. In cases where both construction costs and on-bill savings are negative, the construction cost savings are treated as the benefit while the on-bill negative savings are the cost.

For CZs with cost-effectiveness analyses reviewed for two utility rate structures, the Reach Code Team added a "-2" to indicate the second utility. For example, Climate Zone 4 cost-effectiveness analysis was performed for both PG&E and CPAU rate structures, so the CZs are indicated as "CZ04" and "CZ04-2" respectively in the following tables.

Overarching factors to keep in mind when reviewing the results include:

- **All-electric packages will have lower GHG emissions** than mixed-fuel packages in all cases, due to the clean power sources currently available from California's power providers.

- To pass the CEC's application process, local reach codes that amend the energy code must both be cost effective compared to the mixed-fuel baseline package and exceed the energy performance budget using TDV (i.e., have a positive compliance margin) compared to the standard design in the compliance software. To emphasize these two important factors, **the figures in this section highlight in green the modeling results that have either a positive compliance margin or are cost effective**. This will allow readers to identify whether a scenario is fully or partially supportive of a reach code. When a modeling result is not cost effective, it is highlighted in red. Conversely, Section 5 highlights only results that have both a positive compliance margin and are cost effective, to allow readers to identify reach code-ready scenarios.

- Title 24 does not specify electric or gas HVAC and SHW equipment in a prescriptive section, and a designer is allowed to specify either equipment type as long as it meets mandatory efficiency requirements. However, when using the performance approach to comply with code, HVAC and SHW equipment is compared to a mixed-fuel standard design for restaurants. This typically results in **TDV-related penalties and associated negative compliance margins for electric equipment**. These negative compliance margins are reflected in the baseline AE packages, listed below for each prototype, and they must be overcome with the addition of building energy efficiency measures.

- Process loads, including cooking, are non-regulated loads and are not included in the compliance TDV calculation, thus there is no credit or penalty associated with equipment selection. Heat transfer to the space associated with process loads is equal in both the standard and proposed design and have the same impact on HVAC energy consumption in the model. **While using electric cooking appliances can reduce HVAC energy use, this benefit is not reflected in the compliance margin** as the compliance software reduces the HVAC load for both models equally. Nonetheless, for cost-effectiveness analysis, the Reach Code Team compares the total TDV of the proposed package to a

fixed mixed-fuel package (not the standard design) and captures the interactive impacts of process loads, including reduced HVAC loads.

- Under the 2019 energy code, the **CEC does not currently allow compliance credit for either solar PV or battery storage in nonresidential buildings**. Thus, compliance margins for nonresidential packages containing these technologies are the same as packages without. However, the Reach Code Team did include the impact of solar PV and battery when calculating overall TDV cost effectiveness.

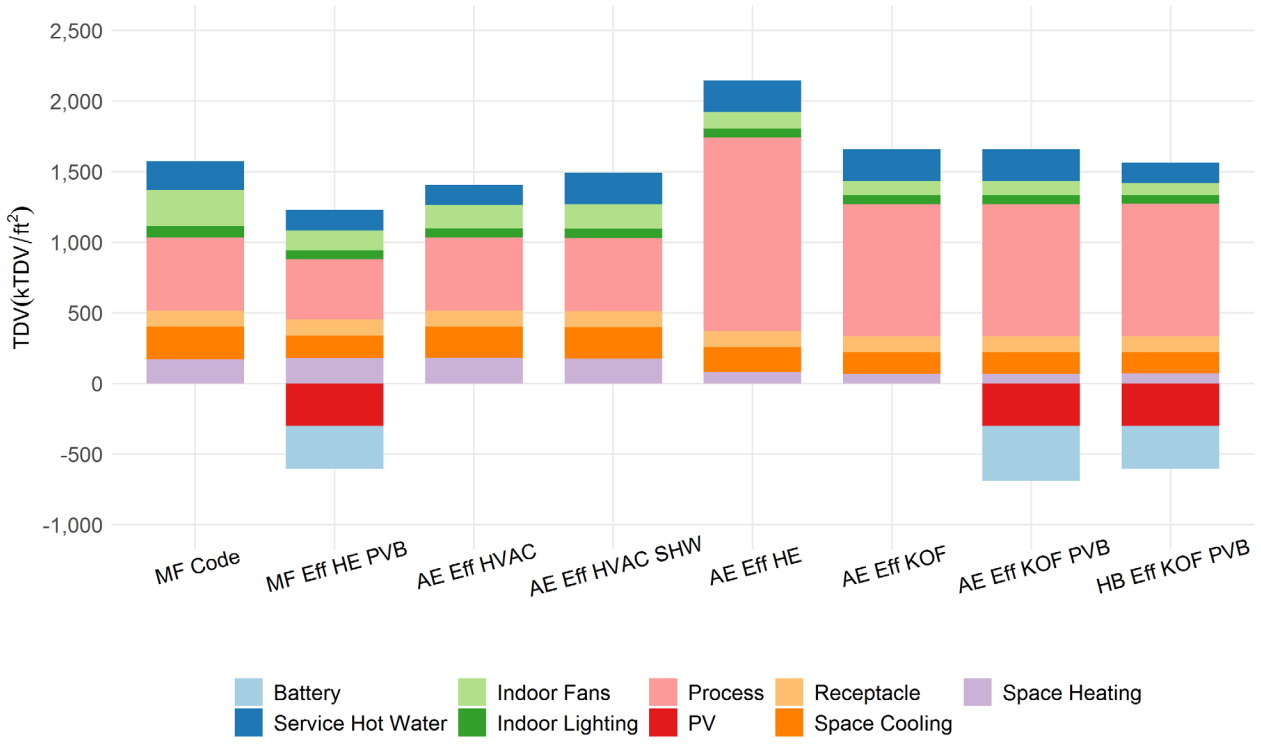
- The cost-effectiveness results for 2022 analysis differs from 2019 mainly in $TDV savings, but they also differ slightly in energy consumption, which translates in minor difference in on-bill energy savings. The Reach Code Team has not reported the software outputs for 2022 compliance margins, as the 2022 Title 24 compliance software is still being developed.

As a point of comparison, mixed-fuel baseline energy figures are provided in Section 7.4 Mixed-Fuel Baseline Energy Figures.

4.1 FSR

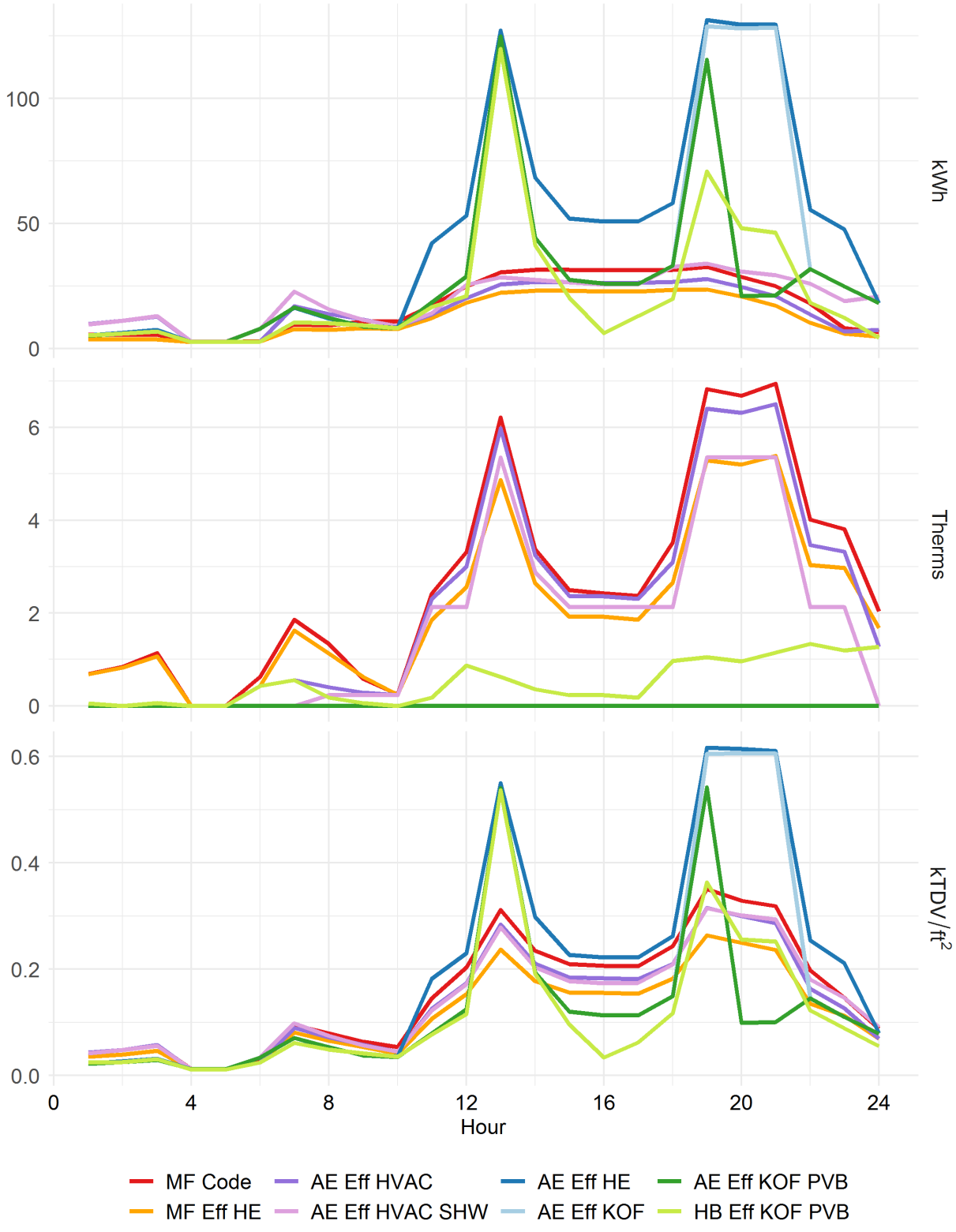
Figure 9 shows the TDV end-use breakdown for the FSR in CZ 12. The AE packages with electric cooking have a higher TDV energy usage than the mixed-fuel baseline. Thus, the primary opportunity to reduce the TDV energy consumption of an AE restaurant is to offset the process (i.e., cooking) energy use with solar PV generation and battery storage.

Figure 9. TDV of FSR Packages: CZ12



To attempt to optimize size and operation of the battery storage system, the Reach Code Team analyzed the cooking appliance load profiles developed through research described in Section 7.3. Figure 10 shows the 24-hour load profiles of the FSR in CZ 12 on June 15, 2021 As expected, the AE packages have substantially higher lunchtime and dinnertime peak kWh loads than the mixed-fuel baselines, which are steady throughout the day.

Figure 10. Hourly Load Profile of FSR Packages - CZ12 (June 15, 2021)



4.1.1 Mixed-Fuel

Figure 11 shows results of the mixed-fuel energy efficiency measure packages compared to a mixed-fuel baseline. These measure packages are highly cost effective and could integrate more costly efficiency measures to further enhance energy performance.

Figure 12 shows integrating HE gas cooking products with the energy efficiency packages remains cost effective in all CZs. In some CZs, the compliance margin increases as compared to Mixed-Fuel + Eff, and conversely, the compliance margin decreases in other CZs.[8] The cost effectiveness of adding HE cooking appliances is slightly lower than the prior package containing only building efficiency measures.

The solar PV and battery measure package is TDV cost effective in all CZs (Figure 13).

[8] The software modeling of restaurant energy use is highly sensitive to kitchen HVAC unit design flowrate, even though the fan is variable speed. This sensitivity results in a climate-zone dependent tradeoff between fan energy and space heating energy. In some CZs, the electricity savings increases more due to the smaller fan design flowrate in the proposed design than for the baseline condition, which also results in larger gas savings. Unexpectedly, in some other CZs, an increased fan design flowrate also results in electricity savings, but gas usage increases. This study does not examine the software algorithms that determine these results, nor attempt to optimize fan air flow selections for each CZ.

Figure 11. Cost Effectiveness for FSR: Mixed-Fuel + Eff

CZ	Utility	Annual Elec Savings (kWh)	Annual Gas Savings (therms)	Annual GHG Reductions (mtons)	Comp-liance Margin	Upfront Incremental Package Cost	Lifecycle Utility Cost Savings	Lifecycle $TDV Savings	B/C Ratio (On-bill)	B/C Ratio (TDV)	NPV (On-bill)	NPV (TDV)
CZ01	PG&E	21,349	3,707	24.3	8.5%	$8,483	$139,880	$114,022	16.5	13.4	$131,397	$105,540
CZ02	PG&E	25,985	3,070	21.3	13.4%	$8,624	$146,313	$125,049	17.0	14.5	$137,688	$116,425
CZ03	PG&E	21,355	2,924	19.8	11.7%	$8,483	$126,255	$106,741	14.9	12.6	$117,772	$98,258
CZ03-2	PCE	21,355	2,924	19.8	11.7%	$8,483	$124,708	$106,741	14.7	12.6	$116,225	$98,258
CZ04	PG&E	25,391	2,711	19.3	16.0%	$8,624	$137,370	$122,087	15.9	14.2	$128,745	$113,462
CZ04-2	CPAU	25,391	2,711	19.3	16.0%	$8,624	$111,831	$122,087	13.0	14.2	$103,207	$113,462
CZ05	PG&E	21,408	3,051	20.5	12.1%	$8,624	$128,230	$106,358	14.9	12.3	$119,606	$97,734
CZ05-2	SCG	21,408	3,051	20.5	12.1%	$8,624	$108,816	$106,358	12.6	12.3	$100,192	$97,734
CZ06	SCE	25,911	2,325	17.1	17.2%	$8,624	$71,411	$112,342	8.3	13.0	$62,787	$103,717
CZ06-2	LA	25,911	2,325	17.1	17.2%	$8,624	$61,650	$112,342	7.1	13.0	$53,026	$103,717
CZ07	SDG&E	22,958	2,131	15.7	16.1%	$8,624	$100,336	$100,629	11.6	11.7	$91,712	$92,005
CZ08	SCE	28,487	2,182	16.8	17.7%	$8,624	$74,098	$119,144	8.6	13.8	$65,474	$110,520
CZ08-2	LA	28,487	2,182	16.8	17.7%	$8,624	$61,604	$119,144	7.1	13.8	$52,980	$110,520
CZ09	SCE	28,834	2,302	17.6	15.5%	$8,624	$76,456	$120,498	8.9	14.0	$67,832	$111,874
CZ09-2	LA	28,834	2,302	17.6	15.5%	$8,624	$63,443	$120,498	7.4	14.0	$54,818	$111,874
CZ10	SDG&E	31,867	2,374	18.3	17.4%	$8,624	$140,704	$135,811	16.3	15.7	$132,080	$127,187
CZ10-2	SCE	31,867	2,374	18.3	17.4%	$8,624	$83,624	$135,811	9.7	15.7	$75,000	$127,187
CZ11	PG&E	32,576	2,765	20.8	15.2%	$8,624	$165,048	$138,095	19.1	16.0	$156,424	$129,471
CZ12	PG&E	29,935	2,795	20.5	14.4%	$8,624	$155,764	$130,042	18.1	15.1	$147,140	$121,418
CZ12-2	SMUD	29,935	2,795	20.5	14.4%	$8,624	$105,267	$130,042	12.2	15.1	$96,643	$121,418
CZ13	PG&E	33,782	2,684	20.6	16.6%	$8,624	$167,570	$141,575	19.4	16.4	$158,946	$132,951
CZ14	SDG&E	34,597	2,751	20.9	18.0%	$8,624	$131,584	$144,361	15.3	16.7	$122,960	$135,736
CZ14-2	SCE	34,597	2,751	20.9	18.0%	$8,624	$85,580	$144,361	9.9	16.7	$76,956	$135,736
CZ15	SCE	42,495	1,805	16.8	18.8%	$8,624	$86,440	$146,095	10.0	16.9	$77,816	$137,470
CZ16	PG&E	24,049	3,659	24.4	10.7%	$8,624	$151,408	$128,636	17.6	14.9	$142,783	$120,012
CZ16-2	LA	24,049	3,659	24.4	10.7%	$8,624	$59,985	$128,636	7.0	14.9	$51,361	$120,012

Figure 12. Cost Effectiveness for FSR: Mixed-Fuel + Eff + HE Cooking

CZ	Utility	Annual Elec Savings (kWh)	Annual Gas Savings (therms)	Annual GHG Reductions (mtons)	Comp-liance Margin	Upfront Incremental Package Cost	Lifecycle Utility Cost Savings	Lifecycle $TDV Savings	B/C Ratio (On-bill)	B/C Ratio (TDV)	NPV (On-bill)	NPV (TDV)
CZ01	PG&E	19,996	4,302	27.4	13.5%	$49,533	$146,438	$120,287	3.0	2.4	$96,905	$70,754
CZ02	PG&E	27,512	4,476	29.5	13.6%	$49,674	$177,531	$154,779	3.6	3.1	$127,857	$105,104
CZ03	PG&E	22,714	4,091	26.6	16.2%	$49,533	$152,538	$131,325	3.1	2.7	$103,005	$81,792
CZ03-2	PCE	22,714	4,091	26.6	16.2%	$49,533	$150,862	$131,325	3.0	2.7	$101,329	$81,792
CZ04	PG&E	27,402	4,189	27.9	15.6%	$49,674	$171,770	$149,195	3.5	3.0	$122,096	$99,521
CZ04-2	CPAU	27,402	4,189	27.9	15.6%	$49,674	$145,862	$149,195	2.9	3.0	$96,188	$99,521
CZ05	PG&E	22,672	4,211	27.1	16.4%	$49,674	$153,843	$130,467	3.1	2.6	$104,168	$80,793
CZ05-2	SCG	22,672	4,211	27.1	16.4%	$49,674	$127,612	$130,467	2.6	2.6	$77,937	$80,793
CZ06	SCE	29,196	4,098	27.7	18.0%	$49,674	$99,448	$151,415	2.0	3.0	$49,774	$101,741
CZ06-2	LA	29,196	4,098	27.7	18.0%	$49,674	$87,205	$151,415	1.8	3.0	$37,530	$101,741
CZ07	SDG&E	27,676	3,914	26.6	21.1%	$49,674	$142,496	$145,434	2.9	2.9	$92,822	$95,760
CZ08	SCE	30,220	4,122	28.1	16.2%	$49,674	$100,540	$153,233	2.0	3.1	$50,866	$103,558
CZ08-2	LA	30,220	4,122	28.1	16.2%	$49,674	$87,357	$153,233	1.8	3.1	$37,683	$103,558
CZ09	SCE	32,355	4,219	29.0	12.9%	$49,674	$107,875	$163,970	2.2	3.3	$58,201	$114,296
CZ09-2	LA	32,355	4,219	29.0	12.9%	$49,674	$95,371	$163,970	1.9	3.3	$45,696	$114,296
CZ10	SDG&E	35,052	4,299	29.7	13.5%	$49,674	$177,333	$175,162	3.6	3.5	$127,659	$125,487
CZ10-2	SCE	35,052	4,299	29.7	13.5%	$49,674	$113,132	$175,162	2.3	3.5	$63,457	$125,487
CZ11	PG&E	32,348	4,508	30.6	11.0%	$49,674	$196,023	$168,737	3.9	3.4	$146,349	$119,063
CZ12	PG&E	32,101	4,409	30.0	13.7%	$49,674	$192,962	$168,764	3.9	3.4	$143,288	$119,089
CZ12-2	SMUD	32,101	4,409	30.0	13.7%	$49,674	$139,420	$168,764	2.8	3.4	$89,746	$119,089
CZ13	PG&E	32,667	4,474	30.5	10.8%	$49,674	$196,086	$169,596	3.9	3.4	$146,411	$119,922
CZ14	SDG&E	34,755	4,570	31.2	11.7%	$49,674	$168,066	$176,983	3.4	3.6	$118,391	$127,309
CZ14-2	SCE	34,755	4,570	31.2	11.7%	$49,674	$112,294	$176,983	2.3	3.6	$62,619	$127,309
CZ15	SCE	52,022	4,184	32.0	11.1%	$49,674	$135,412	$217,652	2.7	4.4	$85,738	$167,977
CZ16	PG&E	27,262	5,080	33.1	15.1%	$49,674	$188,253	$158,946	3.8	3.2	$138,579	$109,271
CZ16-2	LA	27,262	5,080	33.1	15.1%	$49,674	$81,321	$158,946	1.6	3.2	$31,647	$109,271

Figure 13. Cost Effectiveness for FSR: Mixed-Fuel + Eff + HE Cooking + PV + B

CZ	Utility	Annual Elec Savings (kWh)	Annual Gas Savings (therms)	Annual GHG Reductions (mtons)	Comp-liance Margin	Upfront Incremental Package Cost	Lifecycle Utility Cost Savings	Lifecycle $TDV Savings	B/C Ratio (On-bill)	B/C Ratio (TDV)	NPV (On-bill)	NPV (TDV)
CZ01	PG&E	71,211	4,302	35.8	13.5%	$285,975	$317,667	$356,736	1.1	1.2	$31,693	$70,762
CZ02	PG&E	88,669	4,476	40.4	13.6%	$286,116	$392,809	$436,959	1.4	1.5	$106,693	$150,842
CZ03	PG&E	84,088	4,091	37.1	16.2%	$285,975	$349,110	$406,777	1.2	1.4	$63,135	$120,803
CZ03-2	PCE	84,088	4,091	37.1	16.2%	$285,975	$343,158	$406,777	1.2	1.4	$57,183	$120,803
CZ04	PG&E	90,887	4,189	39.3	15.6%	$286,116	$389,912	$450,394	1.4	1.6	$103,796	$164,278
CZ04-2	CPAU	90,887	4,189	39.3	15.6%	$286,116	$285,981	$450,394	1.0	1.6	($135)	$164,278
CZ05	PG&E	88,890	4,211	38.4	16.4%	$286,116	$362,600	$422,422	1.3	1.5	$76,484	$136,306
CZ05-2	SCG	88,890	4,211	38.4	16.4%	$286,116	$354,983	$422,422	1.2	1.5	$68,867	$136,306
CZ06	SCE	91,437	4,098	38.7	18.0%	$286,116	$182,874	$411,731	0.6	1.4	($103,242)	$125,615
CZ06-2	LA	91,437	4,098	38.7	18.0%	$286,116	$151,356	$411,731	0.5	1.4	($134,760)	$125,615
CZ07	SDG&E	92,597	3,914	38.4	21.1%	$286,116	$244,655	$407,237	0.9	1.4	($41,461)	$121,120
CZ08	SCE	93,046	4,122	39.5	16.2%	$286,116	$181,883	$429,192	0.6	1.5	($104,233)	$143,076
CZ08-2	LA	93,046	4,122	39.5	16.2%	$286,116	$130,347	$429,192	0.5	1.5	($155,769)	$143,076
CZ09	SCE	97,201	4,219	40.8	12.9%	$286,116	$190,963	$450,181	0.7	1.6	($95,153)	$164,065
CZ09-2	LA	97,201	4,219	40.8	12.9%	$286,116	$139,885	$450,181	0.5	1.6	($146,231)	$164,065
CZ10	SDG&E	99,958	4,299	41.3	13.5%	$286,116	$285,225	$466,595	1.0	1.6	($891)	$180,479
CZ10-2	SCE	99,958	4,299	41.3	13.5%	$286,116	$195,786	$466,595	0.7	1.6	($90,330)	$180,479
CZ11	PG&E	95,178	4,508	41.1	11.0%	$286,116	$419,666	$480,873	1.5	1.7	$133,550	$194,757
CZ12	PG&E	93,947	4,409	40.6	13.7%	$286,116	$413,614	$465,064	1.4	1.6	$127,498	$178,948
CZ12-2	SMUD	93,947	4,409	40.6	13.7%	$286,116	$237,457	$465,064	0.8	1.6	($48,659)	$178,948
CZ13	PG&E	94,100	4,474	40.6	10.8%	$286,116	$415,973	$465,800	1.5	1.6	$129,857	$179,684
CZ14	SDG&E	106,148	4,570	43.2	11.7%	$286,116	$284,010	$476,415	1.0	1.7	($2,106)	$190,299
CZ14-2	SCE	106,148	4,570	43.2	11.7%	$286,116	$202,061	$476,415	0.7	1.7	($84,055)	$190,299
CZ15	SCE	119,391	4,184	41.7	11.1%	$286,116	$214,278	$505,715	0.7	1.8	($71,838)	$219,599
CZ16	PG&E	94,189	5,080	44.5	15.1%	$286,116	$411,819	$420,226	1.4	1.5	$125,703	$134,110
CZ16-2	LA	94,189	5,080	44.5	15.1%	$286,116	$158,859	$420,226	0.6	1.5	($127,257)	$134,110

4.1.2 All-Electric

The Reach Code Team initially analyzed several AE packages. Figure 14 demonstrates that AE HVAC packages, due to low or negligible upfront costs and significant TDV savings, can be TDV cost effective in all CZs.

Figure 15 shows the cost-effectiveness results for adding HPWH, electric space heating, and efficiency measures. With hot water efficiency measures, the service hot water demand is reduced substantially, and a smaller heat pump hot water system can be installed. Without hot water efficiency measures, the AE SHW package would not be cost effective in any CZs due to the high upfront costs of the HPWH. See Section 7.3 Basis of Design for Restaurants for further description of how these measures enable reduction in upfront cost and operational cost. As a result of the reduced hot water demand, this package is now cost effective and with a positive compliance margin in several CZs. Results improve to cost-effective outcomes in all CZs when analyzed under 2022 TDV, as shown in Figure 16.

Figure 14. Cost Effectiveness for FSR: All-Electric Eff HVAC

CZ	Utility	Annual Elec Savings (kWh)	Annual Gas Savings (therms)	Annual GHG Reductions (mtons)	Comp-liance Margin	Upfront Incremental Package Cost	Lifecycle Utility Cost Savings	Lifecycle $TDV Savings	B/C Ratio (On-bill)	B/C Ratio (TDV)	NPV (On-bill)	NPV (TDV)
CZ01	PG&E	(53,021)	9,942	44.7	0.6%	($11,739)	$16,228	$39,427	>1	>1	$27,967	$51,166
CZ02	PG&E	(30,176)	7,520	34.8	10.8%	($12,469)	$50,211	$73,768	>1	>1	$62,680	$86,237
CZ03	PG&E	(22,899)	6,649	31.8	11.5%	($12,489)	$55,254	$69,093	>1	>1	$67,742	$81,581
CZ03-2	PCE	(22,899)	6,649	31.8	11.5%	($12,489)	$56,649	$69,093	>1	>1	$69,138	$81,581
CZ04	PG&E	(13,856)	5,853	29.0	15.0%	($13,502)	$71,767	$82,773	>1	>1	$85,269	$96,276
CZ04-2	CPAU	(13,856)	5,853	29.0	15.0%	($13,502)	$78,280	$82,773	>1	>1	$91,782	$96,276
CZ05	PG&E	(27,972)	7,162	32.9	9.6%	($11,607)	$46,048	$63,558	>1	>1	$57,655	$75,166
CZ05-2	SCG	(27,972)	7,162	32.9	9.6%	($11,607)	($563)	$63,558	20.6	>1	$11,045	$75,166
CZ06	SCE	(2,613)	4,433	22.7	16.9%	($11,605)	$42,686	$82,293	>1	>1	$54,290	$93,898
CZ06-2	LA	(2,613)	4,433	22.7	16.9%	($11,605)	$41,674	$82,293	>1	>1	$53,279	$93,898
CZ07	SDG&E	2,375	3,594	19.9	18.0%	($12,811)	$66,428	$78,591	>1	>1	$79,238	$91,402
CZ08	SCE	2,960	3,969	21.5	18.2%	($13,982)	$52,357	$87,981	>1	>1	$66,339	$101,963
CZ08-2	LA	2,960	3,969	21.5	18.2%	($13,982)	$51,234	$87,981	>1	>1	$65,217	$101,963
CZ09	SCE	(88)	4,340	23.2	16.5%	($15,382)	$49,080	$85,674	>1	>1	$64,462	$101,056
CZ09-2	LA	(88)	4,340	23.2	16.5%	($15,382)	$63,976	$85,674	>1	>1	$79,358	$101,056
CZ10	SDG&E	(1,208)	4,661	24.5	16.4%	($17,332)	$50,703	$89,914	>1	>1	$68,035	$107,247
CZ10-2	SCE	(1,208)	4,661	24.5	16.4%	($17,332)	$44,526	$89,914	>1	>1	$61,858	$107,247
CZ11	PG&E	(18,133)	6,362	30.4	12.4%	($10,405)	$71,185	$81,911	>1	>1	$81,590	$92,316
CZ12	PG&E	(19,314)	6,497	31.0	12.6%	($12,789)	$68,878	$81,958	>1	>1	$81,667	$94,747
CZ12-2	SMUD	(19,314)	6,497	31.0	12.6%	($12,789)	$79,340	$81,958	>1	>1	$92,130	$94,747
CZ13	PG&E	(14,893)	6,021	29.1	12.6%	($10,343)	$74,927	$83,644	>1	>1	$85,269	$93,986
CZ14	SDG&E	(15,718)	6,241	29.5	14.5%	($13,402)	$2,273	$90,203	>1	>1	$15,675	$103,605
CZ14-2	SCE	(15,718)	6,241	29.5	14.5%	($13,402)	$33,370	$90,203	>1	>1	$46,772	$103,605
CZ15	SCE	16,341	2,920	18.0	16.4%	($19,630)	$55,388	$97,595	>1	>1	$75,018	$117,225
CZ16	PG&E	(60,841)	9,660	41.3	-9.9%	($13,431)	($3,188)	($1,999)	4.2	6.7	$10,243	$11,432
CZ16-2	LA	(60,841)	9,660	41.3	-9.9%	($13,431)	$50,333	($1,999)	>1	6.7	$63,765	$11,432

Figure 15. Cost Effectiveness for FSR: All-Electric Eff HVAC SHW

CZ	Utility	Annual Elec Savings (kWh)	Annual Gas Savings (therms)	Annual GHG Reductions (mtons)	Comp-liance Margin	Upfront Incremental Package Cost	Lifecycle Utility Cost Savings	Lifecycle $TDV Savings	B/C Ratio (On-bill)	B/C Ratio (TDV)	NPV (On-bill)	NPV (TDV)
CZ01	PG&E	(107,352)	14,754	59.7	-21.7%	$32,336	($76,858)	($35,421)	-2.4	-1.1	($109,194)	($67,758)
CZ02	PG&E	(78,490)	12,078	49.5	-2.3%	$36,481	($25,826)	$22,191	-0.7	0.6	($62,307)	($14,290)
CZ03	PG&E	(71,691)	11,176	46.0	-7.8%	$36,162	($23,741)	$8,817	-0.7	0.2	($59,903)	($27,345)
CZ03-2	PCE	(71,691)	11,176	46.0	-7.8%	$36,162	($18,679)	$8,817	-0.5	0.2	($54,841)	($27,345)
CZ04	PG&E	(60,259)	10,299	43.3	1.3%	$35,163	$62	$33,827	0.0	1.0	($35,101)	($1,336)
CZ04-2	CPAU	(60,259)	10,299	43.3	1.3%	$35,163	$61,152	$33,827	1.7	1.0	$25,989	($1,336)
CZ05	PG&E	(78,042)	11,739	47.2	-10.7%	$32,529	($36,752)	$453	-1.1	0.0	($69,281)	($32,075)
CZ05-2	SCG	(78,042)	11,739	47.2	-10.7%	$32,529	($116,332)	$453	-3.6	0.0	($148,861)	($32,075)
CZ06	SCE	(46,522)	8,710	36.5	3.1%	$32,438	$32,035	$37,285	1.0	1.1	($402)	$4,847
CZ06-2	LA	(46,522)	8,710	36.5	3.1%	$32,438	$65,268	$37,285	2.0	1.1	$32,831	$4,847
CZ07	SDG&E	(40,532)	7,806	33.7	3.1%	$31,995	($8,044)	$34,817	-0.3	1.1	($40,039)	$2,822
CZ08	SCE	(38,499)	8,146	35.3	7.9%	$30,942	$42,192	$51,525	1.4	1.7	$11,250	$20,583
CZ08-2	LA	(38,499)	8,146	35.3	7.9%	$30,942	$75,528	$51,525	2.4	1.7	$44,586	$20,583
CZ09	SCE	(42,376)	8,540	37.1	7.2%	$28,745	$39,232	$47,743	1.4	1.7	$10,487	$18,999
CZ09-2	LA	(42,376)	8,540	37.1	7.2%	$28,745	$80,893	$47,743	2.8	1.7	$52,148	$18,999
CZ10	SDG&E	(42,852)	8,868	38.4	8.6%	$27,591	$5,996	$56,566	0.2	2.1	($21,595)	$28,975
CZ10-2	SCE	(42,852)	8,868	38.4	8.6%	$27,591	$42,778	$56,566	1.6	2.1	$15,186	$28,975
CZ11	PG&E	(62,425)	10,760	45.1	3.8%	$34,537	$7,058	$40,522	0.2	1.2	($27,480)	$5,984
CZ12	PG&E	(64,266)	10,931	45.7	2.8%	$32,229	$2,692	$39,463	0.1	1.2	($29,537)	$7,234
CZ12-2	SMUD	(64,266)	10,931	45.7	2.8%	$32,229	$98,804	$39,463	3.1	1.2	$66,575	$7,234
CZ13	PG&E	(58,234)	10,360	43.6	3.8%	$34,553	$12,997	$41,565	0.4	1.2	($21,555)	$7,013
CZ14	SDG&E	(59,240)	10,673	44.7	6.7%	$30,526	($49,630)	$53,201	-1.6	1.7	($80,156)	$22,675
CZ14-2	SCE	(59,240)	10,673	44.7	6.7%	$30,526	$27,339	$53,201	0.9	1.7	($3,187)	$22,675
CZ15	SCE	(16,661)	6,629	31.1	12.4%	$24,473	$53,656	$75,004	2.2	3.1	$29,182	$50,530
CZ16	PG&E	(101,609)	14,648	60.6	-15.3%	$30,691	($47,448)	($23,330)	-1.5	-0.8	($78,139)	($54,021)
CZ16-2	LA	(101,609)	14,648	60.6	-15.3%	$30,691	$82,636	($23,330)	2.7	-0.8	$51,946	($54,021)

Figure 16. Cost Effectiveness for FSR: All-Electric Eff HVAC SHW, 2022 TDV

CZ	Utility	Elec Savings (kWh)	Gas Savings (therms)	GHG Reductions (mtons)	Compliance Margin	Incremental Package Cost	Lifecycle Utility Cost Savings	$TDV Savings	B/C Ratio (On-bill)	B/C Ratio (TDV)	NPV (On-bill)	NPV (TDV)
CZ01	PG&E	(104,296)	14,569	58.6	<0	$32,336	($71,683)	$36,930	-2.2	1.1	($104,020)	$4,593
CZ02	PG&E	(75,647)	11,676	46.6	>0	$36,481	($26,047)	$78,752	-0.7	2.2	($62,528)	$42,271
CZ03	PG&E	(64,889)	10,566	43.2	>0	$36,162	($14,330)	$73,548	-0.4	2.0	($50,492)	$37,386
CZ03-2	PCE	(64,889)	10,566	43.2	>0	$36,162	($9,692)	$73,548	-0.3	2.0	($45,854)	$37,386
CZ04	PG&E	(52,557)	9,589	39.9	>0	$35,163	$11,389	$88,226	0.3	2.5	($23,774)	$53,063
CZ04-2	CPAU	(52,557)	9,589	39.9	>0	$35,163	$64,468	$88,226	1.8	2.5	$29,305	$53,063
CZ05	PG&E	(66,306)	10,671	42.6	>0	$32,529	($18,338)	$55,992	-0.6	1.7	($50,867)	$23,464
CZ05-2	SCG	(66,306)	10,671	42.6	>0	$32,529	($91,357)	$55,992	-2.8	1.7	($123,886)	$23,464
CZ06	SCE	(37,780)	7,821	33.2	>0	$32,438	$38,339	$75,988	1.2	2.3	$5,901	$43,550
CZ06-2	LA	(37,780)	7,821	33.2	>0	$32,438	$69,512	$75,988	2.1	2.3	$37,074	$43,550
CZ07	SDG&E	(33,603)	7,403	32.2	>0	$31,995	$2,673	$75,587	0.1	2.4	($29,321)	$43,592
CZ08	SCE	(32,276)	7,607	32.9	>0	$30,942	$48,273	$89,745	1.6	2.9	$17,331	$58,803
CZ08-2	LA	(32,276)	7,607	32.9	>0	$30,942	$71,895	$89,745	2.3	2.9	$40,953	$58,803
CZ09	SCE	(33,671)	7,989	34.8	>0	$28,745	$49,881	$97,976	1.7	3.4	$21,137	$69,231
CZ09-2	LA	(33,671)	7,989	34.8	>0	$28,745	$86,535	$97,976	3.0	3.4	$57,791	$69,231
CZ10	SDG&E	(34,826)	8,434	36.4	>0	$27,591	$23,614	$105,948	0.9	3.8	($3,978)	$78,357
CZ10-2	SCE	(34,826)	8,434	36.4	>0	$27,591	$50,538	$105,948	1.8	3.8	$22,946	$78,357
CZ11	PG&E	(57,971)	10,310	42.5	>0	$34,537	$12,079	$97,620	0.3	2.8	($22,458)	$63,083
CZ12	PG&E	(60,114)	10,437	42.7	>0	$32,229	$5,128	$90,003	0.2	2.8	($27,101)	$57,774
CZ12-2	SMUD	(60,114)	10,437	42.7	>0	$32,229	$98,903	$90,003	3.1	2.8	$66,674	$57,774
CZ13	PG&E	(49,088)	9,620	40.6	>0	$34,553	$28,186	$102,527	0.8	3.0	($6,366)	$67,975
CZ14	SDG&E	(54,290)	10,082	41.4	>0	$30,526	($34,601)	$103,071	-1.1	3.4	($65,127)	$72,545
CZ14-2	SCE	(54,290)	10,082	41.4	>0	$30,526	$28,781	$103,071	0.9	3.4	($1,745)	$72,545
CZ15	SCE	(6,074)	6,325	30.7	>0	$24,473	$72,073	$135,782	2.9	5.5	$47,600	$111,308
CZ16	PG&E	(96,116)	13,972	57.3	<0	$30,691	($44,465)	$31,516	-1.4	1.0	($75,156)	$825
CZ16-2	LA	(96,116)	13,972	57.3	<0	$30,691	$76,534	$31,516	2.5	1.0	$45,843	$825

The Reach Code Team analyzed the following AE cooking equipment FSR packages but found they are not cost effective under current assumptions. Discussion on these results is available in Section 7.5 Additional Restaurant All-Electric Package Analysis.

- All-Electric (AE HE)
- All-Electric + Efficiency (AE Eff HE)
- All-Electric + KOF + Efficiency (AE Eff KOF)
- All-Electric + Efficiency + Solar PV and Battery (AE Eff KOF PVB)
- Hybrid + Efficiency + Solar PV and Battery (HB Eff KOF PVB)

All these packages include electric cooking appliances, which is the biggest barrier to TDV and on-bill cost effectiveness. Although there are minimal technical barriers in replacing gas cooking appliances with electric alternatives, the utility cost and TDV (code compliance) penalties are significant, primarily because the cooking activities are coincident with high TDV and utility rate periods. Nonetheless, switching to HE electric cooking appliances can save 30 to 50% of the energy consumption, but this falls short of the differences in cost of electric energy versus natural gas, which is about 400% higher per kBtu. The keys to electrify cooking include utility rate offerings to address the operational cost barrier, as well as education and training to address the market actor concerns.

It is challenging to electrify SHW using HPWH technology, both in terms of technical feasibility and practicality, due to the large volume and high peaks of hot water demand. High efficiency SHW design approaches substantially reduce hot water demand and enable the low-demand electric SHW plant design. Reducing peak hot water demand also improves HPWH operation efficiency, as the HPWH system does not need to engage backup electric resistance to keep up with demand. It should be noted that, not only are there limited demonstrations of the HPWH technology in restaurants, but the efficiency measures used in this study are emerging best practices and not widely implemented by the food service design industry. See more detailed discussion in Section 7.3.3.

4.2 QSRs

4.2.1 Mixed-Fuel

Figure 17 shows the energy efficiency measure packages are cost effective in all CZs. The QSR prototype achieved lower energy savings than the FSR prototype, because the lighting efficiency measures are only applicable to FSR and because of lower transfer air potential in the QSR to reduce the makeup air requirement and commensurate HVAC load reductions. Compliance margins in CZs 1, 3-7, and 16 are higher compared to other CZs because the HVAC units are smaller, which enables application of the economizer, two-stage compressor cooling, and variable speed fan energy efficiency measures, which are otherwise required by code for larger units.

When adding HE cooking appliances (Figure 18), the packages are still both TDV and on-bill cost effective. Compared to the Mixed-Fuel + Eff package, there are significant gas savings from using more efficient cooking appliances. However, the cost effectiveness in some colder CZs decreases due to increases in space heating energy use and associated fan power.

Figure 19 shows that the solar PV and battery package is also TDV cost effective.

Figure 17. Cost Effectiveness for QSR: Mixed-Fuel + Eff

CZ	Utility	Annual Elec Savings (kWh)	Annual Gas Savings (therms)	Annual GHG Reductions (mtons)	Comp-liance Margin	Upfront Incremental Package Cost	Lifecycle Utility Cost Savings	Lifecycle $TDV Savings	B/C Ratio (On-bill)	B/C Ratio (TDV)	NPV (On-bill)	NPV (TDV)
CZ01	PG&E	12,334	1,447	10.14	29.7%	$12,578	$68,650	$54,634	5.5	4.3	$56,071	$42,056
CZ02	PG&E	6,011	815	5.43	15.2%	$10,036	$35,537	$31,064	3.5	3.1	$25,501	$21,028
CZ03	PG&E	12,320	742	6.21	27.1%	$12,578	$54,856	$42,046	4.4	3.3	$42,278	$29,467
CZ03-2	PCE	12,320	742	6.21	27.1%	$12,578	$53,986	$42,046	4.3	3.3	$41,407	$29,467
CZ04	PG&E	12,645	652	5.76	25.7%	$12,643	$54,272	$43,660	4.3	3.5	$41,629	$31,017
CZ04-2	CPAU	12,645	652	5.76	25.7%	$12,643	$42,416	$43,660	3.4	3.5	$29,773	$31,017
CZ05	PG&E	12,489	789	6.53	27.8%	$12,643	$56,354	$43,637	4.5	3.5	$43,712	$30,994
CZ05-2	SCG	12,489	789	6.53	27.8%	$12,643	$51,251	$43,637	4.1	3.5	$38,609	$30,994
CZ06	SCE	12,673	508	4.95	26.4%	$12,643	$24,825	$39,913	2.0	3.2	$12,182	$27,270
CZ06-2	LA	12,673	508	4.95	26.4%	$12,643	$22,087	$39,913	1.7	3.2	$9,444	$27,270
CZ07	SDG&E	15,135	430	4.93	31.6%	$12,643	$51,927	$44,311	4.1	3.5	$39,284	$31,668
CZ08	SCE	5,899	457	3.44	17.9%	$10,036	$33,928	$26,684	3.4	2.7	$23,891	$16,648
CZ08-2	LA	5,899	457	3.44	17.9%	$10,036	$15,857	$26,684	1.6	2.7	$5,821	$16,648
CZ09	SCE	6,412	495	3.73	13.7%	$10,036	$17,007	$24,555	1.7	2.4	$6,971	$14,518
CZ09-2	LA	6,412	495	3.73	13.7%	$10,036	$14,781	$24,555	1.5	2.4	$4,745	$14,518
CZ10	SDG&E	5,221	532	3.73	15.0%	$10,036	$26,451	$23,795	2.6	2.4	$16,415	$13,759
CZ10-2	SCE	5,221	532	3.73	15.0%	$10,036	$15,181	$23,795	1.5	2.4	$5,144	$13,759
CZ11	PG&E	6,745	699	4.98	13.7%	$10,036	$36,736	$32,913	3.7	3.3	$26,699	$22,877
CZ12	PG&E	6,689	709	4.97	15.2%	$10,036	$36,358	$32,542	3.6	3.2	$26,322	$22,506
CZ12-2	SMUD	6,689	709	4.97	15.2%	$10,036	$25,858	$32,542	2.6	3.2	$15,822	$22,506
CZ13	PG&E	8,129	660	4.95	12.6%	$10,036	$40,694	$31,534	4.1	3.1	$30,658	$21,497
CZ14	SDG&E	6,447	678	4.77	14.2%	$10,036	$36,121	$31,143	3.6	3.1	$26,085	$21,107
CZ14-2	SCE	6,447	678	4.77	14.2%	$10,036	$20,043	$31,143	2.0	3.1	$10,007	$21,107
CZ15	SCE	11,580	349	3.73	12.5%	$10,036	$21,960	$41,151	2.2	4.1	$11,923	$31,114
CZ16	PG&E	12,023	980	7.42	22.4%	$12,643	$58,785	$46,016	4.6	3.6	$46,143	$33,374
CZ16-2	LA	12,023	980	7.42	22.4%	$12,643	$28,824	$46,016	2.3	3.6	$16,181	$33,374

Figure 18. Cost Effectiveness for QSR: Mixed-Fuel + Eff + HE Cooking

CZ	Utility	Annual Elec Savings (kWh)	Annual Gas Savings (therms)	Annual GHG Reductions (mtons)	Comp-liance Margin	Upfront Incremental Package Cost	Lifecycle Utility Cost Savings	Lifecycle $TDV Savings	B/C Ratio (On-bill)	B/C Ratio (TDV)	NPV (On-bill)	NPV (TDV)
CZ01	PG&E	11,918	3,845	23.50	26.0%	$42,973	$111,524	$91,920	2.6	2.1	$68,551	$48,947
CZ02	PG&E	7,326	3,573	21.04	12.2%	$40,431	$90,896	$75,425	2.2	1.9	$50,465	$34,994
CZ03	PG&E	13,429	3,459	21.61	24.9%	$42,973	$108,960	$89,650	2.5	2.1	$65,987	$46,677
CZ03-2	PCE	13,429	3,459	21.61	24.9%	$42,973	$107,984	$89,650	2.5	2.1	$65,011	$46,677
CZ04	PG&E	14,582	3,504	22.03	20.3%	$43,037	$113,731	$90,706	2.6	2.1	$70,694	$47,669
CZ04-2	CPAU	14,582	3,504	22.03	20.3%	$43,037	$104,480	$90,706	2.4	2.1	$61,443	$47,669
CZ05	PG&E	13,675	3,507	21.88	30.7%	$43,037	$110,503	$91,479	2.6	2.1	$67,466	$48,442
CZ05-2	SCG	13,675	3,507	21.88	30.7%	$43,037	$88,731	$91,479	2.1	2.1	$45,694	$48,442
CZ06	SCE	16,062	3,526	22.38	27.9%	$43,037	$66,756	$95,748	1.6	2.2	$23,719	$52,711
CZ06-2	LA	16,062	3,526	22.38	27.9%	$43,037	$62,916	$95,748	1.5	2.2	$19,879	$52,711
CZ07	SDG&E	19,324	3,495	22.87	33.5%	$43,037	$110,884	$107,654	2.6	2.5	$67,847	$64,617
CZ08	SCE	9,546	3,517	21.13	14.5%	$40,431	$57,144	$80,577	1.4	2.0	$16,713	$40,147
CZ08-2	LA	9,546	3,517	21.13	14.5%	$40,431	$57,654	$80,577	1.4	2.0	$17,224	$40,147
CZ09	SCE	10,803	3,519	21.37	14.2%	$40,431	$61,946	$82,986	1.5	2.1	$21,515	$42,556
CZ09-2	LA	10,803	3,519	21.37	14.2%	$40,431	$58,836	$82,986	1.5	2.1	$18,405	$42,556
CZ10	SDG&E	10,611	3,548	21.38	11.6%	$40,431	$83,228	$81,530	2.1	2.0	$42,798	$41,100
CZ10-2	SCE	10,611	3,548	21.38	11.6%	$40,431	$59,853	$81,530	1.5	2.0	$19,422	$41,100
CZ11	PG&E	8,798	3,587	21.34	12.0%	$40,431	$96,330	$88,396	2.4	2.2	$55,899	$47,965
CZ12	PG&E	7,707	3,561	20.99	18.0%	$40,431	$91,871	$79,898	2.3	2.0	$51,440	$39,468
CZ12-2	SMUD	7,707	3,561	20.99	18.0%	$40,431	$80,635	$79,898	2.0	2.0	$40,204	$39,468
CZ13	PG&E	8,727	3,571	21.18	12.1%	$40,431	$95,717	$84,669	2.4	2.1	$55,286	$44,238
CZ14	SDG&E	8,218	3,624	21.36	9.4%	$40,431	$97,022	$84,090	2.4	2.1	$56,592	$43,659
CZ14-2	SCE	8,218	3,624	21.36	9.4%	$40,431	$62,152	$84,090	1.5	2.1	$21,721	$43,659
CZ15	SCE	17,392	3,540	22.57	12.5%	$40,431	$73,852	$112,846	1.8	2.8	$33,422	$72,415
CZ16	PG&E	15,089	3,723	23.32	21.7%	$43,037	$119,993	$98,472	2.8	2.3	$76,957	$55,436
CZ16-2	LA	15,089	3,723	23.32	21.7%	$43,037	$66,946	$98,472	1.6	2.3	$23,909	$55,436

Figure 19. Cost Effectiveness for QSR: Mixed-Fuel + Eff + HE Cooking + PV + B

CZ	Utility	Annual Elec Savings (kWh)	Annual Gas Savings (therms)	Annual GHG Reductions (mtons)	Comp-liance Margin	Upfront Incremental Package Cost	Lifecycle Utility Cost Savings	Lifecycle $TDV Savings	B/C Ratio (On-bill)	B/C Ratio (TDV)	NPV (On-bill)	NPV (TDV)
CZ01	PG&E	35,662	3,845	26.32	26.0%	$154,616	$191,522	$188,244	1.2	1.2	$36,906	$33,628
CZ02	PG&E	35,773	3,573	24.33	12.2%	$152,074	$187,636	$199,990	1.2	1.3	$35,562	$47,916
CZ03	PG&E	41,795	3,459	25.30	24.9%	$154,616	$206,677	$208,332	1.3	1.3	$52,061	$53,716
CZ03-2	PCE	41,795	3,459	25.30	24.9%	$154,616	$203,526	$208,332	1.3	1.3	$48,911	$53,716
CZ04	PG&E	44,059	3,504	25.63	20.3%	$154,680	$215,946	$223,652	1.4	1.4	$61,266	$68,971
CZ04-2	CPAU	44,059	3,504	25.63	20.3%	$154,680	$169,595	$223,652	1.1	1.4	$14,915	$68,971
CZ05	PG&E	44,250	3,507	25.99	30.7%	$154,680	$215,193	$215,804	1.4	1.4	$60,513	$61,123
CZ05-2	SCG	44,250	3,507	25.99	30.7%	$154,680	$193,421	$215,804	1.3	1.4	$38,740	$61,123
CZ06	SCE	45,087	3,526	25.65	27.9%	$154,680	$105,010	$210,166	0.7	1.4	($49,670)	$55,486
CZ06-2	LA	45,087	3,526	25.65	27.9%	$154,680	$98,624	$210,166	0.6	1.4	($56,056)	$55,486
CZ07	SDG&E	49,495	3,495	26.73	33.5%	$154,680	$204,679	$223,053	1.3	1.4	$49,999	$68,373
CZ08	SCE	38,869	3,517	24.45	14.5%	$152,074	$90,760	$203,189	0.6	1.3	($61,314)	$51,115
CZ08-2	LA	38,869	3,517	24.45	14.5%	$152,074	$92,970	$203,189	0.6	1.3	($59,104)	$51,115
CZ09	SCE	41,046	3,519	24.83	14.2%	$152,074	$96,163	$210,136	0.6	1.4	($55,911)	$58,062
CZ09-2	LA	41,046	3,519	24.83	14.2%	$152,074	$95,263	$210,136	0.6	1.4	($56,811)	$58,062
CZ10	SDG&E	40,892	3,548	24.77	11.6%	$152,074	$129,085	$210,342	0.8	1.4	($22,989)	$58,268
CZ10-2	SCE	40,892	3,548	24.77	11.6%	$152,074	$93,611	$210,342	0.6	1.4	($58,463)	$58,268
CZ11	PG&E	38,042	3,587	24.41	12.0%	$152,074	$196,172	$226,002	1.3	1.5	$44,098	$73,928
CZ12	PG&E	36,483	3,561	24.07	18.0%	$152,074	$190,818	$210,781	1.3	1.4	$38,744	$58,707
CZ12-2	SMUD	36,483	3,561	24.07	18.0%	$152,074	$133,097	$210,781	0.9	1.4	($18,977)	$58,707
CZ13	PG&E	37,350	3,571	24.14	12.1%	$152,074	$193,292	$215,686	1.3	1.4	$41,218	$63,612
CZ14	SDG&E	41,477	3,624	24.97	9.4%	$152,074	$146,404	$217,226	1.0	1.4	($5,670)	$65,153
CZ14-2	SCE	41,477	3,624	24.97	9.4%	$152,074	$99,076	$217,226	0.7	1.4	($52,998)	$65,153
CZ15	SCE	48,848	3,540	25.39	12.5%	$152,074	$106,478	$236,666	0.7	1.6	($45,596)	$84,592
CZ16	PG&E	46,033	3,723	27.21	21.7%	$154,680	$225,243	$212,289	1.5	1.4	$70,563	$57,609
CZ16-2	LA	46,033	3,723	27.21	21.7%	$154,680	$103,723	$212,289	0.7	1.4	($50,957)	$57,609

4.2.2 All-Electric

Figure 20 shows that AE HVAC packages with efficiency measures, due to low upfront costs and significant TDV savings, can be TDV and on-bill cost effective in most CZs. Compared to FSR, the efficiency measure incremental costs are higher because: 1) the lighting measure, which has cost savings, is not applicable to QSR, and 2) cost increases to include efficiency measures for smaller capacity HVAC units.

In contrast with the FSR, the lower cost water heater (AO Smith CHP 120) also allows for the cost-effective addition of AE water heating in nearly all CZs. This is shown in Figure 21, which shows the cost-effectiveness results for adding this HPWH in addition to electric space heating and efficiency measures. As with the FSR, cost effectiveness expands to all CZs when analyzed with 2022 TDV, shown in Figure 22.

Figure 20. Cost Effectiveness for QSR: All-Electric Eff HVAC

CZ	Utility	Annual Elec Savings (kWh)	Annual Gas Savings (therms)	Annual GHG Reductions (mtons)	Comp-liance Margin	Upfront Incremental Package Cost	Lifecycle Utility Cost Savings	Lifecycle $TDV Savings	B/C Ratio (On-bill)	B/C Ratio (TDV)	NPV (On-bill)	NPV (TDV)
CZ01	PG&E	(16,488)	3,839	17.50	20.4%	$938	$20,835	$23,093	22.2	24.6	$19,898	$22,155
CZ02	PG&E	(15,146)	2,540	10.42	12.2%	$8,352	$599	$10,380	0.1	1.2	($7,753)	$2,028
CZ03	PG&E	(2,901)	2,021	9.94	25.4%	$7,464	$30,706	$26,894	4.1	3.6	$23,242	$19,430
CZ03-2	PCE	(2,901)	2,021	9.94	25.4%	$7,464	$30,851	$26,894	4.1	3.6	$23,387	$19,430
CZ04	PG&E	(539)	1,738	8.85	24.0%	$7,517	$33,014	$29,777	4.4	4.0	$25,497	$22,260
CZ04-2	CPAU	(539)	1,738	8.85	24.0%	$7,517	$30,817	$29,777	4.1	4.0	$23,300	$22,260
CZ05	PG&E	(5,476)	2,292	10.71	24.5%	$8,267	$26,923	$25,679	3.3	3.1	$18,656	$17,412
CZ05-2	SCG	(5,476)	2,292	10.71	24.5%	$8,267	$11,673	$25,679	1.4	3.1	$3,406	$17,412
CZ06	SCE	4,100	1,209	6.61	26.1%	$8,278	($5,401)	$31,063	-0.7	3.8	($13,679)	$22,786
CZ06-2	LA	4,100	1,209	6.61	26.1%	$8,278	$26,114	$31,063	3.2	3.8	$17,837	$22,786
CZ07	SDG&E	10,293	798	5.73	32.1%	$8,225	$44,277	$38,157	5.4	4.6	$36,052	$29,932
CZ08	SCE	(1,205)	1,013	4.73	17.0%	$9,159	$7,190	$19,020	0.8	2.1	($1,969)	$9,861
CZ08-2	LA	(1,205)	1,013	4.73	17.0%	$9,159	$13,204	$19,020	1.4	2.1	$4,045	$9,861
CZ09	SCE	(1,927)	1,159	5.43	15.9%	$2,386	$7,273	$15,762	3.0	6.6	$4,888	$13,376
CZ09-2	LA	(1,927)	1,159	5.43	15.9%	$2,386	$12,007	$15,762	5.0	6.6	$9,621	$13,376
CZ10	SDG&E	(4,678)	1,322	5.74	17.0%	$1,569	($2,990)	$13,774	-1.9	8.8	($4,559)	$12,205
CZ10-2	SCE	(4,678)	1,322	5.74	17.0%	$1,569	$3,464	$13,774	2.2	8.8	$1,895	$12,205
CZ11	PG&E	(10,612)	2,149	8.98	13.2%	$9,155	$9,441	$17,812	1.0	1.9	$286	$8,657
CZ12	PG&E	(11,312)	2,129	8.81	12.8%	$9,139	$6,108	$12,068	0.7	1.3	($3,031)	$2,928
CZ12-2	SMUD	(11,312)	2,129	8.81	12.8%	$9,139	$17,513	$12,068	1.9	1.3	$8,374	$2,928
CZ13	PG&E	(8,951)	1,983	8.42	12.4%	$3,048	$11,753	$12,313	3.9	4.0	$8,705	$9,265
CZ14	SDG&E	(12,360)	2,102	8.17	12.9%	$3,149	($16,471)	$13,381	-5.2	4.2	($19,619)	$10,233
CZ14-2	SCE	(12,360)	2,102	8.17	12.9%	$3,149	$54	$13,381	0.0	4.2	($3,095)	$10,233
CZ15	SCE	4,207	698	3.95	12.4%	$1,652	$9,936	$25,742	6.0	15.6	$8,284	$24,090
CZ16	PG&E	(25,130)	3,656	14.72	0.2%	$7,535	($7,729)	($13,697)	-1.0	-1.8	($15,264)	($21,232)
CZ16-2	LA	(25,130)	3,656	14.72	0.2%	$7,535	$34,581	($13,697)	4.6	-1.8	$27,046	($21,232)

Figure 21. Cost Effectiveness for QSR: All-Electric Eff HVAC SHW

CZ	Utility	Annual Elec Savings (kWh)	Annual Gas Savings (therms)	Annual GHG Reductions (mtons)	Comp-liance Margin	Upfront Incremental Package Cost	Lifecycle Utility Cost Savings	Lifecycle $TDV Savings	B/C Ratio (On-bill)	B/C Ratio (TDV)	NPV (On-bill)	NPV (TDV)
CZ01	PG&E	(27,689)	5,294	23.13	14.7%	$7,423	$8,433	$13,970	1.1	1.9	$1,010	$6,547
CZ02	PG&E	(25,125)	3,923	15.89	9.6%	$14,837	($8,583)	$6,080	-0.6	0.4	($23,420)	($8,758)
CZ03	PG&E	(13,038)	3,395	15.29	21.0%	$13,949	$20,687	$20,480	1.5	1.5	$6,739	$6,531
CZ03-2	PCE	(13,038)	3,395	15.29	21.0%	$13,949	$21,622	$20,480	1.6	1.5	$7,673	$6,531
CZ04	PG&E	(10,231)	3,088	14.18	21.5%	$14,002	$24,249	$25,593	1.7	1.8	$10,247	$11,591
CZ04-2	CPAU	(10,231)	3,088	14.18	21.5%	$14,002	$35,925	$25,593	2.6	1.8	$21,923	$11,591
CZ05	PG&E	(15,854)	3,680	16.11	19.7%	$14,752	$16,239	$18,729	1.1	1.3	$1,487	$3,977
CZ05-2	SCG	(15,854)	3,680	16.11	19.7%	$14,752	($7,642)	$18,729	-0.5	1.3	($22,394)	$3,977
CZ06	SCE	(5,088)	2,511	11.76	23.8%	$14,763	($2,392)	$27,495	-0.2	1.9	($17,155)	$12,733
CZ06-2	LA	(5,088)	2,511	11.76	23.8%	$14,763	$36,124	$27,495	2.4	1.9	$21,362	$12,733
CZ07	SDG&E	1,288	2,081	10.83	29.6%	$14,710	($9,627)	$34,486	-0.7	2.3	($24,337)	$19,775
CZ08	SCE	(10,044)	2,287	9.80	15.3%	$15,644	$10,306	$16,538	0.7	1.1	($5,338)	$894
CZ08-2	LA	(10,044)	2,287	9.80	15.3%	$15,644	$19,304	$16,538	1.2	1.1	$3,660	$894
CZ09	SCE	(10,663)	2,439	10.57	14.7%	$8,871	$10,209	$13,744	1.2	1.5	$1,338	$4,873
CZ09-2	LA	(10,663)	2,439	10.57	14.7%	$8,871	$32,867	$13,744	3.7	1.5	$23,996	$4,873
CZ10	SDG&E	(13,497)	2,605	10.88	15.8%	$8,054	($4,580)	$11,507	-0.6	1.4	($12,634)	$3,453
CZ10-2	SCE	(13,497)	2,605	10.88	15.8%	$8,054	$7,140	$11,507	0.9	1.4	($914)	$3,453
CZ11	PG&E	(19,663)	3,486	14.39	12.5%	$15,640	$2,909	$16,214	0.2	1.0	($12,731)	$574
CZ12	PG&E	(20,704)	3,476	14.21	11.3%	$15,624	($1,553)	$9,114	-0.1	0.6	($17,178)	($6,511)
CZ12-2	SMUD	(20,704)	3,476	14.21	11.3%	$15,624	$28,030	$9,114	1.8	0.6	$12,405	($6,511)
CZ13	PG&E	(18,222)	3,303	13.68	11.0%	$9,533	$4,054	$9,254	0.4	1.0	($5,479)	($279)
CZ14	SDG&E	(21,614)	3,449	13.64	11.7%	$9,634	($17,508)	$10,701	-1.8	1.1	($27,142)	$1,067
CZ14-2	SCE	(21,614)	3,449	13.64	11.7%	$9,634	$3,782	$10,701	0.4	1.1	($5,852)	$1,067
CZ15	SCE	(2,771)	1,837	8.69	12.1%	$8,137	$14,536	$25,075	1.8	3.1	$6,399	$16,938
CZ16	PG&E	(33,322)	5,162	21.36	2.0%	$14,020	($8,911)	($10,172)	-0.6	-0.7	($22,931)	($24,192)
CZ16-2	LA	(33,322)	5,162	21.36	2.0%	$14,020	$48,559	($10,172)	3.5	-0.7	$34,539	($24,192)

Figure 22. Cost Effectiveness for QSR: All-Electric Eff HVAC SHW, 2022 TDV

CZ	Utility	Elec Savings (kWh)	Gas Savings (therms)	GHG Reductions (mtons)	Compliance Margin	Incremental Package Cost	Lifecycle Utility Cost Savings	$TDV Savings	B/C Ratio (On-bill)	B/C Ratio (TDV)	NPV (On-bill)	NPV (TDV)
CZ01	PG&E	(26,352)	5,172	22.45	>0	$7,423	$9,976	$37,013	1.3	5.0	$2,554	$29,590
CZ02	PG&E	(23,481)	3,751	14.77	>0	$14,837	($6,719)	$24,468	-0.5	1.6	($21,557)	$9,631
CZ03	PG&E	(10,888)	3,158	14.10	>0	$13,949	$22,768	$38,165	1.6	2.7	$8,820	$24,216
CZ03-2	PCE	(10,888)	3,158	14.10	>0	$13,949	$23,572	$38,165	1.7	2.7	$9,623	$24,216
CZ04	PG&E	(8,005)	2,841	12.93	>0	$14,002	$26,808	$42,422	1.9	3.0	$12,806	$28,419
CZ04-2	CPAU	(8,005)	2,841	12.93	>0	$14,002	$36,155	$42,422	2.6	3.0	$22,153	$28,419
CZ05	PG&E	(11,632)	3,222	14.09	>0	$14,752	$21,345	$34,170	1.4	2.3	$6,594	$19,418
CZ05-2	SCG	(11,632)	3,222	14.09	>0	$14,752	$322	$34,170	0.0	2.3	($14,430)	$19,418
CZ06	SCE	(1,547)	2,149	10.46	>0	$14,763	$21,444	$40,213	1.5	2.7	$6,681	$25,450
CZ06-2	LA	(1,547)	2,149	10.46	>0	$14,763	$25,542	$40,213	1.7	2.7	$10,779	$25,450
CZ07	SDG&E	2,003	1,987	10.33	>0	$14,710	($9,617)	$42,846	-0.7	2.9	($24,327)	$28,136
CZ08	SCE	(7,375)	2,113	9.16	>0	$15,644	$13,934	$28,080	0.9	1.8	($1,710)	$12,436
CZ08-2	LA	(7,375)	2,113	9.16	>0	$15,644	$19,489	$28,080	1.2	1.8	$3,845	$12,436
CZ09	SCE	(8,193)	2,243	9.75	>0	$8,871	$14,316	$33,393	1.6	3.8	$5,445	$24,522
CZ09-2	LA	(8,193)	2,243	9.75	>0	$8,871	$21,037	$33,393	2.4	3.8	$12,166	$24,522
CZ10	SDG&E	(12,219)	2,473	10.06	>0	$8,054	$2,282	$24,904	0.3	3.1	($5,772)	$16,850
CZ10-2	SCE	(12,219)	2,473	10.06	>0	$8,054	$9,707	$24,904	1.2	3.1	$1,653	$16,850
CZ11	PG&E	(16,745)	3,298	13.50	>0	$15,640	$8,784	$34,797	0.6	2.2	($6,856)	$19,157
CZ12	PG&E	(18,223)	3,291	13.27	>0	$15,624	$2,941	$26,575	0.2	1.7	($12,684)	$10,951
CZ12-2	SMUD	(18,223)	3,291	13.27	>0	$15,624	$30,866	$26,575	2.0	1.7	$15,242	$10,951
CZ13	PG&E	(14,520)	3,003	12.52	>0	$9,533	$10,277	$34,598	1.1	3.6	$743	$25,064
CZ14	SDG&E	(19,146)	3,206	12.39	>0	$9,634	($15,317)	$21,871	-1.6	2.3	($24,951)	$12,237
CZ14-2	SCE	(19,146)	3,206	12.39	>0	$9,634	$4,392	$21,871	0.5	2.3	($5,242)	$12,237
CZ15	SCE	(2,540)	1,744	8.14	>0	$8,137	$15,868	$30,001	2.0	3.7	$7,731	$21,865
CZ16	PG&E	(30,488)	4,812	19.75	>0	$14,020	($7,969)	$6,622	-0.6	0.5	($21,989)	($7,398)
CZ16-2	LA	(30,488)	4,812	19.75	>0	$14,020	$45,018	$6,622	3.2	0.5	$30,998	($7,398)

The Reach Code Team analyzed the following AE packages but, as with the AE FSR, was unable to determine cost-effective outcomes for packages including electrification of cooking appliances due to the efficiency of these appliances, as well as time of use utility rates. These results are available in Appendix 7.5 Additional Restaurant All-Electric Package Analysis.

- All-Electric (AE HE)
- All-Electric + Efficiency (AE Eff HE)
- All-Electric + Efficiency + Solar PV and Battery (AE Eff HE PVB)
- Hybrid + Efficiency + Solar PV and Battery (HB Eff HE PVB)

All these packages include electric cooking appliances, which is the biggest barrier to TDV and on-bill cost effectiveness. Although there are minimal technical barriers in replacing gas cooking appliances with electric alternatives, the utility cost and TDV (code compliance) penalties are significant, primarily because the cooking activities are coincident with high TDV and utility rate periods. Nonetheless, switching to HE electric cooking appliances can save 30 to 50% of the energy consumption, but this falls short of the differences in cost of electric energy versus natural gas, which is about 400% higher per kBtu. The keys to electrify cooking include utility rate offerings to address the operational cost barrier, as well as education and training to address the market actor concerns.

5 Summary of Results

The Reach Code Team developed packages of energy efficiency measures as well as packages combining energy efficiency with PV generation and battery storage systems, simulated them in CBECC-Com, and gathered costs to determine the cost effectiveness of multiple scenarios. The Reach Code Team coordinated assumptions with multiple utilities, cities, and restaurant 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.

Figure 23 and Figure 24 summarize results for each prototype and depict the compliance margins achieved for each CZ and package. Because local reach codes must both exceed the CEC performance budget (i.e., have a positive compliance margin) and be cost effective, the Reach Code Team highlighted cells meeting these two requirements to help clarify the potential for reach code policies:

- 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 either depict a negative compliance margin or a package that was not cost effective using either the on-bill or TDV approach.

The Reach Code Team provides the following high-level takeaways from the results for both the FSR and QSR.

- Mixed-fuel packages with efficiency measures are cost effective in all CZs using both on-bill and TDV metrics. Adding PV with battery measures is cost effective in all CZs using TDV, and in many CZs using the on-bill approach.
- Electrifying HVAC and adding efficiency measures is most cost effective. Additionally, electrifying SHW is generally cost effective when hot water efficiency measures are included.
- Reach codes may be adopted in several CZs that require higher efficiency mixed-fuel restaurants, AE HVAC, or AE HVAC + SHW + Efficiency.
- A cost-effective pathway has not yet been determined for packages including AE kitchen appliances. Minor exceptions occur in CPAU and LADWP territories for QSR packages that include solar PV and battery storage, depicted in Figure 58 in the appendix.
- All end uses including HVAC, SHW, and cooking appliances can be installed to comply to the Energy Code without significant barriers: heat pump HVAC and SHW results in positive compliance margins, and cooking process loads do not affect compliance margins except for slight interactive effects with HVAC equipment.

Figure 23. FSR Summary of Compliance Margin and Cost Effectiveness

CZ	Utility	Mixed-Fuel			All-Electric		
		MF Eff	MF Eff HE	MF Eff HE PVB	AE Eff HVAC	AE Eff HVAC SHW	AE Eff HVAC SHW, 2022 TDV
CZ01	PG&E	8%	14%	14%	1%	-22%	<0
CZ02	PG&E	13%	14%	14%	11%	-2%	>0
CZ03	PG&E	12%	16%	16%	11%	-8%	>0
CZ03-2	PCE	12%	16%	16%	11%	-8%	>0
CZ04	PG&E	16%	16%	16%	15%	1%	>0
CZ04-2	CPAU	16%	16%	16%	15%	1%	>0
CZ05	PG&E	12%	16%	16%	10%	-11%	>0
CZ05-2	SCG	12%	16%	16%	10%	-11%	>0
CZ06	SCE	17%	18%	18%	17%	3%	>0
CZ06-2	LA	17%	18%	18%	17%	3%	>0
CZ07	SDG&E	16%	21%	21%	18%	3%	>0
CZ08	SCE	18%	16%	16%	18%	8%	>0
CZ08-2	LA	18%	16%	16%	18%	8%	>0
CZ09	SCE	15%	13%	13%	17%	7%	>0
CZ09-2	LA	15%	13%	13%	17%	7%	>0
CZ10	SDG&E	17%	14%	14%	16%	9%	>0
CZ10-2	SCE	17%	14%	14%	16%	9%	>0
CZ11	PG&E	15%	11%	11%	12%	4%	>0
CZ12	PG&E	14%	14%	14%	13%	3%	>0
CZ12-2	SMUD	14%	14%	14%	13%	3%	>0
CZ13	PG&E	17%	11%	11%	13%	4%	>0
CZ14	SDG&E	18%	12%	12%	15%	7%	>0
CZ14-2	SCE	18%	12%	12%	15%	7%	>0
CZ15	SCE	19%	11%	11%	16%	12%	>0
CZ16	PG&E	11%	15%	15%	-10%	-15%	<0
CZ16-2	LA	11%	15%	15%	-10%	-15%	<0

Figure 24. QSR Summary of Compliance Margin and Cost Effectiveness

CZ	Utility	Mixed-Fuel			All-Electric		
		MF Eff	MF Eff HE	MF Eff HE PVB	AE Eff HVAC	AE Eff HVAC SHW	AE Eff HVAC SHW, 2022 TDV
CZ01	PG&E	30%	26%	26%	20%	15%	>0
CZ02	PG&E	15%	12%	12%	12%	10%	>0
CZ03	PG&E	27%	25%	25%	25%	21%	>0
CZ03-2	PCE	27%	25%	25%	25%	21%	>0
CZ04	PG&E	26%	20%	20%	24%	22%	>0
CZ04-2	CPAU	26%	20%	20%	24%	22%	>0
CZ05	PG&E	28%	31%	31%	24%	20%	>0
CZ05-2	SCG	28%	31%	31%	24%	20%	>0
CZ06	SCE	26%	28%	28%	26%	24%	>0
CZ06-2	LA	26%	28%	28%	26%	24%	>0
CZ07	SDG&E	32%	33%	33%	32%	30%	>0
CZ08	SCE	18%	15%	15%	17%	15%	>0
CZ08-2	LA	18%	15%	15%	17%	15%	>0
CZ09	SCE	14%	14%	14%	16%	15%	>0
CZ09-2	LA	14%	14%	14%	16%	15%	>0
CZ10	SDG&E	15%	12%	12%	17%	16%	>0
CZ10-2	SCE	15%	12%	12%	17%	16%	>0
CZ11	PG&E	14%	12%	12%	13%	12%	>0
CZ12	PG&E	15%	18%	18%	13%	11%	>0
CZ12-2	SMUD	15%	18%	18%	13%	11%	>0
CZ13	PG&E	13%	12%	12%	12%	11%	>0
CZ14	SDG&E	14%	9%	9%	13%	12%	>0
CZ14-2	SCE	14%	9%	9%	13%	12%	>0
CZ15	SCE	13%	12%	12%	12%	12%	>0
CZ16	PG&E	22%	22%	22%	0%	2%	>0
CZ16-2	LA	22%	22%	22%	0%	2%	>0

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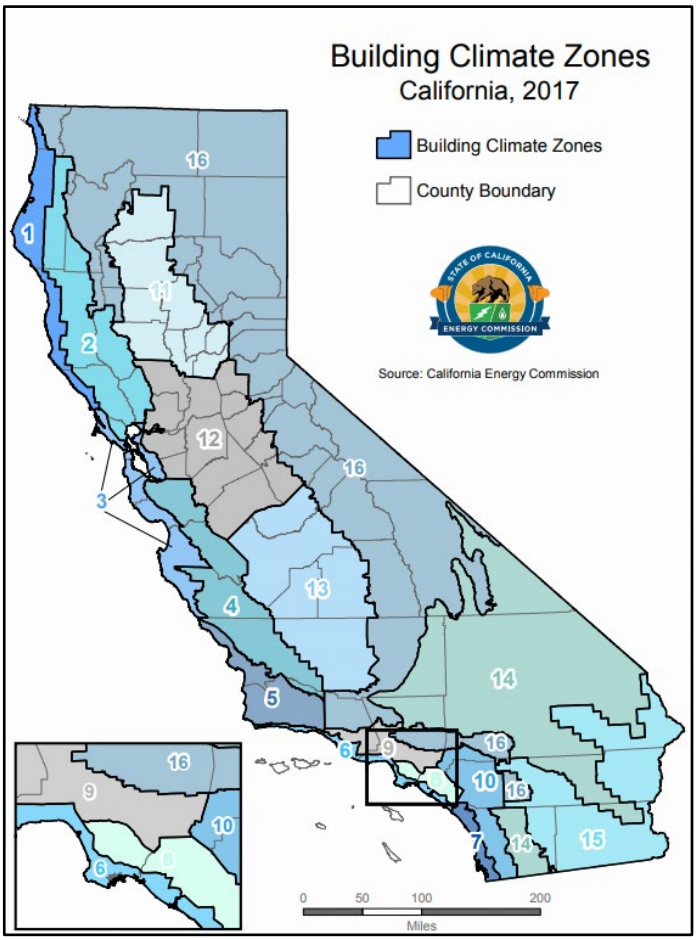
7 Appendices

7.1 Map of California CZs

CZ geographical boundaries are depicted in Figure 25. The map in Figure 25 along with a zip-code search directory is available at:
https://ww2.energy.ca.gov/maps/renewable/building_climate_zones.html

Figure 25. Map of California CZs



7.2 Utility Rate Schedules

The Reach Code Team used the IOU rate tariffs listed in Some climate zones have two options for rates as it varies by energy demand of different measure packages.

Figure 26 to determine the on-bill savings for each prototype. Some climate zones have two options for rates as it varies by energy demand of different measure packages.

Figure 26. Utility Tariffs Analyzed Based on CZ: Detailed View

CZ	Electric/Gas Utility	Electricity (TOU)		Natural Gas
		QSR	FSR	All Prototypes
CZ01	PG&E	B-1	B-1 or B-10	G-NR1
CZ02	PG&E	B-1	B-1 or B-10	G-NR1
CZ03	PG&E	B-1	B-1 or B-10	G-NR1
CZ04	PG&E	B-1	B-1 or B-10	G-NR1
CZ04-2	CPAU	E-2	E-2	G-2
CZ05	PG&E	B-1	B-1 or B-10	G-NR1
CZ05-2	PG&E/SOCALGAS	B-1	B-1 or B-10	G-10 (GN-10)
CZ06	SCE/SOCALGAS	TOU-GS-1 or TOU-GS-2	TOU-GS-2	G-10 (GN-10)
CZ06-2	LADWP/SOCALGAS	A-1 or A-2	A-2	G-10 (GN-10)
CZ07	SDG&E	TOU-A or AL-TOU+EECC	AL-TOU+EECC	GN-3
CZ08	SCE/SOCALGAS	TOU-GS-1 or TOU-GS-2	TOU-GS-2	G-10 (GN-10)
CZ08-2	LADWP/SOCALGAS	A-1 or A-2	A-2	G-10 (GN-10)
CZ09	SCE/SOCALGAS	TOU-GS-2	TOU-GS-2	G-10 (GN-10)
CZ09-2	LADWP/SOCALGAS	A-1 or A-2	A-2	G-10 (GN-10)
CZ10	SDG&E	AL-TOU+EECC	AL-TOU+EECC	GN-3
CZ10-2	SCE/SOCALGAS	TOU-GS-2	TOU-GS-2	G-10 (GN-10)
CZ11	PG&E	B-1 or B-10	B-1 or B-10	G-NR1
CZ12	PG&E	B-1 or B-10	B-1 or B-10	G-NR1
CZ12-2	SMUD/PG&E	GSN or GSS	GSS	G-NR1
CZ13	PG&E	B-1 or B-10	B-1 or B-10	G-NR1
CZ14	SDG&E	AL-TOU+EECC	AL-TOU+EECC	GN-3
CZ14-2	SCE/SOCALGAS	TOU-GS-2	TOU-GS-2	G-10 (GN-10)
CZ15	SCE/SOCALGAS	TOU-GS-2	TOU-GS-2	G-10 (GN-10)
CZ16	PG&E	B-1 or B-10	B-1 or B-10	G-NR1
CZ16-2	LADWP/PG&E	A-1 or A-2	A-1 or A-2	G-NR1

Utility rates are assumed to escalate over time, using assumptions from research conducted by Energy and Environmental Economics (E3) in the 2019 study Residential Building Electrification in California (Energy & Environmental Economics 2019) and escalation rates used in the development of the 2022 TDV multipliers. Figure 27 below demonstrates the escalation rates used for nonresidential buildings.

Figure 27. Real Utility Rate Escalation Rate Assumptions Above Inflation

Year	Source	Statewide Electric Nonresidential Average Rate (%/year, real)	Natural Gas Nonresidential Core Rate (%/year, real)
2020	E3 2019	2.0%	4.3%
2021	E3 2019	2.0%	4.3%
2022	E3 2019	2.0%	2.7%
2023	E3 2019	2.0%	4.0%
2024	2022 TDV	0.7%	7.7%
2025	2022 TDV	0.5%	5.5%
2026	2022 TDV	0.7%	5.6%
2027	2022 TDV	0.2%	5.6%
2028	2022 TDV	0.6%	5.7%
2029	2022 TDV	0.7%	5.7%
2030	2022 TDV	0.6%	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%

7.3 Basis of Design for Restaurants

The Reach Code Team developed these bases of designs to develop simulation inputs for restaurants after exhaustive literature review and interviews with food service subject matter experts. Note that where '***' is used in the model name and number, it is a placeholder representing multiple model options.

7.3.1 Kitchen hooded cooking appliances

The BOD for kitchen hooded cooking appliances covers four scenarios:

- Baseline gas appliances
- HE gas appliances, defined as either ENERGY STAR compliant or qualified for IOU rebates
- High-efficiency electric appliances, including induction appliances.
- KOF AE for FSR only. In addition to the AE package that focuses on one-to-one replacement of each gas appliance, the Reach Code Team also investigated using advanced AE cooking appliance package to reduce space requirements, improve energy efficiency and reduce cook time. The KOF involves careful design and selection of more advanced electric appliances that combine cooking processes. For example, combination and rapid cook ovens are used to replace broilers, convection ovens, range oven, and stock pot.

The selected appliances in each package can achieve equivalent cooking capacity and needs. Energy efficiency comes from improved technologies.

7.3.1.1 FSR

Figure 28 shows the cooking appliance included in the BOD for FSR mixed-fuel baseline scenario.

Figure 28. Hooded cooking appliance for FSR - Baseline Gas Appliance

Hooded Cooking Appliances	Number of units	Model	Width	Name plate power (Btu/hr)	Idle energy (Btu/hr)	Duty	Source	Cost/unit
Broiler, Underfired	1	Vulcan HGB34	3	96,000	73,900	Heavy	Market data	$2,745
French Fryer	2	Frymaster GF40	1.3	122000	9000	Medium	Market data	$2,144
Griddle, single sided	1	Imperial ITG-36	3	90,000	20,400	Medium	Market data	$2,747
Broiler, Salamander	1	Vulcan Sar 34R	2.8	35,000	33,300	Light	RP 1362	$2,875
Oven, convection	2	Montague Vectaire R85	3.188	85,000	12000	Light	Market data	$14,340
Oven, Range	2	Wolf C36C -6, oven	3	25,000	7,400	Light	RP 1362	Combined cost with Range, Open Top, 6 burner
Range, Open Burner	2	Wolf C36C -6	3.0	180,000	181,800	Medium	GTI and Fisher Nickel (2013) Table 12	$5,095
Range, Stock pot	2	Royal RSP18	1.5	90,000	90,900	Medium	Market data	$868

Figure 29 shows the cooking appliances included in the BOD for FSR high efficiency gas scenario.

Figure 29. Hooded cooking appliance for FSR: HE Gas Appliance

Hooded Cooking Appliances	Number of units	Model	Width	Name plate power (Btu/hr)	Idle energy (Btu/hr)	Duty	Source	Cost/unit
Broiler, Underfired	1	Vulcan VTEC36	3	66,000	51,000	Heavy	DEER[9]	$5,304
French Fryer	2	Frymaster PH155	1	80,000	5,604	Medium	IOU Rebate	$4,537
Griddle, single sided	1	AccuTemp GGF1201A3650	3	70,000	11,850	Medium	IOU Rebate	$6,554
Broiler, Salamander	1	Vulcan Sar 34R	2.8	35,000	33,300	Light	RP 1362	$2,875
Oven, convection	2	Blodgett HVH100G	3.2	60,000	9,082	Light	IOU Rebate	$15,378
Oven, Range	2	Southbend C0300, oven	3	25,000	7,400	Light	RP 1362	Combined cost with Range, Open top, 6 burner
Range, Open Burner[10] with turbo pot	2	Montague 136-5	3	120,000	121,200	Medium	GTI and Fisher Nickel (2013) Table 13	$9,666
Range, Stock pot	2	Royal RSP18	1.5	90,000	90,900	Medium	Market data	$7,578

Figure 30 shows the cooking appliances included in the BOD for FSR electric scenario.

Figure 30. Hooded cooking appliance for FSR: Electric Appliance

Hooded Cooking Appliances	Number of units	Model	Width	Nameplate power (W)	Idle energy (W)	Duty	Source	Cost/unit
Broiler, chain	1	Nieco JF63	3	18,000	15,120	Medium	Market data	$23,427
French Fryer	2	Frymaster RE14***	1	14,000	620	Medium	IOU Rebate	$5,609
Griddle, single sided	1	AccuTemp EGF****A3650	3	15,250	2,034	Medium	IOU Rebate	$6,760
Broiler, Salamander	1	Garland SERC	2.8	7,003	6,827	Light	RP 1362	$4,444
Oven, convection	2	Blodgett Zephaire-100-E	3.2	11,000	1,400	Light	IOU Rebate	$6,114

[9] Efficiency is based on DEER commercial underfired broiler workpaper for IR Plate Broiler with 17,000 Btu/hr/ft idle rate

[10] HE gas scenario includes replacing high-input burners with low-input burners in combination with turbo pot.

Oven, Range	2	Garland GME36-I20C Oven	3	5,100	1,224	Light	Market data	Combined cost with Range, Open top, 6 burner
Range, Open burner induction	2	Garland GME36-120C	3	21,000	0	Light	Market data	$15,936
Range, Stock pot induction	2	CookTek MSP7000-200	1.8	7,000	0	Light	Market data	$5,845

Figure 31 shows the cooking appliances included in the BOD for FSR kitchen on the future scenario.

Figure 31. Hooded cooking appliance for FSR: Electric Appliance – KOF

Hooded Cooking Appliances	Number of units	Model	Width (ft)	Rated Input (W)	Idle Energy Rate (W)	Duty	Source	Cost/unit
French Fryer	2	Frymaster RE14***	1	14,000	620	Medium	IOU Rebate	$5,609
Griddle, single sided[a]	1	AccuTemp EGF****A4850	4	14,250	2,657	Medium	IOU Rebate	$6,760
Oven, Combination[b]	1	Rational ICP 6-FULL E	3.5	22,400	950	Light	IOU Rebate	$18,196
Oven, Combination[b]	1	Rational ICP 10-FULL E	3.5	37,400	1,150	Light	Market Data	$22,395
Range, Induction Hot Top	2	CookTek Six-Burner Range	3	21,000	0	Light	Market data	$13,405
Range, Induction Hot Top[c]	2	CookTek Four-Burner Range	3	17,000	0	Light	Market data	$9,845
Rapid Cook Oven[d]	2	TurboChef Sota	1.2	6,200	800	Light	Market Data	$9,606

[a] One four-foot griddle replaces the broiler cooking process

[b] One full-size, six-hotel pan combination oven stacked atop one full size, ten hotel pan combination oven replaces the convection oven, range oven, stock pot, and charbroiler cooking processes

[c] One four-burner induction range burner replaces the oven, range burner cooking processes

[d] Two rapid cook ovens replace the broiler, salamander cooking/finishing process

7.3.1.2 QSR: Burger Diner

Figure 32 shows the cooking appliances included in the BOD for QSR mixed-fuel baseline scenario.

Figure 32. Hooded cooking appliances for QSR: Baseline Gas Appliance

Hooded Cooking Appliances	Number of units	Model	Width (ft)	Nameplate power (Btu/hr)	Idle energy (Btu/hr)	Duty (ASHRAE 2020)	Source	Cost/unit
French Fryer, small	4	Frymaster GF40	1.3	122,000	9,000	Medium	Market data	$2,144
Griddle, single sided	2	Imperial ITG-36	3	90,000	20,400	Medium	Market data	$2,747
Oven, half-size electric convection*	1	Montague Vectaire EK8	2.5	26,955	5,390	Light	Market data	$7,578

*Interviewees suggested that a half-size electric oven is commonly used for gas QSR, with no exhaust hood is required.

Figure 33 shows the cooking appliances included in the BOD for QSR high efficiency gas scenario.

Figure 33. Hooded cooking appliances for QSR: HE Gas Appliance

Hooded Cooking Appliances	Number	Model	Width (ft)	Nameplate power (Btu/hr)	Idle energy (Btu/hr)	Duty	Source	Cost/unit
French Fryer, small	4	Frymaster PH155	1	80,000	5,604	Medium	IOU Rebate	$4,537
Griddle, single sided	2	AccuTemp GGF1201A3650	3	70,000	7,900	Medium	IOU Rebate	$6,554
Oven, half-size electric convection*	1	Montague Vectaire EK8	2.5	26,955	5390	Light	Market data	$7,578

Figure 34 shows the cooking appliances included in the BOD for QSR electric scenario.

Figure 34. Hooded cooking appliances for QSR: Electric Appliance

Hooded Cooking Appliances	Number of units	Model	Width (ft)	Nameplate power (W)	Idle energy (W)	Duty	Source	Cost/unit
French Fryer, small	4	Frymaster RE14***	1	14,000	620	Medium	IOU Rebate	$5,609
Griddle, single sided	2	AccuTemp EGF****A3650	3	15,250	2,034	Medium	IOU Rebate	$6,760
Oven, convection	1	Blodgett CBT	2.5	5,600	300	Light	IOU Rebate	$6,114

7.3.1.3 QSR: Taqueria

Figure 35 shows the cooking appliances included in the BOD for QSR mixed-fuel baseline scenario.

Figure 35. Hooded cooking appliances for QSR: Baseline Gas Appliance

Hooded Cooking Appliances	Number of units	Model	Width (ft)	Nameplate power (Btu/hr)	Idle energy (Btu/hr)	Duty	Source	Cost/unit
Broiler, Underfired	1	Vulcan HGB34	3	96,000	73,900	Heavy	RP 1362	$2,745
French Fryer, small	1	Frymaster GF40	1.3	122,000	9,000	Medium	Market data	$2,144
Griddle, single sided	1	Imperial ITG-36	3	90,000	20,400	Medium	Market data	$2,747
Oven, half-size electric convection	1	Montague Vectaire EK8	2.5	26,955	5,390	Light	Market data	$7,578
Oven, Range	1	Wolf C36C -6, oven	3	25,000	7,400	Light	RP 1362	Combined cost with Range, Open burner
Range, Open Burner	1	Wolf C36C -6	3.0	180,000	181,800	Medium	GTI and Fisher Nickel (2013) Table 12	$5,095

Figure 36 shows the cooking appliances included in the BOD for QSR high efficiency gas scenario.

Figure 36. Hooded cooking appliances for QSR: HE Gas Appliance

Hooded Cooking Appliances	Number	Model	Width (ft)	Nameplate power (Btu/hr)	Idle energy (Btu/hr)	Duty	Source	Cost/unit
Broiler, Underfired	1	Vulcan VTEC36	3	66,000	51,000	Heavy	DEER	$5,304
French Fryer, small	1	Frymaster H55	1	80,000	5,604	Medium	IOU Rebate	$4,537
Griddle, single sided	1	AccuTemp GGF1201A3650	3	70,000	7,900	Medium	IOU Rebate	$6,554
Oven, half-size electric convection*	1	Montague Vectaire EK8	2.5	26,955	5,390	Light	Market data	$7,578
Oven, Range	1	Southbend C0300, oven	3	25,000	7,400	Light	RP 1362	Combined cost with Range,

								Open Burner with turbo pot
Range, Open Burner with turbo pot	1	Montague 136-5	3	120,000	121,200	Medium	GTI and Fisher Nickel (2013) Table 13	$9,666

Figure 37 shows the cooking appliances included in the BOD for QSR electric scenario.

Figure 37. Hooded cooking appliances for QSR: Electric Appliance

Hooded Cooking Appliances	Number of units	Model	Width (ft)	Nameplate power (W)	Idle energy (W)	Duty	Source	Cost/unit
Broiler, chain	1	Nieco JF63	3	18,000	15,120	Medium	Market data	$23,437
French Fryer, small	1	Frymaster RE14***	1	14,000	620	Medium	IOU Rebate	$5,609
Griddle, single sided	1	AccuTemp EGF****A3650	3	15,250	2,034	Medium	IOU Rebate	$6,760
Oven, convection	1	Blodgett CBT	2.5	5,600	300	Light	IOU Rebate	$6,114
Range, Open burner induction	1	Garland GME36-120C	3	21,000	0	Light	Market data	$15,936
Range, Stock pot induction	1	CookTek MSP7000-200	1.8	7,000	0	Light	Market data	$5,845

7.3.1.4 Annual Cooking Energy Use

The Reach Code Team used a bottom-up approach to estimate annual cooking energy usage. We developed hourly load profiles for each appliance based on occupancy schedule, equipment nameplate power, idle energy rate, and energy input as a function of appliance cooking state if data is available.

Figure 38 shows the aggregated cooking appliances load profile for the FSR. The annual energy use for each scenario is:

- Baseline gas appliances: 248 kBtu/ft2
- HE gas appliances: 188 kBtu/ft2
- All-electric appliances: 40 kWh/ft2 (136 kBtu/ft2)
- All-electric KOF appliances: 26 kWh/ft2 (89 kBtu/ft2)

Figure 38. FSR Weekday Cooking Appliance Load Profiles, Percent of Total Capacity

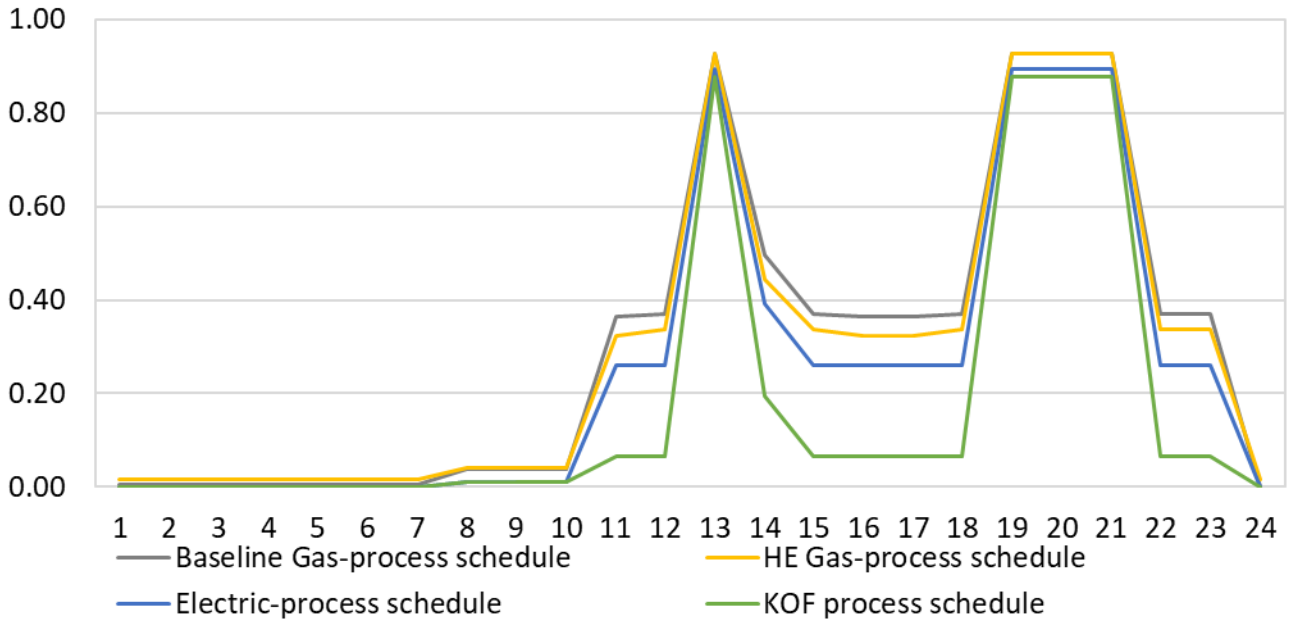
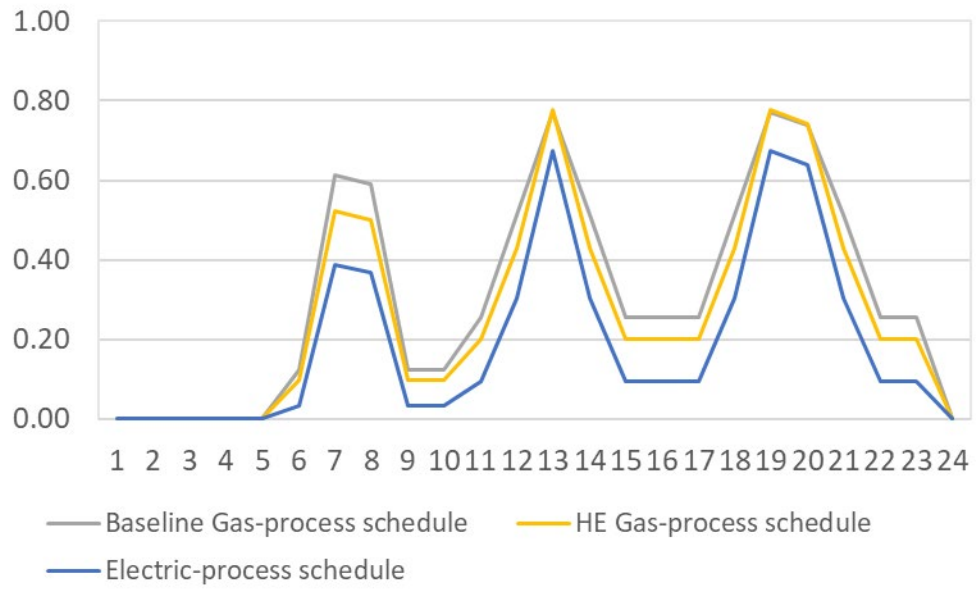


Figure 39 shows the aggregated cooking appliances load profile for the QSR-Burger. The annual energy uses for each scenario are:

- Baseline gas appliances: 293 kBtu/ft^2 for gas consumption and 3.3 kWh/ft^2 for electric convection oven
- HE gas appliances: 190.5 kBtu/ft^2 for gas consumption and 3.3 kWh/ft^2 for electric convection oven
- All-electric appliances: 42.3 kwh/ft^2 (144 kBtu/ft^2)

Figure 39. QSR Weekday Cooking Appliance Load Profiles, Percent of Total Capacity



As a reference, 2003 Commercial Building Energy Consumption Survey (CBECS) has a wide range of restaurant annual cooking energy use index (EUI) for, as shown in Figure 40. CBECS data includes restaurants serving different menus, including sandwich or cafés, which use much less energy than a burger restaurant. A Pacific Northwest National Laboratory (PNNL) report suggests a cooking EUI of 400 to 450 kBtu/ft^2 as reasonable for a burger QSR (PNNL 2010). Figure 41 also demonstrates where the mixed-fuel prototypes fall in comparison to a wider range of restaurants—the selected prototypes generally have more gas appliances and a higher cumulate idle rate (which is indicative of the energy use intensity). Thus, the annual energy use the Reach Code Team developed for the FSR and QSR baseline scenarios are appropriately on the higher end of PNNL's EUI findings.

Figure 40. Annual Cooking Energy EUI of Post-1980 Restaurants from CBECS 2003 (PNNL 2010)

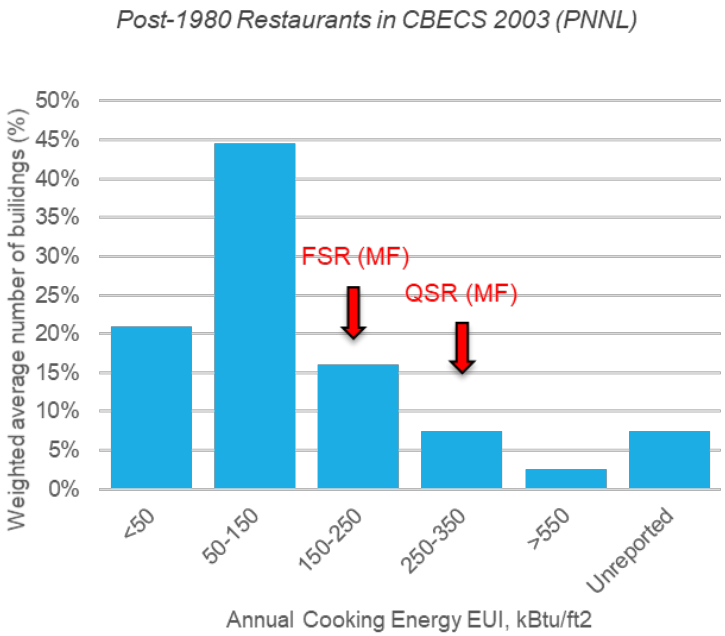
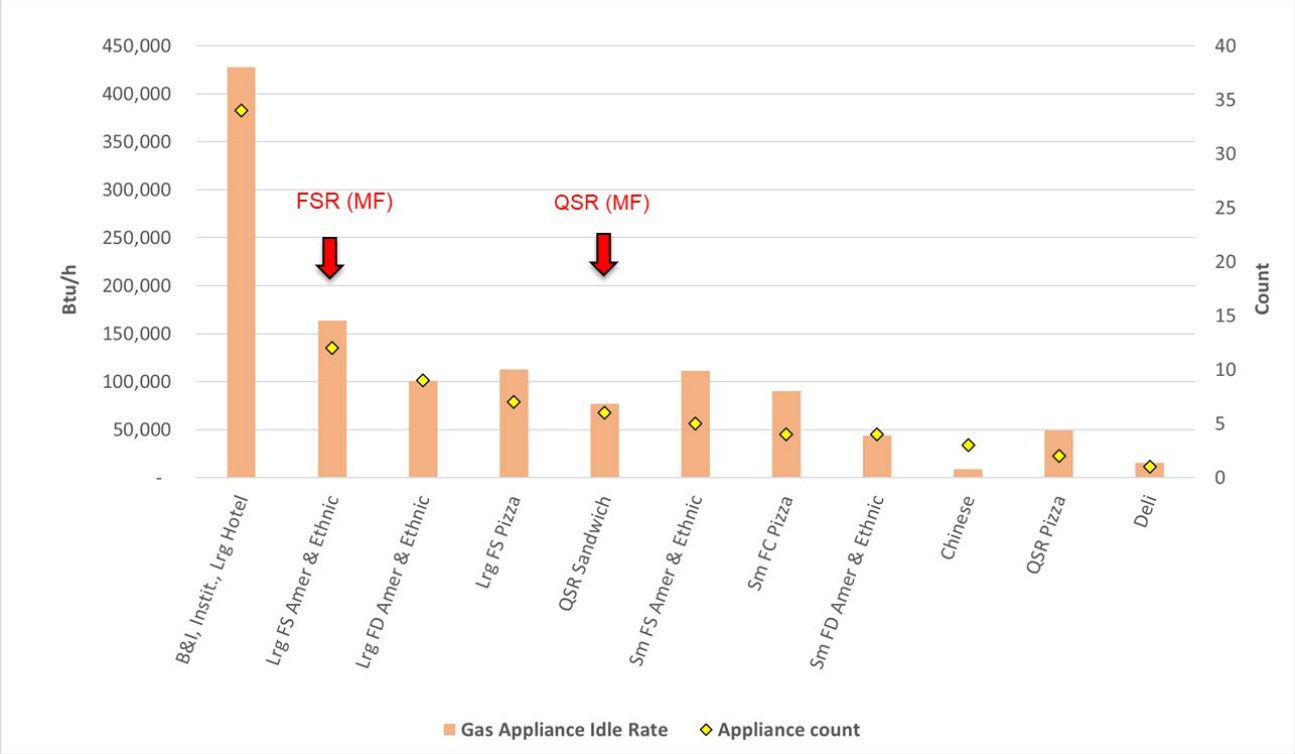


Figure 41. Gas Cooking Energy Idle Rate in Different Types of Commercial Kitchens[11]



7.3.2 Kitchen Exhaust Hood

The Reach Code Team determined the exhaust hood length by adding all appliance widths and six inches of overhang on each side. This is the approach used in the ASHRAE 154 Appendix example. The total exhaust rate is the maximum airflow allowed by 2019 Title 24 Table 140.9. For control, if total exhaust rate exceeds 5,000 ft^3/min, DCKV is specified per 2019 Title 24 prescriptive requirement.

Figure 42. FSR Type I exhaust hood design

	Length (ft)	Exhaust rate	Equipment Duty	Control
Gas baseline	26	7,280	Heavy	DCKV
HE gas	26	7,280	Heavy	DCKV
Electric	26	5,460	Medium	DCKV
Kitchen of Future	22	4620	Medium	DCKV

11 The reach code team developed this graph with support from subject matter experts at Food Service Technology Center, Frontier Energy, Inc.

Figure 43. QSR Type I exhaust hood design

	Length (ft)	Exhaust rate (ft^3/min)	Equipment Duty	Control
Gas baseline	13	2,730	Medium	Constant
HE gas	13	2,730	Medium	Constant
Electric	13	2,730	Medium	Constant

For cooking appliances, the Reach Code Team focused on gas cooking appliances that require a Type I exhaust hood[12]. Compared to appliances needing a Type II exhaust hood, Type I appliances present the biggest challenges for electrification and have large impacts on HVAC loads. Most appliances requiring Type II are already electrical appliances and the amount of exhaust air required is small.

7.3.3 Hot Water System

Design parameters for the hot water systems are based on research by PG&E and Fisher-Nickel (Fisher-Nickel and PG&E 2010), California Energy Wise design guide (California Energy Wise 2020) and subject matter expert interviews. The baseline scenarios represent design practice with typical hot water use appliances and fixtures for a medium QSR and medium FSR. Fixture types and counts assumed in the FSR and QSR are presented in Figure 44.

Figure 44. Fixture Type and Counts Included in the FSR and QSR Baselines

Fixture type	FSR	QSR
Restroom sinks	4	2
Hand sinks	6	2
3-comp sink (18"x18")	2	1
Dishwasher - Undercounter	1	0
Dishwasher - door type	1	0
Pre-rinse valve	1	0
Mop sink	1	1
Utility sink	2	1
Dipper well	1	0

[12] Type I hoods are installed over cooking appliances, and they include listed grease filters, baffles, and a fire suppression system. Type II hood may nor may not have grease filters or baffles and is not designed to have a fire-suppression system. Compared to Type II hoods, Type I hoods have higher exhaust rate requirements and thus have a larger energy impact. Thus, Type I hoods require more design optimization and control.

Hot water use in restaurants features high demand for an extended period, which can be very challenging for a cost-effective heat pump water design. HPWHs have low recovery rates compared to gas heaters, and their capacity reduces significantly when there is a large difference between supply hot water temperature and incoming cold-water temperature.

For the AE baseline scenario with typical hot water design load, the design uses large capacity split heat pump (i.e., Colmac), which are much more expensive than a gas storage water heater. Alternatively, the design can use integrated heat pumps (i.e., AO Smith), which are less expensive than the split heat pumps. However, the high hot water demand in a restaurant, in particularly for FSR, would require several integrated heat pumps supplemented by an electric resistance heater, which may not be a practical design solution.

To address these issues, the team investigated high efficiency SHW design approaches to drastically reduce hot water demand and supply hot water temperature requirement, which are critical to improve the feasibility and cost effectiveness of a HPWH design. The measures investigated include the following:

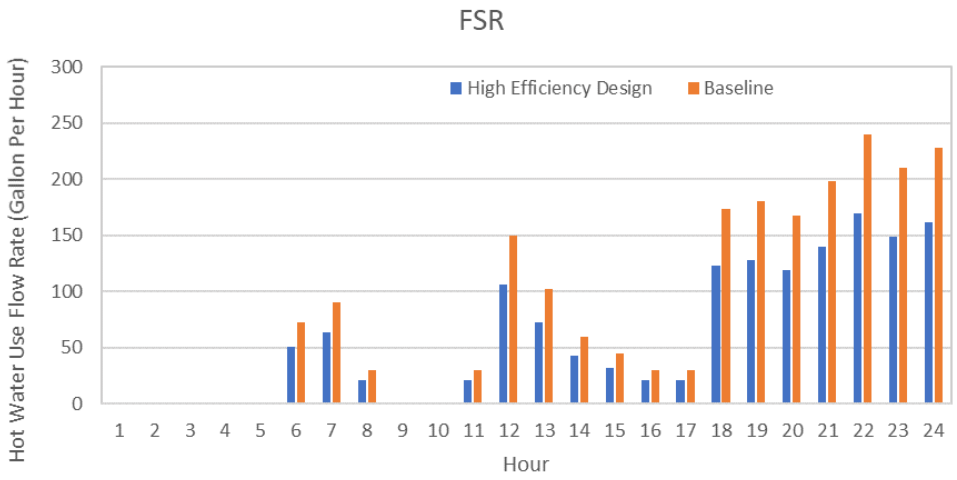
- **Low-flow pre-rinse valves:** Specifies PRSV qualified for IOU rebates to reduce design flowrate from 45 gallon per hour (gph) to 24 gph.
- **Low-flow restroom and hand sinks:** Specifies highly efficient faucet aerators in restroom and hand-washing sinks in the kitchen to reduce design flowrate from 1.8 to 1.0 gpm.
- **Heat recovery dishwasher in the FSR:** For the FSR design, specifies dishwasher that includes heat recovery function such that it only needs connection to cold water and reduces hot water demand and sizes of the central SHW system. Typical design supply hot water temperature for FSR is 140°F for both high-temperature and low-temperature dishwasher types. With heat recovery function at dishwasher, the central house SHW system only needs to provide 125°F hot water to meet other demands. The lowered temperature significantly improves the practicality of an AE solution that uses a HPWH, which has much lower output capacity when supplying a higher supply temperature, especially during the winter when the design temperature rise is at the highest. Although market penetration of heat recovery dishwasher is low, they appear to be a critical piece to electrify SHW in restaurant.
- **Highly efficient dishwasher in QSR:** QSRs typically specify a three-compartment sink for dishwashing, and this measure would add a dishwasher to reduce total hot water load.
- **Compact design to avoid recirculation loop in FSR:** the team investigated this measure but did not include it in the final package. Recirculation loops are typically included in designs where hot water end use locations are far away from the water heater. For example, when the restroom hand sinks are far away from the heater, the hot water delivery time between heater and sink would be unacceptable (30 seconds or greater) without a recirculation loop. The need for a recirculation loop depends on the architectural floor layout, which is not within the scope of the study. Designers could consider the use of a point-of-use heater for far-away end uses, such as the restroom, to eliminate recirculation loop. The energy impact would be about the same for the baseline and AE design scenarios, so the Reach Code Team decided to not analyze this scenario.

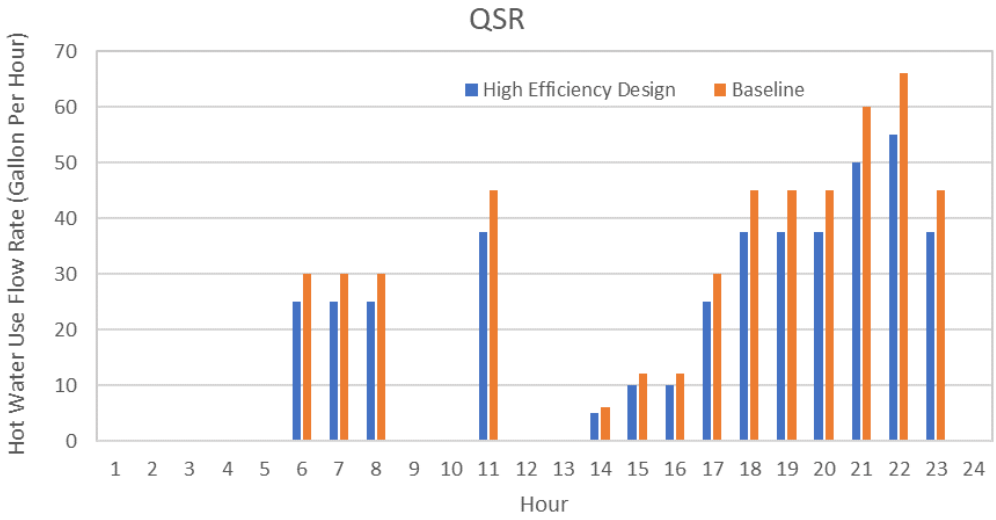
The design parameters for baseline and low-demand scenarios are presented in Figure 45, and the hot water load profiles are presented in Figure 46. The team consulted with design-build contractors and representatives from water heater manufacturers COLMAC and A.O. Smith for equipment selection. The team also leveraged data and lessons learned from 2022 Title 24 CASE work on central HPWH for multifamily buildings. ((CEC) California Energy Commission 2021) Figure 48 provides equipment selection for each design scenario.

Figure 45. Design Parameters for Hot Water Systems

Design Parameters	FSR Baseline	QSR Baseline	FSR – Low-Demand	QSR – Low-Demand
Daily hot water usage (gal)	2000	500	1450	420
Minimum recovery rate gallons per hour (gph)	240	66	170	55
Hot water supply temperature (°F)	140	125	125	125
Winter cold water inlet temperature (°F)	50	50	50	50
Design temperature rise (°F)	90	75	75	75

Figure 46. Hot Water Daily Usage Profile (based on Fisher and Pietrucha, 2008 (Fisher, et al. 2008) and interviews for FSR and QSR





Like energy use for cooking, hot water consumption in restaurants varies significantly depending on the food they serve, their operation schedule, and number of customers. Figure 47 compares monitored daily hot water use in several national chain restaurants and the assumptions used for the reach code analysis. The baseline assumption is consistent with recommendation in the California Energy Wise design guide for a typical medium full-service restaurant. Since monitored data were from existing restaurants, the team assumed more efficient hot water fixtures are used in new construction restaurants. For FSR, designers must carefully select hot water appliances and fixtures and use design approach that can achieve deep hot water savings to enable cost-effective HPWH solutions.

Figure 47. Monitored Daily Hot Water Use in Full-service Restaurants vs. Daily Hot Water Use in Reach Code FSR Prototype (Fisher-Nickel and PG&E 2010)

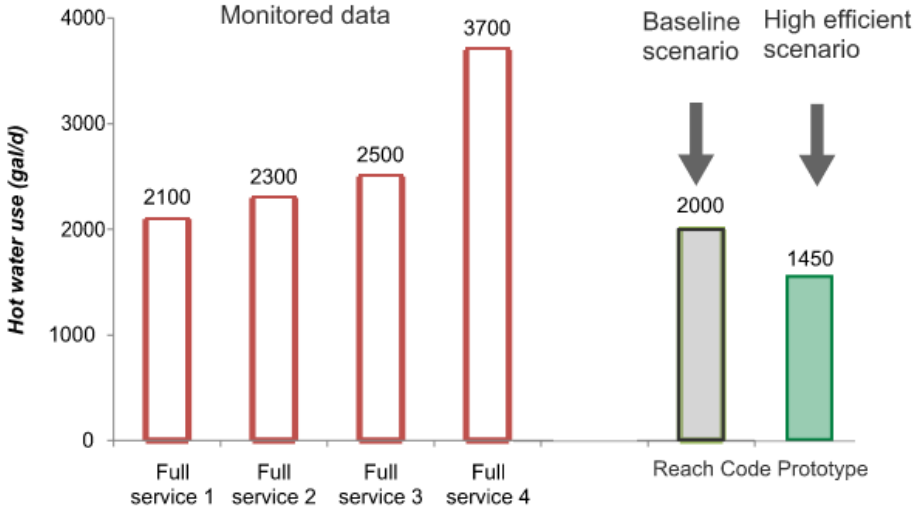


Figure 48. Hot Water Equipment Selection

Measure	HW System	FSR	QSR
Gas baseline water heater	Type	Storage water heater	Storage water heater
	Number of heaters	2	1
	Heater Product	Bosch Buderus G234X/55	A.O Smith gas storage water heater
	Total rated input rate (Btu/hr)	400,000	150,000
	Storage capacity (gal)	150	100
	Distribution system	Recirculation system with recirculation pump	No recirculation
Electric water heater	Type	HPWH with storage	HPWH with storage
	Number of heaters	4	1
	HPWH Model	Colmac CxV-5 or 2 CxV-15	A.O. Smith CHP 120, with 12 W built-in resistive electric element
	HPWH recovery rate (gph)	240	66
	Electric resistance heater for temperature maintenance	5 kW	n/a
	Primary storage capacity (gal)	500	120
	Recirculation tank (gal)	120	n/a
	Distribution system	Recirculation system with recirculation pump	No recirculation
Low-demand electric water heater	Type	HPWH with storage	HPWH with storage
	Number of primary heaters	2	1
	HPWH Model	A.O. Smith CHP 120	A.O. Smith CHP 120
	HPWH recovery rate (gph)	170	55
	Electric resistance heater for loop temperature maintenance	12 kW	n/a
	Primary storage capacity (gal)	240	120
	Recirculation tank (gal)	120	n/a
	Distribution system	Recirculation system with recirculation pump	No recirculation

7.4 Mixed-Fuel Baseline Energy Figures

Figure 49 and Figure 50 show the annual electricity and natural gas consumption and cost, compliance TDV, and GHG emissions for each prototype under the mixed-fuel design baseline. The compliance margins are non-zero in some cases and represent typical baseline compliance margins with prescriptive prototypes. The non-zero compliance margins are largely a result of compliance software complexities, and they are not expected to significantly impact the proposed case results or nature of recommendations.

Figure 49. FSR: Mixed-Fuel Baseline

CZ	Utility	Annual Electricity Consumption (kWh)	Annual Natural Gas Consumption (therms)	Annual Electricity Cost	Annual Natural Gas Cost	Compliance TDV	Annual GHG Emissions (mton)
CZ01	PG&E	86,953	28,678	$22,750	$31,140	-2.6%	175
CZ02	PG&E	105,553	26,003	$28,227	$28,362	-1.0%	163
CZ03	PG&E	90,394	25,101	$23,831	$27,375	-1.8%	156
CZ03-2	PCE	90,394	25,101	$23,323	$27,375	-1.8%	156
CZ04	PG&E	101,561	24,223	$27,093	$26,455	-0.6%	153
CZ04-2	CPAU	101,561	24,223	$17,531	$29,686	-0.6%	153
CZ05	PG&E	89,869	25,664	$23,552	$27,930	-1.9%	158
CZ05-2	SCG	89,869	25,664	$23,552	$19,287	-1.9%	158
CZ06	SCE	103,218	22,635	$15,370	$17,158	-0.2%	144
CZ06-2	LA	103,218	22,635	$10,041	$17,158	-0.2%	144
CZ07	SDG&E	96,695	21,731	$27,565	$16,471	0.1%	138
CZ08	SCE	112,859	22,071	$16,656	$16,762	0.7%	142
CZ08-2	LA	112,859	22,071	$11,003	$16,762	0.7%	142
CZ09	SCE	121,912	22,465	$18,132	$17,039	1.7%	146
CZ09-2	LA	121,912	22,465	$12,216	$17,039	1.7%	146
CZ10	SDG&E	128,726	22,793	$38,166	$17,154	1.4%	149
CZ10-2	SCE	128,726	22,793	$18,812	$17,269	1.4%	149
CZ11	PG&E	134,324	24,685	$36,433	$27,051	0.8%	161
CZ12	PG&E	119,068	24,856	$32,107	$27,211	-0.2%	159
CZ12-2	SMUD	119,068	24,856	$16,976	$27,211	-0.2%	159
CZ13	PG&E	135,872	24,284	$36,757	$26,635	0.5%	159
CZ14	SDG&E	135,580	24,598	$36,634	$18,315	1.0%	160
CZ14-2	SCE	135,580	24,598	$18,700	$18,538	1.0%	160
CZ15	SCE	187,946	20,554	$25,095	$15,695	3.1%	146
CZ16	PG&E	103,255	28,573	$27,467	$31,234	-2.2%	178
CZ16-2	LA	103,255	28,573	$9,076	$21,332	-2.2%	178

Figure 50. QSR: Mixed-Fuel Baseline

CZ	Utility	Annual Electricity Consumption (kWh)	Annual Natural Gas Consumption (therms)	Annual Electricity Cost	Annual Natural Gas Cost	Compliance TDV	Annual GHG Emissions (mton)
CZ01	PG&E	61,491.00	12,748.11	$16,272	$13,944	4.5%	82
CZ02	PG&E	63,815.76	11,377.20	$17,142	$12,494	5.1%	74
CZ03	PG&E	64,188.51	10,848.91	$17,031	$11,917	5.3%	72
CZ03-2	PCE	64,188.51	10,848.91	$16,669	$11,917	5.3%	72
CZ04	PG&E	69,215.47	10,542.25	$18,473	$11,593	5.3%	71
CZ04-2	CPAU	69,215.47	10,542.25	$12,040	$13,571	5.3%	71
CZ05	PG&E	64,110.03	11,133.94	$16,942	$12,205	5.4%	73
CZ05-2	SCG	64,110.03	11,133.94	$16,942	$9,074	5.4%	73
CZ06	SCE	70,937.68	9,964.84	$9,206	$8,253	5.7%	68
CZ06-2	LA	70,937.68	9,964.84	$7,512	$8,253	5.7%	68
CZ07	SDG&E	71,753.72	9,535.35	$17,124	$8,137	5.7%	66
CZ08	SCE	68,037.04	9,740.74	$10,504	$8,095	5.8%	66
CZ08-2	LA	68,037.04	9,740.74	$7,403	$8,095	5.8%	66
CZ09	SCE	71,935.81	9,893.01	$11,169	$8,202	5.7%	68
CZ09-2	LA	71,935.81	9,893.01	$7,885	$8,202	5.7%	68
CZ10	SDG&E	74,683.54	10,058.72	$21,701	$8,577	11.4%	69
CZ10-2	SCE	74,683.54	10,058.72	$11,303	$8,319	11.4%	69
CZ11	PG&E	78,011.57	10,939.98	$21,200	$12,063	5.7%	75
CZ12	PG&E	69,910.56	10,929.67	$18,896	$12,044	5.4%	73
CZ12-2	SMUD	69,910.56	10,929.67	$10,005	$12,044	5.4%	73
CZ13	PG&E	78,795.13	10,757.24	$21,367	$11,871	4.8%	74
CZ14	SDG&E	79,339.50	10,902.78	$22,813	$9,212	6.1%	74
CZ14-2	SCE	79,339.50	10,902.78	$11,876	$8,912	6.1%	74
CZ15	SCE	108,848.18	9,291.38	$15,185	$7,779	1.7%	70
CZ16	PG&E	69,867.29	12,616.29	$18,620	$13,877	6.2%	83
CZ16-2	LA	69,867.29	12,616.29	$7,223	$10,116	6.2%	83

7.5 Additional Restaurant All-Electric Package Analysis

The Reach Code Team tested multiple packages that include electric cooking and or TDV multipliers that were developed for the 2022 Title 24 code to test the potential impact on cost effectiveness. Results generally do not change Summary of Results in Section 5.

7.5.1 2019 TDV Results

7.5.1.1 FSR

Figure 51 shows the AE HVAC, SHW, and cooking package is not cost effective nor compliant. Electric cooking appliances contribute negative total TDV and utility cost savings because they have load profiles coincident with peak utility rates and electricity TDV values (reference Figure 9 depiction of the increase in process load TDV in AE packages as compared to the mixed-fuel cases). Additions to electric cooking to the efficiency package (Figure 52), KOF (Figure 53), and solar PV with Battery (Figure 54) are not enough to make AE cost effective when compared to the mixed-fuel baseline.

Figure 55 shows the hybrid package—using AE appliances except for the baseline gas storage SHW system—improves cost effectiveness of the measure package, but not enough to achieve TDV or on-bill cost effectiveness.

Figure 51. Cost Effectiveness for FSR: All-Electric + HE Cooking

CZ	Utility	Annual Elec Savings (kWh)	Annual Gas Savings (therms)	Annual GHG Reductions (mtons)	Compliance Margin	Upfront Incremental Package Cost	Lifecycle Utility Cost Savings	Lifecycle $TDV Savings	B/C Ratio (On-bill)	B/C Ratio (TDV)	NPV (On-bill)	NPV (TDV)
CZ01	PG&E	(334,036)	28,678	94.0	-44.2%	$181,293	($545,242)	($551,560)	-3.0	-3.0	($726,534)	($732,853)
CZ02	PG&E	(310,560)	26,003	82.9	-23.6%	$187,707	($526,051)	($459,586)	-2.8	-2.4	($713,758)	($647,292)
CZ03	PG&E	(304,959)	25,101	79.0	-32.8%	$189,475	($536,633)	($511,423)	-2.8	-2.7	($726,108)	($700,897)
CZ03-2	PCE	(304,959)	25,101	79.0	-32.8%	$189,475	($557,814)	($511,423)	-2.9	-2.7	($747,288)	($700,897)
CZ04	PG&E	(295,999)	24,223	75.9	-25.3%	$188,176	($526,035)	($439,423)	-2.8	-2.3	($714,211)	($627,599)
CZ04-2	CPAU	(295,999)	24,223	75.9	-25.3%	$188,176	($171,390)	($439,423)	-0.9	-2.3	($359,566)	($627,599)
CZ05	PG&E	(310,769)	25,664	80.6	-34.9%	$181,429	($540,490)	($510,647)	-3.0	-2.8	($721,919)	($692,076)
CZ05-2	SCG	(310,769)	25,664	80.6	-34.9%	$181,429	($690,743)	($510,647)	-3.8	-2.8	($872,172)	($692,076)
CZ06	SCE	(285,613)	22,635	68.7	-22.2%	$181,071	($249,587)	($448,864)	-1.4	-2.5	($430,658)	($629,936)
CZ06-2	LA	(285,613)	22,635	68.7	-22.2%	$181,071	($30,572)	($448,864)	-0.2	-2.5	($211,643)	($629,936)
CZ07	SDG&E	(279,622)	21,731	65.6	-24.2%	$183,154	($958,172)	($454,810)	-5.2	-2.5	($1,141,326)	($637,964)
CZ08	SCE	(279,188)	22,071	67.0	-18.2%	$182,105	($248,762)	($407,775)	-1.4	-2.2	($430,866)	($589,879)
CZ08-2	LA	(279,188)	22,071	67.0	-18.2%	$182,105	($31,366)	($407,775)	-0.2	-2.2	($213,470)	($589,879)
CZ09	SCE	(277,870)	22,465	69.6	-13.4%	$177,640	($242,077)	($389,394)	-1.4	-2.2	($419,717)	($567,034)
CZ09-2	LA	(277,870)	22,465	69.6	-13.4%	$177,640	($23,616)	($389,394)	-0.1	-2.2	($201,257)	($567,034)
CZ10	SDG&E	(278,574)	22,793	71.0	-8.9%	$178,754	($908,526)	($378,392)	-5.1	-2.1	($1,087,281)	($557,147)
CZ10-2	SCE	(278,574)	22,793	71.0	-8.9%	$178,754	($235,924)	($378,392)	-1.3	-2.1	($414,678)	($557,147)
CZ11	PG&E	(296,328)	24,685	78.2	-11.2%	$185,929	($496,290)	($392,542)	-2.7	-2.1	($682,220)	($578,471)
CZ12	PG&E	(298,811)	24,856	78.7	-16.4%	$183,548	($510,013)	($412,960)	-2.8	-2.2	($693,562)	($596,509)
CZ12-2	SMUD	(298,811)	24,856	78.7	-16.4%	$183,548	($93,913)	($412,960)	-0.5	-2.2	($277,461)	($596,509)
CZ13	PG&E	(292,257)	24,284	76.5	-13.7%	$185,811	($491,772)	($423,342)	-2.6	-2.3	($677,584)	($609,153)
CZ14	SDG&E	(296,349)	24,598	77.5	-11.3%	$179,323	($957,121)	($393,913)	-5.3	-2.2	($1,136,445)	($573,236)
CZ14-2	SCE	(296,349)	24,598	77.5	-11.3%	$179,323	($248,742)	($393,913)	-1.4	-2.2	($428,066)	($573,236)
CZ15	SCE	(250,391)	20,554	63.9	-3.4%	$173,302	($229,121)	($358,323)	-1.3	-2.1	($402,423)	($531,625)
CZ16	PG&E	(322,335)	28,573	96.2	-19.8%	$179,749	($507,852)	($483,272)	-2.8	-2.7	($687,601)	($663,020)
CZ16-2	LA	(322,335)	28,573	96.2	-19.8%	$179,749	$42	($483,272)	0.0	-2.7	($179,707)	($663,020)

Figure 52. Cost Effectiveness for FSR: All-Electric + Eff+ HE Cooking

CZ	Utility	Annual Elec Savings (kWh)	Annual Gas Savings (therms)	Annual GHG Reductions (mtons)	Compliance Margin	Upfront Incremental Package Cost	Lifecycle Utility Cost Savings	Lifecycle $TDV Savings	B/C Ratio (On-bill)	B/C Ratio (TDV)	NPV (On-bill)	NPV (TDV)
CZ01	PG&E	(281,651)	28,678	104.2	-25.3%	$119,385	($405,377)	($417,527)	-3.4	-3.5	($524,762)	($536,913)
CZ02	PG&E	(261,809)	26,003	92.4	-3.8%	$123,530	($389,019)	($327,659)	-3.1	-2.7	($512,549)	($451,189)
CZ03	PG&E	(261,781)	25,101	87.6	-12.9%	$123,211	($418,620)	($395,437)	-3.4	-3.2	($541,831)	($518,648)
CZ03-2	PCE	(261,781)	25,101	87.6	-12.9%	$123,211	($438,223)	($395,437)	-3.6	-3.2	($561,434)	($518,648)
CZ04	PG&E	(253,467)	24,223	84.3	-2.8%	$122,212	($406,548)	($319,692)	-3.3	-2.6	($528,760)	($441,904)
CZ04-2	CPAU	(253,467)	24,223	84.3	-2.8%	$122,212	($72,233)	($319,692)	-0.6	-2.6	($194,445)	($441,904)
CZ05	PG&E	(265,469)	25,664	89.7	-13.5%	$119,578	($416,746)	($390,982)	-3.5	-3.3	($536,324)	($510,560)
CZ05-2	SCG	(265,469)	25,664	89.7	-13.5%	$119,578	($566,999)	($390,982)	-4.7	-3.3	($686,577)	($510,560)
CZ06	SCE	(245,889)	22,635	76.5	-0.4%	$119,487	($189,630)	($338,006)	-1.6	-2.8	($309,117)	($457,493)
CZ06-2	LA	(245,889)	22,635	76.5	-0.4%	$119,487	$10,201	($338,006)	0.1	-2.8	($109,286)	($457,493)
CZ07	SDG&E	(244,333)	21,731	72.6	-3.1%	$119,044	($866,203)	($358,685)	-7.3	-3.0	($985,247)	($477,729)
CZ08	SCE	(239,524)	22,071	74.8	3.5%	$117,991	($187,823)	($297,770)	-1.6	-2.5	($305,814)	($415,761)
CZ08-2	LA	(239,524)	22,071	74.8	3.5%	$117,991	$7,846	($297,770)	0.1	-2.5	($110,145)	($415,761)
CZ09	SCE	(236,169)	22,465	77.6	9.2%	$115,794	($177,311)	($274,493)	-1.5	-2.4	($293,104)	($390,287)
CZ09-2	LA	(236,169)	22,465	77.6	9.2%	$115,794	$18,037	($274,493)	0.2	-2.4	($97,757)	($390,287)
CZ10	SDG&E	(233,451)	22,793	79.6	11.4%	$114,640	($783,964)	($258,035)	-6.8	-2.3	($898,605)	($372,675)
CZ10-2	SCE	(233,451)	22,793	79.6	11.4%	$114,640	($167,646)	($258,035)	-1.5	-2.3	($282,286)	($372,675)
CZ11	PG&E	(243,930)	24,685	88.3	7.9%	$121,586	($351,964)	($256,420)	-2.9	-2.1	($473,550)	($378,006)
CZ12	PG&E	(249,538)	24,856	88.3	3.3%	$119,278	($371,580)	($280,136)	-3.1	-2.3	($490,858)	($399,414)
CZ12-2	SMUD	(249,538)	24,856	88.3	3.3%	$119,278	($11,425)	($280,136)	-0.1	-2.3	($130,703)	($399,414)
CZ13	PG&E	(240,983)	24,284	86.5	6.4%	$121,602	($349,767)	($287,419)	-2.9	-2.4	($471,369)	($409,020)
CZ14	SDG&E	(242,130)	24,598	87.8	12.2%	$117,575	($817,932)	($246,507)	-7.0	-2.1	($935,507)	($364,082)
CZ14-2	SCE	(242,130)	24,598	87.8	12.2%	$117,575	($168,900)	($246,507)	-1.4	-2.1	($286,475)	($364,082)
CZ15	SCE	(201,608)	20,554	72.8	16.5%	$111,522	($155,208)	($225,957)	-1.4	-2.0	($266,730)	($337,480)
CZ16	PG&E	(271,393)	28,573	106.0	0.2%	$117,740	($369,535)	($348,127)	-3.1	-3.0	($487,275)	($465,867)
CZ16-2	LA	(271,393)	28,573	106.0	0.2%	$117,740	$48,620	($348,127)	0.4	-3.0	($69,120)	($465,867)

Figure 53. Cost Effectiveness for FSR: All-Electric + Eff+ KOF Cooking

CZ	Utility	Annual Elec Savings (kWh)	Annual Gas Savings (therms)	Annual GHG Reductions (mtons)	Compliance Margin	Upfront Incremental Package Cost	Lifecycle Utility Cost Savings	Lifecycle $TDV Savings	B/C Ratio (On-bill)	B/C Ratio (TDV)	NPV (On-bill)	NPV (TDV)
CZ01	PG&E	(194,483)	28,678	117.3	-24.0%	$148,141	($203,963)	($215,095)	-1.4	-1.5	($352,104)	($363,236)
CZ02	PG&E	(172,481)	26,003	105.8	2.6%	$152,286	($179,298)	($103,284)	-1.2	-0.7	($331,584)	($255,570)
CZ03	PG&E	(174,943)	25,101	100.6	-7.4%	$151,966	($216,514)	($188,471)	-1.4	-1.2	($368,480)	($340,438)
CZ03-2	PCE	(174,943)	25,101	100.6	-7.4%	$151,966	($232,945)	($188,471)	-1.5	-1.2	($384,911)	($340,438)
CZ04	PG&E	(165,497)	24,223	97.4	4.7%	$150,968	($201,068)	($92,275)	-1.3	-0.6	($352,036)	($243,242)
CZ04-2	CPAU	(165,497)	24,223	97.4	4.7%	$150,968	$128,879	($92,275)	0.9	-0.6	($22,088)	($243,242)
CZ05	PG&E	(177,882)	25,664	102.8	-10.2%	$148,333	($213,750)	($180,925)	-1.4	-1.2	($362,083)	($329,259)
CZ05-2	SCG	(177,882)	25,664	102.8	-10.2%	$148,333	($364,002)	($180,925)	-2.5	-1.2	($512,336)	($329,259)
CZ06	SCE	(157,632)	22,635	89.8	6.9%	$148,242	($94,719)	($112,475)	-0.6	-0.8	($242,962)	($260,717)
CZ06-2	LA	(157,632)	22,635	89.8	6.9%	$148,242	$87,068	($112,475)	0.6	-0.8	($61,174)	($260,717)
CZ07	SDG&E	(156,528)	21,731	85.7	4.3%	$147,799	($761,894)	($134,492)	-5.2	-0.9	($909,693)	($282,291)
CZ08	SCE	(150,585)	22,071	88.2	12.4%	$146,746	($91,045)	($57,225)	-0.6	-0.4	($237,791)	($203,972)
CZ08-2	LA	(150,585)	22,071	88.2	12.4%	$146,746	$88,792	($57,225)	0.6	-0.4	($57,954)	($203,972)
CZ09	SCE	(146,929)	22,465	91.1	13.6%	$144,549	($78,277)	($34,388)	-0.5	-0.2	($222,826)	($178,937)
CZ09-2	LA	(146,929)	22,465	91.1	13.6%	$144,549	$101,622	($34,388)	0.7	-0.2	($42,927)	($178,937)
CZ10	SDG&E	(143,725)	22,793	93.1	17.5%	$143,396	($673,368)	($20,675)	-4.7	-0.1	($816,764)	($164,071)
CZ10-2	SCE	(143,725)	22,793	93.1	17.5%	$143,396	($69,371)	($20,675)	-0.5	-0.1	($212,767)	($164,071)
CZ11	PG&E	(152,463)	24,685	102.2	10.8%	$150,342	($136,220)	($8,371)	-0.9	-0.1	($286,562)	($158,712)
CZ12	PG&E	(159,679)	24,856	101.8	9.5%	$148,033	($160,602)	($41,217)	-1.1	-0.3	($308,635)	($189,250)
CZ12-2	SMUD	(159,679)	24,856	101.8	9.5%	$148,033	$121,718	($41,217)	0.8	-0.3	($26,315)	($189,250)
CZ13	PG&E	(149,412)	24,284	100.5	11.4%	$150,357	($133,107)	($41,908)	-0.9	-0.3	($283,464)	($192,265)
CZ14	SDG&E	(150,571)	24,598	101.8	16.5%	$146,330	($702,930)	$1,120	-4.8	0.0	($849,260)	($145,210)
CZ14-2	SCE	(150,571)	24,598	101.8	16.5%	$146,330	($67,864)	$1,120	-0.5	0.0	($214,194)	($145,210)
CZ15	SCE	(106,606)	20,554	87.3	21.5%	$140,278	($49,938)	$29,545	-0.4	0.2	($190,216)	($110,732)
CZ16	PG&E	(180,444)	28,573	119.9	2.6%	$146,495	($154,418)	($115,209)	-1.1	-0.8	($300,913)	($261,704)
CZ16-2	LA	(180,444)	28,573	119.9	2.6%	$146,495	$131,113	($115,209)	0.9	-0.8	($15,382)	($261,704)

Figure 54. Cost Effectiveness for FSR: All-Electric + Eff + KOF Cooking + PV + B

CZ	Utility	Annual Elec Savings (kWh)	Annual Gas Savings (therms)	Annual GHG Reductions (mtons)	Compliance Margin	Upfront Incremental Package Cost	Lifecycle Utility Cost Savings	Lifecycle $TDV Savings	B/C Ratio (On-bill)	B/C Ratio (TDV)	NPV (On-bill)	NPV (TDV)
CZ01	PG&E	(142,255)	28,678	123.1	-24.0%	$458,582	($84,502)	$36,324	-0.2	0.1	($543,085)	($422,259)
CZ02	PG&E	(110,425)	26,003	114.2	2.6%	$462,727	($23,183)	$210,160	-0.1	0.5	($485,910)	($252,568)
CZ03	PG&E	(112,753)	25,101	108.5	-7.4%	$462,408	($64,325)	$118,596	-0.1	0.3	($526,734)	($343,813)
CZ03-2	PCE	(112,753)	25,101	108.5	-7.4%	$462,408	($78,551)	$118,596	-0.2	0.3	($540,959)	($343,813)
CZ04	PG&E	(101,202)	24,223	106.3	4.7%	$461,409	($38,944)	$252,841	-0.1	0.5	($500,353)	($208,569)
CZ04-2	CPAU	(101,202)	24,223	106.3	4.7%	$461,409	$271,225	$252,841	0.6	0.5	($190,184)	($208,569)
CZ05	PG&E	(110,815)	25,664	111.1	-10.2%	$458,775	($54,243)	$142,081	-0.1	0.3	($513,018)	($316,694)
CZ05-2	SCG	(110,815)	25,664	111.1	-10.2%	$458,775	($204,495)	$142,081	-0.4	0.3	($663,270)	($316,694)
CZ06	SCE	(94,469)	22,635	98.0	6.9%	$458,684	($21,345)	$169,117	0.0	0.4	($480,029)	($289,567)
CZ06-2	LA	(94,469)	22,635	98.0	6.9%	$458,684	$130,281	$169,117	0.3	0.4	($328,403)	($289,567)
CZ07	SDG&E	(90,737)	21,731	94.7	4.3%	$458,241	($672,119)	$147,694	-1.5	0.3	($1,130,360)	($310,547)
CZ08	SCE	(86,897)	22,071	97.0	12.4%	$457,188	($16,674)	$234,972	0.0	0.5	($473,862)	($222,217)
CZ08-2	LA	(86,897)	22,071	97.0	12.4%	$457,188	$131,704	$234,972	0.3	0.5	($325,484)	($222,217)
CZ09	SCE	(81,251)	22,465	100.3	13.6%	$454,991	($775)	$273,910	0.0	0.6	($455,766)	($181,081)
CZ09-2	LA	(81,251)	22,465	100.3	13.6%	$454,991	$148,185	$273,910	0.3	0.6	($306,806)	($181,081)
CZ10	SDG&E	(77,971)	22,793	102.2	17.5%	$453,838	($581,396)	$300,918	-1.3	0.7	($1,035,234)	($152,920)
CZ10-2	SCE	(77,971)	22,793	102.2	17.5%	$453,838	$7,124	$300,918	0.0	0.7	($446,714)	($152,920)
CZ11	PG&E	(88,872)	24,685	110.4	10.8%	$460,783	$23,343	$359,919	0.1	0.8	($437,441)	($100,864)
CZ12	PG&E	(97,060)	24,856	110.0	9.5%	$458,475	($2,593)	$296,102	0.0	0.6	($461,068)	($162,373)
CZ12-2	SMUD	(97,060)	24,856	110.0	9.5%	$458,475	$216,440	$296,102	0.5	0.6	($242,035)	($162,373)
CZ13	PG&E	(87,239)	24,284	108.5	11.4%	$460,799	$22,313	$292,973	0.0	0.6	($438,485)	($167,826)
CZ14	SDG&E	(78,108)	24,598	110.7	16.5%	$456,772	($605,090)	$314,281	-1.3	0.7	($1,061,863)	($142,492)
CZ14-2	SCE	(78,108)	24,598	110.7	16.5%	$456,772	$13,619	$314,281	0.0	0.7	($443,154)	($142,492)
CZ15	SCE	(38,556)	20,554	95.0	21.5%	$450,720	$25,170	$337,443	0.1	0.7	($425,550)	($113,277)
CZ16	PG&E	(112,673)	28,573	128.3	2.6%	$456,937	$12,901	$168,274	0.0	0.4	($444,036)	($288,663)
CZ16-2	LA	(112,673)	28,573	128.3	2.6%	$456,937	$175,901	$168,274	0.4	0.4	($281,036)	($288,663)

Figure 55. Cost Effectiveness for FSR: All-Electric Hybrid + Eff + KOF Cooking + PV + B

CZ	Utility	Annual Elec Savings (kWh)	Annual Gas Savings (therms)	Annual GHG Reductions (mtons)	Compliance Margin	Upfront Incremental Package Cost	Lifecycle Utility Cost Savings	Lifecycle $TDV Savings	B/C Ratio (On-bill)	B/C Ratio (TDV)	NPV (On-bill)	NPV (TDV)
CZ01	PG&E	(87,423)	23,866	108.7	10.1%	$443,203	($11,234)	$95,946	0.0	0.2	($454,437)	($347,257)
CZ02	PG&E	(61,438)	21,444	99.9	21.2%	$442,473	$36,890	$233,583	0.1	0.5	($405,583)	($208,890)
CZ03	PG&E	(63,098)	20,573	94.8	19.9%	$442,453	($1,058)	$149,844	0.0	0.3	($443,512)	($292,610)
CZ03-2	PCE	(63,098)	20,573	94.8	19.9%	$442,453	($13,433)	$149,844	0.0	0.3	($455,886)	($292,610)
CZ04	PG&E	(53,738)	19,778	92.2	24.0%	$441,440	$18,765	$261,573	0.0	0.6	($422,675)	($179,867)
CZ04-2	CPAU	(53,738)	19,778	92.2	24.0%	$441,440	$270,663	$261,573	0.6	0.6	($170,777)	($179,867)
CZ05	PG&E	(60,153)	21,086	97.5	18.7%	$443,334	$12,181	$174,920	0.0	0.4	($431,153)	($268,415)
CZ05-2	SCG	(60,153)	21,086	97.5	18.7%	$443,334	($128,011)	$174,920	-0.3	0.4	($571,346)	($268,415)
CZ06	SCE	(49,686)	18,358	84.8	25.5%	$443,337	($20,680)	$193,921	0.0	0.4	($464,017)	($249,416)
CZ06-2	LA	(49,686)	18,358	84.8	25.5%	$443,337	$96,039	$193,921	0.2	0.4	($347,298)	($249,416)
CZ07	SDG&E	(47,262)	17,519	81.5	24.3%	$442,131	($595,683)	$172,494	-1.3	0.4	($1,037,814)	($269,637)
CZ08	SCE	(44,216)	17,894	83.6	26.6%	$440,960	($19,482)	$257,840	0.0	0.6	($460,442)	($183,120)
CZ08-2	LA	(44,216)	17,894	83.6	26.6%	$440,960	$94,278	$257,840	0.2	0.6	($346,681)	($183,120)
CZ09	SCE	(38,444)	18,265	86.6	26.3%	$439,560	($5,658)	$290,269	0.0	0.7	($445,218)	($149,290)
CZ09-2	LA	(38,444)	18,265	86.6	26.3%	$439,560	$108,934	$290,269	0.2	0.7	($330,626)	($149,290)
CZ10	SDG&E	(35,010)	18,586	88.7	29.6%	$437,609	($520,564)	$310,499	-1.2	0.7	($958,174)	($127,111)
CZ10-2	SCE	(35,010)	18,586	88.7	29.6%	$437,609	$2,881	$310,499	0.0	0.7	($434,728)	($127,111)
CZ11	PG&E	(44,271)	20,287	95.8	22.9%	$444,537	$70,379	$347,447	0.2	0.8	($374,157)	($97,090)
CZ12	PG&E	(51,150)	20,422	95.6	23.7%	$442,153	$49,803	$301,783	0.1	0.7	($392,349)	($140,369)
CZ12-2	SMUD	(51,150)	20,422	95.6	23.7%	$442,153	$210,602	$301,783	0.5	0.7	($231,551)	($140,369)
CZ13	PG&E	(43,206)	19,946	94.1	23.7%	$444,599	$71,373	$298,783	0.2	0.7	($373,226)	($145,816)
CZ14	SDG&E	(33,875)	20,166	95.7	27.5%	$441,539	($549,211)	$340,114	-1.2	0.8	($990,751)	($101,425)
CZ14-2	SCE	(33,875)	20,166	95.7	27.5%	$441,539	$7,138	$340,114	0.0	0.8	($434,401)	($101,425)
CZ15	SCE	(3,412)	16,845	82.5	28.4%	$435,312	$12,948	$346,781	0.0	0.8	($422,364)	($88,531)
CZ16	PG&E	(72,797)	23,585	109.1	9.5%	$441,511	$36,082	$164,952	0.1	0.4	($405,428)	($276,559)
CZ16-2	LA	(72,797)	23,585	109.1	9.5%	$441,511	$121,463	$164,952	0.3	0.4	($320,048)	($276,559)

7.5.1.2 QSR

Results for the AE QSR are similar to the AE FSR. Due to the higher upfront costs of cooking equipment compared to a mixed-fuel baseline and compounded by the negative on-bill and TDV impacts, there are very limited cost-effective QSR AE measure packages.

Figure 56 shows the AE HVAC, SHW, and cooking package is not cost effective nor compliant in the majority of CZs. Electric cooking appliances contribute negative total TDV and utility cost savings, because they have load profiles coincident with peak utility rates and electricity TDV values. Additions to electric cooking to the efficiency package (Figure 57) improve compliance margins, but not cost effectiveness. Adding solar PV with Battery (Figure 58) does deliver narrowly cost-effective packages in CPAU and LADWP territories, as well as CZ11 in PG&E territory.

Figure 59 shows that the hybrid package—using AE appliances except for the baseline gas storage SHW system—reduces cost effectiveness slightly compared to the gas baseline. This is likely because a HPWH has improved efficiency, has a similar cost to the gas baseline, and is well suited for the smaller SHW loads in a QSR.

Figure 56. Cost Effectiveness for QSR: All-Electric + HE Cooking

CZ	Utility	Annual Elec Savings (kWh)	Annual Gas Savings (therms)	Annual GHG Reductions (mtons)	Compliance Margin	Upfront Incremental Package Cost	Lifecycle Utility Cost Savings	Lifecycle $TDV Savings	B/C Ratio (On-bill)	B/C Ratio (TDV)	NPV (On-bill)	NPV (TDV)
CZ01	PG&E	(154,265)	12,748	40.44	-16.8%	$26,155	($282,251)	($244,966)	-10.8	-9.4	($308,406)	($271,121)
CZ02	PG&E	(138,275)	11,377	35.67	-3.8%	$36,112	($254,008)	($207,937)	-7.0	-5.8	($290,120)	($244,048)
CZ03	PG&E	(132,470)	10,849	33.93	-7.4%	$32,681	($245,456)	($213,494)	-7.5	-6.5	($278,137)	($246,175)
CZ03-2	PCE	(132,470)	10,849	33.93	-7.4%	$32,681	($235,433)	($213,494)	-7.2	-6.5	($268,114)	($246,175)
CZ04	PG&E	(128,033)	10,542	33.10	-3.3%	$32,670	($236,035)	($191,535)	-7.2	-5.9	($268,706)	($224,206)
CZ04-2	CPAU	(128,033)	10,542	33.10	-3.3%	$32,670	($62,917)	($191,535)	-1.9	-5.9	($95,587)	($224,206)
CZ05	PG&E	(139,042)	11,134	33.91	-8.8%	$33,420	($263,124)	($226,021)	-7.9	-6.8	($296,544)	($259,441)
CZ05-2	SCG	(139,042)	11,134	33.91	-8.8%	$33,420	($317,553)	($226,021)	-9.5	-6.8	($350,973)	($259,441)
CZ06	SCE	(120,958)	9,965	30.95	-2.8%	$33,431	($115,302)	($179,993)	-3.4	-5.4	($148,733)	($213,424)
CZ06-2	LA	(120,958)	9,965	30.95	-2.8%	$33,431	$13,326	($179,993)	0.4	-5.4	($20,105)	($213,424)
CZ07	SDG&E	(115,852)	9,535	29.96	-2.7%	$33,378	($437,431)	($176,282)	-13.1	-5.3	($470,809)	($209,660)
CZ08	SCE	(117,826)	9,741	30.48	-0.7%	$36,918	($97,520)	($159,488)	-2.6	-4.3	($134,438)	($196,406)
CZ08-2	LA	(117,826)	9,741	30.48	-0.7%	$36,918	$9,397	($159,488)	0.3	-4.3	($27,521)	($196,406)
CZ09	SCE	(119,266)	9,893	31.17	1.3%	$30,145	($97,384)	($162,234)	-3.2	-5.4	($127,530)	($192,379)
CZ09-2	LA	(119,266)	9,893	31.17	1.3%	$30,145	$9,522	($162,234)	0.3	-5.4	($20,624)	($192,379)
CZ10	SDG&E	(120,834)	10,059	31.66	1.2%	$29,329	($420,413)	($168,278)	-14.3	-5.7	($449,741)	($197,607)
CZ10-2	SCE	(120,834)	10,059	31.66	1.2%	$29,329	($99,796)	($168,278)	-3.4	-5.7	($129,124)	($197,607)
CZ11	PG&E	(131,828)	10,940	34.38	-2.9%	$36,914	($228,801)	($181,323)	-6.2	-4.9	($265,716)	($218,238)
CZ12	PG&E	(132,045)	10,930	34.28	-2.7%	$36,899	($232,235)	($185,092)	-6.3	-5.0	($269,134)	($221,990)
CZ12-2	SMUD	(132,045)	10,930	34.28	-2.7%	$36,899	($44,251)	($185,092)	-1.2	-5.0	($81,150)	($221,990)
CZ13	PG&E	(129,405)	10,757	33.82	-0.2%	$30,808	($223,912)	($190,461)	-7.3	-6.2	($254,720)	($221,269)
CZ14	SDG&E	(131,110)	10,903	34.05	2.2%	$30,908	($429,199)	($167,130)	-13.9	-5.4	($460,107)	($198,038)
CZ14-2	SCE	(131,110)	10,903	34.05	2.2%	$30,908	($103,941)	($167,130)	-3.4	-5.4	($134,849)	($198,038)
CZ15	SCE	(107,160)	9,291	30.16	3.6%	$29,411	($90,145)	($144,816)	-3.1	-4.9	($119,557)	($174,227)
CZ16	PG&E	(151,772)	12,616	40.34	-17.0%	$32,688	($248,377)	($247,149)	-7.6	-7.6	($281,066)	($279,837)
CZ16-2	LA	(151,772)	12,616	40.34	-17.0%	$32,688	$15,368	($247,149)	0.5	-7.6	($17,321)	($279,837)

Figure 57. Cost Effectiveness for QSR: All-Electric + Eff + HE Cooking

CZ	Utility	Annual Elec Savings (kWh)	Annual Gas Savings (therms)	Annual GHG Reductions (mtons)	Compliance Margin	Upfront Incremental Package Cost	Lifecycle Utility Cost Savings	Lifecycle $TDV Savings	B/C Ratio (On-bill)	B/C Ratio (TDV)	NPV (On-bill)	NPV (TDV)
CZ01	PG&E	(124,885)	12,748	46.07	14.9%	$38,734	($183,777)	($170,267)	-4.7	-4.4	($222,510)	($209,000)
CZ02	PG&E	(119,881)	11,377	39.16	13.8%	$46,148	($191,867)	($158,493)	-4.2	-3.4	($238,016)	($204,641)
CZ03	PG&E	(109,485)	10,849	38.29	22.0%	$45,260	($168,361)	($155,579)	-3.7	-3.4	($213,621)	($200,839)
CZ03-2	PCE	(109,485)	10,849	38.29	22.0%	$45,260	($159,999)	($155,579)	-3.5	-3.4	($205,259)	($200,839)
CZ04	PG&E	(105,434)	10,542	37.37	23.5%	$45,313	($160,344)	($134,758)	-3.5	-3.0	($205,657)	($180,071)
CZ04-2	CPAU	(105,434)	10,542	37.37	23.5%	$45,313	($10,249)	($134,758)	-0.2	-3.0	($55,562)	($180,071)
CZ05	PG&E	(111,949)	11,134	39.13	26.4%	$46,063	($172,028)	($155,920)	-3.7	-3.4	($218,091)	($201,983)
CZ05-2	SCG	(111,949)	11,134	39.13	26.4%	$46,063	($226,457)	($155,920)	-4.9	-3.4	($272,520)	($201,983)
CZ06	SCE	(99,192)	9,965	35.08	26.9%	$46,074	($84,031)	($125,013)	-1.8	-2.7	($130,105)	($171,087)
CZ06-2	LA	(99,192)	9,965	35.08	26.9%	$46,074	$32,417	($125,013)	0.7	-2.7	($13,656)	($171,087)
CZ07	SDG&E	(92,941)	9,535	34.24	31.9%	$46,021	($384,333)	($119,238)	-8.4	-2.6	($430,354)	($165,259)
CZ08	SCE	(103,720)	9,741	33.20	17.7%	$46,955	($74,367)	($122,155)	-1.6	-2.6	($121,321)	($169,109)
CZ08-2	LA	(103,720)	9,741	33.20	17.7%	$46,955	$25,644	($122,155)	0.5	-2.6	($21,311)	($169,109)
CZ09	SCE	(104,055)	9,893	34.06	17.7%	$40,182	($73,115)	($123,015)	-1.8	-3.1	($113,296)	($163,196)
CZ09-2	LA	(104,055)	9,893	34.06	17.7%	$40,182	$26,619	($123,015)	0.7	-3.1	($13,563)	($163,196)
CZ10	SDG&E	(106,784)	10,059	34.36	14.3%	$39,365	($376,815)	($132,244)	-9.6	-3.4	($416,180)	($171,609)
CZ10-2	SCE	(106,784)	10,059	34.36	14.3%	$39,365	($77,422)	($132,244)	-2.0	-3.4	($116,787)	($171,609)
CZ11	PG&E	(112,209)	10,940	38.11	16.9%	$46,951	($170,129)	($122,073)	-3.6	-2.6	($217,080)	($169,024)
CZ12	PG&E	(114,713)	10,930	37.62	13.3%	$46,935	($182,035)	($138,002)	-3.9	-2.9	($228,970)	($184,937)
CZ12-2	SMUD	(114,713)	10,930	37.62	13.3%	$46,935	($14,336)	($138,002)	-0.3	-2.9	($61,271)	($184,937)
CZ13	PG&E	(110,569)	10,757	37.40	16.7%	$40,844	($168,494)	($138,788)	-4.1	-3.4	($209,338)	($179,632)
CZ14	SDG&E	(113,770)	10,903	37.37	16.0%	$40,944	($376,256)	($121,979)	-9.2	-3.0	($417,200)	($162,923)
CZ14-2	SCE	(113,770)	10,903	37.37	16.0%	$40,944	($76,213)	($121,979)	-1.9	-3.0	($117,157)	($162,923)
CZ15	SCE	(92,859)	9,291	32.78	13.3%	$39,448	($66,525)	($106,292)	-1.7	-2.7	($105,973)	($145,739)
CZ16	PG&E	(127,418)	12,616	44.81	4.6%	$45,331	($190,284)	($184,224)	-4.2	-4.1	($235,615)	($229,555)
CZ16-2	LA	(127,418)	12,616	44.81	4.6%	$45,331	$37,353	($184,224)	0.8	-4.1	($7,978)	($229,555)

Figure 58. Cost Effectiveness for QSR: All-Electric + Eff + HE Cooking + PV + B

CZ	Utility	Annual Elec Savings (kWh)	Annual Gas Savings (therms)	Annual GHG Reductions (mtons)	Compliance Margin	Upfront Incremental Package Cost	Lifecycle Utility Cost Savings	Lifecycle $TDV Savings	B/C Ratio (On-bill)	B/C Ratio (TDV)	NPV (On-bill)	NPV (TDV)
CZ01	PG&E	(100,655)	12,748	47.98	14.9%	$202,810	($107,401)	($64,877)	-0.5	-0.3	($310,211)	($267,688)
CZ02	PG&E	(90,953)	11,377	41.63	13.8%	$210,225	($98,425)	($14,214)	-0.5	-0.1	($308,650)	($224,439)
CZ03	PG&E	(80,544)	10,849	40.77	22.0%	$209,336	($74,363)	($17,861)	-0.4	-0.1	($283,699)	($227,198)
CZ03-2	PCE	(80,544)	10,849	40.77	22.0%	$209,336	($68,001)	($17,861)	-0.3	-0.1	($277,338)	($227,198)
CZ04	PG&E	(75,494)	10,542	40.09	23.5%	$209,390	($60,653)	$25,125	-0.3	0.1	($270,043)	($184,265)
CZ04-2	CPAU	(75,494)	10,542	40.09	23.5%	$209,390	$55,979	$25,125	0.3	0.1	($153,411)	($184,265)
CZ05	PG&E	(80,690)	11,134	41.76	26.4%	$210,139	($71,407)	($13,392)	-0.3	-0.1	($281,547)	($223,531)
CZ05-2	SCG	(80,690)	11,134	41.76	26.4%	$210,139	($125,836)	($13,392)	-0.6	-0.1	($335,976)	($223,531)
CZ06	SCE	(69,738)	9,965	37.55	26.9%	$210,150	($53,646)	$2,114	-0.3	0.0	($263,797)	($208,036)
CZ06-2	LA	(69,738)	9,965	37.55	26.9%	$210,150	$53,803	$2,114	0.3	0.0	($156,348)	($208,036)
CZ07	SDG&E	(62,194)	9,535	36.85	31.9%	$210,098	($344,334)	$7,932	-1.6	0.0	($554,431)	($202,166)
CZ08	SCE	(74,018)	9,741	35.89	17.7%	$211,031	($43,475)	$11,046	-0.2	0.1	($254,506)	($199,985)
CZ08-2	LA	(74,018)	9,741	35.89	17.7%	$211,031	$46,918	$11,046	0.2	0.1	($164,113)	($199,985)
CZ09	SCE	(73,421)	9,893	36.88	17.7%	$204,258	($41,252)	$17,232	-0.2	0.1	($245,511)	($187,026)
CZ09-2	LA	(73,421)	9,893	36.88	17.7%	$204,258	$48,498	$17,232	0.2	0.1	($155,760)	($187,026)
CZ10	SDG&E	(76,116)	10,059	37.17	14.3%	$203,442	($336,511)	$14,687	-1.7	0.1	($539,953)	($188,755)
CZ10-2	SCE	(76,116)	10,059	37.17	14.3%	$203,442	($45,667)	$14,687	-0.2	0.1	($249,109)	($188,755)
CZ11	PG&E	(82,625)	10,940	40.69	16.9%	$211,028	($101,008)	$49,715	-0.5	0.2	($312,035)	($161,312)
CZ12	PG&E	(85,578)	10,930	40.14	13.3%	$211,012	($85,340)	$18,455	-0.4	0.1	($296,352)	($192,557)
CZ12-2	SMUD	(85,578)	10,930	40.14	13.3%	$211,012	$29,085	$18,455	0.1	0.1	($181,927)	($192,557)
CZ13	PG&E	(81,654)	10,757	39.95	16.7%	$204,921	($100,534)	$15,719	-0.5	0.1	($305,454)	($189,202)
CZ14	SDG&E	(79,987)	10,903	40.06	16.0%	$205,021	($331,139)	$20,271	-1.6	0.1	($536,160)	($184,750)
CZ14-2	SCE	(79,987)	10,903	40.06	16.0%	$205,021	($41,990)	$20,271	-0.2	0.1	($247,011)	($184,750)
CZ15	SCE	(61,148)	9,291	35.27	13.3%	$203,524	($34,785)	$27,887	-0.2	0.1	($238,309)	($175,637)
CZ16	PG&E	(95,839)	12,616	47.34	4.6%	$209,407	($89,297)	($57,418)	-0.4	-0.3	($298,705)	($266,826)
CZ16-2	LA	(95,839)	12,616	47.34	4.6%	$209,407	$59,956	($57,418)	0.3	-0.3	($149,452)	($266,826)

Figure 59. Cost Effectiveness for QSR: All-Electric Hybrid + Eff + HE Cooking + PV + B

CZ	Utility	Annual Elec Savings (kWh)	Annual Gas Savings (therms)	Annual GHG Reductions (mtons)	Compliance Margin	Upfront Incremental Package Cost	Lifecycle Utility Cost Savings	Lifecycle $TDV Savings	B/C Ratio (On-bill)	B/C Ratio (TDV)	NPV (On-bill)	NPV (TDV)
CZ01	PG&E	(89,496)	11,293	42.36	20.5%	$64,657	($96,820)	($55,907)	-1.5	-0.9	($161,477)	($120,564)
CZ02	PG&E	(81,020)	9,994	36.16	16.4%	$72,072	($91,016)	($9,996)	-1.3	-0.1	($163,088)	($82,068)
CZ03	PG&E	(70,456)	9,475	35.44	26.5%	$71,183	($66,113)	($11,547)	-0.9	-0.2	($137,296)	($82,731)
CZ03-2	PCE	(70,456)	9,475	35.44	26.5%	$71,183	($60,542)	($11,547)	-0.9	-0.2	($131,725)	($82,731)
CZ04	PG&E	(65,848)	9,192	34.78	26.1%	$71,237	($53,641)	$29,213	-0.8	0.4	($124,878)	($42,023)
CZ04-2	CPAU	(65,848)	9,192	34.78	26.1%	$71,237	$30,726	$29,213	0.4	0.4	($40,510)	($42,023)
CZ05	PG&E	(70,404)	9,746	36.38	30.9%	$71,986	($62,667)	($6,575)	-0.9	-0.1	($134,653)	($78,562)
CZ05-2	SCG	(70,404)	9,746	36.38	30.9%	$71,986	($104,112)	($6,575)	-1.4	-0.1	($176,099)	($78,562)
CZ06	SCE	(60,614)	8,663	32.40	29.3%	$71,997	($52,797)	$5,617	-0.7	0.1	($124,795)	($66,381)
CZ06-2	LA	(60,614)	8,663	32.40	29.3%	$71,997	$45,610	$5,617	0.6	0.1	($26,388)	($66,381)
CZ07	SDG&E	(53,274)	8,252	31.76	34.5%	$71,945	($337,760)	$11,444	-4.7	0.2	($409,705)	($60,501)
CZ08	SCE	(65,353)	8,467	30.79	19.2%	$72,878	($42,475)	$13,094	-0.6	0.2	($115,353)	($59,785)
CZ08-2	LA	(65,353)	8,467	30.79	19.2%	$72,878	$40,513	$13,094	0.6	0.2	($32,366)	($59,785)
CZ09	SCE	(64,673)	8,613	31.75	19.1%	$66,105	($40,802)	$19,370	-0.6	0.3	($106,907)	($46,735)
CZ09-2	LA	(64,673)	8,613	31.75	19.1%	$66,105	$40,087	$19,370	0.6	0.3	($26,018)	($46,735)
CZ10	SDG&E	(67,129)	8,776	32.07	15.9%	$65,289	($328,618)	$17,509	-5.0	0.3	($393,907)	($47,780)
CZ10-2	SCE	(67,129)	8,776	32.07	15.9%	$65,289	($44,017)	$17,509	-0.7	0.3	($109,305)	($47,780)
CZ11	PG&E	(73,742)	9,603	35.25	17.0%	$72,875	($69,732)	$50,019	-1.0	0.7	($142,607)	($22,855)
CZ12	PG&E	(76,159)	9,583	34.75	15.2%	$72,859	($79,219)	$21,817	-1.1	0.3	($152,078)	($51,042)
CZ12-2	SMUD	(76,159)	9,583	34.75	15.2%	$72,859	$18,785	$21,817	0.3	0.3	($54,073)	($51,042)
CZ13	PG&E	(72,827)	9,437	34.60	17.7%	$66,768	($100,918)	$17,645	-1.5	0.3	($167,686)	($49,123)
CZ14	SDG&E	(71,083)	9,556	34.53	16.2%	$66,868	($327,890)	$20,508	-4.9	0.3	($394,759)	($46,360)
CZ14-2	SCE	(71,083)	9,556	34.53	16.2%	$66,868	($41,728)	$20,508	-0.6	0.3	($108,596)	($46,360)
CZ15	SCE	(53,953)	8,152	30.55	13.3%	$65,371	($36,429)	$28,027	-0.6	0.4	($101,801)	($37,344)
CZ16	PG&E	(87,481)	11,110	40.76	3.3%	$71,255	($89,044)	($60,056)	-1.2	-0.8	($160,298)	($131,310)
CZ16-2	LA	(87,481)	11,110	40.76	3.3%	$71,255	$50,044	($60,056)	0.7	-0.8	($21,210)	($131,310)

7.5.2 2022 TDV Results

The Figure 60 through Figure 63 show cost-effectiveness results using 2022 TDV and 2022 weather files, calculated using 15-year non-residential TDV, to determine if the new metric would result in cost-effective outcomes.[13] Note that Figure 16, the FSR AE HVAC with HPWH and efficiency measures is TDV cost effective across all CZs and has been included in Section 4.1.2. However, the packages including electric cooking measures are not cost effective, as shown in Figure 60 and Figure 61. These results largely match those analyzed with 2019 TDV.

Similarly, the QSR AE HVAC with HPWH and efficiency measures shows TDV cost effectiveness for most CZs except CZ 16. Note that Figure 22, the QSR AE HVAC with HPWH and efficiency measures is TDV cost effective across all CZs and has been included in Section 4.2.2. Figure 62 and Figure 63 show that including electric cooking measures are not cost effective in the majority of scenarios, except narrowly in CPAU or LADWP territory that include solar PV and battery storage. These results largely match those analyzed with 2019 TDV.

[13] TDV multipliers can be found in the "2022 TDV CH4 20yr 15RA" workbook. https://www.energy.ca.gov/event/workshop/2020-03/staff-workshop-2022-energy-code-compliance-metrics

7.5.2.1 FSR

Figure 60. Cost Effectiveness for FSR: All-Electric + Eff + KOF Cooking + PV + B, 2022 TDV

CZ	Utility	Elec Savings (kWh)	Gas Savings (therms)	GHG Reductions (mtons)	Compliance Margin	Incremental Package Cost	Lifecycle Utility Cost Savings	$TDV Savings	B/C Ratio (On-bill)	B/C Ratio (TDV)	NPV (On-bill)	NPV (TDV)
CZ01	PG&E	(144,388)	28,494	130.2	<0	$458,582	($50,645)	$162,912	-0.1	0.4	($509,228)	($295,671)
CZ02	PG&E	(113,290)	25,601	119.6	>0	$462,727	($3,017)	$363,929	0.0	0.8	($465,745)	($98,798)
CZ03	PG&E	(111,923)	24,491	114.4	>0	$462,408	($30,546)	$279,401	-0.1	0.6	($492,954)	($183,008)
CZ03-2	PCE	(111,923)	24,491	114.4	>0	$462,408	($44,615)	$279,401	-0.1	0.6	($507,023)	($183,008)
CZ04	PG&E	(96,877)	23,514	111.3	>0	$461,409	$6,529	$333,228	0.0	0.7	($454,880)	($128,181)
CZ04-2	CPAU	(96,877)	23,514	111.3	>0	$461,409	$265,855	$333,228	0.6	0.7	($195,555)	($128,181)
CZ05	PG&E	(106,720)	24,595	116.0	>0	$458,775	($17,051)	$220,613	0.0	0.5	($475,826)	($238,162)
CZ05-2	SCG	(106,720)	24,595	116.0	>0	$458,775	($160,743)	$220,613	-0.4	0.5	($619,518)	($238,162)
CZ06	SCE	(84,839)	21,746	104.9	>0	$458,684	$7,301	$282,594	0.0	0.6	($451,383)	($176,090)
CZ06-2	LA	(84,839)	21,746	104.9	>0	$458,684	$124,186	$282,594	0.3	0.6	($334,498)	($176,090)
CZ07	SDG&E	(88,561)	21,328	100.5	>0	$458,241	($688,128)	$126,776	-1.5	0.3	($1,146,369)	($331,465)
CZ08	SCE	(79,653)	21,531	102.6	>0	$457,188	($13,524)	$273,421	0.0	0.6	($470,712)	($183,767)
CZ08-2	LA	(79,653)	21,531	102.6	>0	$457,188	$113,657	$273,421	0.2	0.6	($343,531)	($183,767)
CZ09	SCE	(75,509)	21,913	105.6	>0	$454,991	($3,190)	$297,906	0.0	0.7	($458,181)	($157,085)
CZ09-2	LA	(75,509)	21,913	105.6	>0	$454,991	$127,843	$297,906	0.3	0.7	($327,148)	($157,085)
CZ10	SDG&E	(72,361)	22,359	108.1	>0	$453,838	($600,702)	$281,048	-1.3	0.6	($1,054,540)	($172,789)
CZ10-2	SCE	(72,361)	22,359	108.1	>0	$453,838	$9,401	$281,048	0.0	0.6	($444,437)	($172,789)
CZ11	PG&E	(91,618)	24,235	114.3	>0	$460,783	($9,851)	$249,117	0.0	0.5	($470,634)	($211,666)
CZ12	PG&E	(97,106)	24,362	114.1	>0	$458,475	($31,519)	$231,080	-0.1	0.5	($489,994)	($227,395)
CZ12-2	SMUD	(97,106)	24,362	114.1	>0	$458,475	$196,776	$231,080	0.4	0.5	($261,699)	($227,395)
CZ13	PG&E	(83,010)	23,544	112.4	>0	$460,799	$2,722	$249,536	0.0	0.5	($458,077)	($211,263)
CZ14	SDG&E	(77,187)	24,006	116.8	>0	$456,772	($632,042)	$327,711	-1.4	0.7	($1,088,814)	($129,061)
CZ14-2	SCE	(77,187)	24,006	116.8	>0	$456,772	$10,897	$327,711	0.0	0.7	($445,875)	($129,061)
CZ15	SCE	(36,927)	20,250	102.6	>0	$450,720	$29,604	$314,575	0.1	0.7	($421,115)	($136,145)
CZ16	PG&E	(116,104)	27,897	132.6	>0	$456,937	($27,933)	$199,948	-0.1	0.4	($484,870)	($256,989)
CZ16-2	LA	(116,104)	27,897	132.6	>0	$456,937	$155,685	$199,948	0.3	0.4	($301,252)	($256,989)

Figure 61. Cost Effectiveness for FSR: All-Electric Hybrid + Eff + KOF Cooking + PV + B, 2022 TDV

CZ	Utility	Elec Savings (kWh)	Gas Savings (therms)	GHG Reductions (mtons)	Compliance Margin	Incremental Package Cost	Lifecycle Utility Cost Savings	$TDV Savings	B/C Ratio (On-bill)	B/C Ratio (TDV)	NPV (On-bill)	NPV (TDV)
CZ01	PG&E	(88,396)	23,682	114.3	>0	$443,203	$23,348	$211,406	0.1	0.5	($419,855)	($231,797)
CZ02	PG&E	(63,053)	21,043	103.3	>0	$442,473	$47,146	$371,125	0.1	0.8	($395,327)	($71,348)
CZ03	PG&E	(61,250)	19,964	98.3	>0	$442,453	$22,368	$283,878	0.1	0.6	($420,085)	($158,575)
CZ03-2	PCE	(61,250)	19,964	98.3	>0	$442,453	$10,131	$283,878	0.0	0.6	($432,322)	($158,575)
CZ04	PG&E	(49,348)	19,068	94.7	>0	$441,440	$49,346	$348,731	0.1	0.8	($392,094)	($92,709)
CZ04-2	CPAU	(49,348)	19,068	94.7	>0	$441,440	$265,475	$348,731	0.6	0.8	($175,965)	($92,709)
CZ05	PG&E	(55,525)	20,018	99.5	>0	$443,334	$36,702	$236,724	0.1	0.5	($406,633)	($206,611)
CZ05-2	SCG	(55,525)	20,018	99.5	>0	$443,334	($96,930)	$236,724	-0.2	0.5	($540,265)	($206,611)
CZ06	SCE	(39,471)	17,468	88.5	>0	$443,337	($1,586)	$290,161	0.0	0.7	($444,923)	($153,176)
CZ06-2	LA	(39,471)	17,468	88.5	>0	$443,337	$89,778	$290,161	0.2	0.7	($353,559)	($153,176)
CZ07	SDG&E	(44,881)	17,116	85.6	>0	$442,131	($618,940)	$152,200	-1.4	0.3	($1,061,071)	($289,931)
CZ08	SCE	(36,981)	17,354	87.5	>0	$440,960	($18,592)	$301,452	0.0	0.7	($459,552)	($139,508)
CZ08-2	LA	(36,981)	17,354	87.5	>0	$440,960	$78,076	$301,452	0.2	0.7	($362,884)	($139,508)
CZ09	SCE	(31,708)	17,714	90.1	>0	$439,560	($6,461)	$323,063	0.0	0.7	($446,021)	($116,496)
CZ09-2	LA	(31,708)	17,714	90.1	>0	$439,560	$92,353	$323,063	0.2	0.7	($347,207)	($116,496)
CZ10	SDG&E	(29,041)	18,152	92.6	>0	$437,609	($540,420)	$304,840	-1.2	0.7	($978,029)	($132,769)
CZ10-2	SCE	(29,041)	18,152	92.6	>0	$437,609	$3,094	$304,840	0.0	0.7	($434,515)	($132,769)
CZ11	PG&E	(46,295)	19,836	98.2	>0	$444,537	$40,140	$272,379	0.1	0.6	($404,397)	($172,158)
CZ12	PG&E	(50,070)	19,927	97.9	>0	$442,153	$21,137	$257,540	0.0	0.6	($421,016)	($184,613)
CZ12-2	SMUD	(50,070)	19,927	97.9	>0	$442,153	$194,144	$257,540	0.4	0.6	($248,009)	($184,613)
CZ13	PG&E	(38,865)	19,206	96.3	>0	$444,599	$50,280	$271,274	0.1	0.6	($394,319)	($173,326)
CZ14	SDG&E	(31,339)	19,575	99.3	>0	$441,539	($565,713)	$348,379	-1.3	0.8	($1,007,252)	($93,160)
CZ14-2	SCE	(31,339)	19,575	99.3	>0	$441,539	$4,940	$348,379	0.0	0.8	($436,599)	($93,160)
CZ15	SCE	(383)	16,541	88.6	>0	$435,312	$18,078	$327,174	0.0	0.8	($417,234)	($108,138)
CZ16	PG&E	(72,759)	22,909	111.5	>0	$441,511	$1,901	$185,982	0.0	0.4	($439,610)	($255,529)
CZ16-2	LA	(72,759)	22,909	111.5	>0	$441,511	$109,937	$185,982	0.2	0.4	($331,573)	($255,529)

7.5.2.2 QSR

Figure 62. Cost Effectiveness for QSR: All-Electric + Eff + HE Cooking + PV + B, 2022 TDV

CZ	Utility	Elec Savings (kWh)	Gas Savings (therms)	GHG Reductions (mtons)	Compliance Margin	Incremental Package Cost	Lifecycle Utility Cost Savings	$TDV Savings	B/C Ratio (On-bill)	B/C Ratio (TDV)	NPV (On-bill)	NPV (TDV)
CZ01	PG&E	(99,735)	12,626	47.96	>0	$202,810	($106,390)	($4,736)	-0.5	0.0	($309,201)	($207,546)
CZ02	PG&E	(90,139)	11,205	40.30	>0	$210,225	($101,236)	$38,849	-0.5	0.2	($311,461)	($171,376)
CZ03	PG&E	(77,979)	10,612	40.69	>0	$209,336	($69,325)	$37,580	-0.3	0.2	($278,662)	($171,757)
CZ03-2	PCE	(77,979)	10,612	40.69	>0	$209,336	($63,230)	$37,580	-0.3	0.2	($272,567)	($171,757)
CZ04	PG&E	(72,295)	10,295	38.84	>0	$209,390	($58,895)	$48,226	-0.3	0.2	($268,285)	($161,164)
CZ04-2	CPAU	(72,295)	10,295	38.84	>0	$209,390	$58,536	$48,226	0.3	0.2	($150,854)	($161,164)
CZ05	PG&E	(75,929)	10,676	39.92	>0	$210,139	($65,548)	($2,227)	-0.3	0.0	($275,688)	($212,367)
CZ05-2	SCG	(75,929)	10,676	39.92	>0	$210,139	($117,120)	($2,227)	-0.6	0.0	($327,259)	($212,367)
CZ06	SCE	(62,958)	9,603	36.99	>0	$210,150	($30,946)	$29,149	-0.1	0.1	($241,097)	($181,001)
CZ06-2	LA	(62,958)	9,603	36.99	>0	$210,150	$55,667	$29,149	0.3	0.1	($154,483)	($181,001)
CZ07	SDG&E	(63,720)	9,441	41.11	>0	$210,098	($360,924)	$880	-1.7	0.0	($571,021)	($209,218)
CZ08	SCE	(71,879)	9,567	40.16	>0	$211,031	($37,987)	$23,241	-0.2	0.1	($249,018)	($187,790)
CZ08-2	LA	(71,879)	9,567	40.16	>0	$211,031	$38,836	$23,241	0.2	0.1	($172,196)	($187,790)
CZ09	SCE	(71,849)	9,698	41.00	>0	$204,258	($37,235)	$27,745	-0.2	0.1	($241,493)	($176,514)
CZ09-2	LA	(71,849)	9,698	41.00	>0	$204,258	$39,553	$27,745	0.2	0.1	($164,705)	($176,514)
CZ10	SDG&E	(75,319)	9,927	41.41	>0	$203,442	($339,770)	$12,314	-1.7	0.1	($543,212)	($191,128)
CZ10-2	SCE	(75,319)	9,927	41.41	>0	$203,442	($40,361)	$12,314	-0.2	0.1	($243,802)	($191,128)
CZ11	PG&E	(82,459)	10,752	43.99	>0	$211,028	($106,940)	$10,513	-0.5	0.0	($317,967)	($200,515)
CZ12	PG&E	(84,621)	10,745	43.62	>0	$211,012	($86,585)	($7,400)	-0.4	0.0	($297,597)	($218,412)
CZ12-2	SMUD	(84,621)	10,745	43.62	>0	$211,012	$23,635	($7,400)	0.1	0.0	($187,377)	($218,412)
CZ13	PG&E	(78,820)	10,457	43.32	>0	$204,921	($102,116)	$3,724	-0.5	0.0	($307,037)	($201,197)
CZ14	SDG&E	(78,828)	10,660	44.55	>0	$205,021	($335,962)	$29,143	-1.6	0.1	($540,983)	($175,878)
CZ14-2	SCE	(78,828)	10,660	44.55	>0	$205,021	($36,595)	$29,143	-0.2	0.1	($241,616)	($175,878)
CZ15	SCE	(61,570)	9,198	40.12	>0	$203,524	($28,136)	$30,623	-0.1	0.2	($231,660)	($172,902)
CZ16	PG&E	(95,629)	12,266	50.81	>0	$209,407	($93,413)	($39,751)	-0.4	-0.2	($302,820)	($249,159)
CZ16-2	LA	(95,629)	12,266	50.81	>0	$209,407	$47,414	($39,751)	0.2	-0.2	($161,993)	($249,159)

Figure 63. Cost Effectiveness for QSR: All-Electric Hybrid + Eff + HE Cooking + PV + B, 2022 TDV

CZ	Utility	Elec Savings (kWh)	Gas Savings (therms)	GHG Reductions (mtons)	Compliance Margin	Incremental Package Cost	Lifecycle Utility Cost Savings	$TDV Savings	B/C Ratio (On-bill)	B/C Ratio (TDV)	NPV (On-bill)	NPV (TDV)
CZ01	PG&E	(88,459)	11,170	42.38	>0	$228,734	($95,400)	($2,845)	-0.4	0.0	($324,134)	($231,579)
CZ02	PG&E	(79,997)	9,822	34.87	>0	$236,149	($93,082)	$35,947	-0.4	0.2	($329,230)	($200,202)
CZ03	PG&E	(67,931)	9,238	35.36	>0	$235,260	($61,186)	$35,946	-0.3	0.2	($296,446)	($199,314)
CZ03-2	PCE	(67,931)	9,238	35.36	>0	$235,260	($55,880)	$35,946	-0.2	0.2	($291,140)	($199,314)
CZ04	PG&E	(62,924)	8,945	33.47	>0	$235,313	($52,840)	$46,009	-0.2	0.2	($288,153)	($189,304)
CZ04-2	CPAU	(62,924)	8,945	33.47	>0	$235,313	$32,715	$46,009	0.1	0.2	($202,599)	($189,304)
CZ05	PG&E	(65,675)	9,288	34.55	>0	$236,063	($56,919)	($2,229)	-0.2	0.0	($292,982)	($238,293)
CZ05-2	SCG	(65,675)	9,288	34.55	>0	$236,063	($95,507)	($2,229)	-0.4	0.0	($331,570)	($238,293)
CZ06	SCE	(53,767)	8,300	31.86	>0	$236,074	($29,001)	$25,874	-0.1	0.1	($265,075)	($210,200)
CZ06-2	LA	(53,767)	8,300	31.86	>0	$236,074	$50,315	$25,874	0.2	0.1	($185,759)	($210,200)
CZ07	SDG&E	(54,967)	8,158	35.96	>0	$236,021	($355,393)	($2,569)	-1.5	0.0	($591,415)	($238,591)
CZ08	SCE	(63,278)	8,293	35.04	>0	$236,955	($38,039)	$18,099	-0.2	0.1	($274,994)	($218,856)
CZ08-2	LA	(63,278)	8,293	35.04	>0	$236,955	$31,767	$18,099	0.1	0.1	($205,188)	($218,856)
CZ09	SCE	(63,147)	8,417	35.87	>0	$230,182	($36,875)	$23,033	-0.2	0.1	($267,057)	($207,150)
CZ09-2	LA	(63,147)	8,417	35.87	>0	$230,182	$32,598	$23,033	0.1	0.1	($197,584)	($207,150)
CZ10	SDG&E	(66,530)	8,645	36.29	>0	$229,365	($336,827)	$8,373	-1.5	0.0	($566,192)	($220,993)
CZ10-2	SCE	(66,530)	8,645	36.29	>0	$229,365	($40,186)	$8,373	-0.2	0.0	($269,551)	($220,993)
CZ11	PG&E	(73,153)	9,415	38.61	>0	$236,951	($105,411)	$5,479	-0.4	0.0	($342,362)	($231,472)
CZ12	PG&E	(75,267)	9,398	38.24	>0	$236,936	($80,713)	($11,266)	-0.3	0.0	($317,649)	($248,202)
CZ12-2	SMUD	(75,267)	9,398	38.24	>0	$236,936	$12,925	($11,266)	0.1	0.0	($224,011)	($248,202)
CZ13	PG&E	(69,940)	9,137	37.95	>0	$230,844	($101,063)	$135	-0.4	0.0	($331,908)	($230,709)
CZ14	SDG&E	(69,831)	9,314	39.01	>0	$230,945	($334,448)	$19,299	-1.4	0.1	($565,393)	($211,646)
CZ14-2	SCE	(69,831)	9,314	39.01	>0	$230,945	($36,803)	$19,299	-0.2	0.1	($267,748)	($211,646)
CZ15	SCE	(54,086)	8,058	35.47	>0	$229,448	($29,308)	$20,209	-0.1	0.1	($258,756)	($209,239)
CZ16	PG&E	(86,884)	10,760	44.26	>0	$235,331	($92,095)	($52,388)	-0.4	-0.2	($327,426)	($287,719)
CZ16-2	LA	(86,884)	10,760	44.26	>0	$235,331	$37,208	($52,388)	0.2	-0.2	($198,124)	($287,719)