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A STATEWIDE UTILITY PROGRAM

Title 24, Parts 6 and 11
Local Energy Efficiency Ordinances

2019 Nonresidential New Construction Reach Code Cost Effectiveness Study

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1 Introduction

The California Building Energy Efficiency Standards Title 24, Part 6 (Title 24) (CEC, 2019) is maintained and updated every three years by two state agencies: the California Energy Commission (the Energy Commission) and the Building Standards Commission (BSC). In addition to enforcing the code, local jurisdictions have the authority to adopt local energy efficiency ordinances—or reach codes—that exceed the minimum standards defined by Title 24 (as established by Public Resources Code Section 25402.1(h)2 and Section 10-106 of the Building Energy Efficiency Standards). Local jurisdictions must demonstrate that the requirements of the proposed ordinance are cost-effective and do not result in buildings consuming more energy than is permitted by Title 24. In addition, the jurisdiction must obtain approval from the Energy Commission and file the ordinance with the BSC for the ordinance to be legally enforceable. This report 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.

This report documents cost-effective combinations of measures that exceed the minimum state requirements for design in newly-constructed nonresidential buildings. Buildings specifically examined include medium office, medium retail, and small hotels. Measures include energy efficiency, solar photovoltaics (PV), and battery storage. In addition, the report includes a comparison between a baseline mixed-fuel design and all-electric design for each occupancy type.

The Reach Code team analyzed the following seven packages as compared to 2019 code compliant mixed-fuel design baseline:

- **Package 1A – Mixed-Fuel + Energy Efficiency (EE):** Mixed-fuel design with energy efficiency measures and federal minimum appliance efficiencies.
- **Package 1B – Mixed-Fuel + EE + PV + Battery (B)**: Same as Package 1A, plus solar PV and batteries.
- **Package 1C – Mixed-fuel + High Efficiency (HE)**: Baseline code-minimum building with high efficiency appliances, triggering federal preemption. The intent of this package is to assess the standalone contribution that high efficiency appliances would make toward achieving high performance thresholds.
- **Package 2 – All-Electric Federal Code-Minimum Reference**: All-electric design with federal code minimum appliance efficiency. No solar PV or battery.
- **Package 3A – All-Electric + EE**: Package 2 all-electric design with energy efficiency measures and federal minimum appliance efficiencies.
- **Package 3B – All-Electric + EE + PV + B**: Same as Package 3A, plus solar PV and batteries.
- **Package 3C – All-Electric + HE**: All-electric design with high efficiency appliances, triggering federal preemption.

Figure 1 summarizes the baseline and measure packages. Please refer to *Section 3* for more details on the measure descriptions.

Figure 1. Measure Category and Package Overview

Measure Category	Report Section	Mixed Fuel				All-Electric			
		Baseline	1A	1B	1C	2	3A	3B	3C
		Fed Code Minimum Efficiency	EE	EE+ PV + B	HE	Fed Code Minimum Efficiency	EE	EE+ PV + B	HE
Energy Efficiency Measures	3.1		X	X			X	X	
Solar PV + Battery	3.2			X				X	
All-Electric Measures	3.3					X	X	X	X
Preemptive Appliance Measures	3.4				X				X

The team separately developed cost effectiveness results for PV-only and PV+Battery packages, excluding any efficiency measures. For these packages, the PV is modeled as a "minimal" size of 3 kW and a larger size based on the available roof area and electric load of the building. PV sizes are combined with two sizes of battery storage for both mixed fuel and all electric buildings to form eight different package combinations as outlined below:

- **Mixed-Fuel + 3 kW PV Only**
- **Mixed-Fuel + 3 kW PV + 5 kWh Battery**
- **Mixed-Fuel + PV Only:** PV sized per the roof size of the building, or to offset the annual electricity consumption, whichever is smaller
- **Mixed-Fuel + PV + 50 kWh Battery:** PV sized per the roof size of the building, or to offset the annual electricity consumption, whichever is smaller, along with 50 kWh battery
- **All-Electric + 3 kW PV Only**
- **All-Electric + 3 kW PV + 5 kWh Battery**
- **All-Electric + PV Only:** PV sized per the roof size of the building, or to offset the annual electricity consumption, whichever is smaller
- **All-Electric + PV + 50 kWh Battery:** PV sized per the roof size of the building, or to offset the annual electricity consumption, whichever is smaller, along with 50 kWh battery.

Each of the eight packages are evaluated against a baseline model designed as per 2019 Title 24 Part 6 requirements. The Standards baseline for all occupancies in this report is a mixed-fuel design.

The Department of Energy (DOE) sets minimum efficiency standards for equipment and appliances that are federally regulated under the National Appliance Energy Conservation Act (NAECA), including heating, cooling, and water heating equipment.[1] Since state and local governments are prohibited from adopting

[1] https://www.ecfr.gov/cgi-bin/retrieveECFR?gp=&SID=8de751f141aaa1c1c9833b36156faf67&mc=true&n=pt10.3.431&r=PART&ty=HTML#se10.3.431_197

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 equipment. However, because high efficiency appliances are often the easiest and most affordable measures to increase energy performance, this study provides an analysis of high efficiency appliances for informational purposes. While federal preemption would limit a reach code, in practice, builders may install any package of compliant measures to achieve the performance requirements, including higher efficiency appliances that are federally regulated.

2 Methodology and Assumptions

With input from several stakeholders, the Reach Codes team selected three building types—medium office, medium retail, and small hotel—to represent a predominant segment of nonresidential new construction in the state.

This analysis used both on-bill and time dependent valuation of energy (TDV) based approaches to evaluate cost-effectiveness. Both methodologies require estimating and quantifying the energy savings associated with energy efficiency measures, as well as quantifying the costs associated with the measures. The main difference between the methodologies is the valuation of energy and thus the cost savings of reduced or avoided energy use. TDV was developed by the Energy Commission to reflect the time dependent value of energy including long-term projected costs of energy such as the cost of providing energy during peak periods of demand and other societal costs including projected costs for carbon emissions. With the TDV approach, electricity used (or saved) during peak periods has a much higher value than electricity used (or saved) during off-peak periods.[2]

The Reach Code Team performed energy simulations using EnergyPro 8.0 software for 2019 Title 24 code compliance analysis, which uses CBECC-Com 2019.1.0 for the calculation engine. The baseline prototype models in all climate zones have been designed to have compliance margins as close as possible to 0 to reflect a prescriptively-built building.[3]

2.1 Building Prototypes

The DOE provides building prototype models which, when modified to comply with 2019 Title 24 requirements, can be used to evaluate the cost effectiveness of efficiency measures. These prototypes have historically been used by the California Energy Commission to assess potential code enhancements. The Reach Code Team performed analysis on a medium office, a medium retail, and a small hotel prototype.

Water heating includes both service water heating (SWH) for office and retail buildings and domestic hot water for hotels. In this report, water heating or SWH is used to refer to both. The Standard Design HVAC and SWH systems are based on the system maps included in the 2019 Nonresidential Alternate

[2] Horii, B., E. Cutter, N. Kapur, J. Arent, and D. Conotyannis. 2014. "Time Dependent Valuation of Energy for Developing Building Energy Efficiency Standards." Available at: http://www.energy.ca.gov/title24/2016standards/prerulemaking/documents/2014-07-09_workshop/2017_TDV_Documents

[3] EnergySoft and TRC were able to develop most baseline prototypes to achieve a compliance margin of less than +/-1 percent except for few models that were at +/- 6 percent. This indicates these prototypes are not exactly prescriptive according to compliance software calculations. To calculate incremental impacts, TRC conservatively compared the package results to that of the proposed design of baseline prototypes (not the standard design).

Calculation Method Reference Manual.[4] The Standard Design is the baseline for all nonresidential projects and assumes a mixed-fuel design using natural gas as the space heating source in all cases. Baseline HVAC and SWH system characteristics are described below and in Figure 2:

- The baseline medium office HVAC design package includes two gas hot water boilers, three packaged rooftop units (one for each floor), and variable air volume (VAV) terminal boxes with hot water reheat coils. The SWH design includes one 8.75 kW electric resistance hot water heater with a 30-gallon storage tank.
- The baseline medium retail HVAC design includes five single zone packaged rooftop units (variable flow and constant flow depending on the zone) with gas furnaces for heating. The SWH design includes one 8.75 kW electric resistance hot water heater with a 30-gallon storage tank.
- The small hotel has two baseline equipment systems, one for the nonresidential spaces and one for the guest rooms.
  - The nonresidential HVAC design includes two gas hot water boilers, four packaged rooftop units and twelve VAV terminal boxes with hot water reheat coils. The SWH design include a small electric resistance water heater with 30-gallon storage tank.
  - The residential HVAC design includes one single zone air conditioner (AC) unit with gas furnace for each guest room and the water heating design includes one central gas water heater with a recirculation pump for all guest rooms.

Figure 2. Prototype Characteristics Summary

	Medium Office	Medium Retail	Small Hotel
Conditioned Floor Area	53,628	24,691	42,552
Number of Stories	3	1	4
Number of Guest Rooms	0	0	78
Window-to-Wall Area Ratio	0.33	0.07	0.11
Baseline HVAC System	Packaged DX VAV with gas furnaces + VAV terminal units with hot water reheat. Central gas hot water boilers	Single zone packaged DX units with gas furnaces	Nonresidential: Packaged DX VAV with hot water coil + VAV terminal units with hot water reheat. Central gas hot water boilers. Residential: Single zone DX AC unit with gas furnaces
Baseline Water Heating System	30-gallon electric resistance water heater	30-gallon electric resistance water heater	Nonresidential: 30-gallon electric resistance water heater Residential: Central gas water heater with recirculation loop

[4] Nonresidential Alternative Calculation Method Reference Manual For the 2019 Building Energy Efficiency Standards. Available at: https://www.energy.ca.gov/2019publications/CEC-400-2019-006/CEC-400-2019-006-CMF.pdf

2.2 Cost Effectiveness

The Reach Code Team analyzed the cost effectiveness of the packages by applying them to building prototypes (as applicable) using the life cycle cost methodology, which is approved and used by the Energy Commission to establish cost effective building energy standards (Title 24, Part 6).[5]

Per Energy Commission's methodology, the Reach Code Team assessed the incremental costs of the energy efficiency measure packages and compared them to the energy cost savings over the measure life of 15 years. Incremental costs represent the equipment, installation, replacements, and maintenance costs of the proposed measure relative to the 2019 Title 24 Standards minimum requirements. The energy savings benefits are estimated using both TDV of energy and typical utility rates for each building type:

- **Time Dependent Valuation:** TDV is a normalized monetary format developed and used by the Energy Commission for comparing electricity and natural gas savings, and it considers the cost of electricity and natural gas consumed during different times of the day and year. Simulation outputs are translated to TDV savings benefits using 2019 TDV multipliers and 15-year discounted costs for the nonresidential measure packages.
- **Utility bill impacts (On-bill):** Utility energy costs are estimated by applying appropriate IOU rates to estimated annual electricity and natural gas consumption. The energy bill savings are calculated as the difference in utility costs between the baseline and proposed package over a 15-year duration accounting for discount rate and energy cost escalation.

In coordination with the IOU rate team, and rate experts at a few electric publicly owned utilities (POUs), the Reach Code Team used the current nonresidential utility rates publicly available at the time of analysis to analyze the cost effectiveness for each proposed package. The utility tariffs, summarized in Figure 3, were determined based on the annual load profile of each prototype, and the most prevalent rate in each territory. For some prototypes there are multiple options for rates because of the varying load profiles of mixed-fuel buildings versus all-electric buildings. Tariffs were integrated in EnergyPro software to be applied to the hourly electricity and gas outputs. The Reach Code Team did not attempt to compare or test a variety of tariffs to determine their impact on cost effectiveness.

The currently available and applicable time-of–use (TOU) nonresidential rates are applied to both the base and proposed cases with PV systems.[6] Any annual electricity production in excess of annual electricity consumption is credited at the applicable wholesale rate based on the approved NEM tariffs for that utility. For a more detailed breakdown of the rates selected refer to *Appendix 6.4 Utility Rate Schedules*. Note that most utility time-of-use rates will be updated in the near future, which can affect cost effectiveness results. For example, Pacific Gas and Electric Company (PG&E) will introduce new rates for new service connections in late 2019, and existing accounts will be automatically rolled over to new rates in November 2020.

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[5] Architectural Energy Corporation (January 2011) Life-Cycle Cost Methodology. California Energy Commission. Available at: http://www.energy.ca.gov/title24/2013standards/prerulemaking/documents/general_cec_documents/2011-01-14_LCC_Methodology_2013.pdf

[6] Under NEM rulings by the CPUC (D-16-01-144, 1/28/16), all new PV customers shall be in an approved TOU rate structure. As of March 2016, all new PG&E net energy metering (NEM) customers are enrolled in a time-of-use rate. (http://www.pge.com/en/myhome/saveenergymoney/plans/tou/index.page?).

Figure 3. Utility Tariffs used based on Climate Zone

Climate Zones	Electric / Gas Utility	Electricity (Time-of-use)	Natural Gas
IOUs			
1-5,11-13,16	PG&E	A-1/A-10	G-NR1
5	PG&E / Southern California Gas Company	A-1/A-10	G-10 (GN-10)
6,8-10,14,15	SCE / Southern California Gas Company	TOU-GS-1/TOU-GS-2/TOU-GS-3	G-10 (GN-10)
7,10,14	San Diego Gas and Electric Company (SDG&E)	A-1/A-10	GN-3
Electric POUs			
4	City of Palo Alto (CPAU)	E-2	n/a
12	Sacramento Municipal Utility District (SMUD)	GS	n/a
6,7,8,16	Los Angeles Department of Water and Power (LADWP)	A-2 (B)	n/a

The Reach Code Team obtained measure costs through interviews with contractors and California distributors and review of online sources, such as Home Depot and RS Means. Taxes and contractor markups were added as appropriate. Maintenance costs were not included because there is no assumed maintenance on the envelope measures. For HVAC and SWH measures the study assumes there are no additional maintenance cost for a more efficient version of the same system type as the baseline. Replacement costs for inverters were included for PV systems, but the useful life all other equipment exceeds the study period.

The Reach Code Team compared the energy benefits with incremental measure cost data to determine cost effectiveness for each measure package. The calculation is performed for a duration of 15 years for all nonresidential prototypes with a 3 percent discount rate and fuel escalation rates based on the most recent General Rate Case filings and historical escalation rates.[7] Cost effectiveness is presented using net present value and benefit-to-cost ratio metrics.

- **Net Present Value (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 (energy cost increase) can still be cost effective if the costs to implement the measure are more negative (i.e., material and maintenance cost savings).
- **Benefit-to-Cost Ratio (B/C)**: Ratio of the present value of all benefits to the present value of all costs over 15 years (NPV benefits *divided by* NPV costs). The criteria for cost effectiveness is a B/C greater than 1.0. A value of one indicates the savings over the life of the measure are equivalent to the incremental cost of that measure.

[7] 2019 TDV Methodology Report, California Energy Commission, Docket number: 16-BSTD-06 https://efiling.energy.ca.gov/GetDocument.aspx?tn=216062

There are several special circumstances to consider when reviewing these results:

- Improving the efficiency of a project often requires an initial incremental investment. 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). Typically, utility bill savings are categorized as a 'benefit' while incremental construction costs are treated as 'costs.' In cases where both construction costs are negative and utility bill savings are negative, the construction cost savings are treated as the 'benefit' while the utility bill negative savings are the 'cost.'
- In cases where a measure package is cost effective immediately (i.e., there are upfront cost savings and lifetime energy cost savings), cost effectiveness is represented by ">1".
- The B/C ratios sometimes appear very high even though the cost numbers are not very high (for example, an upfront cost of $1 but on-bill savings of $200 over 30 years would equate to a B/C ratio of 200). NPV is also displayed to clarify these potentially confusing conclusions – in the example, the NPV would be equal to a modest $199.

3 Measure Description and Cost

Using the 2019 Title 24 code baseline as the starting point, The Reach Code Team identified potential measure packages to determine the projected energy (therm and kWh) and compliance impacts. The Reach Code Team developed an initial measure list based on experience with designers and contractors along with general knowledge of the relative acceptance and preferences of many measures, as well as their incremental costs.

The measures are categorized into energy efficiency, solar PV and battery, all-electric, and preempted high efficiency measures in subsections below.

3.1 Energy Efficiency Measures

This section describes all the energy efficiency measures considered for this analysis to develop a non-preempted, cost-effective efficiency measure package. The Reach Code Team assessed the cost-effectiveness of measures for all climate zones individually and found that the packages did not need to vary by climate zone, with the exception of a solar heat gain coefficient measure in hotels, as described in more detail below. The measures were developed based on reviews of proposed 2022 Title 24 codes and standards enhancement measures, as well as ASHRAE 90.1 and ASHRAE 189.1 Standards. Please refer to *Appendix Section 6.86.7* for a list of efficiency measures that were considered but not implemented.

Figure 4 provides a summary of the cost of each measure and the applicability of each measure to the prototype buildings.

3.1.1 Envelope

- **Modify Solar Heat Gain Coefficient (SHGC) fenestration**
  - Office and Retail - All Climate Zones: reduce window SHGC from the prescriptive value of 0.25 to 0.22
  - Hotel
    - Climate zones 1, 2, 3, 5, and 16: Increase the SHGC for all nonresidential spaces from the prescriptive value of 0.25 to 0.45 in both common and guest room spaces.
    - Climate zones 4, and 6-15: Reduce window SHGC from the prescriptive value of 0.25 to 0.22, only for common spaces.

  In all cases, the fenestration visible transmittance and U-factor remain at prescriptive values.
- **Fenestration as a function of orientation**: Limit the amount of fenestration area as a function of orientation. East-facing and west-facing windows are each limited to one-half of the average amount of north-facing and south-facing windows.

3.1.2 HVAC and SWH

- **Drain water heat recovery (DWHR)**: Add shower drain heat recovery in hotel guest rooms. DWHR captures waste heat from a shower drain line and uses it to preheat hot water. Note that this measure cannot currently be modeled on hotel/motel spaces, and the Reach Code Team integrated estimated savings outside of modeling software based on SWH savings in residential scenarios. Please see *Appendix Section 6.3* for details on energy savings analysis.
- **VAV box minimum flow**: Reduce VAV box minimum airflows from the current T24 prescriptive requirement of 20 percent of maximum (design) airflow to the T24 zone ventilation minimums.
- **Economizers on small capacity systems**: Require economizers and staged fan control in units with cooling capacity ≥ 33,000 Btu/hr and ≤ 54,000 Btu/hr, which matches the requirement in the 2018 International Green Construction Code and adopts ANSI/ASHRAE/ICC/USGBC/IES Standard 189.1. This measure reduces the T24 prescriptive threshold on air handling units that are required to have economizers, which is > 54,000 Btu/hr.
- **Solar thermal hot water:** For all-electric hotel only, add solar thermal water heating to supply the following portions of the water heating load, measured in solar savings fraction (SSF):
  - 20 percent SSF in CZs 2, 3, and 5-9
  - 25 percent in CZ4
  - 35 percent SSF in CZs 1 and 10-16.

3.1.3 Lighting

- **Interior lighting reduced lighting power density (LPD)**: Reduce LPD by 15 percent for Medium Office, 10 percent for Medium Retail and by 10 percent for the nonresidential areas of the Small Hotel.
- **Institutional tuning**: Limit the maximum output or maximum power draw of lighting to 85 percent of full light output or full power draw.
- **Daylight dimming plus off**: Turn daylight-controlled lights completely off when the daylight available in the daylit zone is greater than 150 percent of the illuminance received from the general lighting system at full power. There is no associated cost with this measure, as the 2019 T24 Standards already require multilevel lighting and daylight sensors in primary and secondary daylit spaces. This measure is simply a revised control strategy and does not increase the number of sensors required or labor to install and program a sensor.
- **Occupant sensing in open plan offices**: In an open plan office area greater than 250 ft^2, control lighting based on occupant sensing controls. Two workstations per occupancy sensor.

Details on the applicability and impact of each measure by building type and by space function can be found in *Appendices 6.2*. The appendix also includes the resulting LPD that is modeled as the proposed by building type and by space function.

Figure 4. Energy Efficiency Measures - Specification and Cost

Measure	Baseline T24 Requirement	Measure Applicability ● Included in Packages 1A, 1B, 3A, 3C – Not applicable				Incremental Cost	Sources & Notes
				Small Hotel			
		Med Office	Med Retail	Guest rooms	Comm Spaces		
Envelope							
Modify SHGC Fenestration	SHGC of 0.25	●	●	●	●	$1.60 /ft^2 window for SHGC decreases, $0/ft^2 for SHGC increases	Costs from one manufacturer.
Fenestration as a Function of Orientation	Limit on total window area and west-facing window area as a function of wall area.	●	–	–	–	$0	No additional cost associated with the measure which is a design consideration not an equipment cost.
HVAC and SHW							
Drain Water Heat Recovery	No heat recovery required	–	–	●	–	$841 /unit	Assume 1 heat recovery unit for every 3 guestrooms. Costs from three manufacturers.
VAV Box Minimum Flow	20 percent of maximum (design) airflow	●	–	–	●	$0	No additional cost associated with the measure which is a design consideration not an equipment cost.
Economizers on Small Capacity Systems	Economizers required for units > 54,000 Btu/hr	–	●	–	–	$2,857 /unit	Costs from one manufacturer's representative and one mechanical contractor.

Measure	Baseline T24 Requirement	Measure Applicability ● Included in Packages 1A, 1B, 3A, 3C – Not applicable				Incremental Cost	Sources & Notes
				Small Hotel			
		Med Office	Med Retail	Guest rooms	Comm Spaces		
Solar Thermal Hot Water	For central heat pump water heaters, there is no prescriptive baseline requirement.	–	–	● (electric only)	–	$33/therm-yr	Installed costs reported in the California Solar Initiative Thermal Program Database, 2015-present.[8] Costs include tank and were only available for gas backup systems. Costs are reduced by 19 percent per federal income tax credit average through 2022.
Lighting							
Interior Lighting Reduced LPD	Per Area Category Method, varies by Primary Function Area. Office area 0.60 – 0.70 W/ft^2 depending on area of space. Hotel function area 0.85 W/ft^2. Retail Merchandise Sales 1.00 W/ft^2	●	●	–	●	$0	Industry report on LED pricing analysis shows that costs are not correlated with efficacy.[9]

[8] http://www.csithermalstats.org/download.html

[9] http://calmac.org/publications/LED_Pricing_Analysis_Report_-_Revised_1.19.2018_Final.pdf

Measure	Baseline T24 Requirement	Measure Applicability ● Included in Packages 1A, 1B, 3A, 3C – Not applicable				Incremental Cost	Sources & Notes
				Small Hotel			
		Med Office	Med Retail	Guest rooms	Comm Spaces		
Institutional Tuning	No requirement, but Power Adjustment Factor (PAF) credit of 0.10 available for luminaires in non-daylit areas and 0.05 for luminaires in daylit areas[10]	●	●	–	●	$0.06/ft^2	Industry report on institutional tuning[11]
Daylight Dimming Plus Off	No requirement, but PAF credit of 0.10 available.	●	–	–	–	$0	Given the amount of lighting controls already required, this measure is no additional cost.
Occupant Sensing in Open Plan Offices	No requirement, but PAF credit of 0.30 available.	●	–	–	–	$189 /sensor; $74 /powered relay; $108 /secondary relay	2 workstations per sensor; 1 fixture per workstation; 4 workstations per master relay; 120 ft^2/workstation in open office area, which is 53% of total floor area of the medium office

[10] Power Adjustment Factors allow designers to tradeoff increased lighting power densities for more efficient designs. In this study, PAF-related measures assume that the more efficient design is incorporated without a tradeoff for increased lighting power density.

[11] https://slipstreaminc.org/sites/default/files/2018-12/task-tuning-report-mndoc-2015.pdf

3.2 Solar Photovoltaics and Battery Measures

This section describes the PV and battery measures considered for this analysis. The Reach Code Team estimated the required PV sizes for each building prototype for the efficiency measure packages and the stand alone PV and battery options.

3.2.1 Solar Photovoltaics

2019 Title 24 requires nonresidential buildings to reserve at least 15 percent of the roof area as a "solar zone," but does not include any requirements or compliance credits for the installation of photovoltaic systems. The Reach Code Team analyzed a range of PV system sizes to determine cost effectiveness. To determine upper end of potential PV system size, the Reach Code Team assumed a PV generation capacity of either

- 15 W/ft^2 covering 50 percent of the roof area, or
- Enough to nearly offset the annual energy consumption.

The medium office and small hotel prototypes had small roof areas compared to their annual electricity demand, thus the PV system capacity at 50 percent of the roof area was less than the estimated annual usage. The medium office and small hotel had a 135 kW and 80 kW array, respectively. The medium retail building has a substantially large roof area that would accommodate a PV array that generates more than the annual electricity load of the building. The PV array for the medium retail building was sized at 110 kW to not exceed the annual electricity consumption of the building when accounting for the minimum annual energy demand across climate zones with efficiency packages.

The modeling software for nonresidential buildings does not allow auto-sizing of PV based on a desired percent offset of electricity use. Moreover, the PV size is also constrained by the availability of roof area. Hence, a common size of PV is modeled for all the packages including all electric design. Figure 5 through Figure 7 below demonstrate the percent of electricity offset by PV for both mixed fuel and all electric buildings over their respective federal minimum design package.

Figure 5. Medium Office – Annual Percent kWh Offset with 135 kW Array

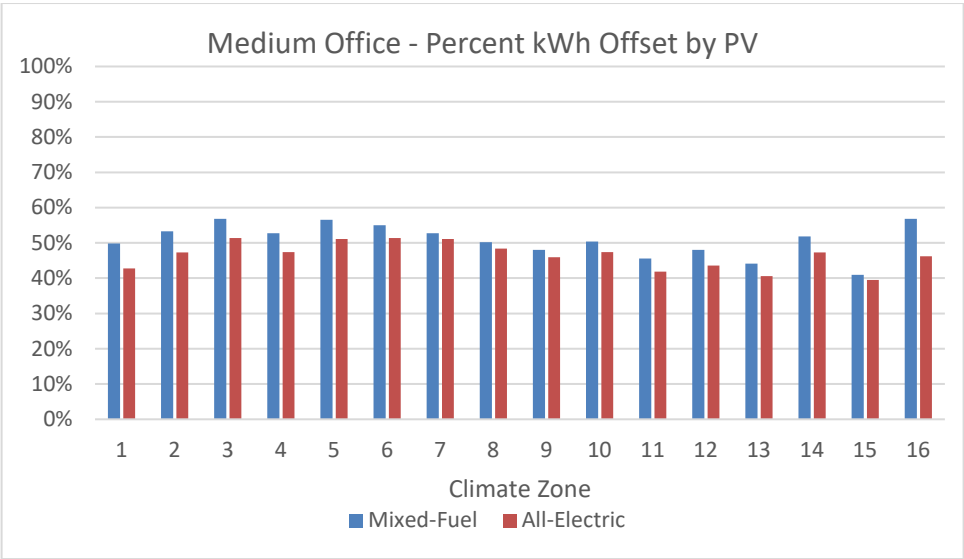


Figure 6. Medium Retail – Annual Percent kWh Offset with 110 kW Array

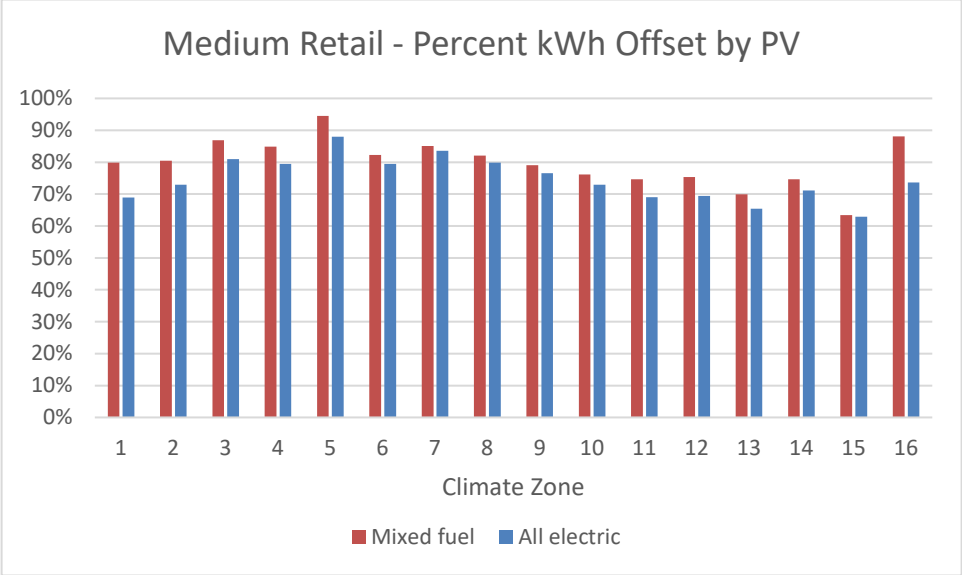
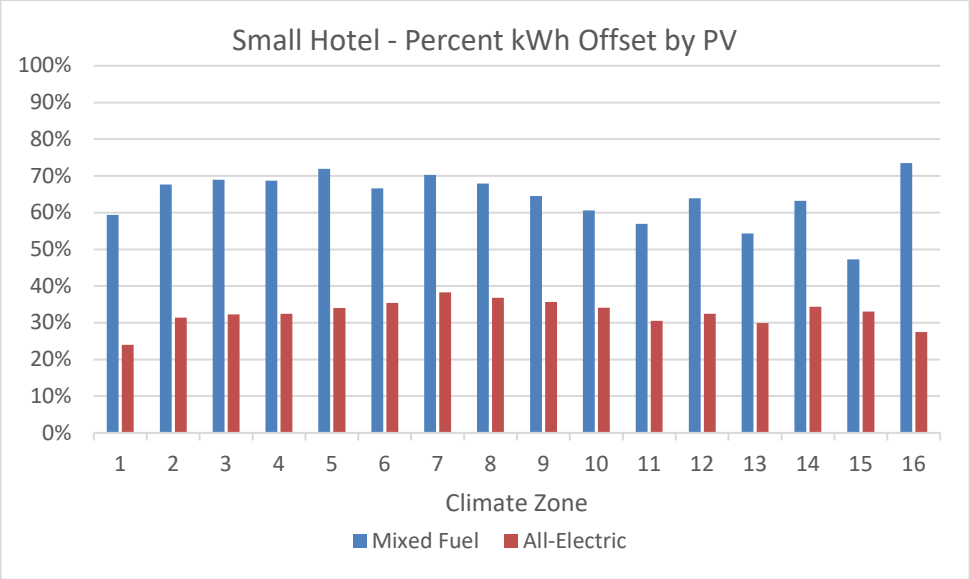


Figure 7. Small Hotel – Annual Percent kWh Offset with 80 kW Array



The costs for PV include first cost to purchase and install the system, inverter replacement costs, and annual maintenance costs. A summary of the medium office costs and sources is given in Figure 8. Upfront solar PV system costs are reduced by the federal income tax credit (ITC), approximately 19 percent due to a phased reduction in the credit through the year 2022.[12]

[12] The federal credit drops to 26% in 2020, and 22% in 2021 before dropping permanently to 10% for commercial projects and 0% for residential projects in 2022. More information on federal Investment Tax Credits available at: https://www.seia.org/initiatives/solar-investment-tax-credit-itc

Figure 8. Medium Office Upfront PV Costs

	Unit Cost	Cost	Useful Life (yrs.)	Source
Solar PV System	$2.30 / Wdc	$310,500	30	National Renewable Energy Laboratory (NREL) Q1 2016[13]
Inverter Replacement	$0.15 / Wdc	$20,250	10	E3 Rooftop Solar PV System Report[14]
Maintenance Costs	$0.02 / Wdc	$2,700	1	

PV energy output is built into CBECC-Com and is based on NREL's PVWatts calculator, which includes long term performance degradation estimates.[15]

3.2.2 Battery Storage

This measure includes installation of batteries to allow energy generated through PV to be stored and used later, providing additional energy cost benefits. This report does not focus on optimizing battery sizes or controls for each prototype and climate zone, though the Reach Code Team ran test simulations to assess the impact of battery sizes on TDV savings and found diminishing returns as the battery size increased.

The team set battery control to the Time of Use Control (TOU) method, which assumes batteries are charged anytime PV generation is greater than the building load but discharges to the electric grid beginning during the highest priced hours of the day (the "First Hour of the Summer Peak"). Because there is no default hour available in CBECC-Com, the team applied the default hour available in CBECC-Res to start discharging (hour 19 in CZs 2, 4, and 8-15, and hour 20 in other CZs). This control option is most reflective of the current products on the market. While this control strategy is being used in the analysis, there would be no mandate on the control strategy used in practice.

The current simulation software has approximations of how performance characteristics change with environmental conditions, charge/discharge rates, and degradation with age and use. More information is on the software battery control capabilities and associated qualification requirements are available in the Residential Alternative Calculation Method Reference Manual and the 2019 Reference Appendices for the 2019 Title 24 Standards.[16,17]

The Reach Code Team used costs of $558 kWh based on a 2018 IOU Codes and Standards Program report, assuming a replacement is necessary in year 15.[18] Batteries are also eligible for the ITC if they are installed at the same time as the renewable generation source and at least 75 percent of the energy used to charge

[13] Available at: https://www.nrel.gov/docs/fy16osti/66532.pdf

[14] Available at: https://efiling.energy.ca.gov/getdocument.aspx?tn=221366

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

[16] Battery controls are discussed in Sections 2.1.5.4 and Appendix D of the Residential Alternative Calculation Method Reference Manual, available here: https://ww2.energy.ca.gov/2019publications/CEC-400-2019-005/CEC-400-2019-005-CMF.pdf

[17] Qualification Requirements for Battery Storage Systems are available in JA12 of the 2019 Reference Appendices: https://ww2.energy.ca.gov/2018publications/CEC-400-2018-021/CEC-400-2018-021-CMF.pdf

[18] Available at: http://localenergycodes.com/download/430/file_path/fieldList/PV%20Plus%20Battery%20Storage%20Report

the battery comes from a renewable source. Thus, the Reach Code Team also applied a 19 percent cost reduction to battery costs.

3.2.3 PV-only and PV+Battery Packages

The Reach Code Team analyzed solar PV and battery storage only, without other efficiency measures in both mixed-fuel and all-electric building designs. Two different sizes of solar PV and battery storage were analyzed.

- **Small PV Size**: 3 kW, assumed to be the minimal PV system considered for installation in a nonresidential building.
- **Large PV Size**: PV capacity equal to 15 W/ft^2 over 50 percent of the roof area, or sized to nearly offset annual electricity consumption, as described in Section 3.2.1.
- **Small Battery Size:** 5 kWh, assumed to be the minimal battery system considered for installation in a nonresidential building, and representative of smaller products currently available on the market.
- **Large Battery Size:** 50 kWh, assumed to be a substantially large size for a nonresidential setting. Generally, the reach code team found diminishing on-bill and TDV benefits as the battery size increased.

As described in Section 1 and Section 4.4, each PV size was run as a standalone measure. When packaged with a battery measure, the small PV size was paired with the small battery size, and the large PV size was paired with the large battery size.

3.3 All Electric Measures

The Reach Code Team investigated the cost and performance impacts and associated infrastructure costs associated with changing the baseline HVAC and water heating systems to all-electric equipment. This includes heat pump space heating, electric resistance reheat coils, electric water heater with storage tank, heat pump water heating, increasing electrical capacity, and eliminating natural gas connections that would have been present in mixed-fuel new construction. The Reach Code Team selected electric systems that would be installed instead of gas-fueled systems in each prototype.

3.3.1 HVAC and Water Heating

The nonresidential standards use a mixed-fuel baseline for the Standard Design systems. In most nonresidential occupancies, the baseline is natural gas space heating. Hotel/motels and high-rise residential occupancies also assume natural gas baseline water heating systems for the guest rooms and dwelling units. In the all-electric scenario, gas equipment serving these end-uses is replaced with electric equipment, as described in Figure 9.

Figure 9. All-Electric HVAC and Water Heating Characteristics Summary.

		Medium Office	Medium Retail	Small Hotel
HVAC System	Baseline	Packaged DX + VAV with HW reheat. Central **gas** boilers.	Single zone packaged DX with **gas** furnaces	NonRes: Packaged DX + VAV with HW reheat. Central **gas** boilers. Res: Single zone DX AC unit with **gas** furnaces
	Proposed All-Electric	Packaged DX + VAV with electric **resistance** reheat.	Single zone packaged **heat pumps**	NonRes: Packaged DX + VAV with electric **resistance** reheat Res: Single zone **heat pumps**
Water Heating System	Baseline	Electric **resistance** with storage	Electric **resistance** with storage	NonRes: **Electric** resistance storage Res: Central **gas** storage with recirculation
	Proposed All-Electric	Electric **resistance** with storage	Electric **resistance** with storage	NonRes: Electric **resistance** storage Res: Individual **heat pumps**

The Reach Code Team received cost data for baseline mixed-fuel equipment as well as electric equipment from an experienced mechanical contractor in the San Francisco Bay Area. The total construction cost includes equipment and material, labor, subcontractors (for example, HVAC and SHW control systems), and contractor overhead.

3.3.1.1 Medium Office

The baseline HVAC system includes two gas hot water boilers, three packaged rooftop units, and VAV hot water reheat boxes. The SHW design includes one 8.75 kW electric resistance hot water heater with a 30-gallon storage tank.

For the medium office all-electric HVAC design, the Reach Code Team investigated several potential all-electric design options, including variable refrigerant flow, packaged heat pumps, and variable volume and temperature systems. After seeking feedback from the design community, the Reach Code Team determined that the most feasible all-electric HVAC system, given the software modeling constraints is a VAV system with an electric resistance reheat instead of hot water reheat coil. A parallel fan-powered box (PFPB) implementation of electric resistance reheat would further improve efficiency due to reducing ventilation requirements, but an accurate implementation of PFPBs is not currently available in compliance software.

Note that the actual natural gas consumption for the VAV hot water reheat baseline may be higher than the current simulation results due to a combination of boiler and hot water distribution losses. A recent research study shows that the total losses can account for as high as 80 percent of the boiler energy use.[19]

[19] Raftery, P., A. Geronazzo, H. Cheng, and G. Paliaga. 2018. Quantifying energy losses in hot water reheat systems. Energy and Buildings, 179: 183-199. November. https://doi.org/10.1016/j.enbuild.2018.09.020. Retrieved from https://escholarship.org/uc/item/3qs8f8qx

If these losses are considered savings for the electric resistance reheat (which has zero associated distribution loss) may be higher.

The all-electric SHW system remains the same electric resistance water heater as the baseline and has no associated incremental costs.

Cost data for medium office designs are presented in Figure 10. The all-electric HVAC system presents cost savings compared to the hot water reheat system from elimination of the hot water boiler and associated hot water piping distribution. CZ10 and CZ15 all-electric design costs are slightly higher because they require larger size rooftop heat pumps than the other climate zones.

Figure 10. Medium Office HVAC System Costs

Climate Zone	Mixed Fuel Baseline	All Electric System	Incremental cost for All-Electric
CZ01	$1,202,538	$1,106,432	$(96,106)
CZ02	$1,261,531	$1,178,983	$(82,548)
CZ03	$1,205,172	$1,113,989	$(91,183)
CZ04	$1,283,300	$1,205,434	$(77,865)
CZ05	$1,207,345	$1,113,989	$(93,356)
CZ06	$1,216,377	$1,131,371	$(85,006)
CZ07	$1,227,932	$1,148,754	$(79,178)
CZ08	$1,250,564	$1,172,937	$(77,626)
CZ09	$1,268,320	$1,196,365	$(71,955)
CZ10	$1,313,580	$1,256,825	$(56,755)
CZ11	$1,294,145	$1,221,305	$(72,840)
CZ12	$1,274,317	$1,197,121	$(77,196)
CZ13	$1,292,884	$1,221,305	$(71,579)
CZ14	$1,286,245	$1,212,236	$(74,009)
CZ15	$1,357,023	$1,311,994	$(45,029)
CZ16	$1,295,766	$1,222,817	$(72,949)

3.3.1.2 Medium Retail

The baseline HVAC system includes five packaged single zone rooftop ACs with gas furnaces. Based on fan control requirements in section 140.4(m), units with cooling capacity ≥ 65,000 Btu/h have variable air volume fans, while smaller units have constant volume fans. The SHW design includes one 8.75 kW electric resistance hot water heater with a 30-gallon storage tank.

For the medium retail all-electric HVAC design, the Reach Code Team assumed packaged heat pumps instead of the packaged ACs. The all-electric SHW system remains the same electric resistance water heater as the baseline and has no associated incremental costs.

Cost data for medium retail designs are presented in Figure 11. Costs for rooftop air-conditioning systems are very similar to rooftop heat pump systems.

Figure 11. Medium Retail HVAC System Costs

Climate Zone	Mixed Fuel Baseline	All Electric System	Incremental cost for All-Electric
CZ01	$328,312	$333,291	$4,978
CZ02	$373,139	$373,702	$563
CZ03	$322,849	$326,764	$3,915
CZ04	$329,900	$335,031	$5,131
CZ05	$359,888	$362,408	$2,520
CZ06	$335,728	$341,992	$6,265
CZ07	$345,544	$349,808	$4,265
CZ08	$368,687	$369,792	$1,104
CZ09	$415,155	$411,069	$(4,087)
CZ10	$345,993	$346,748	$755
CZ11	$418,721	$414,546	$(4,175)
CZ12	$405,110	$400,632	$(4,477)
CZ13	$376,003	$375,872	$(131)
CZ14	$405,381	$406,752	$1,371
CZ15	$429,123	$427,606	$(1,517)
CZ16	$401,892	$404,147	$2,256

3.3.1.3 Small Hotel

The small hotel has two different baseline equipment systems, one for the nonresidential spaces and one for the guest rooms. The nonresidential HVAC system includes two gas hot water boilers, four packaged rooftop units and twelve VAV terminal boxes with hot water reheat coil. The SHW design includes a small electric water heater with storage tank. The residential HVAC design includes one single zone AC unit with gas furnace for each guest room and the water heating design includes one central gas storage water heater with a recirculation pump for all guest rooms.

For the small hotel all-electric design, the Reach Code Team assumed the nonresidential HVAC system to be packaged heat pumps with electric resistance VAV terminal units, and the SHW system to remain a small electric resistance water heater.

For the guest room all-electric HVAC system, the analysis used a single zone (packaged terminal) heat pump and a central heat pump water heater serving all guest rooms. Central heat pump water heating with recirculation serving guest rooms cannot yet be modeled in CBECC-Com, and energy impacts were modeled by simulating individual heat pump water heaters in each guest room. The reach code team believes this is a conservative assumption, since individual heat pump water heaters will have much higher tank standby losses. The Reach Code Team attained costs for central heat pump water heating installation including storage tanks and controls and used these costs in the study.

Cost data for small hotel designs are presented in Figure 12. The all-electric design presents substantial cost savings because there is no hot water plant or piping distribution system serving the nonresidential spaces, as well as the lower cost of packaged terminal heat pumps serving the residential spaces compared to split DX/furnace systems with individual flues.

Figure 12. Small Hotel HVAC and Water Heating System Costs

Climate Zone	Mixed Fuel Baseline	All Electric System	Incremental cost for All-Electric
CZ01	$2,337,531	$1,057,178	$(1,280,353)
CZ02	$2,328,121	$1,046,795	$(1,281,326)
CZ03	$2,294,053	$1,010,455	$(1,283,598)
CZ04	$2,302,108	$1,018,675	$(1,283,433)
CZ05	$2,298,700	$1,015,214	$(1,283,486)
CZ06	$2,295,380	$1,011,753	$(1,283,627)
CZ07	$2,308,004	$1,026,029	$(1,281,975)
CZ08	$2,333,662	$1,053,717	$(1,279,946)
CZ09	$2,312,099	$1,030,355	$(1,281,744)
CZ10	$2,354,093	$1,075,348	$(1,278,745)
CZ11	$2,347,980	$1,068,426	$(1,279,554)
CZ12	$2,328,654	$1,047,660	$(1,280,994)
CZ13	$2,348,225	$1,068,858	$(1,279,367)
CZ14	$2,345,988	$1,066,263	$(1,279,725)
CZ15	$2,357,086	$1,079,241	$(1,277,845)
CZ16	$2,304,094	$1,019,973	$(1,284,121)

3.3.2 Infrastructure Impacts

Electric heating appliances and equipment often require a larger electrical connection than an equivalent natural gas appliance because of the higher voltage and amperage necessary to electrically generate heat. Thus, many buildings may require larger electrical capacity than a comparable building with natural gas appliances. This includes:

- Electric resistance VAV space heating in the medium office and common area spaces of the small hotel.
- Heat pump water heating for the guest room spaces of the small hotel.

3.3.2.1 Electrical Panel Sizing and Wiring

This section details the additional electrical panel sizing and wiring required for all-electric measures. In an all-electric new construction scenario, heat pumps replace packaged DX units which are paired with either a gas furnace or a hot water coil (supplied by a gas boiler). The electrical requirements of the replacement heat pump would be the same as the packaged DX unit it replaces, as the electrical requirements would be driven by the cooling capacity, which would remain the same between the two units.

VAV terminal units with hot water reheat coils that are replaced with electric resistance reheat coils require additional electrical infrastructure. In the case of electric resistance coils, the Reach Code Team assumed that on average, a VAV terminal unit serves around 900 ft^2 of conditioned space and has a heating capacity of 5 kW (15 $kBtu/hr/ft^2$). The incremental electrical infrastructure costs were determined based on RS Means. Calculations for the medium office shown in Figure 13 include the cost to add electrical panels as well as the cost to add electrical lines to each VAV terminal unit electric resistance coil in the medium office prototype. Additionally, the Reach Code Team subtracted the electrical infrastructure costs associated with hot water pumps required in the mixed fuel baseline, which are not required in the all-electric measures.

The Reach Code Team calculated costs to increase electrical capacity for heat pump water heaters in the small hotel similarly.

Figure 13. Medium Office Electrical Infrastructure Costs for All-Electric Design

A	-	No. VAV Boxes	60
B	-	VAV box heating capacity (watts)	4,748
C	-	No. hot water pumps	2
D	-	Hot water pump power (watts)	398
E	-	Voltage	208
F	(AxB - CxD)/E	Panel ampacity required	1,366
G	F/400	Number of 400-amp panels required	4
H	-	Cost per 400-amp panel	$3,100
I	GxH	Total panel cost	$12,400
J	-	Total electrical line length required (ft)	4,320
K	-	Cost per linear foot of electrical line	$3.62
L	JxK	Total electrical line cost	$15,402
	I + L	**Total electrical infrastructure incremental cost**	**$27,802**

3.3.2.2 Natural Gas

This analysis assumes that in an all-electric new construction scenario natural gas would not be supplied to the site. Eliminating natural gas in new construction would save costs associated with connecting a service line from the street main to the building, piping distribution within the building, and monthly connection charges by the utility.

The Reach Code Team determined that for a new construction building with natural gas piping, there is a service line (branch connection) from the natural gas main to the building meter. In the medium office prototype, natural gas piping is routed to the boiler. The Reach Code Team assumed that the boiler is on the first floor, and that 30 feet of piping is required from the connection to the main to the boiler. The Reach Code Team assumed 1” corrugated stainless steel tubing (CSST) material is used for the plumbing distribution. The Reach Code Team included costs for a natural gas plan review, service extension, and a gas meter, as shown in Figure 14 below. The natural gas plan review cost is based on information received from the City of Palo Alto Utilities. The 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 highly uncertain, the 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 development in a previously developed area.

Figure 14. Natural Gas Infrastructure Cost Savings for All-Electric Prototypes

Cost Type	Medium Office	Medium Retail	Small Hotel
Natural Gas Plan Review	$2,316	$2,316	$2,316
Service Extension	$13,000	$13,000	$13,000
Meter	$3,000	$3,000	$3,000
Plumbing Distribution	$633	$9,711	$37,704
Total Cost	**$18,949**	**$28,027**	**$56,020**

3.4 Preempted High Efficiency Appliances

The Reach Code Team developed a package of high efficiency (HE) space and water heating appliances based on commonly available products for both the mixed-fuel and all-electric scenarios. This package assesses the standalone contribution that high efficiency measures would make toward achieving high performance thresholds. The Reach Code Team reviewed the Air Conditioning, Heating, and Refrigeration Institute (AHRI) certified product database to estimate appropriate efficiencies.[20]

The Reach Code Team determined the efficiency increases to be appropriate based on equipment type, summarized in Figure 15, with cost premiums attained from a Bay Area mechanical contractor. The ranges in efficiency are indicative of varying federal standard requirements based on equipment size.

Figure 15. High Efficiency Appliance Assumptions

	Federal Minimum Efficiency	Preempted Efficiency	Cost Premium for HE Appliance
Gas space heating and water heating	80-82%	90-95%	10-15%
Large packaged rooftop cooling	9.8-12 EER 11.4-12.9 IEER	10.5-13 EER 15-15.5 IEER	10-15%
Single zone heat pump space heating	7.7 HSPF 3.2 COP	10 HSPF 3.5 COP	6-15%
Heat pump water heating	2.0 UEF	3.3 UEF	None (market does not carry 2.0 UEF)

3.5 Greenhouse Gas Emissions

The analysis uses the greenhouse gas (GHG) emissions estimates from Zero Code reports available in CBECC-Com.[21] Zero Code uses 8760 hourly multipliers accounting for time dependent energy use and carbon emissions based on source emissions, including renewable portfolio standard projections. Fugitive

[20] Available at: https://www.ahridirectory.org/Search/SearchHome?ReturnUrl=%2f

[21] More information available at: https://zero-code.org/wp-content/uploads/2018/11/ZERO-Code-TSD-California.pdf

emissions are not included. There are two strings of multipliers – one for Northern California climate zones, and another for Southern California climate zones.[22]

4 Results

The Reach Code Team evaluated cost effectiveness of the following measure packages over a 2019 mixed-fuel code compliant baseline for all climate zones, as detailed in Sections 4.1 -- 4.3 and reiterated in Figure 16:

- **Package 1A – Mixed-Fuel + EE:** Mixed-fuel design with energy efficiency measures and federal minimum appliance efficiencies.
- **Package 1B – Mixed-Fuel + EE + PV + B**: Same as Package 1A, plus solar PV and batteries.
- **Package 1C – Mixed-fuel + HE**: Alternative design with high efficiency appliances, triggering federal preemption.
- **Package 2 – All-Electric Federal Code-Minimum Reference**: All-electric design with federal code minimum appliance efficiency. No solar PV or battery.
- **Package 3A – All-Electric + EE**: All-electric design with energy efficiency measures and federal minimum appliance efficiencies.
- **Package 3B – All-Electric + EE + PV + B**: Same as Package 3A, plus solar PV and batteries.
- **Package 3C – All-Electric + HE**: All-electric design with high efficiency appliances, triggering federal preemption.

Figure 16. Package Summary

Package	Fuel Type		Energy Efficiency Measures	PV & Battery (PV + B)	High Efficiency Appliances (HE)
	Mixed Fuel	All-Electric			
Mixed-Fuel Code Minimum Baseline	X				
1A – Mixed-Fuel + EE	X		X		
1B – Mixed-Fuel + EE + PV + B	X		X	X	
1C – Mixed-fuel + HE	X				X
2 – All-Electric Federal Code-Minimum Reference		X			
3A – All-Electric + EE		X	X		
3B – All-Electric + EE + PV + B		X	X	X	
3C – All-Electric + HE		X			X

[22] CBECC-Com documentation does not state which climate zones fall under which region. CBECC-Res multipliers are the same for CZs 1-5 and 11-13 (presumed to be Northern California), while there is another set of multipliers for CZs 6-10 and 14-16 (assumed to be Southern California).

Section 4.4 presents the results of the PV-only and PV+Battery analysis.

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

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

- To pass the Energy Commission's application process, local reach codes must both be cost effective and exceed the energy performance budget using TDV (i.e., have a positive compliance margin). 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, and the opportunities/challenges that the scenario presents. Conversely, Section 4.4 only highlights results that **both** have a positive compliance margin and are cost effective, to allow readers to identify reach code-ready scenarios.
  - **Note:** Compliance margin represents the proportion of energy usage that is saved compared to the baseline, measured on a TDV basis.
- The Energy Commission does not currently allow compliance credit for either solar PV or battery storage. Thus, the compliance margins in Packages 1A are the same as 1B, and Package 3A is the same as 3B. However, The Reach Code Team did include the impact of solar PV and battery when calculating TDV cost-effectiveness.
- When performance modeling residential buildings, the Energy Commission allows the Standard Design to be electric if the Proposed Design is electric, which removes TDV-related penalties and associated negative compliance margins. This essentially allows for a compliance pathway for all-electric residential buildings. Nonresidential buildings are not treated in the same way and are compared to a mixed-fuel standard design.
- Results do not include an analysis and comparison of utility rates. As mentioned in *Section 2.2*, The Reach Code Team coordinated with utilities to select tariffs for each prototype given the annual energy demand profile and the most prevalent rates in each utility territory. The Reach Code Team did not compare a variety of tariffs to determine their impact on cost effectiveness. Note that most utility time-of-use rates are continuously updated, which can affect cost effectiveness results.
- As a point of comparison, mixed-fuel baseline energy figures are provided in *Appendix 6.5*.

4.1 Cost Effectiveness Results – Medium Office

Figure 17 through Figure 23 contain the cost-effectiveness findings for the Medium Office packages. Notable findings for each package include:

- **1A – Mixed-Fuel + EE:** Packages achieve +12 to +20 percent compliance margins depending on climate zone. All packages are cost effective in all climate zones using the TDV approach. All packages are cost effective using the On-Bill approach except for LADWP territory.

- **1B – Mixed-Fuel + EE + PV + B:** All packages are cost effective using the On-Bill and TDV approaches, except On-Bill in LADWP territory. When compared to 1A, the B/C ratio changes depending on the utility and climate zone (some increase while others decrease). However, NPV savings are increased across the board, suggesting that larger investments yield larger returns.
- **1C – Mixed-Fuel + HE:** Packages achieve +3 to +5 percent compliance margins depending on climate zone, but no packages were cost effective. The incremental costs of a high efficiency condensing boiler compared to a non-condensing boiler contributes to 26-47% of total incremental cost depending on boiler size. Benefits of condensing boiler efficiency come from resetting hot water return temperature as boiler efficiency increases at lower hot water temperature. However, hot water temperature reset control cannot currently be implemented in the software. In addition, the natural gas energy cost constitutes no more than 5% of total cost for 15 climate zones, so improving boiler efficiency has limited contribution to reduction of total energy cost.
- **2 – All-Electric Federal Code-Minimum Reference:**
  - Packages achieve between -27 percent and +1 percent compliance margins depending on climate zone. This is likely because the modeled system is electric resistance, and TDV values electricity consumption more heavily than natural gas. This all-electric design without other efficiency measures does not comply with the Energy Commission's TDV performance budget.
  - All incremental costs are negative due to the elimination of natural gas infrastructure.
  - Packages achieve utility cost savings and are cost effective using the On-Bill approach in CZs 6-10 and 14-15. Packages do not achieve savings and are not cost effective using the On-Bill approach in most of PG&E territory (CZs 1,2,4, 11-13, and 16). Packages achieve savings and are cost effective using TDV in all climate zones except CZ16.
- **3A – All-Electric + EE:** Packages achieve positive compliance margins except -15 percent in CZ16, which has a higher space heating load than other climate zones. All packages are cost effective in all climate zones except CZ16.
- **3B – All-Electric + EE + PV + B:** Packages achieve positive compliance margins except -15 percent in CZ16. All packages are cost-effective from a TDV perspective in all climate zones. All packages are cost effective from an On-Bill perspective in all climate zones except in CZ 2 and CZ 16 in LADWP territory.
- **3C – All-Electric + HE:** Packages achieve between -26 percent and +2 percent compliance margins depending on climate zone. The only packages that are cost effective and with a positive compliance margin are in CZs 7-9 and 15. As described in Package 1C results, space heating is a relatively low proportion of energy costs in most climate zones, limiting the costs gains for higher efficiency equipment.

Figure 17. Cost Effectiveness for Medium Office Package 1A – Mixed-Fuel + EE

CZ	Utility	Elec Savings (kWh)	Gas Savings (therms)	GHG Reduc-tions (mtons)	Comp-liance Margin	Incremental Package Cost	Lifecycle Utility Cost Savings	$TDV Savings	B/C Ratio (On-bill)	B/C Ratio (TDV)	NPV (On-bill)	NPV (TDV)
Package 1A: Mixed Fuel + EE												
CZ01	PG&E	34,421	-808	4.5	18%	$66,649	$125,902	$71,307	1.9	1.1	$59,253	$4,658
CZ02	PG&E	40,985	-505	8.1	17%	$66,649	$163,655	$99,181	2.5	1.5	$97,005	$32,532
CZ03	PG&E	36,266	-463	7.0	20%	$66,649	$141,897	$84,051	2.1	1.3	$75,248	$17,401
CZ04	PG&E	40,590	-547	7.7	14%	$66,649	$162,139	$95,410	2.4	1.4	$95,489	$28,761
CZ04-2	CPAU	40,590	-547	7.7	14%	$66,649	$85,537	$95,410	1.3	1.4	$18,887	$28,761
CZ05	PG&E	38,888	-499	7.4	18%	$66,649	$154,044	$91,115	2.3	1.4	$87,395	$24,465
CZ05-2	SCG	38,888	-499	7.4	18%	$66,649	$156,315	$91,115	2.3	1.4	$89,665	$24,465
CZ06	SCE	39,579	-305	8.7	20%	$66,649	$86,390	$100,469	1.3	1.5	$19,741	$33,820
CZ06-2	LADWP	39,579	-305	8.7	20%	$66,649	$51,828	$100,469	0.8	1.5	($14,821)	$33,820
CZ07	SDG&E	41,817	-6	11.3	20%	$66,649	$204,394	$112,497	3.1	1.7	$137,745	$45,848
CZ08	SCE	41,637	-60	10.8	18%	$66,649	$89,783	$113,786	1.3	1.7	$23,134	$47,137
CZ08-2	LADWP	41,637	-60	10.8	18%	$66,649	$54,876	$113,786	0.8	1.7	($11,773)	$47,137
CZ09	SCE	42,539	-210	10.1	16%	$66,649	$95,636	$115,647	1.4	1.7	$28,987	$48,998
CZ09-2	LADWP	42,539	-210	10.1	16%	$66,649	$58,168	$115,647	0.9	1.7	($8,481)	$48,998
CZ10	SDG&E	41,857	-216	9.8	17%	$66,649	$210,303	$108,726	3.2	1.6	$143,654	$42,077
CZ10-2	SCE	41,857	-216	9.8	17%	$66,649	$92,736	$108,726	1.4	1.6	$26,087	$42,077
CZ11	PG&E	42,523	-390	9.1	13%	$66,649	$166,951	$104,001	2.5	1.6	$100,301	$37,352
CZ12	PG&E	41,521	-466	8.4	14%	$66,649	$161,594	$100,135	2.4	1.5	$94,945	$33,486
CZ12-2	SMUD	41,521	-466	8.4	14%	$66,649	$71,734	$100,135	1.1	1.5	$5,085	$33,486
CZ13	PG&E	42,898	-434	9.0	13%	$66,649	$169,107	$99,992	2.5	1.5	$102,457	$33,343
CZ14	SDG&E	42,224	-441	8.6	14%	$66,649	$211,529	$106,913	3.2	1.6	$144,880	$40,264
CZ14-2	SCE	42,224	-441	8.6	14%	$66,649	$95,809	$106,913	1.4	1.6	$29,160	$40,264
CZ15	SCE	45,723	-147	11.2	12%	$66,649	$102,714	$118,034	1.5	1.8	$36,065	$51,384
CZ16	PG&E	37,758	-736	5.8	14%	$66,649	$145,947	$79,755	2.2	1.2	$79,297	$13,106
CZ16-2	LADWP	37,758	-736	5.8	14%	$66,649	$40,115	$79,755	0.6	1.2	($26,534)	$13,106

Figure 18. Cost Effectiveness for Medium Office Package 1B – Mixed-Fuel + EE + PV + B

CZ	Utility	Elec Savings (kWh)	Gas Savings (therms)	GHG savings (mtons)	Comp-liance Margin (%)	Incremental Package Cost	Lifecycle Energy Cost Savings	$-TDV Savings	B/C Ratio (On-bill)	B/C Ratio (TDV)	NPV (On-bill)	NPV (TDV)
Mixed Fuel + PV + Battery												
CZ01	PG&E	211,225	-808	39.9	18%	$397,405	$645,010	$454,284	1.6	1.1	$247,605	$56,879
CZ02	PG&E	255,787	-505	50.6	17%	$397,405	$819,307	$573,033	2.1	1.4	$421,902	$175,628
CZ03	PG&E	245,421	-463	48.8	20%	$397,405	$777,156	$536,330	2.0	1.3	$379,751	$138,925
CZ04	PG&E	267,612	-547	52.7	14%	$397,405	$836,221	$597,471	2.1	1.5	$438,816	$200,066
CZ04-2	CPAU	267,612	-547	52.7	14%	$397,405	$621,879	$597,471	1.6	1.5	$224,474	$200,066
CZ05	PG&E	264,581	-499	52.5	18%	$397,405	$897,216	$578,856	2.3	1.5	$499,811	$181,451
CZ05-2	SCG	264,581	-499	52.5	18%	$397,405	$899,487	$578,856	2.3	1.5	$502,082	$181,451
CZ06	SCE	257,474	-305	52.1	20%	$397,405	$484,229	$594,416	1.2	1.5	$86,824	$197,011
CZ06-2	LA	257,474	-305	52.1	20%	$397,405	$282,360	$594,416	0.7	1.5	($115,045)	$197,011
CZ07	SDG&E	264,530	-6	55.7	20%	$397,405	$817,528	$610,548	2.1	1.5	$420,123	$213,143
CZ08	SCE	258,348	-60	54.0	18%	$397,405	$479,073	$625,249	1.2	1.6	$81,668	$227,844
CZ08-2	LA	258,348	-60	54.0	18%	$397,405	$275,704	$625,249	0.7	1.6	($121,701)	$227,844
CZ09	SCE	262,085	-210	54.3	16%	$397,405	$480,241	$622,528	1.2	1.6	$82,836	$225,123
CZ09-2	LA	262,085	-210	54.3	16%	$397,405	$282,209	$622,528	0.7	1.6	($115,196)	$225,123
CZ10	SDG&E	258,548	-216	53.4	17%	$397,405	$839,931	$595,323	2.1	1.5	$442,526	$197,918
CZ10-2	SCE	258,548	-216	53.4	17%	$397,405	$485,523	$595,323	1.2	1.5	$88,118	$197,918
CZ11	PG&E	253,623	-390	50.9	13%	$397,405	$826,076	$585,682	2.1	1.5	$428,671	$188,277
CZ12	PG&E	252,868	-466	50.3	14%	$397,405	$802,715	$582,866	2.0	1.5	$405,310	$185,461
CZ12-2	SMUD	252,868	-466	50.3	14%	$397,405	$415,597	$582,866	1.0	1.5	$18,192	$185,461
CZ13	PG&E	250,915	-434	50.4	13%	$397,405	$806,401	$573,606	2.0	1.4	$408,996	$176,201
CZ14	SDG&E	283,684	-441	56.4	14%	$397,405	$874,753	$676,271	2.2	1.7	$477,348	$278,866
CZ14-2	SCE	283,684	-441	56.4	14%	$397,405	$493,888	$676,271	1.2	1.7	$96,483	$278,866
CZ15	SCE	274,771	-147	56.0	12%	$397,405	$476,327	$640,379	1.2	1.6	$78,922	$242,974
CZ16	PG&E	266,490	-736	51.8	14%	$397,405	$842,205	$575,563	2.1	1.4	$444,800	$178,158
CZ16-2	LA	266,490	-736	51.8	14%	$397,405	$260,372	$575,563	0.7	1.4	($137,033)	$178,158

Figure 19. Cost Effectiveness for Medium Office Package 1C – Mixed-Fuel + HE

CZ	Utility	Elec Savings (kWh)	Gas Savings (therms)	GHG Reductions (mtons)	Comp-liance Margin	Incremental Package Cost	Lifecycle Utility Cost Savings	$TDV Savings	B/C Ratio (On-bill)	B/C Ratio (TDV)	NPV (On-bill)	NPV (TDV)
Package 1C: Mixed Fuel + HE												
CZ01	PG&E	288	688	4.1	3%	$61,253	$18,656	$12,314	0.3	0.2	($42,597)	($48,939)
CZ02	PG&E	3,795	550	4.3	4%	$68,937	$36,683	$24,676	0.5	0.4	($32,254)	($44,261)
CZ03	PG&E	1,241	439	2.9	3%	$57,529	$20,150	$11,885	0.4	0.2	($37,379)	($45,644)
CZ04	PG&E	5,599	529	4.7	5%	$72,074	$44,915	$30,928	0.6	0.4	($27,158)	($41,145)
CZ04-2	CPAU	5,599	529	4.7	5%	$72,074	$24,175	$30,928	0.3	0.4	($47,898)	($41,145)
CZ05	PG&E	3,470	453	3.6	4%	$60,330	$35,072	$18,232	0.6	0.3	($25,258)	($42,097)
CZ05-2	SCG	3,470	453	3.6	4%	$60,330	$32,777	$18,232	0.5	0.3	($27,553)	($42,097)
CZ06	SCE	3,374	298	2.6	3%	$55,594	$19,446	$16,132	0.3	0.3	($36,148)	($39,462)
CZ06-2	LADWP	3,374	298	2.6	3%	$55,594	$13,450	$16,132	0.2	0.3	($42,145)	($39,462)
CZ07	SDG&E	5,257	140	2.3	4%	$54,111	$41,086	$19,903	0.8	0.4	($13,025)	($34,208)
CZ08	SCE	5,921	176	2.7	4%	$60,497	$22,210	$24,055	0.4	0.4	($38,287)	($36,442)
CZ08-2	LADWP	5,921	176	2.7	4%	$60,497	$14,064	$24,055	0.2	0.4	($46,434)	($36,442)
CZ09	SCE	7,560	224	3.5	4%	$61,311	$28,576	$31,835	0.5	0.5	($32,735)	($29,476)
CZ09-2	LADWP	7,560	224	3.5	4%	$61,311	$18,262	$31,835	0.3	0.5	($43,049)	($29,476)
CZ10	SDG&E	5,786	288	3.2	4%	$62,685	$50,717	$24,628	0.8	0.4	($11,968)	($38,057)
CZ10-2	SCE	5,786	288	3.2	4%	$62,685	$24,575	$24,628	0.4	0.4	($38,110)	($38,057)
CZ11	PG&E	8,128	441	4.9	5%	$71,101	$54,188	$37,849	0.8	0.5	($16,912)	($33,252)
CZ12	PG&E	6,503	478	4.7	5%	$68,329	$47,329	$34,556	0.7	0.5	($20,999)	($33,773)
CZ12-2	SMUD	6,503	478	4.7	5%	$68,329	$24,003	$34,556	0.4	0.5	($44,325)	($33,773)
CZ13	PG&E	8,398	432	5.0	5%	$69,474	$51,347	$37,229	0.7	0.5	($18,128)	($32,246)
CZ14	SDG&E	7,927	470	5.0	5%	$69,463	$62,744	$37,133	0.9	0.5	($6,718)	($32,329)
CZ14-2	SCE	7,927	470	5.0	5%	$69,463	$32,517	$37,133	0.5	0.5	($36,946)	($32,329)
CZ15	SCE	15,140	219	5.5	5%	$66,702	$43,773	$52,359	0.7	0.8	($22,929)	($14,344)
CZ16	PG&E	3,111	912	6.3	5%	$71,765	$36,002	$24,914	0.5	0.3	($35,763)	($46,851)
CZ16-2	LADWP	3,111	912	6.3	5%	$71,765	$23,057	$24,914	0.3	0.3	($48,708)	($46,851)

Figure 20. Cost Effectiveness for Medium Office Package 2 – All-Electric Federal Code Minimum

CZ	Utility	Elec Savings (kWh)	Gas Savings (therms)	GHG Reductions (mtons)	Comp-liance Margin	Incremental Package Cost*	Lifecycle Utility Cost Savings	$TDV Savings	B/C Ratio (On-bill)	B/C Ratio (TDV)	NPV (On-bill)	NPV (TDV)
Package 2: All-Electric Federal Code Minimum												
CZ01	PG&E	-53,657	4967	10.1	-15%	($87,253)	($98,237)	($58,420)	0.9	1.5	($10,984)	$28,833
CZ02	PG&E	-49,684	3868	5.0	-7%	($73,695)	($101,605)	($41,429)	0.7	1.8	($27,910)	$32,266
CZ03	PG&E	-35,886	3142	5.6	-7%	($82,330)	($57,345)	($29,592)	1.4	2.8	$24,986	$52,738
CZ04	PG&E	-48,829	3759	4.7	-6%	($69,012)	($90,527)	($40,570)	0.8	1.7	($21,515)	$28,443
CZ04-2	CPAU	-48,829	3759	4.7	-6%	($69,012)	($19,995)	($40,570)	3.5	1.7	$49,018	$28,443
CZ05	PG&E	-40,531	3240	4.5	-8%	($84,503)	($63,663)	($39,997)	1.3	2.1	$20,840	$44,506
CZ06	SCE	-26,174	2117	3.1	-4%	($76,153)	$24,908	($20,571)	>1	3.7	$101,061	$55,581
CZ06-2	LADWP	-26,174	2117	3.1	-4%	($76,153)	$26,366	($20,571)	>1	3.7	$102,518	$55,581
CZ07	SDG&E	-12,902	950	0.9	-2%	($70,325)	$46,879	($11,407)	>1	6.2	$117,204	$58,918
CZ08	SCE	-15,680	1219	1.5	-2%	($68,774)	$17,859	($12,648)	>1	5.4	$86,633	$56,125
CZ08-2	LADWP	-15,680	1219	1.5	-2%	($68,774)	$18,603	($12,648)	>1	5.4	$87,376	$56,125
CZ09	SCE	-19,767	1605	2.4	-2%	($63,102)	$20,920	($14,462)	>1	4.4	$84,022	$48,640
CZ09-2	LADWP	-19,767	1605	2.4	-2%	($63,102)	$21,929	($14,462)	>1	4.4	$85,030	$48,640
CZ10	SDG&E	-27,414	2053	2.2	-4%	($47,902)	$38,918	($23,339)	>1	2.1	$86,820	$24,562
CZ10-2	SCE	-27,414	2053	2.2	-4%	($47,902)	$20,765	($23,339)	>1	2.1	$68,666	$24,562
CZ11	PG&E	-40,156	3062	3.6	-4%	($63,987)	($72,791)	($32,837)	0.9	1.9	($8,804)	$31,150
CZ12	PG&E	-43,411	3327	4.1	-5%	($68,343)	($85,856)	($35,463)	0.8	1.9	($17,512)	$32,880
CZ12-2	SMUD	-43,411	3327	4.1	-5%	($68,343)	($5,109)	($35,463)	13.4	1.9	$63,234	$32,880
CZ13	PG&E	-39,649	3063	3.8	-4%	($62,726)	($70,705)	($32,408)	0.9	1.9	($7,980)	$30,318
CZ14	SDG&E	-44,322	3266	3.4	-5%	($65,156)	$6,043	($38,422)	>1	1.7	$71,199	$26,735
CZ14-2	SCE	-44,322	3266	3.4	-5%	($65,156)	$4,798	($38,422)	>1	1.7	$69,954	$26,735
CZ15	SCE	-19,917	1537	1.8	-2%	($36,176)	$12,822	($15,464)	>1	2.3	$48,998	$20,711
CZ16	PG&E	-94,062	6185	5.6	-27%	($64,096)	($212,158)	($150,871)	0.3	0.4	($148,062)	($86,775)
CZ16-2	LADWP	-94,062	6185	5.6	-27%	($64,096)	$1,493	($150,871)	>1	0.4	$65,589	($86,775)

*The Incremental Package Cost is equal to the sum of the incremental HVAC and water heating equipment costs from Figure 10, the electrical infrastructure incremental cost of $27,802 (see section 3.3.2.1), and the natural gas infrastructure incremental costs of $(18,949) (see section 3.3.2.2).

Figure 21. Cost Effectiveness for Medium Office Package 3A – All-Electric + EE

CZ	Utility	Elec Savings (kWh)	Gas Savings (therms)	GHG Reductions (mtons)	Comp-liance Margin	Incremental Package Cost	Lifecycle Utility Cost Savings	$TDV Savings	B/C Ratio (On-bill)	B/C Ratio (TDV)	NPV (On-bill)	NPV (TDV)
Package 3A: All-Electric + EE												
CZ01	PG&E	-19,115	4967	19.4	7%	($20,604)	$20,630	$28,112	>1	>1	$41,234	$48,716
CZ02	PG&E	-11,811	3868	15.2	10%	($7,046)	$39,260	$58,563	>1	>1	$46,306	$65,609
CZ03	PG&E	2,530	3142	16.2	16%	($15,681)	$85,241	$68,682	>1	>1	$100,922	$84,363
CZ04	PG&E	-10,839	3759	14.8	9%	($2,363)	$59,432	$58,420	>1	>1	$61,795	$60,783
CZ04-2	CPAU	-10,839	3759	14.8	9%	($2,363)	$70,680	$58,420	>1	>1	$73,043	$60,783
CZ05	PG&E	-2,316	3240	14.6	12%	($17,854)	$85,380	$58,802	>1	>1	$103,234	$76,656
CZ06	SCE	15,399	2117	14.3	18%	($9,503)	$114,962	$89,921	>1	>1	$124,466	$99,425
CZ06-2	LADWP	15,399	2117	14.3	18%	($9,503)	$82,389	$89,921	>1	>1	$91,893	$99,425
CZ07	SDG&E	33,318	950	13.8	20%	($3,676)	$256,704	$111,399	>1	>1	$260,380	$115,076
CZ08	SCE	30,231	1219	14.2	18%	($2,124)	$110,144	$111,781	>1	>1	$112,268	$113,906
CZ08-2	LADWP	30,231	1219	14.2	18%	($2,124)	$76,069	$111,781	>1	>1	$78,194	$113,906
CZ09	SCE	24,283	1605	14.3	15%	$3,547	$119,824	$108,249	33.8	30.5	$116,277	$104,702
CZ09-2	LADWP	24,283	1605	14.3	15%	$3,547	$83,549	$108,249	23.6	30.5	$80,001	$104,702
CZ10	SDG&E	12,344	2053	12.6	13%	$18,748	$230,553	$82,905	12.3	4.4	$211,806	$64,158
CZ10-2	SCE	12,344	2053	12.6	13%	$18,748	$105,898	$82,905	5.6	4.4	$87,150	$64,158
CZ11	PG&E	929	3062	14.5	10%	$2,662	$85,988	$75,030	32.3	28.2	$83,326	$72,368
CZ12	PG&E	-3,419	3327	14.8	10%	($1,694)	$68,866	$69,589	>1	>1	$70,560	$71,283
CZ12-2	SMUD	-3,419	3327	14.8	10%	($1,694)	$71,761	$69,589	>1	>1	$73,455	$71,283
CZ13	PG&E	1,398	3063	14.8	9%	$3,923	$89,799	$71,307	22.9	18.2	$85,875	$67,384
CZ14	SDG&E	-5,469	3266	13.5	9%	$1,493	$206,840	$69,016	138.6	46.2	$205,347	$67,523
CZ14-2	SCE	-5,469	3266	13.5	9%	$1,493	$94,143	$69,016	63.1	46.2	$92,650	$67,523
CZ15	SCE	25,375	1537	13.7	10%	$30,474	$114,909	$104,335	3.8	3.4	$84,435	$73,862
CZ16	PG&E	-65,877	6185	12.7	-15%	$2,553	($91,477)	($85,673)	-35.8	-33.6	($94,030)	($88,226)
CZ16-2	LADWP	-65,877	6185	12.7	-15%	$2,553	$72,780	($85,673)	28.5	-33.6	$70,227	($88,226)

Figure 22. Cost Effectiveness for Medium Office Package 3B – All-Electric + EE + PV + B

CZ	IOU territory	Elec Savings (kWh)	Gas Savings (therms)	GHG savings (mtons)	Compliance Margin (%)	Incremental Package Cost	Lifecycle Energy Cost Savings	$-TDV Savings	B/C Ratio (On-bill)	B/C Ratio (TDV)	NPV (On-bill)	NPV (TDV)
All-Electric + PV + B												
CZ01	PG&E	157,733	4967	54.9	7%	$310,152	$518,421	$410,946	1.7	1.3	$208,269	$100,794
CZ02	PG&E	203,026	3868	57.8	10%	$323,710	$692,336	$532,273	2.1	1.6	$368,626	$208,563
CZ03	PG&E	211,706	3142	58.0	16%	$315,075	$708,235	$520,866	2.2	1.7	$393,160	$205,791
CZ04	PG&E	216,204	3759	59.9	9%	$328,393	$741,382	$560,576	2.3	1.7	$412,989	$232,183
CZ04-2	CPAU	216,204	3759	59.9	9%	$328,393	$607,074	$560,576	1.8	1.7	$278,681	$232,183
CZ05	PG&E	223,399	3240	59.8	12%	$312,902	$799,992	$546,592	2.6	1.7	$487,090	$233,690
CZ06	SCE	233,299	2117	57.7	18%	$321,252	$509,969	$583,963	1.6	1.8	$188,716	$262,711
CZ06-2	LA	233,299	2117	57.7	18%	$321,252	$311,931	$583,963	1.0	1.8	($9,322)	$262,711
CZ07	SDG&E	256,034	950	58.3	20%	$327,079	$870,156	$609,498	2.7	1.9	$543,076	$282,419
CZ08	SCE	246,944	1219	57.4	18%	$328,631	$499,506	$623,292	1.5	1.9	$170,874	$294,661
CZ08-2	LA	246,944	1219	57.4	18%	$328,631	$296,991	$623,292	0.9	1.9	($31,640)	$294,661
CZ09	SCE	243,838	1605	58.5	15%	$334,303	$504,498	$615,178	1.5	1.8	$170,195	$280,875
CZ09-2	LA	243,838	1605	58.5	15%	$334,303	$307,626	$615,178	0.9	1.8	($26,677)	$280,875
CZ10	SDG&E	229,044	2053	56.2	13%	$349,503	$851,810	$569,549	2.4	1.6	$502,306	$220,046
CZ10-2	SCE	229,044	2053	56.2	13%	$349,503	$491,383	$569,549	1.4	1.6	$141,880	$220,046
CZ11	PG&E	212,047	3062	56.4	10%	$333,418	$743,403	$556,758	2.2	1.7	$409,985	$223,340
CZ12	PG&E	207,955	3327	56.7	10%	$329,062	$713,054	$552,415	2.2	1.7	$383,993	$223,353
CZ12-2	SMUD	207,955	3327	56.7	10%	$329,062	$414,371	$552,415	1.3	1.7	$85,310	$223,353
CZ13	PG&E	209,431	3063	56.3	9%	$334,679	$728,822	$544,969	2.2	1.6	$394,143	$210,289
CZ14	SDG&E	236,002	3266	61.3	9%	$332,249	$865,181	$638,517	2.6	1.9	$532,933	$306,269
CZ14-2	SCE	236,002	3266	61.3	9%	$332,249	$488,163	$638,517	1.5	1.9	$155,914	$306,269
CZ15	SCE	254,426	1537	58.5	10%	$361,229	$487,715	$626,728	1.4	1.7	$126,486	$265,499
CZ16	PG&E	162,915	6185	58.6	-15%	$333,309	$580,353	$406,746	1.7	1.2	$247,044	$73,437
CZ16-2	LA	162,915	6185	58.6	-15%	$333,309	$290,566	$406,746	0.9	1.2	($42,742)	$73,437

Figure 23. Cost Effectiveness for Medium Office Package 3C – All-Electric + HE

CZ	Utility	Elec Savings (kWh)	Gas Savings (therms)	GHG Reductions (mtons)	Comp-liance Margin	Incremental Package Cost	Lifecycle Utility Cost Savings	$TDV Savings	B/C Ratio (On-bill)	B/C Ratio (TDV)	NPV (On-bill)	NPV (TDV)
Package 3C: All-Electric + HE												
CZ01	PG&E	-53,390	4967	10.2	-14%	($43,987)	($93,740)	($57,752)	0.5	0.8	($49,753)	($13,765)
CZ02	PG&E	-45,916	3868	6.1	-5%	($22,722)	($77,212)	($26,394)	0.3	0.9	($54,490)	($3,672)
CZ03	PG&E	-34,656	3142	6.0	-6%	($38,261)	($45,796)	($25,153)	0.8	1.5	($7,535)	$13,108
CZ04	PG&E	-43,248	3759	6.3	-3%	($15,229)	($56,932)	($18,996)	0.3	0.8	($41,703)	($3,767)
CZ04-2	CPAU	-43,248	3759	6.3	-3%	($15,229)	($5,298)	($18,996)	2.9	0.8	$9,932	($3,767)
CZ05	PG&E	-37,068	3240	5.4	-6%	($40,434)	($38,330)	($29,544)	1.1	1.4	$2,104	$10,890
CZ06	SCE	-22,805	2117	4.0	-2%	($30,237)	$39,812	($9,594)	>1	3.2	$70,050	$20,644
CZ06-2	LADWP	-22,805	2117	4.0	-2%	($30,237)	$35,414	($9,594)	>1	3.2	$65,651	$20,644
CZ07	SDG&E	-7,646	950	2.5	1%	($22,564)	$86,159	$6,062	>1	>1	$108,722	$28,625
CZ08	SCE	-9,761	1219	3.2	1%	($18,443)	$37,375	$8,305	>1	>1	$55,818	$26,748
CZ08-2	LADWP	-9,761	1219	3.2	1%	($18,443)	$29,973	$8,305	>1	>1	$48,416	$26,748
CZ09	SCE	-12,211	1605	4.5	2%	($10,282)	$46,335	$13,364	>1	>1	$56,617	$23,646
CZ09-2	LADWP	-12,211	1605	4.5	2%	($10,282)	$37,030	$13,364	>1	>1	$47,313	$23,646
CZ10	SDG&E	-21,642	2053	3.7	-1%	$11,340	$84,901	($3,818)	7.5	-0.3	$73,561	($15,158)
CZ10-2	SCE	-21,642	2053	3.7	-1%	$11,340	$40,659	($3,818)	3.6	-0.3	$29,319	($15,158)
CZ11	PG&E	-32,052	3062	5.9	0%	($8,519)	($29,013)	($3,007)	0.3	2.8	($20,495)	$5,512
CZ12	PG&E	-36,926	3327	6.0	-1%	($15,443)	($48,955)	($9,546)	0.3	1.6	($33,511)	$5,898
CZ12-2	SMUD	-36,926	3327	6.0	-1%	($15,443)	$9,916	($9,546)	>1	1.6	$25,359	$5,898
CZ13	PG&E	-31,253	3063	6.3	0%	($7,257)	($27,782)	($3,055)	0.3	2.4	($20,525)	$4,202
CZ14	SDG&E	-36,402	3266	5.7	-1%	($10,651)	$61,605	($9,832)	>1	1.1	$72,256	$819
CZ14-2	SCE	-36,402	3266	5.7	-1%	($10,651)	$30,625	($9,832)	>1	1.1	$41,276	$819
CZ15	SCE	-4,775	1537	6.0	3%	$28,927	$52,955	$32,790	1.8	1.1	$24,028	$3,863
CZ16	PG&E	-90,949	6185	6.5	-26%	($8,467)	($194,115)	($142,041)	0.0	0.1	($185,648)	($133,574)
CZ16-2	LADWP	-90,949	6185	6.5	-26%	($8,467)	$37,127	($142,041)	>1	0.1	$45,594	($133,574)

4.2 Cost Effectiveness Results – Medium Retail

Figure 24 through Figure 30 contain the cost-effectiveness findings for the Medium Retail packages. Notable findings for each package include:

- **1A – Mixed-Fuel + EE:**
  - Packages achieve +9% to +18% compliance margins depending on climate zone, and all packages are cost effective in all climate zones.
  - Incremental package costs vary across climate zones because of the HVAC system size in some climate zones are small enough (<54 kBtu/h) to have the economizers measure applied.
  - B/C ratios are high compared to other prototypes because the measures applied are primarily low-cost lighting measures. This suggests room for the inclusion of other energy efficiency measures with lower cost-effectiveness to achieve even higher compliance margins for a cost effective package.
- **1B – Mixed-Fuel + EE + PV + B:** All packages are cost effective using both the On-Bill and TDV approach, except On-Bill in LADWP territory. Adding PV and battery to the efficiency packages reduces the B/C ratio but increases overall NPV savings.
- **1C – Mixed-fuel + HE:** Packages achieve +1 to +4% compliance margins depending on climate zone, and packages are cost effective in all climate zones except CZs 1, 3 and 5 using the TDV approach.
- **2 – All-Electric Federal Code-Minimum Reference:**
  - Packages achieve between -12% and +1% compliance margins depending on climate zone.
  - Packages achieve positive savings using both the On-Bill and TDV approaches in CZs 6-10 and 14-15. Packages do not achieve On-Bill or TDV savings in most of PG&E territory (CZs 1, 2, 4, 5, 12-13, and 16).
  - Packages are cost effective in all climate zones except CZ16.
  - All incremental costs are negative primarily due to elimination of natural gas infrastructure.
- **3A – All-Electric + EE:** Packages achieve between +3% and +16% compliance margins depending on climate zone. All packages are cost effective in all climate zones.
- **3B – All-Electric + EE + PV + B:** All packages are cost effective using both the On-Bill and TDV approaches, except On-Bill in LADWP territory. Adding PV and Battery to the efficiency package reduces the B/C ratio but increases overall NPV savings.
- **3C – All-Electric + HE:** Packages achieve between -8% and +5% compliance margins depending on climate zone, and packages are cost effective using both On-Bill and TDV approaches in all CZs except CZs 1 and 16.

Figure 24. Cost Effectiveness for Medium Retail Package 1A – Mixed-Fuel + EE

CZ	Utility	Elec Savings (kWh)	Gas Savings (therms)	GHG Reductions (mtons)	Comp-liance Margin	Incremental Package Cost	Lifecycle Utility Cost Savings	$TDV Savings	B/C Ratio (On-bill)	B/C Ratio (TDV)	NPV (On-bill)	NPV (TDV)
Package 1A: Mixed Fuel + EE												
CZ01	PG&E	15,210	1209	11.10	18%	$2,712	$68,358	$60,189	25.2	22.2	$65,646	$57,478
CZ02	PG&E	18,885	613	8.73	13%	$5,569	$76,260	$59,135	13.7	10.6	$70,691	$53,566
CZ03	PG&E	18,772	462	7.87	16%	$5,569	$66,813	$57,135	12.0	10.3	$61,244	$51,566
CZ04	PG&E	19,100	439	7.84	14%	$5,569	$75,989	$58,036	13.6	10.4	$70,420	$52,467
CZ04-2	CPAU	19,100	439	7.84	14%	$5,569	$51,556	$58,036	9.3	10.4	$45,987	$52,467
CZ05	PG&E	17,955	415	7.41	16%	$5,569	$63,182	$55,003	11.3	9.9	$57,613	$49,435
CZ05-2	SCG	17,955	415	7.41	16%	$5,569	$61,810	$55,003	11.1	9.9	$56,241	$49,435
CZ06	SCE	12,375	347	5.54	10%	$2,712	$31,990	$41,401	11.8	15.3	$29,278	$38,689
CZ06-2	LADWP	12,375	347	5.54	10%	$2,712	$21,667	$41,401	8.0	15.3	$18,956	$38,689
CZ07	SDG&E	17,170	136	5.65	13%	$5,569	$73,479	$49,883	13.2	9.0	$67,910	$44,314
CZ08	SCE	12,284	283	5.15	10%	$2,712	$30,130	$41,115	11.1	15.2	$27,419	$38,403
CZ08-2	LADWP	12,284	283	5.15	10%	$2,712	$20,243	$41,115	7.5	15.2	$17,531	$38,403
CZ09	SCE	13,473	302	5.51	10%	$5,569	$32,663	$46,126	5.9	8.3	$27,094	$40,557
CZ09-2	LADWP	13,473	302	5.51	10%	$5,569	$22,435	$46,126	4.0	8.3	$16,866	$40,557
CZ10	SDG&E	19,873	267	6.99	12%	$5,569	$83,319	$58,322	15.0	10.5	$77,751	$52,753
CZ10-2	SCE	19,873	267	6.99	12%	$5,569	$39,917	$58,322	7.2	10.5	$34,348	$52,753
CZ11	PG&E	21,120	578	9.14	13%	$5,569	$86,663	$67,485	15.6	12.1	$81,095	$61,916
CZ12	PG&E	20,370	562	8.85	13%	$5,569	$81,028	$64,409	14.6	11.6	$75,459	$58,840
CZ12-2	SMUD	20,370	562	8.85	13%	$5,569	$44,991	$64,409	8.1	11.6	$39,422	$58,840
CZ13	PG&E	22,115	620	9.98	15%	$2,712	$109,484	$83,109	40.4	30.6	$106,772	$80,398
CZ14	SDG&E	25,579	406	9.38	13%	$2,712	$116,354	$80,055	42.9	29.5	$113,643	$77,343
CZ14-2	SCE	26,327	383	9.42	13%	$2,712	$57,290	$83,065	21.1	30.6	$54,578	$80,354
CZ15	SCE	26,433	169	8.35	12%	$2,712	$57,152	$79,506	21.1	29.3	$54,440	$76,794
CZ16	PG&E	15,975	752	8.72	13%	$2,712	$72,427	$55,025	26.7	20.3	$69,715	$52,314
CZ16-2	LADWP	15,975	752	8.72	13%	$2,712	$31,906	$55,025	11.8	20.3	$29,194	$52,314

Figure 25. Cost Effectiveness for Medium Retail Package 1B – Mixed-Fuel + EE + PV + B

CZ	IOU territory	Elec Savings (kWh)	Gas Savings (therms)	GHG savings (tons)	Compliance Margin (%)	Incremental Package Cost	Lifecycle Energy Cost Savings	$-TDV Savings	B/C Ratio (On-bill)	B/C Ratio (TDV)	NPV (On-bill)	NPV (TDV)
Mixed Fuel + PV + Battery												
CZ01	PG&E	158,584	1209	40.79	18%	$277,383	$509,092	$383,683	1.8	1.4	$231,709	$106,300
CZ02	PG&E	189,400	613	43.75	13%	$280,240	$590,043	$465,474	2.1	1.7	$309,803	$185,234
CZ03	PG&E	191,016	462	43.52	16%	$280,240	$578,465	$452,795	2.1	1.6	$298,224	$172,554
CZ04	PG&E	195,014	439	44.14	14%	$280,240	$605,369	$480,989	2.2	1.7	$325,129	$200,748
CZ04-2	CPAU	195,014	439	44.14	14%	$280,240	$451,933	$480,989	1.6	1.7	$171,693	$200,748
CZ05	PG&E	196,654	415	44.30	16%	$280,240	$589,771	$464,749	2.1	1.7	$309,530	$184,509
CZ05-2	SCG	196,654	415	44.30	16%	$280,240	$588,407	$464,749	2.1	1.7	$308,167	$184,509
CZ06	SCE	185,903	347	41.61	10%	$277,383	$322,495	$456,596	1.2	1.6	$45,111	$179,213
CZ06-2	LA	185,903	347	41.61	10%	$277,383	$191,428	$456,596	0.7	1.6	($85,955)	$179,213
CZ07	SDG&E	197,650	136	43.24	13%	$280,240	$496,786	$477,582	1.8	1.7	$216,545	$197,342
CZ08	SCE	187,869	283	41.48	10%	$277,383	$326,810	$478,132	1.2	1.7	$49,427	$200,749
CZ08-2	LA	187,869	283	41.48	10%	$277,383	$190,379	$478,132	0.7	1.7	($87,004)	$200,749
CZ09	SCE	191,399	302	42.32	10%	$280,240	$334,869	$472,770	1.2	1.7	$54,629	$192,530
CZ09-2	LA	191,399	302	42.32	10%	$280,240	$201,759	$472,770	0.7	1.7	($78,481)	$192,530
CZ10	SDG&E	200,033	267	44.01	12%	$280,240	$547,741	$472,880	2.0	1.7	$267,501	$192,640
CZ10-2	SCE	200,033	267	44.01	12%	$280,240	$340,822	$472,880	1.2	1.7	$60,582	$192,640
CZ11	PG&E	192,846	578	44.07	13%	$280,240	$582,969	$490,855	2.1	1.8	$302,728	$210,615
CZ12	PG&E	191,720	562	43.70	13%	$280,240	$586,836	$485,076	2.1	1.7	$306,596	$204,836
CZ12-2	SMUD	191,720	562	43.70	13%	$280,240	$319,513	$485,076	1.1	1.7	$39,273	$204,836
CZ13	PG&E	195,031	620	45.19	15%	$277,383	$605,608	$486,285	2.2	1.8	$328,225	$208,901
CZ14	SDG&E	217,183	406	47.86	13%	$277,383	$559,148	$534,915	2.0	1.9	$281,765	$257,532
CZ14-2	SCE	217,927	383	47.91	14%	$277,383	$354,757	$538,058	1.3	1.9	$77,373	$260,674
CZ15	SCE	208,662	169	44.51	12%	$277,383	$338,772	$496,107	1.2	1.8	$61,389	$218,724
CZ16	PG&E	210,242	752	48.76	13%	$277,383	$608,779	$490,262	2.2	1.8	$331,395	$212,879
CZ16-2	LA	210,242	752	48.76	13%	$277,383	$207,160	$490,262	0.7	1.8	($70,223)	$212,879

Figure 26. Cost Effectiveness for Medium Retail Package 1C – Mixed-Fuel + HE

CZ	Utility	Elec Savings (kWh)	Gas Savings (therms)	GHG Reductions (mtons)	Comp-liance Margin	Incremental Package Cost	Lifecycle Utility Cost Savings	$TDV Savings	B/C Ratio (On-bill)	B/C Ratio (TDV)	NPV (On-bill)	NPV (TDV)
Package 1C: Mixed Fuel + HE												
CZ01	PG&E	57	346	2.04	2%	$9,006	$6,301	$6,065	0.7	0.7	($2,705)	($2,941)
CZ02	PG&E	2,288	229	2.01	3%	$9,726	$23,016	$13,998	2.4	1.4	$13,291	$4,273
CZ03	PG&E	1,087	171	1.31	2%	$9,063	$6,782	$7,186	0.7	0.8	($2,282)	($1,877)
CZ04	PG&E	1,862	159	1.46	3%	$9,004	$17,891	$10,878	2.0	1.2	$8,887	$1,874
CZ04-2	CPAU	1,862	159	1.46	3%	$9,004	$7,821	$10,878	0.9	1.2	($1,182)	$1,874
CZ05	PG&E	664	162	1.11	1%	$9,454	$5,119	$4,725	0.5	0.5	($4,335)	($4,729)
CZ05-2	SCG	664	162	1.11	1%	$9,454	$4,558	$4,725	0.5	0.5	($4,896)	($4,729)
CZ06	SCE	2,648	90	1.24	3%	$8,943	$11,646	$11,427	1.3	1.3	$2,703	$2,484
CZ06-2	LADWP	2,648	90	1.24	3%	$8,943	$7,329	$11,427	0.8	1.3	($1,614)	$2,484
CZ07	SDG&E	2,376	49	0.95	2%	$9,194	$20,103	$9,779	2.2	1.1	$10,909	$585
CZ08	SCE	2,822	72	1.20	3%	$9,645	$11,989	$12,877	1.2	1.3	$2,344	$3,233
CZ08-2	LADWP	2,822	72	1.20	3%	$9,645	$7,427	$12,877	0.8	1.3	($2,218)	$3,233
CZ09	SCE	4,206	88	1.73	4%	$10,446	$16,856	$18,745	1.6	1.8	$6,410	$8,299
CZ09-2	LADWP	4,206	88	1.73	4%	$10,446	$10,604	$18,745	1.0	1.8	$158	$8,299
CZ10	SDG&E	4,226	119	1.88	4%	$9,514	$36,412	$19,008	3.8	2.0	$26,898	$9,494
CZ10-2	SCE	4,226	119	1.88	4%	$9,514	$17,094	$19,008	1.8	2.0	$7,580	$9,494
CZ11	PG&E	4,188	225	2.56	4%	$10,479	$31,872	$22,393	3.0	2.1	$21,392	$11,913
CZ12	PG&E	3,675	214	2.34	4%	$10,409	$29,653	$20,525	2.8	2.0	$19,243	$10,115
CZ12-2	SMUD	3,675	214	2.34	4%	$10,409	$12,823	$20,525	1.2	2.0	$2,414	$10,115
CZ13	PG&E	4,818	180	2.46	4%	$9,809	$34,149	$23,623	3.5	2.4	$24,340	$13,814
CZ14	SDG&E	6,439	153	2.71	4%	$12,103	$44,705	$26,348	3.7	2.2	$32,601	$14,245
CZ14-2	SCE	6,439	153	2.71	4%	$12,103	$22,032	$26,348	1.8	2.2	$9,929	$14,245
CZ15	SCE	8,802	48	2.76	5%	$12,534	$25,706	$31,402	2.1	2.5	$13,171	$18,868
CZ16	PG&E	2,316	390	2.97	3%	$11,999	$22,663	$13,888	1.9	1.2	$10,665	$1,890
CZ16-2	LADWP	2,316	390	2.97	3%	$11,999	$11,921	$13,888	1.0	1.2	($78)	$1,890

Figure 27. Cost Effectiveness for Medium Retail Package 2 – All-Electric Federal Code Minimum

CZ	Utility	Elec Savings (kWh)	Gas Savings (therms)	GHG Reductions (mtons)	Comp-liance Margin	Incremental Package Cost*	Lifecycle Utility Cost Savings	$TDV Savings	B/C Ratio (On-bill)	B/C Ratio (TDV)	NPV (On-bill)	NPV (TDV)
Package 2: All-Electric Federal Code Minimum												
CZ01	PG&E	-29,155	3893	13.85	-4.1%	($23,048)	($8,333)	($13,910)	2.8	1.7	$14,715	$9,138
CZ02	PG&E	-21,786	2448	7.49	-1.0%	($27,464)	($16,476)	($4,483)	1.7	6.1	$10,987	$22,981
CZ03	PG&E	-14,583	1868	6.26	-0.4%	($24,111)	$263	($1,450)	>1	16.6	$24,374	$22,661
CZ04	PG&E	-14,186	1706	5.30	-0.1%	($22,896)	($8,753)	($220)	2.6	104.2	$14,143	$22,676
CZ04-2	CPAU	-14,186	1706	5.30	-0.1%	($22,896)	$12,493	($220)	>1	104.2	$35,389	$22,676
CZ05	PG&E	-14,334	1746	5.47	-1.2%	($25,507)	($1,567)	($4,197)	16.3	6.1	$23,940	$21,309
CZ06	SCE	-7,527	1002	3.32	0.5%	($21,762)	$18,590	$1,868	>1	>1	$40,351	$23,630
CZ06-2	LADWP	-7,527	1002	3.32	0.5%	($21,762)	$19,309	$1,868	>1	>1	$41,071	$23,630
CZ07	SDG&E	-3,812	522	1.76	0.3%	($23,762)	$54,345	$1,318	>1	>1	$78,107	$25,080
CZ08	SCE	-5,805	793	2.70	0.4%	($26,922)	$16,735	$1,846	>1	>1	$43,658	$28,768
CZ08-2	LADWP	-5,805	793	2.70	0.4%	($26,922)	$17,130	$1,846	>1	>1	$44,052	$28,768
CZ09	SCE	-7,241	970	3.32	0.4%	($32,113)	$18,582	$1,978	>1	>1	$50,695	$34,091
CZ09-2	LADWP	-7,241	970	3.32	0.4%	($32,113)	$19,089	$1,978	>1	>1	$51,202	$34,091
CZ10	SDG&E	-10,336	1262	3.99	0.1%	($27,272)	$54,453	$505	>1	>1	$81,724	$27,777
CZ10-2	SCE	-10,336	1262	3.99	0.1%	($27,272)	$20,996	$505	>1	>1	$48,268	$27,777
CZ11	PG&E	-19,251	2415	7.95	0.5%	($32,202)	($7,951)	$2,615	4.1	>1	$24,251	$34,817
CZ12	PG&E	-19,471	2309	7.28	-0.1%	($32,504)	($14,153)	($461)	2.3	70.4	$18,351	$32,042
CZ12-2	SMUD	-19,471	2309	7.28	-0.1%	($32,504)	$12,939	($461)	>1	70.4	$45,443	$32,042
CZ13	PG&E	-16,819	1983	6.15	-0.4%	($28,158)	($10,575)	($2,022)	2.7	13.9	$17,582	$26,136
CZ14	SDG&E	-13,208	1672	5.44	0.7%	($26,656)	$41,117	$4,461	>1	>1	$67,772	$31,117
CZ14-2	SCE	-13,208	1672	5.44	0.7%	($26,656)	$18,467	$4,461	>1	>1	$45,123	$31,117
CZ15	SCE	-2,463	518	2.14	0.9%	($29,544)	$16,796	$5,823	>1	>1	$46,339	$35,367
CZ16	PG&E	-41,418	4304	13.23	-12.2%	($25,771)	($49,862)	($52,542)	0.5	0.5	($24,091)	($26,771)
CZ16-2	LADWP	-41,418	4304	13.23	-12.2%	($25,771)	$39,319	($52,542)	>1	0.5	$65,090	($26,771)

* The Incremental Package Cost is the addition of the incremental HVAC and water heating equipment costs from Figure 11 and the natural gas infrastructure incremental cost savings of $28,027 (see section 3.3.2.2).

Figure 28. Cost Effectiveness for Medium Retail Package 3A – All-Electric + EE

CZ	Utility	Elec Savings (kWh)	Gas Savings (therms)	GHG Reductions (mtons)	Comp-liance Margin	Incremental Package Cost	Lifecycle Utility Cost Savings	$TDV Savings	B/C Ratio (On-bill)	B/C Ratio (TDV)	NPV (On-bill)	NPV (TDV)
Package 3A: All-Electric + EE												
CZ01	PG&E	-5,478	3893	20.64	15%	($20,336)	$63,593	$51,224	>1	>1	$83,929	$71,560
CZ02	PG&E	2,843	2448	14.58	13%	($21,895)	$74,997	$56,893	>1	>1	$96,892	$78,788
CZ03	PG&E	7,791	1868	12.73	16%	($18,542)	$68,968	$56,586	>1	>1	$87,511	$75,128
CZ04	PG&E	8,572	1706	11.89	14%	($17,327)	$81,957	$57,904	>1	>1	$99,284	$75,231
CZ04-2	CPAU	8,572	1706	11.89	14%	($17,327)	$63,082	$57,904	>1	>1	$80,408	$75,231
CZ05	PG&E	6,973	1746	11.68	15%	($19,938)	$63,677	$51,949	>1	>1	$83,615	$71,887
CZ06	SCE	7,431	1002	7.72	11%	($19,050)	$47,072	$42,610	>1	>1	$66,122	$61,660
CZ06-2	LADWP	7,431	1002	7.72	11%	($19,050)	$37,078	$42,610	>1	>1	$56,128	$61,660
CZ07	SDG&E	14,350	522	6.98	13%	($18,193)	$127,461	$50,828	>1	>1	$145,654	$69,021
CZ08	SCE	8,524	793	6.90	10%	($24,210)	$43,679	$42,258	>1	>1	$67,890	$66,468
CZ08-2	LADWP	8,524	793	6.90	10%	($24,210)	$34,038	$42,258	>1	>1	$58,248	$66,468
CZ09	SCE	8,403	970	7.81	10%	($26,545)	$47,819	$47,356	>1	>1	$74,364	$73,901
CZ09-2	LADWP	8,403	970	7.81	10%	($26,545)	$37,934	$47,356	>1	>1	$64,478	$73,901
CZ10	SDG&E	11,737	1262	10.23	12%	($21,703)	$137,436	$58,761	>1	>1	$159,139	$80,464
CZ10-2	SCE	11,737	1262	10.23	12%	($21,703)	$58,257	$58,761	>1	>1	$79,959	$80,464
CZ11	PG&E	5,892	2415	15.13	12%	($26,633)	$85,256	$65,859	>1	>1	$111,889	$92,492
CZ12	PG&E	5,548	2309	14.46	12%	($26,935)	$80,631	$63,903	>1	>1	$107,566	$90,838
CZ12-2	SMUD	5,548	2309	14.46	12%	($26,935)	$59,311	$63,903	>1	>1	$86,246	$90,838
CZ13	PG&E	10,184	1983	14.15	14%	($25,446)	$110,105	$80,604	>1	>1	$135,551	$106,050
CZ14	SDG&E	16,583	1672	13.83	15%	($23,944)	$171,200	$88,471	>1	>1	$195,145	$112,415
CZ14-2	SCE	16,583	1672	13.83	15%	($23,944)	$656,178	$159,604	>1	>1	$680,122	$183,548
CZ15	SCE	23,642	518	9.44	12%	($26,832)	$65,573	$76,781	>1	>1	$92,404	$103,612
CZ16	PG&E	-18,232	4304	19.80	3%	($23,059)	$38,796	$14,152	>1	>1	$61,855	$37,211
CZ16-2	LADWP	-18,232	4304	19.80	3%	($23,059)	$67,793	$14,152	>1	>1	$90,852	$37,211

Figure 29. Cost Effectiveness for Medium Retail Package 3B – All-Electric + EE + PV + B

CZ	IOU territory	Elec Savings (kWh)	Gas Savings (therms)	GHG savings (tons)	Compliance Margin (%)	Incremental Package Cost	Lifecycle Energy Cost Savings	$-TDV Savings	B/C Ratio (On-bill)	B/C Ratio (TDV)	NPV (On-bill)	NPV (TDV)
All-Electric + PV + B												
CZ01	PG&E	137,956	3893	50.51	15%	$254,335	$510,831	$374,432	2.0	1.5	$256,496	$120,097
CZ02	PG&E	173,387	2448	49.87	13%	$252,777	$590,112	$463,431	2.3	1.8	$337,336	$210,654
CZ03	PG&E	180,055	1868	48.55	16%	$256,129	$585,861	$452,399	2.3	1.8	$329,732	$196,270
CZ04	PG&E	184,499	1706	48.38	14%	$257,345	$608,814	$481,011	2.4	1.9	$351,470	$223,666
CZ04-2	CPAU	184,499	1706	48.38	14%	$257,345	$465,690	$481,011	1.8	1.9	$208,345	$223,666
CZ05	PG&E	185,690	1746	48.84	15%	$254,734	$600,933	$461,804	2.4	1.8	$346,199	$207,071
CZ06	SCE	180,968	1002	43.91	11%	$255,621	$335,909	$457,959	1.3	1.8	$80,288	$202,337
CZ06-2	LADWP	180,968	1002	43.91	11%	$255,621	$206,021	$457,959	0.8	1.8	($49,601)	$202,337
CZ07	SDG&E	194,837	522	44.67	13%	$256,478	$550,714	$478,637	2.1	1.9	$294,236	$222,159
CZ08	SCE	184,120	793	43.32	10%	$250,461	$340,301	$479,406	1.4	1.9	$89,840	$228,945
CZ08-2	LADWP	184,120	793	43.32	10%	$250,461	$203,813	$479,406	0.8	1.9	($46,648)	$228,945
CZ09	SCE	186,346	970	44.77	10%	$248,127	$349,524	$474,176	1.4	1.9	$101,397	$226,049
CZ09-2	LADWP	186,346	970	44.77	10%	$248,127	$216,654	$474,176	0.9	1.9	($31,473)	$226,049
CZ10	SDG&E	191,923	1262	47.46	12%	$252,969	$593,514	$473,605	2.3	1.9	$340,545	$220,636
CZ10-2	SCE	191,923	1262	47.46	12%	$252,969	$356,958	$473,605	1.4	1.9	$103,989	$220,636
CZ11	PG&E	177,639	2415	50.26	12%	$248,039	$585,689	$489,317	2.4	2.0	$337,650	$241,278
CZ12	PG&E	176,919	2309	49.46	12%	$247,736	$591,104	$484,702	2.4	2.0	$343,368	$236,966
CZ12-2	SMUD	176,919	2309	49.46	12%	$247,736	$335,286	$484,702	1.4	2.0	$87,550	$236,966
CZ13	PG&E	183,129	1983	49.48	14%	$249,226	$608,560	$483,670	2.4	1.9	$359,334	$234,444
CZ14	SDG&E	208,183	1672	52.54	15%	$250,727	$593,232	$544,079	2.4	2.2	$342,505	$293,351
CZ14-2	SCE	264,589	1672	80.97	15%	$250,727	$656,178	$580,403	2.6	2.3	$405,450	$329,676
CZ15	SCE	205,869	518	45.67	12%	$247,840	$347,125	$493,339	1.4	2.0	$99,285	$245,499
CZ16	PG&E	176,114	4304	60.13	3%	$251,612	$567,822	$446,795	2.3	1.8	$316,210	$195,183
CZ16-2	LADWP	176,114	4304	60.13	3%	$251,612	$241,757	$446,795	1.0	1.8	($9,856)	$195,183

Figure 30. Cost Effectiveness for Medium Retail Package 3C – All-Electric + HE

CZ	Utility	Elec Savings (kWh)	Gas Savings (therms)	GHG Reductions (mtons)	Comp-liance Margin	Incremental Package Cost	Lifecycle Utility Cost Savings	$TDV Savings	B/C Ratio (On-bill)	B/C Ratio (TDV)	NPV (On-bill)	NPV (TDV)
Package 3C: All-Electric + HE												
CZ01	PG&E	-26,199	3893	14.76	-2%	($587)	$369	($5,757)	>1	0.1	$956	($5,170)
CZ02	PG&E	-16,989	2448	8.95	3%	($4,211)	$12,323	$11,251	>1	>1	$16,534	$15,463
CZ03	PG&E	-11,703	1868	7.15	2%	($2,213)	$9,159	$6,944	>1	>1	$11,372	$9,157
CZ04	PG&E	-10,675	1706	6.37	3%	($316)	$14,317	$11,383	>1	>1	$14,633	$11,700
CZ04-2	CPAU	-10,675	1706	6.37	3%	($316)	$20,599	$11,383	>1	>1	$20,915	$11,700
CZ05	PG&E	-11,969	1746	6.19	1%	($2,298)	$5,592	$1,824	>1	>1	$7,890	$4,122
CZ06	SCE	-3,919	1002	4.35	3%	$1,418	$29,751	$13,734	21.0	9.7	$28,333	$12,316
CZ06-2	LADWP	-3,919	1002	4.35	3%	$1,418	$25,891	$13,734	18.3	9.7	$24,473	$12,316
CZ07	SDG&E	-955	522	2.59	3%	($710)	$74,518	$11,229	>1	>1	$75,227	$11,939
CZ08	SCE	-2,224	793	3.74	4%	($3,719)	$28,067	$15,075	>1	>1	$31,785	$18,793
CZ08-2	LADWP	-2,224	793	3.74	4%	($3,719)	$23,848	$15,075	>1	>1	$27,566	$18,793
CZ09	SCE	-2,089	970	4.84	4%	($8,268)	$34,648	$21,162	>1	>1	$42,916	$29,430
CZ09-2	LADWP	-2,089	970	4.84	4%	($8,268)	$28,837	$21,162	>1	>1	$37,105	$29,430
CZ10	SDG&E	-4,868	1262	5.58	4%	($5,222)	$91,136	$20,041	>1	>1	$96,358	$25,263
CZ10-2	SCE	-4,868	1262	5.58	4%	($5,222)	$37,200	$20,041	>1	>1	$42,422	$25,263
CZ11	PG&E	-12,651	2415	9.95	5%	($8,217)	$29,015	$26,172	>1	>1	$37,232	$34,389
CZ12	PG&E	-13,479	2309	9.10	4%	($9,239)	$20,839	$21,228	>1	>1	$30,078	$30,466
CZ12-2	SMUD	-13,479	2309	9.10	4%	($9,239)	$26,507	$21,228	>1	>1	$35,746	$30,466
CZ13	PG&E	-9,935	1983	8.23	4%	($4,975)	$30,123	$24,063	>1	>1	$35,097	$29,037
CZ14	SDG&E	-5,407	1672	7.71	5%	$121	$88,669	$31,029	732.5	256.3	$88,547	$30,908
CZ14-2	SCE	-5,407	1672	7.71	5%	$121	$40,709	$31,029	336.3	256.3	$40,588	$30,908
CZ15	SCE	6,782	518	4.77	6%	($2,508)	$42,238	$37,379	>1	>1	$44,745	$39,887
CZ16	PG&E	-35,297	4304	15.03	-8%	$1,102	($21,384)	($33,754)	-19.4	-30.6	($22,486)	($34,856)
CZ16-2	LADWP	-35,297	4304	15.03	-8%	$1,102	$48,625	($33,754)	44.1	-30.6	$47,523	($34,856)

4.3 Cost Effectiveness Results – Small Hotel

The following issues must be considered when reviewing the Small Hotel results:

- The Small Hotel is a mix of residential and nonresidential space types, which results in different occupancy and load profiles than the office and retail prototypes.
- A potential laundry load has not been examined for the Small Hotel. The Reach Code Team attempted to characterize and apply the energy use intensity of laundry loads in hotels but did not find readily available data for use. Thus, cost effectiveness including laundry systems has not been examined.
- Contrary to the office and retail prototypes, the Small Hotel baseline water heater is a central gas storage type. Current compliance software cannot model central heat pump water heater systems with recirculation serving guest rooms.[23] The only modeling option for heat pump water heating is individual water heaters at each guest room even though this is a very uncommon configuration. TRC modeled individual heat pump water heaters but as a proxy for central heat pump water heating performance, but integrated costs associated with tank and controls for central heat pump water heating into cost effectiveness calculations.
- Assuming central heat pump water heating also enabled the inclusion of a solar hot water thermal collection system, which was a key efficiency measure to achieving compliance in nearly all climate zones.

Figure 31 through Figure 37 contain the cost-effectiveness findings for the Small Hotel packages. Notable findings for each package include:

- **1A – Mixed-Fuel + EE:**
  - Packages achieve +3 to +10% compliance margins depending on climate zone.
  - Packages are cost effective using either the On-Bill or TDV approach in all CZs except 12 (using SMUD rates), 14 (using SCE rates), and 15 (with SCE rates).
  - The hotel is primarily guest rooms with a smaller proportion of nonresidential space. Thus, the inexpensive VAV minimum flow measure and lighting measures that have been applied to the entirety of the Medium Office and Medium Retail prototypes have a relatively small impact in the Small Hotel.[24]
- **1B – Mixed-Fuel + EE + PV + B:** Packages are cost effective using either the On-Bill or TDV approach in all CZs. Solar PV generally increases cost effectiveness compared to efficiency-only, particularly when using an NPV metric.
- **1C – Mixed-Fuel + HE:** Packages achieve +2 to +5% compliance margins depending on climate zone. The package is cost effective using the On-Bill approach in a minority of climate zones, and cost effective using TDV approach only in CZ15.

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[23] The IOUs and CEC are actively working on including central heat pump water heater modeling with recirculation systems in early 2020.

[24] Title 24 requires that hotel/motel guest room lighting design comply with the residential lighting standards, which are all mandatory and are not awarded compliance credit for improved efficacy.

- **2 – All-Electric Federal Code-Minimum Reference:**
  - This all-electric design does not comply with the Energy Commission's TDV performance budget. Packages achieve between -50% and -4% compliance margins depending on climate zone. This may be because the modeled HW system is constrained to having an artificially low efficiency to avoid triggering federal pre-emption, and the heat pump space heating systems must operate overnight when operation is less efficient.
  - All packages are cost effective in all climate zones.
- **3A – All-Electric + EE:** Packages achieve positive compliance margins in all CZs ranging from 0% to +17%, except CZ16 which had a -18% compliance margin. All packages are cost effective in all climate zones. The improved degree of cost effectiveness outcomes in Package 3A compared to Package 1A appear to be due to the significant incremental package cost savings.
- **3B – All-Electric + EE + PV + B:** All packages are cost effective. Packages improve in B/C ratio when compared to 3A and increase in magnitude of overall NPV savings. PV appears to be more cost-effective with higher building electricity loads.
- **3C – All-Electric + HE:**
  - Packages do not comply with Title 24 in all CZs except CZ15 which resulted in a +0.04% compliance margin.
  - All packages are cost effective.

Figure 31. Cost Effectiveness for Small Hotel Package 1A – Mixed-Fuel + EE

CZ	Utility	Elec Savings (kWh)	Gas Savings (therms)	GHG Reductions (mtons)	Comp-liance Margin	Incremental Package Cost	Lifecycle Utility Cost Savings	$TDV Savings	B/C Ratio (On-bill)	B/C Ratio (TDV)	NPV (On-bill)	NPV (TDV)
Package 1A: Mixed Fuel + EE												
CZ01	PG&E	3,855	1288	5.65	9%	$20,971	$34,339	$36,874	1.6	1.8	$13,368	$15,903
CZ02	PG&E	3,802	976	3.91	7%	$20,971	$26,312	$29,353	1.3	1.4	$5,341	$8,381
CZ03	PG&E	4,153	1046	4.48	10%	$20,971	$31,172	$35,915	1.5	1.7	$10,201	$14,944
CZ04	PG&E	5,007	395	0.85	6%	$21,824	$24,449	$24,270	1.1	1.1	$2,625	$2,446
CZ04-2	CPAU	4,916	422	0.98	6%	$21,824	$18,713	$24,306	0.9	1.1	($3,111)	$2,483
CZ05	PG&E	3,530	1018	4.13	9%	$20,971	$28,782	$34,448	1.4	1.6	$7,810	$13,477
CZ05-2	SCG	3,530	1018	4.13	9%	$20,971	$23,028	$34,448	1.1	1.6	$2,057	$13,477
CZ06	SCE	5,137	418	1.16	8%	$21,824	$16,001	$26,934	0.7	1.2	($5,823)	$5,110
CZ06-2	LADWP	5,137	418	1.16	8%	$21,824	$11,706	$26,934	0.5	1.2	($10,118)	$5,110
CZ07	SDG&E	5,352	424	1.31	8%	$21,824	$26,699	$27,975	1.2	1.3	$4,876	$6,152
CZ08	SCE	5,151	419	1.21	7%	$21,824	$15,931	$23,576	0.7	1.1	($5,893)	$1,752
CZ08-2	LADWP	5,151	419	1.21	7%	$21,824	$11,643	$23,576	0.5	1.1	($10,180)	$1,752
CZ09	SCE	5,229	406	1.16	6%	$21,824	$15,837	$22,365	0.7	1.0	($5,987)	$541
CZ09-2	LADWP	5,229	406	1.16	6%	$21,824	$11,632	$22,365	0.5	1.0	($10,192)	$541
CZ10	SDG&E	4,607	342	0.92	5%	$21,824	$25,506	$22,219	1.2	1.0	$3,683	$396
CZ10-2	SCE	4,607	342	0.92	5%	$21,824	$13,868	$22,219	0.6	1.0	($7,956)	$396
CZ11	PG&E	4,801	325	0.87	4%	$21,824	$22,936	$19,503	1.1	0.9	$1,112	($2,321)
CZ12	PG&E	5,276	327	0.90	5%	$21,824	$22,356	$21,305	1.0	0.98	$532	($519)
CZ12-2	SMUD	5,276	327	0.90	5%	$21,824	$15,106	$21,305	0.7	0.98	($6,717)	($519)
CZ13	PG&E	4,975	310	0.87	4%	$21,824	$23,594	$19,378	1.1	0.9	$1,770	($2,445)
CZ14	SDG&E	4,884	370	0.82	4%	$21,824	$24,894	$21,035	1.1	0.96	$3,070	($789)
CZ14-2	SCE	4,884	370	0.82	4%	$21,824	$14,351	$21,035	0.7	0.96	($7,473)	($789)
CZ15	SCE	5,187	278	1.23	3%	$21,824	$13,645	$18,089	0.6	0.8	($8,178)	($3,735)
CZ16	PG&E	2,992	1197	4.95	6%	$20,971	$27,813	$30,869	1.3	1.5	$6,842	$9,898
CZ16-2	LADWP	2,992	1197	4.95	6%	$20,971	$19,782	$30,869	0.9	1.5	($1,190)	$9,898

Figure 32. Cost Effectiveness for Small Hotel Package 1B – Mixed-Fuel + EE + PV + B

CZ	Utility	Elec Savings (kWh)	Gas Savings (therms)	GHG Reductions (mtons)	Comp-liance Margin	Incremental Package Cost	Lifecycle Utility Cost Savings	$TDV Savings	B/C Ratio (On-bill)	B/C Ratio (TDV)	NPV (On-bill)	NPV (TDV)
Package 1B: Mixed Fuel + EE + PV + B												
CZ01	PG&E	107,694	1288	28.73	9%	$228,341	$366,509	$295,731	1.6	1.3	$138,168	$67,390
CZ02	PG&E	130,144	976	31.14	7%	$228,341	$359,248	$336,575	1.6	1.5	$130,907	$108,233
CZ03	PG&E	129,107	1046	31.57	10%	$228,341	$430,737	$335,758	1.9	1.5	$202,396	$107,416
CZ04	PG&E	132,648	395	28.46	6%	$229,194	$355,406	$338,455	1.6	1.5	$126,212	$109,262
CZ04-2	CPAU	132,556	422	28.59	6%	$229,194	$322,698	$338,492	1.4	1.5	$93,504	$109,298
CZ05	PG&E	136,318	1018	32.73	9%	$228,341	$452,611	$352,342	2.0	1.5	$224,269	$124,001
CZ05-2	SCG	136,318	1018	32.73	9%	$228,341	$446,858	$352,342	2.0	1.5	$218,516	$124,001
CZ06	SCE	131,051	418	28.47	8%	$229,194	$217,728	$336,843	0.9	1.5	($11,466)	$107,649
CZ06-2	LADWP	131,051	418	28.47	8%	$229,194	$131,052	$336,843	0.6	1.5	($98,142)	$107,649
CZ07	SDG&E	136,359	424	29.63	8%	$229,194	$306,088	$345,378	1.3	1.5	$76,894	$116,184
CZ08	SCE	132,539	419	28.85	7%	$229,194	$227,297	$353,013	1.0	1.5	($1,897)	$123,819
CZ08-2	LADWP	132,539	419	28.85	7%	$229,194	$134,739	$353,013	0.6	1.5	($94,455)	$123,819
CZ09	SCE	131,422	406	28.82	6%	$229,194	$230,791	$343,665	1.0	1.5	$1,597	$114,471
CZ09-2	LADWP	131,422	406	28.82	6%	$229,194	$136,024	$343,665	0.6	1.5	($93,170)	$114,471
CZ10	SDG&E	134,146	342	29.05	5%	$229,194	$339,612	$342,574	1.5	1.5	$110,418	$113,380
CZ10-2	SCE	134,146	342	29.05	5%	$229,194	$226,244	$342,574	1.0	1.5	($2,949)	$113,380
CZ11	PG&E	128,916	325	27.62	4%	$229,194	$352,831	$337,208	1.5	1.5	$123,637	$108,014
CZ12	PG&E	131,226	327	28.04	5%	$229,194	$425,029	$338,026	1.9	1.5	$195,835	$108,832
CZ12-2	SMUD	131,226	327	28.04	5%	$229,194	$213,176	$338,026	0.9	1.5	($16,018)	$108,832
CZ13	PG&E	127,258	310	27.33	4%	$229,194	$351,244	$324,217	1.5	1.4	$122,050	$95,023
CZ14	SDG&E	147,017	370	30.96	4%	$229,194	$861,445	$217,675	3.8	0.9	$632,251	($11,518)
CZ14-2	SCE	147,017	370	30.96	4%	$229,194	$244,100	$381,164	1.1	1.7	$14,906	$151,970
CZ15	SCE	137,180	278	29.12	3%	$229,194	$225,054	$348,320	1.0	1.5	($4,140)	$119,127
CZ16	PG&E	141,478	1197	34.60	6%	$228,341	$377,465	$357,241	1.7	1.6	$149,124	$128,899
CZ16-2	LADWP	141,478	1197	34.60	6%	$228,341	$136,563	$357,241	0.6	1.6	($91,778)	$128,899

Figure 33. Cost Effectiveness for Small Hotel Package 1C – Mixed-Fuel + HE

CZ	Utility	Elec Savings (kWh)	Gas Savings (therms)	GHG Reductions (mtons)	Comp-liance Margin	Incremental Package Cost	Lifecycle Utility Cost Savings	$TDV Savings	B/C Ratio (On-bill)	B/C Ratio (TDV)	NPV (On-bill)	NPV (TDV)
Package 1C: Mixed Fuel + HE												
CZ01	PG&E	10	632	3.76	2%	$22,839	$11,015	$10,218	0.5	0.4	($11,823)	($12,621)
CZ02	PG&E	981	402	2.69	3%	$23,092	$16,255	$11,808	0.7	0.5	($6,837)	($11,284)
CZ03	PG&E	81	383	2.30	2%	$20,510	$7,066	$6,850	0.3	0.3	($13,444)	($13,660)
CZ04	PG&E	161	373	2.26	2%	$22,164	$8,593	$7,645	0.4	0.3	($13,571)	($14,519)
CZ04-2	CPAU	161	373	2.26	2%	$22,164	$7,097	$7,645	0.3	0.3	($15,067)	($14,519)
CZ05	PG&E	154	361	2.19	2%	$21,418	$6,897	$6,585	0.3	0.3	($14,521)	($14,833)
CZ05-2	SCG	154	361	2.19	2%	$21,418	$4,786	$6,585	0.2	0.3	($16,632)	($14,833)
CZ06	SCE	237	201	1.27	2%	$20,941	$3,789	$4,882	0.2	0.2	($17,152)	($16,059)
CZ06-2	LADWP	237	201	1.27	2%	$20,941	$3,219	$4,882	0.2	0.2	($17,722)	($16,059)
CZ07	SDG&E	1,117	158	1.28	2%	$19,625	$13,771	$7,342	0.7	0.4	($5,854)	($12,283)
CZ08	SCE	1,302	169	1.39	2%	$20,678	$8,378	$8,591	0.4	0.4	($12,300)	($12,088)
CZ08-2	LADWP	1,302	169	1.39	2%	$20,678	$5,802	$8,591	0.3	0.4	($14,877)	($12,088)
CZ09	SCE	1,733	178	1.56	3%	$20,052	$10,489	$11,164	0.5	0.6	($9,563)	($8,888)
CZ09-2	LADWP	1,733	178	1.56	3%	$20,052	$7,307	$11,164	0.4	0.6	($12,745)	($8,888)
CZ10	SDG&E	3,170	220	2.29	4%	$22,682	$35,195	$19,149	1.6	0.8	$12,513	($3,533)
CZ10-2	SCE	3,170	220	2.29	4%	$22,682	$16,701	$19,149	0.7	0.8	($5,981)	($3,533)
CZ11	PG&E	3,343	323	2.96	4%	$23,344	$27,633	$20,966	1.2	0.9	$4,288	($2,379)
CZ12	PG&E	1,724	320	2.44	4%	$22,302	$11,597	$15,592	0.5	0.7	($10,705)	($6,710)
CZ12-2	SMUD	1,724	320	2.44	4%	$22,302	$11,156	$15,592	0.5	0.7	($11,146)	($6,710)
CZ13	PG&E	3,083	316	2.81	3%	$22,882	$23,950	$17,068	1.0	0.7	$1,068	($5,814)
CZ14	SDG&E	3,714	312	2.99	4%	$23,299	$35,301	$21,155	1.5	0.9	$12,002	($2,144)
CZ14-2	SCE	3,714	312	2.99	4%	$23,299	$18,460	$21,155	0.8	0.9	($4,839)	($2,144)
CZ15	SCE	8,684	97	3.21	5%	$20,945	$26,738	$31,600	1.3	1.5	$5,792	$10,655
CZ16	PG&E	836	700	4.42	3%	$24,616	$18,608	$14,494	0.8	0.6	($6,007)	($10,121)
CZ16-2	LADWP	836	700	4.42	3%	$24,616	$15,237	$14,494	0.6	0.6	($9,378)	($10,121)

Figure 34. Cost Effectiveness for Small Hotel Package 2 – All-Electric Federal Code Minimum

CZ	Utility	Elec Savings (kWh)	Gas Savings (therms)	GHG Reductions (mtons)	Comp-liance Margin	Incremental Package Cost*	Lifecycle Utility Cost Savings	$TDV Savings	B/C Ratio (On-bill)	B/C Ratio (TDV)	NPV (On-bill)	NPV (TDV)
Package 2: All-Electric Federal Code Minimum												
CZ01	PG&E	-159,802	16917	53.92	-28%	($1,296,784)	($582,762)	($115,161)	2.2	11.3	$714,022	$1,181,623
CZ02	PG&E	-118,739	12677	40.00	-12%	($1,297,757)	($245,434)	($51,620)	5.3	25.1	$1,052,322	$1,246,137
CZ03	PG&E	-110,595	12322	40.48	-14%	($1,300,029)	($326,633)	($51,166)	4.0	25.4	$973,396	$1,248,863
CZ04	PG&E	-113,404	11927	36.59	-13%	($1,299,864)	($225,307)	($53,134)	5.8	24.5	$1,074,556	$1,246,730
CZ04-2	CPAU	-113,404	11927	36.59	-13%	($1,299,864)	($17,768)	($53,134)	73.2	24.5	$1,282,096	$1,246,730
CZ05	PG&E	-108,605	11960	38.34	-15%	($1,299,917)	($350,585)	($54,685)	3.7	23.8	$949,332	$1,245,232
CZ06	SCE	-78,293	8912	29.36	-5%	($1,300,058)	($61,534)	($28,043)	21.1	46.4	$1,238,524	$1,272,015
CZ06-2	LA	-78,293	8912	29.36	-5%	($1,300,058)	$43,200	($28,043)	>1	46.4	$1,343,258	$1,272,015
CZ07	SDG&E	-69,819	8188	28.04	-7%	($1,298,406)	($137,638)	($23,199)	9.4	56.0	$1,160,768	$1,275,207
CZ08	SCE	-71,914	8353	28.21	-6%	($1,296,376)	($53,524)	($22,820)	24.2	56.8	$1,242,852	$1,273,556
CZ08-2	LA	-71,914	8353	28.21	-6%	($1,296,376)	$42,841	($22,820)	>1	56.8	$1,339,217	$1,273,556
CZ09	SCE	-72,262	8402	28.38	-6%	($1,298,174)	($44,979)	($21,950)	28.9	59.1	$1,253,196	$1,276,224
CZ09-2	LA	-72,262	8402	28.38	-6%	($1,298,174)	$46,679	($21,950)	>1	59.1	$1,344,853	$1,276,224
CZ10	SDG&E	-80,062	8418	26.22	-8%	($1,295,176)	($172,513)	($36,179)	7.5	35.8	$1,122,663	$1,258,997
CZ10-2	SCE	-80,062	8418	26.22	-8%	($1,295,176)	($63,974)	($36,179)	20.2	35.8	$1,231,202	$1,258,997
CZ11	PG&E	-99,484	10252	30.99	-10%	($1,295,985)	($186,037)	($49,387)	7.0	26.2	$1,109,948	$1,246,598
CZ12	PG&E	-99,472	10403	32.08	-10%	($1,297,425)	($340,801)	($45,565)	3.8	28.5	$956,624	$1,251,860
CZ12-2	SMUD	-99,067	10403	32.21	-10%	($1,297,425)	$5,794	($44,354)	>1	29.3	$1,303,219	$1,253,071
CZ13	PG&E	-96,829	10029	30.60	-10%	($1,295,797)	($184,332)	($50,333)	7.0	25.7	$1,111,465	$1,245,464
CZ14	SDG&E	-101,398	10056	29.68	-11%	($1,296,156)	($325,928)	($56,578)	4.0	22.9	$970,228	$1,239,578
CZ14-2	SCE	-101,398	10056	29.68	-11%	($1,296,156)	($121,662)	($56,578)	10.7	22.9	$1,174,494	$1,239,578
CZ15	SCE	-49,853	5579	18.07	-4%	($1,294,276)	$209	($21,420)	>1	60.4	$1,294,485	$1,272,856
CZ16	PG&E	-216,708	17599	41.89	-50%	($1,300,552)	($645,705)	($239,178)	2.0	5.4	$654,847	$1,061,374
CZ16-2	LA	-216,708	17599	41.89	-50%	($1,300,552)	$30,974	($239,178)	>1	5.4	$1,331,526	$1,061,374

* The Incremental Package Cost is the addition of the incremental HVAC and water heating equipment costs from Figure 12, the electrical infrastructure incremental cost of $26,800 (see section 3.3.2.1), and the natural gas infrastructure incremental cost savings of $56,020 (see section 3.3.2.2).

Figure 35. Cost Effectiveness for Small Hotel Package 3A – All-Electric + EE

CZ	Utility	Elec Savings (kWh)	Gas Savings (therms)	GHG Reductions (mtons)	Comp-liance Margin	Incremental Package Cost	Lifecycle Utility Cost Savings	$TDV Savings	B/C Ratio (On-bill)	B/C Ratio (TDV)	NPV (On-bill)	NPV (TDV)
Package 3A: All-Electric + EE												
CZ01	PG&E	-113,259	16917	62.38	1.3%	($1,251,544)	($200,367)	$5,460	6.2	>1	$1,051,177	$1,257,005
CZ02	PG&E	-90,033	12677	45.46	4%	($1,265,064)	($108,075)	$15,685	11.7	>1	$1,156,989	$1,280,749
CZ03	PG&E	-83,892	12322	45.93	6%	($1,267,509)	($198,234)	$20,729	6.4	>1	$1,069,274	$1,288,237
CZ04	PG&E	-91,197	11927	40.36	0.2%	($1,263,932)	($112,892)	$703	11.2	>1	$1,151,041	$1,264,635
CZ04-2	CPAU	-90,981	11927	40.42	0.2%	($1,263,932)	$32,557	$918	>1	>1	$1,296,489	$1,264,850
CZ05	PG&E	-82,491	11960	43.62	5%	($1,267,355)	($221,492)	$18,488	5.7	>1	$1,045,863	$1,285,843
CZ06	SCE	-61,523	8912	32.45	7%	($1,267,916)	($33,475)	$15,142	37.9	>1	$1,234,441	$1,283,057
CZ06-2	LADWP	-61,523	8912	32.45	7%	($1,267,916)	$57,215	$15,142	>1	>1	$1,325,130	$1,283,057
CZ07	SDG&E	-53,308	8188	31.22	7%	($1,266,354)	($81,338)	$22,516	15.6	>1	$1,185,015	$1,288,870
CZ08	SCE	-55,452	8353	31.33	3%	($1,264,408)	($23,893)	$9,391	52.9	>1	$1,240,515	$1,273,800
CZ08-2	LADWP	-55,452	8353	31.33	3%	($1,264,408)	$57,058	$9,391	>1	>1	$1,321,466	$1,273,800
CZ09	SCE	-55,887	8402	31.40	2%	($1,266,302)	($19,887)	$9,110	63.7	>1	$1,246,415	$1,275,412
CZ09-2	LADWP	-55,887	8402	31.40	2%	($1,266,302)	$60,441	$9,110	>1	>1	$1,326,743	$1,275,412
CZ10	SDG&E	-60,239	8418	29.96	2%	($1,256,002)	($126,072)	$7,365	10.0	>1	$1,129,930	$1,263,367
CZ10-2	SCE	-60,239	8418	29.96	2%	($1,256,002)	($33,061)	$7,365	38.0	>1	$1,222,940	$1,263,367
CZ11	PG&E	-77,307	10252	35.12	1%	($1,256,149)	($80,187)	$3,114	15.7	>1	$1,175,962	$1,259,263
CZ12	PG&E	-75,098	10403	36.73	2%	($1,256,824)	($234,275)	$9,048	5.4	>1	$1,022,550	$1,265,872
CZ12-2	SMUD	-75,098	10403	36.73	2%	($1,256,824)	$54,941	$9,048	>1	>1	$1,311,765	$1,265,872
CZ13	PG&E	-75,052	10029	34.72	0.3%	($1,256,109)	($79,378)	$1,260	15.8	>1	$1,176,731	$1,257,369
CZ14	SDG&E	-76,375	10056	34.28	0.1%	($1,255,704)	($170,975)	$543	7.3	>1	$1,084,729	$1,256,247
CZ14-2	SCE	-76,375	10056	34.28	0.1%	($1,255,704)	($34,418)	$543	36.5	>1	$1,221,286	$1,256,247
CZ15	SCE	-33,722	5579	21.43	2%	($1,257,835)	$26,030	$12,262	>1	>1	$1,283,864	$1,270,097
CZ16	PG&E	-139,676	17599	55.25	-14%	($1,255,364)	($197,174)	($66,650)	6.4	18.8	$1,058,190	$1,188,714
CZ16-2	LADWP	-139,676	17599	55.25	-14%	($1,255,364)	$165,789	($66,650)	>1	18.8	$1,421,153	$1,188,714

Figure 36. Cost Effectiveness for Small Hotel Package 3B – All-Electric + EE + PV + B

CZ	Utility	Elec Savings (kWh)	Gas Savings (therms)	GHG Reductions (mtons)	Comp-liance Margin	Incremental Package Cost	Lifecycle Utility Cost Savings	$TDV Savings	B/C Ratio (On-bill)	B/C Ratio (TDV)	NPV (On-bill)	NPV (TDV)
Package 3B: All-Electric + EE + PV + B												
CZ01	PG&E	-8,900	16917	87.15	1%	($1,044,174)	$90,964	$324,376	>1	>1	$1,135,139	$1,368,551
CZ02	PG&E	36,491	12677	73.03	4%	($1,057,694)	$242,514	$313,711	>1	>1	$1,300,208	$1,371,405
CZ03	PG&E	41,239	12322	73.43	6%	($1,060,139)	$155,868	$308,385	>1	>1	$1,216,007	$1,368,524
CZ04	PG&E	36,628	11927	69.70	0.2%	($1,056,562)	$240,799	$308,682	>1	>1	$1,297,361	$1,365,244
CZ04-2	CPAU	36,844	11927	69.76	0.2%	($1,056,562)	$336,813	$418,836	>1	>1	$1,393,375	$1,475,398
CZ05	PG&E	36,365	11960	73.11	5%	($1,059,985)	$119,173	$317,952	>1	>1	$1,179,158	$1,377,937
CZ06	SCE	64,476	8912	60.47	7%	($1,060,545)	$156,327	$311,730	>1	>1	$1,216,872	$1,372,275
CZ06-2	LADWP	64,476	8912	60.47	7%	($1,060,545)	$180,648	$311,730	>1	>1	$1,241,193	$1,372,275
CZ07	SDG&E	77,715	8188	60.45	7%	($1,058,983)	$197,711	$330,458	>1	>1	$1,256,694	$1,389,441
CZ08	SCE	71,990	8353	59.49	3%	($1,057,038)	$165,393	$320,814	>1	>1	$1,222,432	$1,377,852
CZ08-2	LADWP	71,990	8353	60.24	3%	($1,057,038)	$180,367	$443,809	>1	>1	$1,237,405	$1,500,847
CZ09	SCE	70,465	8402	59.29	2%	($1,058,932)	$175,602	$301,459	>1	>1	$1,234,534	$1,360,391
CZ09-2	LADWP	70,465	8402	59.29	2%	($1,058,932)	$183,220	$301,459	>1	>1	$1,242,152	$1,360,391
CZ10	SDG&E	69,581	8418	58.04	2%	($1,048,632)	$161,513	$294,530	>1	>1	$1,210,145	$1,343,162
CZ10-2	SCE	69,581	8418	58.04	2%	($1,048,632)	$164,837	$294,530	>1	>1	$1,213,469	$1,343,162
CZ11	PG&E	47,260	10252	61.57	1%	($1,048,779)	$253,717	$286,797	>1	>1	$1,302,496	$1,335,576
CZ12	PG&E	51,115	10403	64.07	2%	($1,049,454)	$104,523	$305,446	>1	>1	$1,153,977	$1,354,900
CZ12-2	SMUD	51,115	10403	64.99	2%	($1,049,454)	$253,197	$430,977	>1	>1	$1,302,651	$1,480,431
CZ13	PG&E	47,757	10029	60.77	0.3%	($1,048,739)	$251,663	$281,877	>1	>1	$1,300,402	$1,330,616
CZ14	SDG&E	66,084	10056	64.54	0.1%	($1,048,334)	$148,510	$334,938	>1	>1	$1,196,844	$1,383,272
CZ14-2	SCE	66,084	10056	64.54	0.1%	($1,048,334)	$185,018	$334,938	>1	>1	$1,233,352	$1,383,272
CZ15	SCE	98,755	5579	49.04	2.1%	($1,050,465)	$233,308	$311,121	>1	>1	$1,283,772	$1,361,585
CZ16	PG&E	-873	17599	84.99	-14%	($1,047,994)	$191,994	$240,724	>1	>1	$1,239,987	$1,288,718
CZ16-2	LADWP	-873	17599	84.99	-14%	($1,047,994)	$291,279	$240,724	>1	>1	$1,339,273	$1,288,718

Figure 37. Cost Effectiveness for Small Hotel Package 3C – All-Electric + HE

CZ	Utility	Elec Savings (kWh)	Gas Savings (therms)	GHG Reductions (mtons)	Comp-liance Margin	Incremental Package Cost	Lifecycle Utility Cost Savings	$TDV Savings	B/C Ratio (On-bill)	B/C Ratio (TDV)	NPV (On-bill)	NPV (TDV)
Package 3C: All-Electric + HE												
CZ01	PG&E	-154,840	16917	56.24	-24%	($1,281,338)	($606,619)	($101,272)	2.1	12.7	$674,719	$1,180,066
CZ02	PG&E	-118,284	12677	41.18	-11%	($1,283,243)	($395,641)	($44,505)	3.2	28.8	$887,602	$1,238,738
CZ03	PG&E	-113,413	12322	40.80	-14%	($1,288,782)	($522,458)	($51,582)	2.5	25.0	$766,324	$1,237,200
CZ04	PG&E	-115,928	11927	37.09	-13%	($1,287,878)	($383,177)	($53,285)	3.4	24.2	$904,701	$1,234,593
CZ04-2	CPAU	-115,928	11927	37.09	-13%	($1,287,878)	($24,170)	($53,285)	53.3	24.2	$1,263,708	$1,234,593
CZ05	PG&E	-111,075	11960	38.75	-15%	($1,288,242)	($530,740)	($56,124)	2.4	23.0	$757,502	$1,232,119
CZ06	SCE	-83,000	8912	29.41	-15%	($1,288,695)	($154,625)	($32,244)	8.3	40.0	$1,134,069	$1,256,451
CZ06-2	LADWP	-83,000	8912	29.41	-15%	($1,288,695)	($17,626)	($32,244)	73.1	40.0	$1,271,068	$1,256,451
CZ07	SDG&E	-73,823	8188	28.32	-7%	($1,285,759)	($268,207)	($24,069)	4.8	53.4	$1,017,552	$1,261,690
CZ08	SCE	-75,573	8353	28.56	-6%	($1,281,241)	($157,393)	($21,912)	8.1	58.5	$1,123,848	$1,259,329
CZ08-2	LADWP	-75,573	8353	28.56	-6%	($1,281,241)	($18,502)	($21,912)	69.2	58.5	$1,262,739	$1,259,329
CZ09	SCE	-74,790	8402	29.04	-4%	($1,285,139)	($138,746)	($16,992)	9.3	75.6	$1,146,393	$1,268,147
CZ09-2	LADWP	-74,790	8402	29.04	-4%	($1,285,139)	($6,344)	($16,992)	202.6	75.6	$1,278,794	$1,268,147
CZ10	SDG&E	-80,248	8418	27.57	-5%	($1,278,097)	($235,479)	($24,107)	5.4	53.0	$1,042,617	$1,253,990
CZ10-2	SCE	-80,248	8418	27.57	-5%	($1,278,097)	($123,371)	($24,107)	10.4	53.0	$1,154,726	$1,253,990
CZ11	PG&E	-98,041	10252	32.73	-7%	($1,279,528)	($278,242)	($35,158)	4.6	36.4	$1,001,286	$1,244,370
CZ12	PG&E	-100,080	10403	33.24	-9%	($1,282,834)	($480,347)	($38,715)	2.7	33.1	$802,487	$1,244,119
CZ12-2	SMUD	-100,080	10403	33.24	-9%	($1,282,834)	($23,362)	($38,715)	54.9	33.1	$1,259,472	$1,244,119
CZ13	PG&E	-94,607	10029	32.47	-7%	($1,279,301)	($276,944)	$244,552	4.6	>1	$1,002,357	$1,523,853
CZ14	SDG&E	-97,959	10056	31.91	-7%	($1,279,893)	($302,123)	($37,769)	4.2	33.9	$977,770	$1,242,124
CZ14-2	SCE	-97,959	10056	31.91	-7%	($1,279,893)	($129,082)	($37,769)	9.9	33.9	$1,150,811	$1,242,124
CZ15	SCE	-45,226	5579	20.17	0.04%	($1,276,847)	($6,533)	$227	195.4	>1	$1,270,314	$1,277,074
CZ16	PG&E	-198,840	17599	47.73	-39%	($1,288,450)	($605,601)	($185,438)	2.1	6.9	$682,848	$1,103,011
CZ16-2	LADWP	-198,840	17599	47.73	-39%	($1,288,450)	$40,268	($185,438)	>1	6.9	$1,328,718	$1,103,011

4.4 Cost Effectiveness Results – PV-only and PV+Battery

The Reach Code Team ran packages of PV-only and PV+Battery measures, without any additional efficiency measures, to assess cost effectiveness on top of the mixed-fuel baseline building and the all-electric federal code minimum reference (Package 2 in Sections 4.1 – 4.3).

Jurisdictions interested in adopting PV-only reach codes should reference the mixed-fuel cost effectiveness results because a mixed-fuel building is the baseline for the nonresidential prototypes analyzed in this study. PV or PV+Battery packages are added to all-electric federal code minimum reference which (in many scenarios) do not have a positive compliance margin compared to the mixed-fuel baseline model, and are solely provided for informational purposes. Jurisdictions interested in reach codes requiring all-electric+PV or all-electric+PV+battery should reference package 3B results in Sections 4.1 – 4.3.[25]

Each of the following eight packages were evaluated against a mixed fuel baseline designed as per 2019 Title 24 Part 6 requirements.

- **Mixed-Fuel + 3 kW PV Only:**
- **Mixed-Fuel + 3 kW PV + 5 kWh battery**
- **Mixed-Fuel + PV Only**: PV sized per the roof size of the building, or to offset the annual electricity consumption, whichever is smaller
- **Mixed-Fuel + PV + 50 kWh Battery:** PV sized per the roof size of the building, or to offset the annual electricity consumption, whichever is smaller, along with 50 kWh battery
- **All-Electric + 3 kW PV Only**
- **All-Electric + 3 kW PV + 5 kWh Battery**
- **All-Electric + PV Only**: PV sized per the roof size of the building, or to offset the annual electricity consumption, whichever is smaller
- **All-Electric + PV + 50 kWh Battery:** PV sized per the roof size of the building, or to offset the annual electricity consumption, whichever is smaller, along with 50 kWh battery

Figure 38 through Figure 40 summarize the on-bill and TDV B/C ratios for each prototype for the two PV only packages and the two PV plus battery packages. Compliance margins are 0 percent for all mixed-fuel packages. For all-electric packages, compliance margins are equal to those found in Package 2 for each prototype in Sections 4.1 – 4.3. The compliance margins are not impacted by renewables and battery storage measures and hence not shown in the tables. These figures are formatted in the following way:

- Cells highlighted in green have a B/C ratio greater than 1 and are cost-effective. The shade of green gets darker as cost effectiveness increases.
- Cells not highlighted have a B/C ratio less than one and are not cost effective.

[25] Because this study shows that the addition of battery generally reduces cost effectiveness, removing a battery measure would only increase cost effectiveness. Thus, a jurisdiction can apply the EE+PV+Battery cost effectiveness findings to support EE+PV reach codes, because EE+PV would still remain cost effective without a battery.

Please see Appendix 6.7 for results in full detail. Generally, for mixed-fuel packages across all prototypes, all climate zones were proven to have cost effective outcomes using TDV except in CZ1 with a 3 kW PV + 5 kWh Battery scenario. Most climate zones also had On-Bill cost effectiveness. The addition of a battery slightly reduces cost effectiveness.

In all-electric packages, the results for most climate zones were found cost effective using both TDV and On-Bill approaches with larger PV systems or PV+Battery systems. Most 3 kW PV systems were also found to be cost effective except in some scenarios analyzing the Medium Office using the On-Bill method. CZ16 results continue to show challenges being cost effective with all electric buildings, likely due to the high heating loads in this climate. The addition of a battery slightly reduces the cost effectiveness for all-electric buildings with PV.

Figure 38. Cost Effectiveness for Medium Office - PV and Battery

		Mixed Fuel								All-Electric							
	PV	3kW		3kW		135kW		135kW		3kW		3kW		135kW		135kW	
	Battery	0		5kWh		0		50kWh		0		5kWh		0		50kWh	
CZ	Utility	On-Bill	TDV	On-Bill	TDV	On-Bill	TDV	On-Bill	TDV	On-Bill	TDV	On-Bill	TDV	On-Bill	TDV	On-Bill	TDV
CZ01	PG&E	2.8	1.5	1.7	0.9	1.7	1.3	1.6	1.2	0.9	1.6	0.9	1.6	2.5	2.0	2.1	1.7
CZ02	PG&E	3.7	1.9	2.1	1.1	2.2	1.6	2.0	1.4	0.8	2.2	0.9	2.6	3.2	2.4	2.7	2.1
CZ03	PG&E	3.7	1.8	2.2	1.0	2.1	1.5	1.9	1.4	1.9	3.9	2.0	4.0	3.4	2.5	2.9	2.2
CZ04	PG&E	3.6	2.0	2.1	1.2	2.3	1.6	2.1	1.5	0.9	2.1	1.1	2.7	3.3	2.5	2.9	2.2
CZ04-2	CPAU	2.1	2.0	1.3	1.2	1.8	1.6	1.6	1.5	7.7	2.1	9.8	2.7	2.9	2.5	2.5	2.2
CZ05	PG&E	4.2	1.9	2.4	1.1	2.5	1.6	2.3	1.5	1.8	2.7	1.9	2.7	4.0	2.7	3.4	2.3
CZ05-2	SCG	4.2	1.9	2.4	1.1	2.5	1.6	2.3	1.5	>1	>1	>1	>1	>1	3.0	9.4	2.6
CZ06	SCE	2.0	2.0	1.2	1.1	1.3	1.6	1.2	1.5	>1	7.2	>1	8.2	2.4	2.7	2.1	2.3
CZ06-2	LA	1.2	2.0	0.7	1.1	0.8	1.6	0.7	1.5	>1	7.2	>1	8.2	1.5	2.7	1.3	2.3
CZ07	SDG&E	3.2	2.0	1.9	1.2	2.1	1.6	1.9	1.5	>1	>1	>1	>1	3.7	2.7	3.2	2.3
CZ08	SCE	1.9	2.0	1.1	1.2	1.3	1.7	1.2	1.5	>1	>1	>1	>1	2.2	2.7	1.9	2.4
CZ08-2	LA	1.2	2.0	0.7	1.2	0.7	1.7	0.7	1.5	>1	>1	>1	>1	1.3	2.7	1.1	2.4
CZ09	SCE	1.9	2.0	1.1	1.2	1.3	1.7	1.2	1.5	>1	>1	>1	>1	2.2	2.6	1.9	2.3
CZ09-2	LA	1.1	2.0	0.7	1.2	0.7	1.7	0.7	1.5	>1	>1	>1	>1	1.3	2.6	1.2	2.3
CZ10	SDG&E	3.8	1.9	2.2	1.1	2.1	1.6	1.9	1.5	>1	3.3	>1	6.3	3.3	2.3	2.9	2.0
CZ10-2	SCE	2.1	1.9	1.2	1.1	1.3	1.6	1.2	1.5	>1	3.3	>1	6.3	2.0	2.3	1.8	2.0
CZ11	PG&E	3.6	1.9	2.1	1.1	2.2	1.6	2.0	1.5	1.1	2.6	1.5	3.6	3.2	2.4	2.8	2.1
CZ12	PG&E	3.5	1.9	2.1	1.1	2.2	1.6	2.0	1.5	0.9	2.5	1.2	3.2	3.1	2.4	2.7	2.1
CZ12-2	SMUD	1.4	1.9	0.8	1.1	1.1	1.6	1.04	1.5	>1	2.5	>1	3.2	1.9	2.4	1.6	2.1
CZ13	PG&E	3.5	1.8	2.0	1.1	2.2	1.5	2.0	1.4	1.1	2.5	1.5	3.6	3.1	2.3	2.7	2.0
CZ14	SDG&E	3.4	2.3	2.0	1.3	2.2	1.9	2.0	1.7	>1	2.3	>1	3.1	3.6	2.8	3.2	2.5
CZ14-2	SCE	1.9	2.3	1.1	1.3	1.3	1.9	1.2	1.7	>1	2.3	>1	3.1	2.2	2.8	1.9	2.5
CZ15	SCE	1.8	2.1	1.1	1.2	1.2	1.7	1.1	1.6	>1	7.5	>1	>1	1.8	2.4	1.6	2.1
CZ16	PG&E	3.9	2.0	2.3	1.1	2.3	1.6	2.1	1.5	0.3	0.4	0.4	0.6	2.5	1.8	2.2	1.6
CZ16-2	LA	1.2	2.0	0.7	1.1	0.7	1.6	0.7	1.5	>1	0.4	>1	0.6	1.3	1.8	1.2	1.6

Figure 39. Cost Effectiveness for Medium Retail - PV and Battery

		Mixed Fuel								All-Electric							
	PV	3kW		3kW		90 kW		90 kW		3kW		3kW		90 kW		90 kW	
	Battery	0		5kWh		0		50kWh		0		5kWh		0		50kWh	
CZ	Utility	On-Bill	TDV	On-Bill	TDV	On-Bill	TDV	On-Bill	TDV	On-Bill	TDV	On-Bill	TDV	On-Bill	TDV	On-Bill	TDV
CZ01	PG&E	2.3	1.5	1.3	0.9	1.8	1.3	1.6	1.2	>1	3.0	>1	2.7	2.5	1.6	2.2	1.5
CZ02	PG&E	3.2	1.8	1.9	1.1	1.9	1.5	1.8	1.5	>1	>1	>1	>1	2.7	2.1	2.3	1.9
CZ03	PG&E	2.7	1.8	1.6	1.1	2.2	1.5	2.0	1.4	>1	>1	>1	>1	3.0	2.1	2.6	1.9
CZ04	PG&E	3.3	1.9	1.9	1.1	2.0	1.6	1.9	1.5	>1	>1	>1	>1	2.7	2.1	2.5	2.0
CZ04-2	CPAU	2.1	1.9	1.2	1.1	1.7	1.6	1.5	1.5	>1	>1	>1	>1	2.4	2.1	2.1	2.0
CZ05	PG&E	2.8	1.9	1.6	1.1	2.3	1.6	2.0	1.5	>1	>1	>1	>1	3.2	2.1	2.7	2.0
CZ05-2	SCG	2.8	1.9	1.6	1.1	2.3	1.6	2.0	1.5	>1	>1	>1	>1	3.7	1.9	3.2	1.6
CZ06	SCE	2.0	1.9	1.2	1.1	1.2	1.6	1.1	1.5	>1	>1	>1	>1	1.7	2.2	1.5	2.0
CZ06-2	LA	1.3	1.9	0.7	1.1	0.7	1.6	0.6	1.5	>1	>1	>1	>1	1.01	2.2	0.9	2.0
CZ07	SDG&E	4.0	2.0	2.4	1.2	1.5	1.6	1.6	1.6	>1	>1	>1	>1	2.4	2.3	2.3	2.1
CZ08	SCE	2.1	2.0	1.2	1.2	1.2	1.7	1.1	1.6	>1	>1	>1	>1	1.7	2.4	1.5	2.1
CZ08-2	LA	1.3	2.0	0.8	1.2	0.7	1.7	0.6	1.6	>1	>1	>1	>1	1.01	2.4	0.9	2.1
CZ09	SCE	2.0	2.0	1.2	1.2	1.2	1.7	1.1	1.5	>1	>1	>1	>1	1.8	2.4	1.6	2.1
CZ09-2	LA	1.2	2.0	0.7	1.2	0.7	1.7	0.7	1.5	>1	>1	>1	>1	1.1	2.4	0.99	2.1
CZ10	SDG&E	3.8	2.0	2.2	1.2	1.7	1.6	1.7	1.5	>1	>1	>1	>1	2.6	2.3	2.5	2.0
CZ10-2	SCE	2.0	2.0	1.2	1.2	1.2	1.6	1.1	1.5	>1	>1	>1	>1	1.8	2.3	1.6	2.0
CZ11	PG&E	2.8	1.9	1.6	1.1	1.9	1.6	1.8	1.5	>1	>1	>1	>1	2.7	2.3	2.5	2.1
CZ12	PG&E	3.0	1.9	1.7	1.1	1.9	1.6	1.8	1.5	>1	>1	>1	>1	2.7	2.3	2.5	2.1
CZ12-2	SMUD	1.5	1.9	0.9	1.1	1.1	1.6	0.997	1.5	>1	>1	>1	>1	1.7	2.3	1.4	2.1
CZ13	PG&E	3.0	1.9	1.7	1.1	1.9	1.6	1.8	1.4	>1	>1	>1	>1	2.7	2.2	2.4	1.9
CZ14	SDG&E	3.5	2.2	2.1	1.3	1.6	1.8	1.5	1.6	>1	>1	>1	>1	2.5	2.6	2.2	2.2
CZ14-2	SCE	1.8	2.2	1.1	1.3	1.2	1.8	1.1	1.6	>1	>1	>1	>1	1.7	2.6	1.5	2.2
CZ15	SCE	1.9	2.0	1.1	1.2	1.1	1.7	1.02	1.5	>1	>1	>1	>1	1.7	2.4	1.5	2.1
CZ16	PG&E	3.7	2.0	2.1	1.2	2.1	1.7	1.9	1.6	0.6	0.5	0.5	0.4	2.7	2.0	2.3	1.8
CZ16-2	LA	1.3	2.0	0.7	1.2	0.7	1.7	0.6	1.6	>1	0.5	>1	0.4	1.2	2.0	1.0	1.8

Figure 40. Cost Effectiveness for Small Hotel - PV and Battery

		Mixed Fuel								All-Electric							
	PV	3kW		3kW		80kW		80kW		3kW		3kW		80kW		80kW	
	Battery	0		5kWh		0		50kWh		0		5kWh		0		50kWh	
CZ	Utility	On-Bill	TDV	On-Bill	TDV	On-Bill	TDV	On-Bill	TDV	On-Bill	TDV	On-Bill	TDV	On-Bill	TDV	On-Bill	TDV
CZ01	PG&E	2.3	1.5	1.3	0.9	1.9	1.2	1.6	1.1	2.3	>1	2.3	>1	4.8	>1	4.7	>1
CZ02	PG&E	2.3	1.9	1.3	1.1	1.8	1.5	1.6	1.4	5.6	>1	5.6	>1	>1	>1	>1	>1
CZ03	PG&E	2.7	1.8	1.6	1.05	2.3	1.5	1.9	1.4	4.2	>1	4.2	>1	>1	>1	>1	>1
CZ04	PG&E	2.4	1.9	1.4	1.1	1.8	1.6	1.6	1.5	6.2	>1	6.2	>1	>1	>1	>1	>1
CZ04-2	CPAU	2.1	1.9	1.2	1.1	1.7	1.6	1.5	1.5	>1	>1	>1	>1	>1	>1	>1	>1
CZ05	PG&E	2.9	1.9	1.7	1.1	2.4	1.6	2.0	1.5	3.9	>1	3.9	>1	>1	>1	>1	>1
CZ05-2	SCG	2.9	1.9	1.7	1.1	2.4	1.6	2.0	1.5	>1	>1	>1	>1	>1	>1	>1	>1
CZ06	SCE	1.8	1.9	1.1	1.1	1.1	1.6	0.9	1.4	>1	>1	>1	>1	>1	>1	>1	>1
CZ06-2	LA	1.1	1.9	0.7	1.1	0.7	1.6	0.6	1.4	>1	>1	>1	>1	>1	>1	>1	>1
CZ07	SDG&E	2.6	2.0	1.5	1.1	1.4	1.6	1.3	1.5	>1	>1	>1	>1	>1	>1	>1	>1
CZ08	SCE	1.9	2.0	1.1	1.2	1.2	1.7	1.0	1.5	>1	>1	>1	>1	>1	>1	>1	>1
CZ08-2	LA	1.2	2.0	0.7	1.2	0.7	1.7	0.6	1.5	>1	>1	>1	>1	>1	>1	>1	>1
CZ09	SCE	1.9	1.9	1.1	1.1	1.2	1.6	0.997	1.4	>1	>1	>1	>1	>1	>1	>1	>1
CZ09-2	LA	1.1	1.9	0.7	1.1	0.7	1.6	0.6	1.4	>1	>1	>1	>1	>1	>1	>1	>1
CZ10	SDG&E	2.9	1.9	1.7	1.1	1.5	1.6	1.4	1.4	8.2	>1	8.2	>1	>1	>1	>1	>1
CZ10-2	SCE	1.7	1.9	0.99	1.1	1.2	1.6	0.99	1.4	>1	>1	>1	>1	>1	>1	>1	>1
CZ11	PG&E	2.6	1.9	1.5	1.1	1.8	1.6	1.5	1.4	7.6	>1	7.6	>1	>1	>1	>1	>1
CZ12	PG&E	2.7	1.9	1.6	1.1	2.3	1.6	1.9	1.4	4.0	>1	4.0	>1	>1	>1	>1	>1
CZ12-2	SMUD	1.4	1.9	0.8	1.1	1.1	1.6	0.95	1.4	>1	>1	>1	>1	>1	>1	>1	>1
CZ13	PG&E	2.6	1.8	1.5	1.1	1.8	1.5	1.5	1.4	7.7	>1	7.7	>1	>1	>1	>1	>1
CZ14	SDG&E	3.0	2.2	1.7	1.3	1.7	1.8	1.5	1.6	4.2	>1	4.2	>1	>1	>1	>1	>1
CZ14-2	SCE	1.8	2.2	1.1	1.3	1.3	1.8	1.1	1.6	>1	>1	>1	>1	>1	>1	>1	>1
CZ15	SCE	1.7	2.0	1.002	1.2	1.2	1.7	1.003	1.4	>1	>1	>1	>1	>1	>1	>1	>1
CZ16	PG&E	2.7	2.0	1.6	1.2	1.9	1.6	1.7	1.5	2.1	5.7	2.1	5.6	5.8	>1	5.8	>1
CZ16-2	LA	1.02	2.0	0.6	1.2	0.6	1.6	0.6	1.5	>1	5.7	>1	5.6	>1	>1	>1	>1

5 Summary, Conclusions, and Further Considerations

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

5.1 Summary

Figure 41 through Figure 43 summarize results for each prototype and depict the compliance margins achieved for each climate zone and package. Because local reach codes must both exceed the Energy Commission performance budget (i.e., have a positive compliance margin) and be cost-effective, the Reach Code Team highlighted cells meeting these two requirements to help clarify the upper boundary for potential reach code policies:

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

For more detail on the results in the Figures, please refer to *Section 4 Results*. As described in Section 4.4, PV-only and PV+Battery packages in the mixed-fuel building were found to be cost effective across all prototypes, climate zones, and packages using the TDV approach, and results are not reiterated in the following figures.

Figure 41. Medium Office Summary of Compliance Margin and Cost Effectiveness

CZ	Utility	Mixed Fuel			All Electric			
		EE	EE + PV + B	HE	Fed Code	EE	EE + PV + B	HE
CZ01	PG&E	18%	18%	3%	-15%	7%	7%	-14%
CZ02	PG&E	17%	17%	4%	-7%	10%	10%	-5%
CZ03	PG&E	20%	20%	3%	-7%	16%	16%	-6%
CZ04	PG&E	14%	14%	5%	-6%	9%	9%	-3%
CZ04-2	CPAU	14%	14%	5%	-6%	9%	9%	-3%
CZ05	PG&E	18%	18%	4%	-8%	12%	12%	-6%
CZ05-2	SCG	18%	18%	4%	NA	NA	NA	NA
CZ06	SCE	20%	20%	3%	-4%	18%	18%	-2%
CZ06-2	LADWP	20%	20%	3%	-4%	18%	18%	-2%
CZ07	SDG&E	20%	20%	4%	-2%	20%	20%	1%
CZ08	SCE	18%	18%	4%	-2%	18%	18%	1%
CZ08-2	LADWP	18%	18%	4%	-2%	18%	18%	1%
CZ09	SCE	16%	16%	4%	-2%	15%	15%	2%
CZ09-2	LADWP	16%	16%	4%	-2%	15%	15%	2%
CZ10	SDG&E	17%	17%	4%	-4%	13%	13%	-1%
CZ10-2	SCE	17%	17%	4%	-4%	13%	13%	-1%
CZ11	PG&E	13%	13%	5%	-4%	10%	10%	0%
CZ12	PG&E	14%	14%	5%	-5%	10%	10%	-1%
CZ12-2	SMUD	14%	14%	5%	-5%	10%	10%	-1%
CZ13	PG&E	13%	13%	5%	-4%	9%	9%	0%
CZ14	SDG&E	14%	14%	5%	-5%	9%	9%	-1%
CZ14-2	SCE	14%	14%	5%	-5%	9%	9%	-1%
CZ15	SCE	12%	12%	5%	-2%	10%	10%	3%
CZ16	PG&E	14%	14%	5%	-27%	-15%	-15%	-26%
CZ16-2	LADWP	14%	14%	5%	-27%	-15%	-15%	-26%

Figure 42. Medium Retail Summary of Compliance Margin and Cost Effectiveness

CZ	Utility	Mixed Fuel			All Electric			
		EE	EE + PV + B	HE	Fed Code	EE	EE + PV + B	HE
CZ01	PG&E	18%	18%	2%	-4.1%	15%	15%	-2%
CZ02	PG&E	13%	13%	3%	-1.0%	13%	13%	3%
CZ03	PG&E	16%	16%	2%	-0.4%	16%	16%	2%
CZ04	PG&E	14%	14%	3%	-0.1%	14%	14%	3%
CZ04-2	CPAU	14%	14%	3%	-0.1%	14%	14%	3%
CZ05	PG&E	16%	16%	1%	-1.2%	15%	15%	1%
CZ05-2	SCG	16%	16%	1%	NA	NA	NA	NA
CZ06	SCE	10%	10%	3%	0.5%	11%	11%	3%
CZ06-2	LADWP	10%	10%	3%	0.5%	11%	11%	3%
CZ07	SDG&E	13%	13%	2%	0.3%	13%	13%	3%
CZ08	SCE	10%	10%	3%	0.4%	10%	10%	4%
CZ08-2	LADWP	10%	10%	3%	0.4%	10%	10%	4%
CZ09	SCE	10%	10%	4%	0.4%	10%	10%	4%
CZ09-2	LADWP	10%	10%	4%	0.4%	10%	10%	4%
CZ10	SDG&E	12%	12%	4%	0.1%	12%	12%	4%
CZ10-2	SCE	12%	12%	4%	0.1%	12%	12%	4%
CZ11	PG&E	13%	13%	4%	0.5%	12%	12%	5%
CZ12	PG&E	13%	13%	4%	-0.1%	12%	12%	4%
CZ12-2	SMUD	13%	13%	4%	-0.1%	12%	12%	4%
CZ13	PG&E	15%	15%	4%	-0.4%	14%	14%	4%
CZ14	SDG&E	13%	13%	4%	0.7%	15%	15%	5%
CZ14-2	SCE	13%	13%	4%	0.7%	15%	15%	5%
CZ15	SCE	12%	12%	5%	0.9%	12%	12%	6%
CZ16	PG&E	13%	13%	3%	-12.2%	3%	3%	-8%
CZ16-2	LADWP	13%	13%	3%	-12.2%	3%	3%	-8%

Figure 43. Small Hotel Summary of Compliance Margin and Cost Effectiveness

CZ	Utility	Mixed Fuel			All Electric			
		EE	EE + PV + B	HE	Fed Code	EE	EE + PV + B	HE
CZ01	PG&E	9%	9%	2%	-28%	1%	1%	-24%
CZ02	PG&E	7%	7%	3%	-12%	4%	4%	-11%
CZ03	PG&E	10%	10%	2%	-14%	6%	6%	-14%
CZ04	PG&E	6%	6%	2%	-13%	0.2%	0.2%	-13%
CZ04-2	CPAU	6%	6%	2%	-13%	0.2%	0.2%	-13%
CZ05	PG&E	9%	9%	2%	-15%	5%	5%	-15%
CZ05-2	SCG	9%	9%	2%	NA	NA	NA	NA
CZ06	SCE	8%	8%	2%	-5%	7%	7%	-15%
CZ06-2	LADWP	8%	8%	2%	-5%	7%	7%	-15%
CZ07	SDG&E	8%	8%	2%	-7%	7%	7%	-7%
CZ08	SCE	7%	7%	2%	-6%	3%	3%	-6%
CZ08-2	LADWP	7%	7%	2%	-6%	3%	3%	-6%
CZ09	SCE	6%	6%	3%	-6%	2%	2%	-4%
CZ09-2	LADWP	6%	6%	3%	-6%	2%	2%	-4%
CZ10	SDG&E	5%	5%	4%	-8%	2%	2%	-5%
CZ10-2	SCE	5%	5%	4%	-8%	2%	2%	-5%
CZ11	PG&E	4%	4%	4%	-10%	1%	1%	-7%
CZ12	PG&E	5%	5%	4%	-10%	2%	2%	-9%
CZ12-2	SMUD	5%	5%	4%	-10%	2%	2%	-9%
CZ13	PG&E	4%	4%	3%	-10%	0.3%	0.3%	-7%
CZ14	SDG&E	4%	4%	4%	-11%	0.1%	0.1%	-7%
CZ14-2	SCE	4%	4%	4%	-11%	0.1%	0.1%	-7%
CZ15	SCE	3%	3%	5%	-4%	2%	2%	0.04%
CZ16	PG&E	6%	6%	3%	-50%	-14%	-14%	-39%
CZ16-2	LADWP	6%	6%	3%	-50%	-14%	-14%	-39%

5.2 Conclusions and Further Considerations

Findings are specific to the scenarios analyzed under this specific methodology, and largely pertain to office, retail, and hotel-type occupancies. Nonresidential buildings constitute a wide variety of occupancy profiles and process loads, making findings challenging to generalize across multiple building types.

Findings indicate the following overall conclusions:

1. This study assumed that electrifying space heating and service water heating could eliminate natural gas infrastructure alone, because these were the only gas end-uses included the prototypes. Avoiding the installation of natural gas infrastructure results in significant cost savings and is a primary factor toward cost-effective outcomes in all-electric designs, even with necessary increases in electrical capacity.
2. There is ample opportunity for cost effective energy efficiency improvements, as demonstrated by the compliance margins achieved in many of the efficiency-only and efficiency + PV packages. Though much of the energy savings are attributable to lighting measures, efficiency measures selected for these prototypes are confined to the building systems that can be modeled. There is

likely further opportunity for energy savings through measures that cannot be currently demonstrated in compliance software, such as high-performance control sequences or variable speed parallel fan powered boxes.

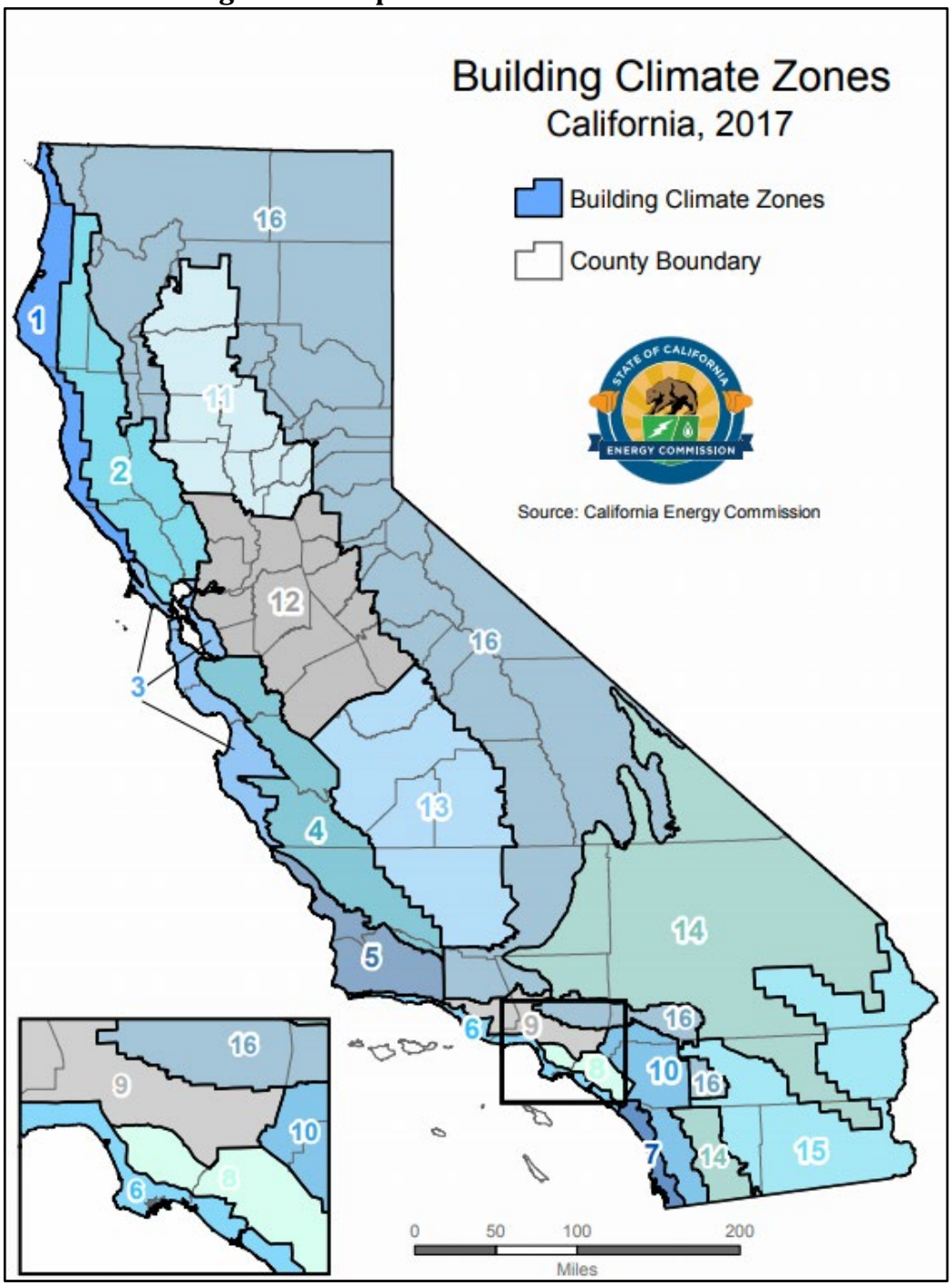
3. High efficiency appliances triggering federal preemption do not achieve as high compliance margins as the other efficiency measures analyzed in this study. Cost effectiveness appears to be dependent on the system type and building type. Nonetheless, specifying high efficiency equipment will always be a key feature in integrated design.
4. Regarding the Small Hotel prototype:
    a. The Small Hotel presents a challenging prototype to cost-effectively exceed the state's energy performance budget without efficiency measures. The Reach Code Team is uncertain of the precision of the results due to the inability to directly model either drain water heat recovery or a central heat pump water heater with a recirculation loop.
    b. Hotel results may be applicable to high-rise (4 or more stories) multifamily buildings. Both hotel and multifamily buildings have the same or similar mandatory and prescriptive compliance options for hot water systems, lighting, and envelope. Furthermore, the Alternate Calculation Method Reference Manual specifies the same baseline HVAC system for both building types.
    c. Hotel compliance margins were the lowest among the three building types analyzed, and thus the most conservative performance thresholds applicable to other nonresidential buildings not analyzed in this study. As stated previously, the varying occupancy and energy profiles of nonresidential buildings makes challenging to directly apply these results across all buildings.
5. Many all-electric and solar PV packages demonstrated greater GHG reductions than their mixed-fuel counterparts, contrary to TDV-based performance, suggesting a misalignment among the TDV metric and California's long-term GHG-reduction goals. The Energy Commission has indicated that they are aware of this issue and are seeking to address it.
6. Changes to the Nonresidential Alternative Calculation Method (ACM) Reference Manual can drastically impact results. Two examples include:
    a. When performance modeling residential buildings, the Standard Design is electric if the Proposed Design is electric, which removes TDV-related penalties and associated negative compliance margins. This essentially allows for a compliance pathway for all-electric residential buildings. If nonresidential buildings were treated in the same way, all-electric cost effectiveness using the TDV approach would improve.
    b. The baseline mixed-fuel system for a hotel includes a furnace in each guest room, which carries substantial plumbing costs and labor costs for assembly. A change in the baseline system would lead to different base case costs and different cost effectiveness outcomes.
7. All-electric federal code-minimum packages appear to be cost effective, largely due to avoided natural gas infrastructure, but in most cases do not comply with the Energy Commission's minimum performance budget (as described in item 7a above). For most cases it appears that adding cost-effective efficiency measures achieves compliance. All-electric nonresidential projects can leverage the initial cost savings of avoiding natural gas infrastructure by adding energy efficiency measures that would not be cost effective independently.

6 Appendices

6.1 Map of California Climate Zones

Climate zone geographical boundaries are depicted in Figure 44. The map in Figure 44 along with a zip-code search directory is available at:
https://ww2.energy.ca.gov/maps/renewable/building_climate_zones.html

Figure 44. Map of California Climate Zones



6.2 Lighting Efficiency Measures

Figure 45 details the applicability and impact of each lighting efficiency measure by prototype and space function and includes the resulting LPD that is modeled as the proposed by building type and by space function.

Figure 45. Impact of Lighting Measures on Proposed LPDs by Space Function

	Baseline	Impact				Modeled Proposed
Space Function	LPD (W/ft2)	Interior Lighting Reduced LPD	Institutional Tuning	Daylight Dimming Plus OFF	Occupant Sensing in Open Office Plan	LPD (W/ft^2)
Medium Office						
Office Area (Open plan office) - Interior	0.65	15%	10%	-	17%	0.429
Office Area (Open plan office) - Perimeter	0.65	15%	5%	10%	30%	0.368
Medium Retail						
Commercial/Industrial Storage (Warehouse)	0.45	10%	5%	-	-	0.386
Main Entry Lobby	0.85	10%	5%	-	-	0.729
Retail Sales Area (Retail Merchandise Sales)	0.95	5%	5%	-	-	0.857
Small Hotel						
Commercial/Industrial Storage (Warehouse)	0.45	10%	5%	-	-	0.386
Convention, Conference, Multipurpose, and Meeting	0.85	10%	5%	-	-	0.729
Corridor Area	0.60	10%	5%	-	-	0.514
Exercise/Fitness Center and Gymnasium Areas	0.50	10%	-	-	-	0.450
Laundry Area	0.45	10%	-	-	-	0.405
Lounge, Breakroom, or Waiting Area	0.65	10%	5%	-	-	0.557
Mechanical	0.40	10%	-	-	-	0.360
Office Area (>250 ft^2)	0.65	10%	5%	-	-	0.557

6.3 Drain Water Heat Recovery Measure Analysis

To support potential DWHR savings in the Small Hotel prototype, the Reach Code Team modeled the drain water heat recovery measure in CBECC-Res 2019 in the all-electric and mixed fuel 6,960 ft2 prototype residential buildings. The Reach Code Team assumed one heat recovery device for every three showers assuming unequal flow to the shower. Based on specifications from three different drain water heat recovery device manufacturers for device effectiveness in hotel applications, the team assumed a heat recovery efficiency of 50 percent.

The Reach Code Team modeled mixed fuel and all-electric residential prototype buildings both with and without heat recovery in each climate zone. Based on these model results, the Reach Code Team determined the percentage savings of domestic water heating energy in terms of gas, electricity, and TDV for mixed fuel and all-electric, in each climate zone. The Reach Code Team then applied the savings

percentages to the Small Hotel prototype domestic water heating energy in both the mixed-fuel and all-electric to determine energy savings for the drain water heat recovery measure in the Small Hotel. The Reach Code Team applied volumetric energy rates to estimate on-bill cost impacts from this measure.

6.4 Utility Rate Schedules

The Reach Codes Team used the IOU and POU rates depicted in Figure 46 to determine the On-Bill savings for each prototype.

Figure 46. Utility Tariffs Analyzed Based on Climate Zone – Detailed View

Climate Zones	Electric / Gas Utility	Electricity (Time-of-use)			Natural Gas
		Medium Office	Medium Retail	Small Hotel	All Prototypes
CZ01	PG&E	A-10	A-1	A-1 or A-10	G-NR1
CZ02	PG&E	A-10	A-10	A-1 or A-10	G-NR1
CZ03	PG&E	A-10	A-1 or A-10	A-1 or A-10	G-NR1
CZ04	PG&E	A-10	A-10	A-1 or A-10	G-NR1
CZ04-2	CPAU/PG&E	E-2	E-2	E-2	G-NR1
CZ05	PG&E	A-10	A-1	A-1 or A-10	G-NR1
CZ05-2	PG&E/SCG	A-10	A-1	A-1 or A-10	G-10 (GN-10)
CZ06	SCE/SCG	TOU-GS-2	TOU-GS-2	TOU-GS-2 or TOU-GS-3	G-10 (GN-10)
CZ06	LADWP/SCG	TOU-GS-2	TOU-GS-2	TOU-GS-2 or TOU-GS-3	G-10 (GN-10)
CZ07	SDG&E	AL-TOU+EECC (AL-TOU)	AL-TOU+EECC (AL-TOU)	AL-TOU+EECC (AL-TOU)	GN-3
CZ08	SCE/SCG	TOU-GS-2	TOU-GS-2	TOU-GS-2 or TOU-GS-3	G-10 (GN-10)
CZ08-2	LADWP/SCG	A-2 (B)	A-2 (B)	A-2 (B)	G-10 (GN-10)
CZ09	SCE/SCG	TOU-GS-2	TOU-GS-2	TOU-GS-2 or TOU-GS-3	G-10 (GN-10)
CZ09-2	LADWP/SCG	A-2 (B)	A-2 (B)	A-2 (B)	G-10 (GN-10)
CZ10	SCE/SCG	TOU-GS-2	TOU-GS-2	TOU-GS-2	G-10 (GN-10)
CZ10-2	SDG&E	AL-TOU+EECC (AL-TOU)	AL-TOU+EECC (AL-TOU)	AL-TOU+EECC (AL-TOU)	GN-3
CZ11	PG&E	A-10	A-10	A-10	G-NR1
CZ12	PG&E	A-10	A-10	A-1 or A-10	G-NR1
CZ12-2	SMUD/PG&E	GS	GS	GS	G-NR1
CZ13	PG&E	A-10	A-10	A-10	G-NR1
CZ14	SCE/SCG	TOU-GS-3	TOU-GS-3	TOU-GS-3	G-10 (GN-10)
CZ14-2	SDG&E	AL-TOU+EECC (AL-TOU)	AL-TOU+EECC (AL-TOU)	AL-TOU+EECC (AL-TOU)	GN-3
CZ15	SCE/SCG	TOU-GS-3	TOU-GS-2	TOU-GS-2	G-10 (GN-10)
CZ16	PG&E	A-10	A-10	A-1 or A-10	G-NR1
CZ16-2	LADWP/SCG	A-2 (B)	A-2 (B)	A-2 (B)	G-10 (GN-10)

6.5 Mixed Fuel Baseline Energy Figures

Figures 47 to 49 show the annual electricity and natural gas consumption and cost, compliance TDV, and GHG emissions for each prototype under the mixed fuel design baseline.

Figure 47. Medium Office – Mixed Fuel Baseline

Climate Zone	Utility	Electricity Consumption (kWh)	Natural Gas Consumption (Therms)	Electricity Cost	Natural Gas Cost	Compliance TDV	GHG Emissions (lbs)
Medium Office Mixed Fuel Baseline							
CZ01	PG&E	358,455	4,967	$109,507	$6,506	84	266,893
CZ02	PG&E	404,865	3,868	$130,575	$5,256	122	282,762
CZ03	PG&E	370,147	3,142	$116,478	$4,349	88	251,759
CZ04	PG&E	431,722	3,759	$140,916	$5,144	141	299,993
CZ04-2	CPAU	431,722	3,759	$75,363	$5,144	141	299,993
CZ05	PG&E	400,750	3,240	$131,277	$4,481	106	269,768
CZ05-2	SCG	400,750	3,240	$131,277	$3,683	106	269,768
CZ06	SCE	397,441	2,117	$74,516	$2,718	105	253,571
CZ06-2	LA	397,441	2,117	$44,311	$2,718	105	253,571
CZ07	SDG&E	422,130	950	$164,991	$4,429	118	257,324
CZ08	SCE	431,207	1,219	$79,181	$1,820	132	265,179
CZ08-2	LA	431,207	1,219	$46,750	$1,820	132	265,179
CZ09	SCE	456,487	1,605	$86,190	$2,196	155	287,269
CZ09-2	LA	456,487	1,605	$51,111	$2,196	155	287,269
CZ10	SDG&E	431,337	2,053	$173,713	$5,390	130	272,289
CZ10-2	SCE	431,337	2,053	$80,636	$2,603	130	272,289
CZ11	PG&E	464,676	3,062	$150,520	$4,333	163	310,307
CZ12	PG&E	441,720	3,327	$142,902	$4,647	152	299,824
CZ12-2	SMUD	441,720	3,327	$65,707	$4,647	152	299,824
CZ13	PG&E	471,540	3,063	$150,919	$4,345	161	316,228
CZ14	SDG&E	467,320	3,266	$185,812	$6,448	165	314,258
CZ14-2	SCE	467,320	3,266	$92,071	$3,579	165	314,258
CZ15	SCE	559,655	1,537	$105,388	$2,058	211	347,545
CZ16	PG&E	405,269	6,185	$127,201	$8,056	116	312,684
CZ16-2	LA	405,269	6,185	$43,115	$8,056	116	312,684

Figure 48. Medium Retail – Mixed Fuel Baseline

Climate Zone	Utility	Electricity Consumption (kWh)	Natural Gas Consumption (Therms)	Electricity Cost	Natural Gas Cost	Compliance TDV	GHG Emissions (lbs)
Medium Retail Mixed Fuel Baseline							
CZ01	PG&E	184,234	3,893	$43,188	$5,247	155	156,972
CZ02	PG&E	214,022	2,448	$70,420	$3,572	202	157,236
CZ03	PG&E	199,827	1,868	$47,032	$2,871	165	140,558
CZ04	PG&E	208,704	1,706	$66,980	$2,681	187	143,966
CZ04-2	CPAU	208,704	1,706	$36,037	$2,681	187	143,966
CZ05	PG&E	195,864	1,746	$45,983	$2,697	155	135,849
CZ05-2	SCG	195,864	1,746	$45,983	$2,342	155	135,849
CZ06	SCE	211,123	1,002	$36,585	$1,591	183	135,557
CZ06-2	LA	211,123	1,002	$21,341	$1,591	183	135,557
CZ07	SDG&E	211,808	522	$75,486	$4,055	178	130,436
CZ08	SCE	212,141	793	$36,758	$1,373	190	133,999
CZ08-2	LA	212,141	793	$21,436	$1,373	190	133,999
CZ09	SCE	227,340	970	$40,083	$1,560	218	146,680
CZ09-2	LA	227,340	970	$23,487	$1,560	218	146,680
CZ10	SDG&E	235,465	1,262	$87,730	$4,700	228	154,572
CZ10-2	SCE	235,465	1,262	$41,000	$1,853	228	154,572
CZ11	PG&E	234,560	2,415	$76,670	$3,547	244	170,232
CZ12	PG&E	228,958	2,309	$75,084	$3,426	234	165,133
CZ12-2	SMUD	228,958	2,309	$32,300	$3,426	234	165,133
CZ13	PG&E	242,927	1,983	$81,995	$3,034	258	170,345
CZ14	SDG&E	264,589	1,672	$97,581	$5,059	277	178,507
CZ14-2	SCE	264,589	1,672	$46,217	$2,172	277	178,507
CZ15	SCE	290,060	518	$50,299	$1,083	300	179,423
CZ16	PG&E	212,204	4,304	$67,684	$5,815	197	180,630
CZ16-2	LA	212,204	4,304	$20,783	$5,815	197	180,630

Figure 49. Small Hotel – Mixed Fuel Baseline

Climate Zone	Utility	Electricity Consumption (kWh)	Natural Gas Consumption (Therms)	Electricity Cost	Natural Gas Cost	Compliance TDV	GHG Emissions (lbs)
Small Hotel Mixed Fuel Baseline							
CZ01	PG&E	177,734	16,936	40,778	20,465	110	340,491
CZ02	PG&E	189,319	12,696	53,396	15,664	110	293,056
CZ03	PG&E	183,772	12,341	42,325	15,210	98	284,217
CZ04	PG&E	187,482	11,945	52,118	14,806	106	281,851
CZ04-2	CPAU	187,482	11,945	32,176	14,806	106	281,851
CZ05	PG&E	187,150	11,979	43,182	14,733	98	281,183
CZ05-2	SCG	187,150	11,979	43,182	10,869	98	281,183
CZ06	SCE	191,764	8,931	28,036	8,437	98	244,664
CZ06-2	LA	191,764	8,931	16,636	8,437	98	244,664
CZ07	SDG&E	189,174	8,207	58,203	10,752	90	233,884
CZ08	SCE	190,503	8,372	27,823	7,991	94	236,544
CZ08-2	LA	190,503	8,372	16,555	7,991	94	236,544
CZ09	SCE	198,204	8,421	30,262	8,030	103	242,296
CZ09-2	LA	198,204	8,421	17,951	8,030	103	242,296
CZ10	SDG&E	215,364	8,437	71,713	10,926	122	255,622
CZ10-2	SCE	215,364	8,437	33,736	8,043	122	255,622
CZ11	PG&E	219,852	10,271	63,724	12,882	131	282,232
CZ12	PG&E	199,499	10,422	46,245	13,022	115	270,262
CZ12-2	SMUD	199,499	10,422	26,872	13,022	115	270,262
CZ13	PG&E	226,925	10,048	65,559	12,629	132	284,007
CZ14	SDG&E	226,104	10,075	73,621	12,167	134	283,287
CZ14-2	SCE	226,104	10,075	35,187	9,350	134	283,287
CZ15	SCE	280,595	5,598	42,852	5,777	152	260,378
CZ16	PG&E	191,231	17,618	51,644	21,581	127	358,590
CZ16-2	LA	191,231	17,618	16,029	21,581	127	358,590

6.6 Hotel TDV Cost Effectiveness with Propane Baseline

The Reach Codes Team further analyzed TDV cost effectiveness of the all-electric packages with a mixed-fuel design baseline using propane instead of natural gas. Results for each package are shown in Figure 50. through Figure 53. below.

All electric models compared to a propane baseline have positive compliance margins in all climate zones when compared to results using a natural gas baseline. Compliance margin improvement is roughly 30 percent, which also leads to improved cost effectiveness for the all-electric packages. These outcomes are likely due to the TDV penalty associated with propane when compared to natural gas.

Across packages, TDV cost effectiveness with a propane baseline follows similar trends as the natural gas baseline. Adding efficiency measures increased compliance margins by 3 to 10 percent depending on climate zone, while adding high efficiency HVAC and SHW equipment alone increased compliance margins by smaller margins of about 2 to 4 percent compared to the All-Electric package.

Figure 50. TDV Cost Effectiveness for Small Hotel, Propane Baseline – Package 2 All-Electric Federal Code Minimum

Climate Zone	Compliance Margin (%)	Incremental Package Cost	$-TDV Savings	B/C Ratio (TDV)	NPV (TDV)
CZ01	-4%	($1,271,869)	($28,346)	44.9	$1,243,523
CZ02	27%	($1,272,841)	$170,263	>1	$1,443,104
CZ03	-3%	($1,275,114)	($16,425)	77.6	$1,258,689
CZ04	26%	($1,274,949)	$155,466	>1	$1,430,414
CZ05	27%	($1,275,002)	$154,709	>1	$1,429,710
CZ06	17%	($1,275,143)	$126,212	>1	$1,401,355
CZ07	25%	($1,273,490)	$117,621	>1	$1,391,111
CZ08	24%	($1,271,461)	$122,087	>1	$1,393,548
CZ09	23%	($1,273,259)	$123,525	>1	$1,396,784
CZ10	18%	($1,270,261)	$109,522	>1	$1,379,783
CZ11	19%	($1,271,070)	$129,428	>1	$1,400,498
CZ12	-4%	($1,272,510)	($26,302)	48.4	$1,246,208
CZ13	18%	($1,270,882)	$124,357	>1	$1,395,239
CZ14	17%	($1,271,241)	$117,621	>1	$1,388,861
CZ15	-7%	($1,269,361)	($45,338)	28.0	$1,224,023
CZ16	9%	($1,275,637)	$68,272	>1	$1,343,908

Figure 51. TDV Cost Effectiveness for Small Hotel, Propane Baseline – Package 3A (All-Electric + EE)

Climate Zone	Compliance Margin (%)	Incremental Package Cost	$-TDV Savings	B/C Ratio (TDV)	NPV (TDV)
CZ01	35%	($1,250,898)	$252,831	>1	$1,503,729
CZ02	34%	($1,251,870)	$217,238	>1	$1,469,108
CZ03	37%	($1,254,142)	$218,642	>1	$1,472,784
CZ04	31%	($1,250,769)	$191,393	>1	$1,442,162
CZ05	36%	($1,254,031)	$208,773	>1	$1,462,804
CZ06	25%	($1,250,964)	$159,714	>1	$1,410,677
CZ07	32%	($1,249,311)	$154,111	>1	$1,403,422
CZ08	29%	($1,247,282)	$146,536	>1	$1,393,818
CZ09	27%	($1,249,080)	$146,671	>1	$1,395,751
CZ10	22%	($1,246,081)	$134,477	>1	$1,380,559
CZ11	23%	($1,246,891)	$157,138	>1	$1,404,029
CZ12	27%	($1,248,330)	$167,945	>1	$1,416,276
CZ13	22%	($1,246,703)	$149,270	>1	$1,395,973
CZ14	21%	($1,247,061)	$145,269	>1	$1,392,331
CZ15	14%	($1,245,182)	$93,647	>1	$1,338,829
CZ16	20%	($1,254,665)	$154,035	>1	$1,408,701

Figure 52. TDV Cost Effectiveness for Small Hotel, Propane Baseline – Package 3B (All-Electric + EE + PV)

Climate Zone	Compliance Margin (%)	Incremental Package Cost	$-TDV Savings	B/C Ratio (TDV)	NPV (TDV)
CZ01	35%	($1,043,528)	$511,688	>1	$1,555,215
CZ02	34%	($1,044,500)	$524,460	>1	$1,568,960
CZ03	37%	($1,046,772)	$518,485	>1	$1,565,257
CZ04	31%	($1,043,399)	$505,579	>1	$1,548,978
CZ05	36%	($1,046,660)	$526,668	>1	$1,573,328
CZ06	25%	($1,043,594)	$469,623	>1	$1,513,216
CZ07	32%	($1,041,941)	$471,513	>1	$1,513,454
CZ08	29%	($1,039,912)	$475,973	>1	$1,515,885
CZ09	27%	($1,041,710)	$467,971	>1	$1,509,681
CZ10	22%	($1,038,711)	$454,832	>1	$1,493,543
CZ11	23%	($1,039,521)	$474,844	>1	$1,514,364
CZ12	27%	($1,040,960)	$484,667	>1	$1,525,627
CZ13	22%	($1,039,333)	$454,108	>1	$1,493,441
CZ14	21%	($1,039,691)	$505,398	>1	$1,545,090
CZ15	14%	($1,037,811)	$423,879	>1	$1,461,691
CZ16	20%	($1,047,295)	$480,407	>1	$1,527,702

Figure 53. TDV Cost Effectiveness for Small Hotel, Propane Baseline – Package 3C (All Electric + HE)

Climate Zone	Compliance Margin (%)	Incremental Package Cost	$-TDV Savings	B/C Ratio (TDV)	NPV (TDV)
CZ01	27%	($1,256,423)	$194,975	>1	$1,451,398
CZ02	28%	($1,258,328)	$177,378	>1	$1,435,706
CZ03	28%	($1,263,867)	$164,094	>1	$1,427,961
CZ04	26%	($1,262,963)	$155,314	>1	$1,418,277
CZ05	26%	($1,263,327)	$153,271	>1	$1,416,598
CZ06	17%	($1,263,779)	$122,011	>1	$1,385,790
CZ07	24%	($1,260,844)	$116,751	>1	$1,377,594
CZ08	25%	($1,256,326)	$122,995	>1	$1,379,321
CZ09	24%	($1,260,223)	$128,482	>1	$1,388,706
CZ10	20%	($1,253,181)	$121,595	>1	$1,374,776
CZ11	21%	($1,254,613)	$143,658	>1	$1,398,271
CZ12	23%	($1,257,919)	$142,901	>1	$1,400,820
CZ13	21%	($1,254,386)	$138,625	>1	$1,393,011
CZ14	20%	($1,254,978)	$136,430	>1	$1,391,407
CZ15	14%	($1,251,932)	$96,087	>1	$1,348,019
CZ16	15%	($1,263,534)	$122,011	>1	$1,385,545

6.7 PV-only and PV+Battery-only Cost Effectiveness Results Details

The Reach Code Tea evaluated cost effectiveness of installing a PV system and battery storage in six different measure combinations over a 2019 code-compliant baseline for all climate zones. The baseline for all nonresidential buildings is a mixed-fuel design.

All mixed fuel models are compliant with 2019 Title24, whereas all electric models can show negative compliance. The compliance margin is the same as that of their respective federal minimum design and is not affected by addition of solar PV or battery. These scenarios evaluate the cost effectiveness of PV and/or battery measure individually. The climate zones where all-electric design is not compliant will have the flexibility to ramp up the efficiency of appliance or add another measure to be code compliant, as per package 1B and 3B in main body of the report. The large negative lifecycle costs in all electric packages are due to lower all-electric HVAC system costs and avoided natural gas infrastructure costs. This is commonly applied across all climate zones and packages over any additional costs for PV and battery.

6.7.1 Cost Effectiveness Results – Medium Office

Figure 54 through Figure 61 contain the cost-effectiveness findings for the Medium Office packages. Notable findings for each package include:

- **Mixed-Fuel + 3 kW PV Only:** All packages are cost effective using the On-Bill and TDV approaches.
- **Mixed-Fuel + 3 kW PV + 5 kWh Battery:** The packages are mostly cost effective on a TDV basis except in CZ1. As compared to the 3 kW PV only package, battery reduces cost effectiveness. This package is not cost effective for LADWP and SMUD territories using an On-Bill approach.
- **Mixed-Fuel + PV only:** The packages are less cost effective as compared to 3 kW PV packages in most climate zones. In areas served by LADWP, the B/C ratio is narrowly less than 1 and not cost effective.
- **Mixed-Fuel + PV + 50 kWh Battery:** The packages are cost effective in all climate zones except for in the areas served by LADWP. On-Bill and TDV B/C ratios are slightly lower compared to the PV only package.
- **All-Electric + 3 kW PV:** Packages are on-bill cost effective in ten of sixteen climate zones. Climate zones 1,2,4,12, and 16 were not found to be cost-effective from an on-bill perspective. These zones are within PG&E's service area. Packages are cost effective using TDV in all climate zones except CZ16.
- **All-Electric + 3 kW PV + 5 kWh Battery**: Packages are slightly more cost effective than the previous minimal PV only package. Packages are on-bill cost effective in most climate zones except for 1,2 and 16 from an on-bill perspective. These zones are within PG&E's service area. Packages are cost effective using TDV in all climate zones except CZ16.
- **All-Electric + PV only:** All packages are cost effective and achieve savings using the On-Bill and TDV approaches.

- **All-Electric + PV + 50 kWh Battery**: All packages are cost effective and achieve savings using the On-Bill and TDV approaches. On-Bill and TDV B/C ratios are slightly lower compared to the PV only package.

Figure 54. Cost Effectiveness for Medium Office - Mixed Fuel + 3kW PV

CZ	IOU territory	Elec Savings (kWh)	Gas Savings (therms)	GHG savings (tons)	Incremental Package Cost	Lifecycle Energy Cost Savings	Lifecycle $- TDV Savings	B/C Ratio (On-bill)	B/C Ratio (TDV)	NPV (On-bill)	NPV (TDV)
Mixed Fuel + 3kW PV											
CZ01	PG&E	3,941	0	0.8	$5,566	$15,743	$8,448	2.8	1.5	$10,177	$2,882
CZ02	PG&E	4,785	0	0.9	$5,566	$20,372	$10,500	3.7	1.9	$14,806	$4,934
CZ03	PG&E	4,660	0	0.9	$5,566	$20,603	$9,975	3.7	1.8	$15,037	$4,409
CZ04	PG&E	5,056	0	1.0	$5,566	$20,235	$11,073	3.6	2.0	$14,669	$5,507
CZ04-2	CPAU	5,056	0	1.0	$5,566	$11,945	$11,073	2.1	2.0	$6,379	$5,507
CZ05	PG&E	5,027	0	1.0	$5,566	$23,159	$10,834	4.2	1.9	$17,593	$5,268
CZ06	SCE	4,853	0	0.9	$5,566	$10,968	$10,930	2.0	2.0	$5,402	$5,364
CZ06-2	LADWP	4,853	0	0.9	$5,566	$6,575	$10,930	1.2	2.0	$1,009	$5,364
CZ07	SDG&E	4,960	0	1.0	$5,566	$17,904	$11,025	3.2	2.0	$12,338	$5,459
CZ08	SCE	4,826	0	0.9	$5,566	$10,768	$11,359	1.9	2.0	$5,202	$5,793
CZ08-2	LADWP	4,826	0	0.9	$5,566	$6,503	$11,359	1.2	2.0	$937	$5,793
CZ09	SCE	4,889	0	1.0	$5,566	$10,622	$11,216	1.9	2.0	$5,056	$5,650
CZ09-2	LADWP	4,889	0	1.0	$5,566	$6,217	$11,216	1.1	2.0	$651	$5,650
CZ10	SDG&E	4,826	0	0.9	$5,566	$21,280	$10,787	3.8	1.9	$15,714	$5,221
CZ10-2	SCE	4,826	0	0.9	$5,566	$11,598	$10,787	2.1	1.9	$6,032	$5,221
CZ11	PG&E	4,701	0	0.9	$5,566	$19,869	$10,644	3.6	1.9	$14,303	$5,078
CZ12	PG&E	4,707	0	0.9	$5,566	$19,643	$10,644	3.5	1.9	$14,077	$5,078
CZ12-2	SMUD	4,707	0	0.9	$5,566	$8,005	$10,644	1.4	1.9	$2,439	$5,078
CZ13	PG&E	4,633	0	0.9	$5,566	$19,231	$10,262	3.5	1.8	$13,665	$4,696
CZ14	SDG&E	5,377	0	1.0	$5,566	$18,789	$12,600	3.4	2.3	$13,223	$7,034
CZ14-2	SCE	5,377	0	1.0	$5,566	$10,512	$12,600	1.9	2.3	$4,946	$7,034
CZ15	SCE	5,099	0	1.0	$5,566	$10,109	$11,550	1.8	2.1	$4,543	$5,984
CZ16	PG&E	5,096	0	1.0	$5,566	$21,836	$10,882	3.9	2.0	$16,270	$5,316
CZ16-2	LADWP	5,096	0	1.0	$5,566	$6,501	$10,882	1.2	2.0	$935	$5,316

Figure 55. Cost Effectiveness for Medium Office – Mixed Fuel + 3kW PV + 5 kWh Battery

CZ	IOU territory	Elec Savings (kWh)	Gas Savings (therms)	GHG savings (tons)	Incremental Package Cost	Lifecycle Energy Cost Savings	$-TDV Savings	B/C Ratio (On-bill)	B/C Ratio (TDV)	NPV (On-bill)	NPV (TDV)
Mixed Fuel + 3kW PV + 5kWh Battery											
CZ01	PG&E	3,941	0	0.8	$9,520	$15,743	$8,448	1.7	0.9	$6,223	($1,072)
CZ02	PG&E	4,785	0	0.9	$9,520	$20,372	$10,500	2.1	1.1	$10,852	$980
CZ03	PG&E	4,660	0	0.9	$9,520	$20,603	$9,975	2.2	1.0	$11,083	$455
CZ04	PG&E	5,056	0	1.0	$9,520	$20,235	$11,073	2.1	1.2	$10,714	$1,553
CZ04-2	CPAU	5,056	0	1.0	$9,520	$11,945	$11,073	1.3	1.2	$2,425	$1,553
CZ05	PG&E	5,027	0	1.0	$9,520	$23,159	$10,834	2.4	1.1	$13,639	$1,314
CZ06	SCE	4,853	0	0.9	$9,520	$10,968	$10,930	1.2	1.1	$1,448	$1,410
CZ06-2	LADWP	4,853	0	0.9	$9,520	$6,575	$10,930	0.7	1.1	($2,945)	$1,410
CZ07	SDG&E	4,960	0	1.0	$9,520	$17,904	$11,025	1.9	1.2	$8,384	$1,505
CZ08	SCE	4,826	0	0.9	$9,520	$10,768	$11,359	1.1	1.2	$1,248	$1,839
CZ08-2	LADWP	4,826	0	0.9	$9,520	$6,503	$11,359	0.7	1.2	($3,017)	$1,839
CZ09	SCE	4,889	0	1.0	$9,520	$10,622	$11,216	1.1	1.2	$1,102	$1,696
CZ09-2	LADWP	4,889	0	1.0	$9,520	$6,217	$11,216	0.7	1.2	($3,303)	$1,696
CZ10	SDG&E	4,826	0	0.9	$9,520	$21,280	$10,787	2.2	1.1	$11,760	$1,267
CZ10-2	SCE	4,826	0	0.9	$9,520	$11,598	$10,787	1.2	1.1	$2,078	$1,267
CZ11	PG&E	4,701	0	0.9	$9,520	$19,869	$10,644	2.1	1.1	$10,349	$1,123
CZ12	PG&E	4,707	0	0.9	$9,520	$19,643	$10,644	2.1	1.1	$10,123	$1,123
CZ12-2	SMUD	4,707	0	0.9	$9,520	$8,005	$10,644	0.8	1.1	($1,515)	$1,123
CZ13	PG&E	4,633	0	0.9	$9,520	$19,231	$10,262	2.0	1.1	$9,711	$742
CZ14	SDG&E	5,377	0	1.0	$9,520	$18,789	$12,600	2.0	1.3	$9,269	$3,080
CZ14-2	SCE	5,377	0	1.0	$9,520	$10,512	$12,600	1.1	1.3	$992	$3,080
CZ15	SCE	5,099	0	1.0	$9,520	$10,109	$11,550	1.1	1.2	$589	$2,030
CZ16	PG&E	5,096	0	1.0	$9,520	$21,836	$10,882	2.3	1.1	$12,316	$1,362
CZ16-2	LADWP	5,096	0	1.0	$9,520	$6,501	$10,882	0.7	1.1	($3,019)	$1,362

Figure 56. Cost Effectiveness for Medium Office – Mixed Fuel + 135kW PV

CZ	IOU territory	Elec Savings (kWh)	Gas Savings (therms)	GHG savings (tons)	Incremental Package Cost	Lifecycle Energy Cost Savings	Lifecycle TDV Savings	B/C Ratio (On-bill)	B/C Ratio (TDV)	NPV (On-bill)	NPV (TDV)
Mixed Fuel +135kW PV											
CZ01	PG&E	177,340	0	34.3	$302,856	$526,352	$380,399	1.7	1.3	$223,497	$77,544
CZ02	PG&E	215,311	0	41.5	$302,856	$666,050	$471,705	2.2	1.6	$363,194	$168,849
CZ03	PG&E	209,717	0	40.7	$302,856	$645,010	$449,797	2.1	1.5	$342,154	$146,942
CZ04	PG&E	227,535	0	44.0	$302,856	$686,434	$497,431	2.3	1.6	$383,578	$194,575
CZ04-2	CPAU	227,535	0	44.0	$302,856	$537,521	$497,431	1.8	1.6	$234,665	$194,575
CZ05	PG&E	226,195	0	44.1	$302,856	$753,230	$486,596	2.5	1.6	$450,374	$183,741
CZ06	SCE	218,387	0	42.3	$302,856	$401,645	$492,515	1.3	1.6	$98,789	$189,659
CZ06-2	LADWP	218,387	0	42.3	$302,856	$233,909	$492,515	0.8	1.6	($68,947)	$189,659
CZ07	SDG&E	223,185	0	43.3	$302,856	$623,078	$496,667	2.1	1.6	$320,223	$193,811
CZ08	SCE	217,171	0	42.0	$302,856	$389,435	$510,270	1.3	1.7	$86,579	$207,414
CZ08-2	LADWP	217,171	0	42.0	$302,856	$222,066	$510,270	0.7	1.7	($80,790)	$207,414
CZ09	SCE	220,010	0	43.2	$302,856	$387,977	$505,783	1.3	1.7	$85,122	$202,928
CZ09-2	LADWP	220,010	0	43.2	$302,856	$226,516	$505,783	0.7	1.7	($76,340)	$202,928
CZ10	SDG&E	217,148	0	42.5	$302,856	$632,726	$485,451	2.1	1.6	$329,870	$182,595
CZ10-2	SCE	217,148	0	42.5	$302,856	$394,884	$485,451	1.3	1.6	$92,028	$182,595
CZ11	PG&E	211,556	0	40.9	$302,856	$671,691	$478,912	2.2	1.6	$368,835	$176,056
CZ12	PG&E	211,824	0	40.9	$302,856	$653,242	$478,101	2.2	1.6	$350,386	$175,245
CZ12-2	SMUD	211,824	0	40.9	$302,856	$345,255	$478,101	1.1	1.6	$42,399	$175,245
CZ13	PG&E	208,465	0	40.5	$302,856	$651,952	$462,732	2.2	1.5	$349,096	$159,876
CZ14	SDG&E	241,965	0	46.7	$302,856	$659,487	$566,351	2.2	1.9	$356,632	$263,496
CZ14-2	SCE	241,965	0	46.7	$302,856	$401,712	$566,351	1.3	1.9	$98,856	$263,496
CZ15	SCE	229,456	0	43.9	$302,856	$378,095	$520,102	1.2	1.7	$75,239	$217,246
CZ16	PG&E	229,317	0	44.8	$302,856	$707,095	$489,508	2.3	1.6	$404,239	$186,652
CZ16-2	LADWP	229,317	0	44.8	$302,856	$223,057	$489,508	0.7	1.6	($79,799)	$186,652

Figure 57. Cost Effectiveness for Medium Office – Mixed Fuel + 135kW PV + 50 kWh Battery

CZ	IOU territory	Elec Savings (kWh)	Gas Savings (therms)	GHG savings (tons)	Incremental Package Cost	Lifecycle Energy Cost Savings	Lifecycle TDV Savings	B/C Ratio (On-bill)	B/C Ratio (TDV)	NPV (On-bill)	NPV (TDV)
Mixed Fuel + 135kW PV + 50 kWh Battery											
CZ01	PG&E	176,903	0	35.3	$330,756	$525,948	$381,450	1.6	1.2	$195,192	$50,694
CZ02	PG&E	214,861	0	42.6	$330,756	$665,864	$472,898	2.0	1.4	$335,108	$142,142
CZ03	PG&E	209,255	0	41.8	$330,756	$644,170	$451,611	1.9	1.4	$313,414	$120,855
CZ04	PG&E	227,076	0	45.0	$330,756	$685,605	$502,108	2.1	1.5	$354,849	$171,352
CZ04-2	CPAU	227,076	0	45.0	$330,756	$536,463	$502,108	1.6	1.5	$205,707	$171,352
CZ05	PG&E	225,752	0	45.1	$330,756	$753,558	$487,742	2.3	1.5	$422,803	$156,986
CZ06	SCE	217,939	0	43.4	$330,756	$401,356	$494,042	1.2	1.5	$70,601	$163,286
CZ06-2	LADWP	217,939	0	43.4	$330,756	$233,673	$494,042	0.7	1.5	($97,083)	$163,286
CZ07	SDG&E	222,746	0	44.4	$330,756	$628,383	$498,147	1.9	1.5	$297,627	$167,391
CZ08	SCE	216,724	0	43.1	$330,756	$389,184	$511,511	1.2	1.5	$58,428	$180,755
CZ08-2	LADWP	216,724	0	43.1	$330,756	$221,839	$511,511	0.7	1.5	($108,917)	$180,755
CZ09	SCE	219,563	0	44.2	$330,756	$387,728	$506,929	1.2	1.5	$56,972	$176,173
CZ09-2	LADWP	219,563	0	44.2	$330,756	$226,303	$506,929	0.7	1.5	($104,453)	$176,173
CZ10	SDG&E	216,700	0	43.5	$330,756	$638,040	$486,644	1.9	1.5	$307,284	$155,888
CZ10-2	SCE	216,700	0	43.5	$330,756	$394,633	$486,644	1.2	1.5	$63,877	$155,888
CZ11	PG&E	211,129	0	41.9	$330,756	$670,932	$481,298	2.0	1.5	$340,177	$150,543
CZ12	PG&E	211,386	0	41.9	$330,756	$652,465	$482,826	2.0	1.5	$321,709	$152,070
CZ12-2	SMUD	211,386	0	41.9	$330,756	$344,668	$482,826	1.0	1.5	$13,913	$152,070
CZ13	PG&E	208,045	0	41.5	$330,756	$651,191	$473,280	2.0	1.4	$320,435	$142,524
CZ14	SDG&E	241,502	0	47.7	$330,756	$672,601	$569,454	2.0	1.7	$341,846	$238,698
CZ14-2	SCE	241,502	0	47.7	$330,756	$401,450	$569,454	1.2	1.7	$70,694	$238,698
CZ15	SCE	229,062	0	44.8	$330,756	$377,827	$521,963	1.1	1.6	$47,071	$191,208
CZ16	PG&E	228,825	0	45.9	$330,756	$706,201	$496,190	2.1	1.5	$375,445	$165,434
CZ16-2	LADWP	228,825	0	45.9	$330,756	$222,802	$496,190	0.7	1.5	($107,953)	$165,434

Figure 58. Cost Effectiveness for Medium Office– All-Electric + 3kW PV

CZ	IOU territory	Elec Savings (kWh)	Gas Savings (therms)	GHG savings (tons)	Incremental Package Cost	Lifecycle Energy Cost Savings	Lifecycle TDV Savings	B/C Ratio (On-bill)	B/C Ratio (TDV)	NPV (On-bill)	NPV (TDV)
All-Electric + 3kW PV											
CZ01	PG&E	-49,716	4967	10.9	($80,523)	($84,765)	($49,972)	0.9	1.6	($4,242)	$30,551
CZ02	PG&E	-44,899	3868	6.0	($66,965)	($83,115)	($30,928)	0.8	2.2	($16,150)	$36,037
CZ03	PG&E	-31,226	3142	6.5	($75,600)	($39,441)	($19,617)	1.9	3.9	$36,159	$55,983
CZ04	PG&E	-43,772	3759	5.7	($62,282)	($70,999)	($29,496)	0.9	2.1	($8,717)	$32,786
CZ04-2	CPAU	-43,772	3759	5.7	($62,282)	($8,050)	($29,496)	7.7	2.1	$54,232	$32,786
CZ05	PG&E	-35,504	3240	5.5	($77,773)	($42,559)	($29,162)	1.8	2.7	$35,214	$48,611
CZ06	SCE	-21,321	2117	4.0	($69,422)	$35,862	($9,641)	>1	7.2	$105,284	$59,781
CZ06-2	LADWP	-21,321	2117	4.0	($69,422)	$32,936	($9,641)	>1	7.2	$102,358	$59,781
CZ07	SDG&E	-7,943	950	1.9	($63,595)	$64,781	($382)	>1	166.6	$128,376	$63,214
CZ08	SCE	-10,854	1219	2.5	($62,043)	$28,651	($1,289)	>1	48.1	$90,694	$60,755
CZ08-2	LADWP	-10,854	1219	2.5	($62,043)	$25,122	($1,289)	>1	48.1	$87,165	$60,755
CZ09	SCE	-14,878	1605	3.3	($56,372)	$31,542	($3,246)	>1	17.4	$87,913	$53,126
CZ09-2	LADWP	-14,878	1605	3.3	($56,372)	$28,145	($3,246)	>1	17.4	$84,517	$53,126
CZ10	SDG&E	-22,588	2053	3.1	($41,171)	$59,752	($12,553)	>1	3.3	$100,924	$28,619
CZ10-2	SCE	-22,588	2053	3.1	($41,171)	$32,039	($12,553)	>1	3.3	$73,211	$28,619
CZ11	PG&E	-35,455	3062	4.5	($57,257)	($53,776)	($22,194)	1.1	2.6	$3,481	$35,063
CZ12	PG&E	-38,704	3327	5.0	($61,613)	($66,808)	($24,819)	0.9	2.5	($5,195)	$36,794
CZ12-2	SMUD	-38,704	3327	5.0	($61,613)	$2,897	($24,819)	>1	2.5	$64,510	$36,794
CZ13	PG&E	-35,016	3063	4.7	($55,996)	($52,159)	($22,146)	1.1	2.5	$3,836	$33,849
CZ14	SDG&E	-38,945	3266	4.5	($58,426)	$24,867	($25,821)	>1	2.3	$83,293	$32,605
CZ14-2	SCE	-38,945	3266	4.5	($58,426)	$15,338	($25,821)	>1	2.3	$73,764	$32,605
CZ15	SCE	-14,818	1537	2.8	($29,445)	$22,852	($3,914)	>1	7.5	$52,298	$25,532
CZ16	PG&E	-88,966	6185	6.6	($57,366)	($193,368)	($139,989)	0.3	0.4	($136,002)	($82,623)
CZ16-2	LADWP	-88,966	6185	6.6	($57,366)	$36,354	($139,989)	>1	0.4	$93,720	($82,623)

Figure 59. Cost Effectiveness for Medium Office – All-Electric + 3kW PV + 5 kWh Battery

CZ	IOU territory	Elec Savings (kWh)	Gas Savings (therms)	GHG savings (tons)	Incremental Package Cost	Lifecycle Energy Cost Savings	$-TDV Savings	B/C Ratio (On-bill)	B/C Ratio (TDV)	NPV (On-bill)	NPV (TDV)
All-Electric + 3kW PV + 5 kWh Battery											
CZ01	PG&E	-49,716	4967	10.9	($78,897)	($84,765)	($49,972)	0.9	1.6	($5,868)	$28,925
CZ02	PG&E	-44,899	3868	6.0	($78,897)	($83,115)	($30,928)	0.9	2.6	($4,218)	$47,969
CZ03	PG&E	-31,226	3142	6.5	($78,897)	($39,441)	($19,617)	2.0	4.0	$39,456	$59,280
CZ04	PG&E	-43,772	3759	5.7	($78,897)	($70,999)	($29,496)	1.1	2.7	$7,898	$49,400
CZ04-2	CPAU	-43,772	3759	5.7	($78,897)	($8,050)	($29,496)	9.8	2.7	$70,847	$49,400
CZ05	PG&E	-35,504	3240	5.5	($78,897)	($42,559)	($29,162)	1.9	2.7	$36,338	$49,735
CZ06	SCE	-21,321	2117	4.0	($78,897)	$35,862	($9,641)	>1	8.2	$114,759	$69,256
CZ06-2	LADWP	-21,321	2117	4.0	($78,897)	$32,936	($9,641)	>1	8.2	$111,833	$69,256
CZ07	SDG&E	-7,943	950	1.9	($78,897)	$64,781	($382)	>1	206.6	$143,678	$78,515
CZ08	SCE	-10,854	1219	2.5	($78,897)	$28,651	($1,289)	>1	61.2	$107,548	$77,608
CZ08-2	LADWP	-10,854	1219	2.5	($78,897)	$25,122	($1,289)	>1	61.2	$104,019	$77,608
CZ09	SCE	-14,878	1605	3.3	($78,897)	$31,542	($3,246)	>1	24.3	$110,439	$75,651
CZ09-2	LADWP	-14,878	1605	3.3	($78,897)	$28,145	($3,246)	>1	24.3	$107,042	$75,651
CZ10	SDG&E	-22,588	2053	3.1	($78,897)	$59,752	($12,553)	>1	6.3	$138,649	$66,344
CZ10-2	SCE	-22,588	2053	3.1	($78,897)	$32,039	($12,553)	>1	6.3	$110,936	$66,344
CZ11	PG&E	-35,455	3062	4.5	($78,897)	($53,776)	($22,194)	1.5	3.6	$25,121	$56,703
CZ12	PG&E	-38,704	3327	5.0	($78,897)	($66,808)	($24,819)	1.2	3.2	$12,089	$54,078
CZ12-2	SMUD	-38,704	3327	5.0	($78,897)	$2,897	($24,819)	>1	3.2	$81,794	$54,078
CZ13	PG&E	-35,016	3063	4.7	($78,897)	($52,159)	($22,146)	1.5	3.6	$26,738	$56,751
CZ14	SDG&E	-38,945	3266	4.5	($78,897)	$24,867	($25,821)	>1	3.1	$103,764	$53,076
CZ14-2	SCE	-38,945	3266	4.5	($78,897)	$15,338	($25,821)	>1	3.1	$94,235	$53,076
CZ15	SCE	-14,818	1537	2.8	($78,897)	$22,852	($3,914)	>1	20.2	$101,749	$74,983
CZ16	PG&E	-88,966	6185	6.6	($78,897)	($193,368)	($139,989)	0.4	0.6	($114,472)	($61,092)
CZ16-2	LADWP	-88,966	6185	6.6	($78,897)	$36,354	($139,989)	>1	0.6	$115,250	($61,092)

Figure 60. Cost Effectiveness for Medium Office – All-Electric + 135kW PV

CZ	IOU territory	Elec Savings (kWh)	Gas Savings (therms)	GHG savings (tons)	Incremental Package Cost	Lifecycle Energy Cost Savings	Lifecycle TDV Savings	B/C Ratio (On-bill)	B/C Ratio (TDV)	NPV (On-bill)	NPV (TDV)
All-Electric + 135kW PV											
CZ01	PG&E	123,683	4967	44.5	$163,217	$405,731	$321,979	2.5	2.0	$242,514	$158,762
CZ02	PG&E	165,627	3868	46.6	$176,775	$562,528	$430,276	3.2	2.4	$385,753	$253,501
CZ03	PG&E	173,831	3142	46.3	$168,140	$575,864	$420,205	3.4	2.5	$407,725	$252,066
CZ04	PG&E	178,706	3759	48.7	$181,458	$601,431	$456,861	3.3	2.5	$419,973	$275,403
CZ04-2	CPAU	178,706	3759	48.7	$181,458	$517,526	$456,861	2.9	2.5	$336,069	$275,403
CZ05	PG&E	185,664	3240	48.6	$165,967	$664,842	$446,600	4.0	2.7	$498,875	$280,633
CZ06	SCE	192,214	2117	45.3	$174,317	$423,657	$471,944	2.4	2.7	$249,340	$297,626
CZ06-2	LADWP	192,214	2117	45.3	$174,317	$259,270	$471,944	1.5	2.7	$84,953	$297,626
CZ07	SDG&E	210,282	950	44.3	$180,145	$669,979	$485,260	3.7	2.7	$489,834	$305,115
CZ08	SCE	201,491	1219	43.5	$181,696	$407,277	$497,622	2.2	2.7	$225,580	$315,925
CZ08-2	LADWP	201,491	1219	43.5	$181,696	$240,657	$497,622	1.3	2.7	$58,960	$315,925
CZ09	SCE	200,242	1605	45.6	$187,368	$408,922	$491,322	2.2	2.6	$221,554	$303,953
CZ09-2	LADWP	200,242	1605	45.6	$187,368	$248,452	$491,322	1.3	2.6	$61,084	$303,953
CZ10	SDG&E	189,734	2053	44.7	$202,568	$667,551	$462,111	3.3	2.3	$464,982	$259,543
CZ10-2	SCE	189,734	2053	44.7	$202,568	$412,659	$462,111	2.0	2.3	$210,091	$259,543
CZ11	PG&E	171,399	3062	44.5	$186,483	$597,807	$446,074	3.2	2.4	$411,324	$259,592
CZ12	PG&E	168,413	3327	45.0	$182,127	$571,758	$442,638	3.1	2.4	$389,632	$260,511
CZ12-2	SMUD	168,413	3327	45.0	$182,127	$343,602	$442,638	1.9	2.4	$161,475	$260,511
CZ13	PG&E	168,817	3063	44.3	$187,744	$581,964	$430,324	3.1	2.3	$394,220	$242,580
CZ14	SDG&E	197,643	3266	50.1	$185,314	$667,762	$527,930	3.6	2.8	$482,449	$342,616
CZ14-2	SCE	197,643	3266	50.1	$185,314	$408,424	$527,930	2.2	2.8	$223,110	$342,616
CZ15	SCE	209,539	1537	45.7	$214,294	$390,267	$504,638	1.8	2.4	$175,972	$290,343
CZ16	PG&E	135,255	6185	50.4	$186,374	$470,199	$338,637	2.5	1.8	$283,825	$152,263
CZ16-2	LADWP	135,255	6185	50.4	$186,374	$250,807	$338,637	1.3	1.8	$64,433	$152,263

Figure 61. Cost Effectiveness for Medium Office – All-Electric + 135kW PV + 50 kWh Battery

CZ	IOU territory	Elec Savings (kWh)	Gas Savings (therms)	GHG savings (tons)	Incremental Package Cost	Lifecycle Energy Cost Savings	Lifecycle TDV Savings	B/C Ratio (On-bill)	B/C Ratio (TDV)	NPV (On-bill)	NPV (TDV)
All-Electric + 135kW PV + 50 kWh Battery											
CZ01	PG&E	123,280	4967	45.4	$191,117	$404,994	$323,077	2.1	1.7	$213,877	$131,960
CZ02	PG&E	165,200	3868	47.7	$204,675	$561,747	$431,469	2.7	2.1	$357,072	$226,795
CZ03	PG&E	173,384	3142	47.4	$196,040	$575,043	$422,019	2.9	2.2	$379,003	$225,979
CZ04	PG&E	178,259	3759	49.8	$209,358	$600,621	$461,634	2.9	2.2	$391,263	$252,276
CZ04-2	CPAU	178,259	3759	49.8	$209,358	$516,495	$461,634	2.5	2.2	$307,137	$252,276
CZ05	PG&E	185,229	3240	49.7	$193,867	$664,046	$447,793	3.4	2.3	$470,179	$253,926
CZ06	SCE	191,767	2117	46.5	$202,217	$423,369	$473,519	2.1	2.3	$221,152	$271,301
CZ06-2	LADWP	191,767	2117	46.5	$202,217	$259,033	$473,519	1.3	2.3	$56,816	$271,301
CZ07	SDG&E	209,848	950	45.4	$208,045	$675,307	$486,787	3.2	2.3	$467,262	$278,743
CZ08	SCE	201,047	1219	44.7	$209,596	$407,027	$498,910	1.9	2.4	$197,430	$289,314
CZ08-2	LADWP	201,047	1219	44.7	$209,596	$240,432	$498,910	1.1	2.4	$30,835	$289,314
CZ09	SCE	199,802	1605	46.6	$215,268	$408,676	$492,515	1.9	2.3	$193,408	$277,246
CZ09-2	LADWP	199,802	1605	46.6	$215,268	$248,242	$492,515	1.2	2.3	$32,974	$277,246
CZ10	SDG&E	189,293	2053	45.7	$230,468	$672,867	$463,352	2.9	2.0	$442,399	$232,884
CZ10-2	SCE	189,293	2053	45.7	$230,468	$412,412	$463,352	1.8	2.0	$181,944	$232,884
CZ11	PG&E	170,987	3062	45.5	$214,383	$597,062	$448,509	2.8	2.1	$382,680	$234,126
CZ12	PG&E	167,995	3327	46.0	$210,027	$571,002	$447,411	2.7	2.1	$360,975	$237,384
CZ12-2	SMUD	167,995	3327	46.0	$210,027	$343,043	$447,411	1.6	2.1	$133,017	$237,384
CZ13	PG&E	168,408	3063	45.3	$215,644	$581,225	$440,920	2.7	2.0	$365,580	$225,275
CZ14	SDG&E	197,188	3266	51.2	$213,214	$680,893	$531,080	3.2	2.5	$467,679	$317,866
CZ14-2	SCE	197,188	3266	51.2	$213,214	$408,166	$531,080	1.9	2.5	$194,952	$317,866
CZ15	SCE	209,148	1537	46.6	$242,194	$390,000	$506,499	1.6	2.1	$147,806	$264,305
CZ16	PG&E	134,809	6185	51.4	$214,274	$469,378	$341,978	2.2	1.6	$255,105	$127,704
CZ16-2	LADWP	134,809	6185	51.4	$214,274	$250,580	$341,978	1.2	1.6	$36,306	$127,704

6.7.2 Cost Effectiveness Results – Medium Retail

Figure 62 through Figure 69 contain the cost-effectiveness findings for the Medium Retail packages. Notable findings for each package include:

- **Mixed-Fuel + 3 kW PV:** Packages are cost effective and achieve savings for all climate zones using the On-Bill and TDV approaches.
- **Mixed-Fuel + 3 kW PV + 5 kWh Battery:** The packages are less cost effective as compared to the 3 kW PV only package and not cost effective for LADWP and SMUD service area.
- **Mixed-Fuel + PV only:** Packages achieve positive energy cost savings and are cost effective using the On-Bill approach for all climate zones except for LADWP territory (CZs 6, 8, 9 and 16). Packages achieve positive savings and are cost effective using the TDV approach for all climate zones.
- **Mixed Fuel + PV + 5 kWh Battery:** Adding battery slightly reduces On-Bill B/C ratios but is still cost effective for all climate zones except for LADWP territory. Packages achieve savings and cost effective using the TDV approach for all climate zones.
- **All-Electric + 3 kW PV:** Packages are cost effective using the On-Bill and TDV approach for all climate zones except for CZ16 under PG&E service.
- **All-Electric + 3 kW PV + 5 kWh Battery**: Similar to minimal PV only package, adding battery is cost effective as well using the On-Bill and TDV approach for all climate zones except for CZ16 under PG&E service.
- **All-Electric + PV only:** Packages are cost effective and achieve savings in all climate zones for both the On-Bill and TDV approaches
- **All-Electric + PV + 50 kWh Battery**: Adding battery slightly reduces B/C ratios for both the On-Bill and TDV approaches. Packages are not cost effective for all climate zones except CZ6, CZ8 and CZ9 under LADWP service area.

Figure 62. Cost Effectiveness for Medium Retail – Mixed-Fuel + 3kW PV

CZ	IOU territory	Elec Savings (kWh)	Gas Savings (therms)	GHG savings (tons)	Incremental Package Cost	Lifecycle Energy Cost Savings	Lifecycle TDV Savings	B/C Ratio (On-bill)	B/C Ratio (TDV)	NPV (On-bill)	NPV (TDV)
Mixed Fuel + 3kW PV											
CZ01	PG&E	3,941	0	0.76	$5,566	$12,616	$8,460	2.3	1.5	$7,050	$2,894
CZ02	PG&E	4,685	0	0.91	$5,566	$17,635	$10,262	3.2	1.8	$12,069	$4,696
CZ03	PG&E	4,733	0	0.92	$5,566	$15,146	$10,152	2.7	1.8	$9,580	$4,586
CZ04	PG&E	4,834	0	0.94	$5,566	$18,519	$10,614	3.3	1.9	$12,953	$5,048
CZ04-2	CPAU	4,834	0	0.94	$5,566	$11,507	$10,614	2.1	1.9	$5,941	$5,048
CZ05	PG&E	4,910	0	0.95	$5,566	$15,641	$10,548	2.8	1.9	$10,075	$4,982
CZ06	SCE	4,769	0	0.93	$5,566	$11,374	$10,724	2.0	1.9	$5,808	$5,158
CZ06-2	LA	4,769	0	0.93	$5,566	$7,069	$10,724	1.3	1.9	$1,503	$5,158
CZ07	SDG&E	4,960	0	0.96	$5,566	$22,452	$11,031	4.0	2.0	$16,886	$5,465
CZ08	SCE	4,826	0	0.93	$5,566	$11,838	$11,339	2.1	2.0	$6,272	$5,773
CZ08-2	LA	4,826	0	0.93	$5,566	$7,342	$11,339	1.3	2.0	$1,776	$5,773
CZ09	SCE	4,889	0	0.96	$5,566	$11,187	$11,229	2.0	2.0	$5,621	$5,663
CZ09-2	LA	4,889	0	0.96	$5,566	$6,728	$11,229	1.2	2.0	$1,162	$5,663
CZ10	SDG&E	4,948	0	0.97	$5,566	$20,999	$10,987	3.8	2.0	$15,433	$5,421
CZ10-2	SCE	4,948	0	0.97	$5,566	$11,384	$10,987	2.0	2.0	$5,818	$5,421
CZ11	PG&E	4,718	0	0.91	$5,566	$15,381	$10,680	2.8	1.9	$9,815	$5,114
CZ12	PG&E	4,707	0	0.91	$5,566	$16,442	$10,614	3.0	1.9	$10,876	$5,048
CZ12-2	SMUD	4,707	0	0.91	$5,566	$8,247	$10,614	1.5	1.9	$2,681	$5,048
CZ13	PG&E	4,750	0	0.92	$5,566	$16,638	$10,592	3.0	1.9	$11,072	$5,026
CZ14	SDG&E	5,258	0	1.01	$5,566	$19,576	$12,218	3.5	2.2	$14,010	$6,652
CZ14-2	SCE	5,258	0	1.01	$5,566	$10,227	$12,218	1.8	2.2	$4,661	$6,652
CZ15	SCE	4,997	0	0.96	$5,566	$10,476	$11,339	1.9	2.0	$4,910	$5,773
CZ16	PG&E	5,336	0	1.04	$5,566	$20,418	$11,361	3.7	2.0	$14,852	$5,795
CZ16-2	LA	5,336	0	1.04	$5,566	$6,987	$11,361	1.3	2.0	$1,421	$5,795

Figure 63. Cost Effectiveness for Medium Retail – Mixed Fuel + 3kW PV + 5 kWh Battery

CZ	IOU territory	Elec Savings (kWh)	Gas Savings (therms)	GHG savings (tons)	Incremental Package Cost	Lifecycle Energy Cost Savings	$-TDV Savings	B/C Ratio (On-bill)	B/C Ratio (TDV)	NPV (On-bill)	NPV (TDV)
Mixed Fuel + 3kW PV + 5 kWh Battery											
CZ01	PG&E	3,941	0	0.76	$9,520	$12,616	$8,460	1.3	0.9	$3,096	($1,060)
CZ02	PG&E	4,685	0	0.91	$9,520	$17,635	$10,262	1.9	1.1	$8,115	$742
CZ03	PG&E	4,733	0	0.92	$9,520	$15,146	$10,152	1.6	1.1	$5,626	$632
CZ04	PG&E	4,834	0	0.94	$9,520	$18,519	$10,614	1.9	1.1	$8,999	$1,094
CZ04-2	CPAU	4,834	0	0.94	$9,520	$11,507	$10,614	1.2	1.1	$1,987	$1,094
CZ05	PG&E	4,910	0	0.95	$9,520	$15,641	$10,548	1.6	1.1	$6,120	$1,028
CZ05-2	SCG	4,910	0	0.95	$9,520	$15,641	$10,548	1.6	1.1	$6,120	$1,028
CZ06	SCE	4,769	0	0.93	$9,520	$11,374	$10,724	1.2	1.1	$1,854	$1,204
CZ06-2	LA	4,769	0	0.93	$9,520	$7,069	$10,724	0.7	1.1	($2,452)	$1,204
CZ07	SDG&E	4,960	0	0.96	$9,520	$22,452	$11,031	2.4	1.2	$12,932	$1,511
CZ08	SCE	4,826	0	0.93	$9,520	$11,838	$11,339	1.2	1.2	$2,317	$1,819
CZ08-2	LA	4,826	0	0.93	$9,520	$7,342	$11,339	0.8	1.2	($2,178)	$1,819
CZ09	SCE	4,889	0	0.96	$9,520	$11,187	$11,229	1.2	1.2	$1,667	$1,709
CZ09-2	LA	4,889	0	0.96	$9,520	$6,728	$11,229	0.7	1.2	($2,792)	$1,709
CZ10	SDG&E	4,948	0	0.97	$9,520	$20,999	$10,987	2.2	1.2	$11,479	$1,467
CZ10-2	SCE	4,948	0	0.97	$9,520	$11,384	$10,987	1.2	1.2	$1,863	$1,467
CZ11	PG&E	4,718	0	0.91	$9,520	$15,381	$10,680	1.6	1.1	$5,861	$1,160
CZ12	PG&E	4,707	0	0.91	$9,520	$16,442	$10,614	1.7	1.1	$6,922	$1,094
CZ12-2	SMUD	4,707	0	0.91	$9,520	$8,247	$10,614	0.9	1.1	($1,273)	$1,094
CZ13	PG&E	4,750	0	0.92	$9,520	$16,638	$10,592	1.7	1.1	$7,117	$1,072
CZ14	SDG&E	5,258	0	1.01	$9,520	$19,576	$12,218	2.1	1.3	$10,056	$2,698
CZ14-2	SCE	5,258	0	1.01	$9,520	$10,227	$12,218	1.1	1.3	$707	$2,698
CZ15	SCE	4,997	0	0.96	$9,520	$10,476	$11,339	1.1	1.2	$956	$1,819
CZ16	PG&E	5,336	0	1.04	$9,520	$20,418	$11,361	2.1	1.2	$10,898	$1,841
CZ16-2	LA	5,336	0	1.04	$9,520	$6,987	$11,361	0.7	1.2	($2,533)	$1,841

Figure 64. Cost Effectiveness for Medium Retail – Mixed-Fuel + 110kW PV

CZ	IOU territory	Elec Savings (kWh)	Gas Savings (therms)	GHG savings (tons)	Incremental Package Cost	Lifecycle Energy Cost Savings	Lifecycle TDV Savings	B/C Ratio (On-bill)	B/C Ratio (TDV)	NPV (On-bill)	NPV (TDV)
Mixed Fuel + 110kW PV											
CZ01	PG&E	144,499	0	27.97	$201,904	$454,462	$309,935	2.3	1.5	$252,558	$108,031
CZ02	PG&E	171,790	0	33.31	$201,904	$477,584	$376,300	2.4	1.9	$275,681	$174,396
CZ03	PG&E	173,534	0	33.55	$201,904	$538,530	$372,146	2.7	1.8	$336,626	$170,243
CZ04	PG&E	177,229	0	34.42	$201,904	$489,934	$389,067	2.4	1.9	$288,030	$187,163
CZ04-2	CPAU	177,229	0	34.42	$201,904	$418,173	$389,067	2.1	1.9	$216,269	$187,163
CZ05	PG&E	180,044	0	34.84	$201,904	$556,787	$386,958	2.8	1.9	$354,883	$185,054
CZ06	SCE	174,855	0	33.92	$201,904	$288,188	$393,198	1.4	1.9	$86,284	$191,295
CZ06-2	LA	174,855	0	33.92	$201,904	$165,538	$393,198	0.8	1.9	($36,366)	$191,295
CZ07	SDG&E	181,854	0	35.32	$201,904	$373,974	$404,713	1.9	2.0	$172,070	$202,809
CZ08	SCE	176,954	0	34.23	$201,904	$284,481	$415,789	1.4	2.1	$82,577	$213,885
CZ08-2	LA	176,954	0	34.23	$201,904	$161,366	$415,789	0.8	2.1	($40,538)	$213,885
CZ09	SCE	179,267	0	35.18	$201,904	$289,050	$412,097	1.4	2.0	$87,146	$210,193
CZ09-2	LA	179,267	0	35.18	$201,904	$168,822	$412,097	0.8	2.0	($33,082)	$210,193
CZ10	SDG&E	181,443	0	35.41	$201,904	$410,310	$402,999	2.0	2.0	$208,406	$201,095
CZ10-2	SCE	181,443	0	35.41	$201,904	$291,236	$402,999	1.4	2.0	$89,332	$201,095
CZ11	PG&E	172,983	0	33.46	$201,904	$464,776	$391,550	2.3	1.9	$262,872	$189,646
CZ12	PG&E	172,597	0	33.33	$201,904	$467,870	$389,573	2.3	1.9	$265,966	$187,669
CZ12-2	SMUD	172,597	0	33.33	$201,904	$267,086	$389,573	1.3	1.9	$65,182	$187,669
CZ13	PG&E	174,151	0	33.81	$201,904	$478,857	$387,968	2.4	1.9	$276,953	$186,065
CZ14	SDG&E	192,789	0	36.97	$201,904	$396,181	$448,268	2.0	2.2	$194,277	$246,364
CZ14-2	SCE	192,789	0	36.97	$201,904	$288,782	$448,268	1.4	2.2	$86,878	$246,364
CZ15	SCE	183,214	0	35.12	$201,904	$277,867	$415,789	1.4	2.1	$75,963	$213,885
CZ16	PG&E	195,665	0	37.97	$201,904	$522,352	$416,558	2.6	2.1	$320,448	$214,654
CZ16-2	LA	195,665	0	37.97	$201,904	$171,802	$416,558	0.9	2.1	($30,101)	$214,654

Figure 65. Cost Effectiveness for Medium Retail – Mixed-Fuel + 110 kW PV + 50 kWh Battery

CZ	IOU territory	Elec Savings (kWh)	Gas Savings (therms)	GHG savings (tons)	Incremental Package Cost	Lifecycle Energy Cost Savings	Lifecycle TDV Savings	B/C Ratio (On-bill)	B/C Ratio (TDV)	NPV (On-bill)	NPV (TDV)
Mixed Fuel + 110kW PV + 50 kWh Battery											
CZ01	PG&E	143,423	0	29.48	$229,804	$452,119	$324,373	2.0	1.4	$222,315	$94,569
CZ02	PG&E	170,542	0	35.14	$229,804	$486,704	$398,363	2.1	1.7	$256,900	$168,559
CZ03	PG&E	172,266	0	35.66	$229,804	$535,974	$395,374	2.3	1.7	$306,170	$165,570
CZ04	PG&E	175,940	0	36.32	$229,804	$525,788	$422,579	2.3	1.8	$295,984	$192,775
CZ04-2	CPAU	175,940	0	36.32	$229,804	$416,019	$422,579	1.8	1.8	$186,216	$192,775
CZ05	PG&E	178,728	0	36.91	$229,804	$554,968	$409,086	2.4	1.8	$325,164	$179,283
CZ06	SCE	173,567	0	35.99	$229,804	$290,599	$412,690	1.3	1.8	$60,795	$182,886
CZ06-2	LA	173,567	0	35.99	$229,804	$169,786	$412,690	0.7	1.8	($60,018)	$182,886
CZ07	SDG&E	180,508	0	37.61	$229,804	$425,793	$427,040	1.9	1.9	$195,989	$197,236
CZ08	SCE	175,616	0	36.29	$229,804	$296,318	$434,687	1.3	1.9	$66,514	$204,883
CZ08-2	LA	175,616	0	36.29	$229,804	$170,489	$434,687	0.7	1.9	($59,315)	$204,883
CZ09	SCE	177,966	0	36.74	$229,804	$300,540	$421,195	1.3	1.8	$70,736	$191,391
CZ09-2	LA	177,966	0	36.74	$229,804	$178,852	$421,195	0.8	1.8	($50,952)	$191,391
CZ10	SDG&E	180,248	0	36.91	$229,804	$459,486	$410,537	2.0	1.8	$229,683	$180,733
CZ10-2	SCE	180,248	0	36.91	$229,804	$301,219	$410,537	1.3	1.8	$71,415	$180,733
CZ11	PG&E	171,779	0	34.85	$229,804	$490,245	$417,679	2.1	1.8	$260,442	$187,875
CZ12	PG&E	171,392	0	34.77	$229,804	$497,363	$417,371	2.2	1.8	$267,559	$187,567
CZ12-2	SMUD	171,392	0	34.77	$229,804	$273,783	$417,371	1.2	1.8	$43,979	$187,567
CZ13	PG&E	173,052	0	34.97	$229,804	$488,196	$397,791	2.1	1.7	$258,392	$167,987
CZ14	SDG&E	191,703	0	38.31	$229,804	$420,241	$452,641	1.8	2.0	$190,437	$222,837
CZ14-2	SCE	191,703	0	38.31	$229,804	$294,010	$452,641	1.3	2.0	$64,206	$222,837
CZ15	SCE	182,299	0	36.01	$229,804	$279,036	$416,382	1.2	1.8	$49,232	$186,578
CZ16	PG&E	194,293	0	40.00	$229,804	$535,137	$432,951	2.3	1.9	$305,333	$203,147
CZ16-2	LA	194,293	0	40.00	$229,804	$175,573	$432,951	0.8	1.9	($54,231)	$203,147

Figure 66. Cost Effectiveness for Medium Retail – All-Electric + 3kW PV

CZ	IOU territory	Elec Savings (kWh)	Gas Savings (therms)	GHG savings (tons)	Incremental Package Cost	Lifecycle Energy Cost Savings	Lifecycle TDV Savings	B/C Ratio (On-bill)	B/C Ratio (TDV)	NPV (On-bill)	NPV (TDV)
All-Electric + 3kW PV											
CZ01	PG&E	-25,214	3893	14.61	($16,318)	$4,288	($5,450)	>1	3.0	$20,606	$10,868
CZ02	PG&E	-17,101	2448	8.40	($20,734)	$859	$5,779	>1	>1	$21,593	$26,513
CZ03	PG&E	-9,851	1868	7.18	($17,381)	$15,418	$8,702	>1	>1	$32,799	$26,083
CZ04	PG&E	-9,353	1706	6.24	($16,166)	$9,110	$10,394	>1	>1	$25,276	$26,560
CZ04-2	CPAU	-9,353	1706	6.24	($16,166)	$24,000	$10,394	>1	>1	$40,166	$26,560
CZ05	PG&E	-9,423	1746	6.42	($18,776)	$14,076	$6,351	>1	>1	$32,852	$25,127
CZ06	SCE	-2,759	1002	4.24	($15,032)	$29,710	$12,592	>1	>1	$44,741	$27,623
CZ06-2	LA	-2,759	1002	4.24	($15,032)	$26,292	$12,592	>1	>1	$41,324	$27,623
CZ07	SDG&E	1,148	522	2.72	($17,032)	$76,810	$12,350	>1	>1	$93,842	$29,382
CZ08	SCE	-979	793	3.64	($20,192)	$28,576	$13,185	>1	>1	$48,768	$33,377
CZ08-2	LA	-979	793	3.64	($20,192)	$24,475	$13,185	>1	>1	$44,667	$33,377
CZ09	SCE	-2,352	970	4.28	($25,383)	$29,776	$13,207	>1	>1	$55,159	$38,590
CZ09-2	LA	-2,352	970	4.28	($25,383)	$25,823	$13,207	>1	>1	$51,207	$38,590
CZ10	SDG&E	-5,388	1262	4.95	($20,541)	$75,458	$11,493	>1	>1	$95,999	$32,034
CZ10-2	SCE	-5,388	1262	4.95	($20,541)	$32,394	$11,493	>1	>1	$52,936	$32,034
CZ11	PG&E	-14,533	2415	8.86	($25,471)	$7,618	$13,295	>1	>1	$33,090	$38,766
CZ12	PG&E	-14,764	2309	8.19	($25,774)	$2,210	$10,152	>1	>1	$27,984	$35,926
CZ12-2	SMUD	-14,764	2309	8.19	($25,774)	$21,215	$10,152	>1	>1	$46,988	$35,926
CZ13	PG&E	-12,069	1983	7.08	($21,428)	$5,647	$8,570	>1	>1	$27,075	$29,998
CZ14	SDG&E	-7,950	1672	6.45	($19,926)	$60,412	$16,679	>1	>1	$80,338	$36,605
CZ14-2	SCE	-7,950	1672	6.45	($19,926)	$28,631	$16,679	>1	>1	$48,557	$36,605
CZ15	SCE	2,534	518	3.10	($22,813)	$27,271	$17,162	>1	>1	$50,084	$39,976
CZ16	PG&E	-36,081	4304	14.26	($19,041)	($30,111)	($41,181)	0.6	0.5	($11,070)	($22,140)
CZ16-2	LA	-36,081	4304	14.26	($19,041)	$45,706	($41,181)	>1	0.5	$64,747	($22,140)

Figure 67. Cost Effectiveness for Medium Retail – All-Electric + 3kW PV + 5 kWh Battery

CZ	IOU territory	Elec Savings (kWh)	Gas Savings (therms)	GHG savings (tons)	Incremental Package Cost	Lifecycle Energy Cost Savings	$-TDV Savings	B/C Ratio (On-bill)	B/C Ratio (TDV)	NPV (On-bill)	NPV (TDV)
All-Electric + 3kW PV + 5 kWh Battery											
CZ01	PG&E	-25,214	3893	14.61	($14,692)	$4,288	($5,450)	>1	2.7	$18,980	$9,242
CZ02	PG&E	-17,101	2448	8.40	($14,692)	$859	$5,779	>1	>1	$15,551	$20,472
CZ03	PG&E	-9,851	1868	7.18	($14,692)	$15,418	$8,702	>1	>1	$30,110	$23,394
CZ04	PG&E	-9,353	1706	6.24	($14,692)	$9,110	$10,394	>1	>1	$23,802	$25,086
CZ04-2	CPAU	-9,353	1706	6.24	($14,692)	$24,000	$10,394	>1	>1	$38,693	$25,086
CZ05	PG&E	-9,423	1746	6.42	($14,692)	$14,076	$6,351	>1	>1	$28,768	$21,043
CZ06	SCE	-2,759	1002	4.24	($14,692)	$29,710	$12,592	>1	>1	$44,402	$27,284
CZ06-2	LA	-2,759	1002	4.24	($14,692)	$26,292	$12,592	>1	>1	$40,984	$27,284
CZ07	SDG&E	1,148	522	2.72	($14,692)	$76,810	$12,350	>1	>1	$91,502	$27,042
CZ08	SCE	-979	793	3.64	($14,692)	$28,576	$13,185	>1	>1	$43,268	$27,877
CZ08-2	LA	-979	793	3.64	($14,692)	$24,475	$13,185	>1	>1	$39,167	$27,877
CZ09	SCE	-2,352	970	4.28	($14,692)	$29,776	$13,207	>1	>1	$44,468	$27,899
CZ09-2	LA	-2,352	970	4.28	($14,692)	$25,823	$13,207	>1	>1	$40,516	$27,899
CZ10	SDG&E	-5,388	1262	4.95	($14,692)	$75,458	$11,493	>1	>1	$90,150	$26,185
CZ10-2	SCE	-5,388	1262	4.95	($14,692)	$32,394	$11,493	>1	>1	$47,086	$26,185
CZ11	PG&E	-14,533	2415	8.86	($14,692)	$7,618	$13,295	>1	>1	$22,310	$27,987
CZ12	PG&E	-14,764	2309	8.19	($14,692)	$2,210	$10,152	>1	>1	$16,902	$24,845
CZ12-2	SMUD	-14,764	2309	8.19	($14,692)	$21,215	$10,152	>1	>1	$35,907	$24,845
CZ13	PG&E	-12,069	1983	7.08	($14,692)	$5,647	$8,570	>1	>1	$20,339	$23,262
CZ14	SDG&E	-7,950	1672	6.45	($14,692)	$60,412	$16,679	>1	>1	$75,104	$31,371
CZ14-2	SCE	-7,950	1672	6.45	($14,692)	$28,631	$16,679	>1	>1	$43,323	$31,371
CZ15	SCE	2,534	518	3.10	($14,692)	$27,271	$17,162	>1	>1	$41,963	$31,855
CZ16	PG&E	-36,081	4304	14.26	($14,692)	($30,111)	($41,181)	0.5	0.4	($15,419)	($26,489)
CZ16-2	LA	-36,081	4304	14.26	($14,692)	$45,706	($41,181)	>1	0.4	$60,398	($26,489)

Figure 68. Cost Effectiveness for Medium Retail – All-Electric + 110kW PV

CZ	IOU territory	Elec Savings (kWh)	Gas Savings (therms)	GHG savings (tons)	Incremental Package Cost	Lifecycle Energy Cost Savings	Lifecycle TDV Savings	B/C Ratio (On-bill)	B/C Ratio (TDV)	NPV (On-bill)	NPV (TDV)
All-Electric + 110kW PV											
CZ01	PG&E	115,344	3893	41.82	$143,932	$454,277	$296,025	3.2	2.1	$310,345	$152,093
CZ02	PG&E	150,004	2448	40.80	$139,516	$470,236	$371,817	3.4	2.7	$330,720	$232,301
CZ03	PG&E	158,951	1868	39.82	$142,869	$544,095	$370,696	3.8	2.6	$401,226	$227,827
CZ04	PG&E	163,043	1706	39.73	$144,084	$488,619	$388,847	3.4	2.7	$344,534	$244,763
CZ04-2	CPAU	163,043	1706	39.73	$144,084	$432,905	$388,847	3.0	2.7	$288,821	$244,763
CZ05	PG&E	165,711	1746	40.30	$141,473	$565,525	$382,760	4.0	2.7	$424,051	$241,287
CZ06	SCE	167,328	1002	37.24	$145,218	$306,670	$395,066	2.1	2.7	$161,452	$249,848
CZ06-2	LA	167,328	1002	37.24	$145,218	$184,797	$395,066	1.3	2.7	$39,579	$249,848
CZ07	SDG&E	178,042	522	37.07	$143,218	$428,332	$406,032	3.0	2.8	$285,114	$262,814
CZ08	SCE	171,149	793	36.94	$140,058	$301,219	$417,635	2.2	3.0	$161,161	$277,577
CZ08-2	LA	171,149	793	36.94	$140,058	$178,419	$417,635	1.3	3.0	$38,361	$277,577
CZ09	SCE	172,027	970	38.50	$134,867	$307,640	$414,075	2.3	3.1	$172,773	$279,208
CZ09-2	LA	172,027	970	38.50	$134,867	$187,813	$414,075	1.4	3.1	$52,946	$279,208
CZ10	SDG&E	171,107	1262	39.40	$139,708	$463,692	$403,505	3.3	2.9	$323,984	$263,796
CZ10-2	SCE	171,107	1262	39.40	$139,708	$311,464	$403,505	2.2	2.9	$171,755	$263,796
CZ11	PG&E	153,732	2415	41.41	$134,778	$467,356	$394,165	3.5	2.9	$332,578	$259,387
CZ12	PG&E	153,126	2309	40.61	$134,476	$467,106	$389,111	3.5	2.9	$332,630	$254,635
CZ12-2	SMUD	153,126	2309	40.61	$134,476	$283,343	$389,111	2.1	2.9	$148,867	$254,635
CZ13	PG&E	157,332	1983	39.97	$138,822	$477,831	$385,947	3.4	2.8	$339,008	$247,124
CZ14	SDG&E	179,582	1672	42.42	$140,324	$437,575	$452,729	3.1	3.2	$297,251	$312,405
CZ14-2	SCE	179,582	1672	42.42	$140,324	$309,064	$452,729	2.2	3.2	$168,740	$312,405
CZ15	SCE	180,751	518	37.26	$137,436	$294,877	$421,612	2.1	3.1	$157,440	$284,176
CZ16	PG&E	154,248	4304	51.20	$141,209	$473,892	$364,016	3.4	2.6	$332,682	$222,807
CZ16-2	LA	154,248	4304	51.20	$141,209	$211,677	$364,016	1.5	2.6	$70,467	$222,807

Figure 69. Cost Effectiveness for Medium Retail – All-Electric + 110kW PV + 50 kWh Battery

CZ	IOU territory	Elec Savings (kWh)	Gas Savings (therms)	GHG savings (tons)	Incremental Package Cost	Lifecycle Energy Cost Savings	Lifecycle TDV Savings	B/C Ratio (On-bill)	B/C Ratio (TDV)	NPV (On-bill)	NPV (TDV)
All-Electric + 90kW PV + 50 kWh Battery											
CZ01	PG&E	114,356	3893	43.52	$171,832	$451,043	$310,265	2.6	1.8	$279,211	$138,433
CZ02	PG&E	148,793	2448	42.89	$167,416	$475,081	$394,099	2.8	2.4	$307,664	$226,683
CZ03	PG&E	157,707	1868	42.12	$170,769	$541,418	$394,034	3.2	2.3	$370,649	$223,265
CZ04	PG&E	161,769	1706	41.82	$171,984	$523,603	$422,535	3.0	2.5	$351,618	$250,551
CZ04-2	CPAU	161,769	1706	41.82	$171,984	$430,567	$422,535	2.5	2.5	$258,582	$250,551
CZ05	PG&E	164,408	1746	42.68	$169,373	$561,966	$405,087	3.3	2.4	$392,592	$235,714
CZ06	SCE	166,052	1002	39.48	$173,118	$306,697	$414,756	1.8	2.4	$133,579	$241,638
CZ06-2	LA	166,052	1002	39.48	$173,118	$187,941	$414,756	1.1	2.4	$14,823	$241,638
CZ07	SDG&E	176,705	522	39.47	$171,118	$479,038	$428,490	2.8	2.5	$307,920	$257,372
CZ08	SCE	169,825	793	39.14	$167,958	$312,602	$436,709	1.9	2.6	$144,645	$268,751
CZ08-2	LA	169,825	793	39.14	$167,958	$187,142	$436,709	1.1	2.6	$19,185	$268,751
CZ09	SCE	170,747	970	40.23	$162,767	$318,113	$423,370	2.0	2.6	$155,346	$260,604
CZ09-2	LA	170,747	970	40.23	$162,767	$197,006	$423,370	1.2	2.6	$34,240	$260,604
CZ10	SDG&E	169,935	1262	41.08	$167,608	$503,504	$411,284	3.0	2.5	$335,896	$243,675
CZ10-2	SCE	169,935	1262	41.08	$167,608	$317,927	$411,284	1.9	2.5	$150,319	$243,675
CZ11	PG&E	152,559	2415	42.99	$162,678	$491,775	$420,667	3.0	2.6	$329,096	$257,989
CZ12	PG&E	151,956	2309	42.21	$162,376	$494,703	$417,063	3.0	2.6	$332,327	$254,687
CZ12-2	SMUD	151,956	2309	42.21	$162,376	$288,950	$417,063	1.8	2.6	$126,573	$254,687
CZ13	PG&E	156,271	1983	41.25	$166,722	$485,422	$395,770	2.9	2.4	$318,699	$229,047
CZ14	SDG&E	178,505	1672	43.94	$168,224	$452,456	$457,387	2.7	2.7	$284,232	$289,163
CZ14-2	SCE	178,505	1672	43.94	$168,224	$311,520	$457,387	1.9	2.7	$143,296	$289,163
CZ15	SCE	179,840	518	38.23	$165,336	$296,004	$422,293	1.8	2.6	$130,668	$256,957
CZ16	PG&E	152,965	4304	53.53	$169,109	$483,205	$378,299	2.9	2.2	$314,096	$209,190
CZ16-2	LA	152,965	4304	53.53	$169,109	$215,341	$378,299	1.3	2.2	$46,231	$209,190

6.7.3 Cost Effectiveness Results – Small Hotel

Figure 70 through Figure 77 contain the cost-effectiveness findings for the Small Hotel packages. Notable findings for each package include:

- **Mixed-Fuel + 3 kW PV:** Packages are cost effective and achieve savings for all climate zones for both the On-Bill and TDV approaches.
- **Mixed-Fuel + 3 kW PV + 5 kWh Battery:** The packages are less cost effective as compared to the previous minimal PV only package and not cost effective for LADWP and SMUD service area. The addition of battery reduces the cost effectiveness of packages.
- **Mixed-Fuel + PV only:** Packages are cost effective and achieve savings for the On-Bill approach for all climate zones except for LADWP territory. Packages are cost effective and achieve savings for the TDV approach for all climate zones.
- **Mixed-Fuel + PV + 50 kWh Battery:** Adding battery slightly reduces On-Bill B/C ratios. Packages are not cost effective for LADWP territory, SMUD territory as well as for climate zones 6,8,9 under PG&E service area.
- **All-Electric + 3 kW PV:** All packages are cost effective using the On-Bill approach. All packages are cost effective using the TDV approach but do not achieve positive energy cost savings.
- **All-Electric + 3 kW PV + 5 kWh Battery:** Similar to minimal PV only package, all packages are cost effective using the On-Bill approach. All packages are cost effective using the TDV approach but do not achieve positive energy cost savings.
- **All-Electric + PV only**: All packages are cost effective for both On-Bill and TDV approaches. Packages achieve on-bill savings for all climate zones.
- **All-Electric + PV + 50 kWh Battery:** Adding battery slightly reduces On-Bill B/C ratios but is still cost effective for all climate zones.

Figure 70. Cost Effectiveness for Small Hotel – Mixed Fuel + 3kW PV

CZ	IOU territory	Elec Savings (kWh)	Gas Savings (therms)	GHG savings (tons)	Incremental Package Cost	Lifecycle Energy Cost Savings	Lifecycle $- TDV Savings	B/C Ratio (On-bill)	B/C Ratio (TDV)	NPV (On-bill)	NPV (TDV)
Mixed Fuel + 3kW PV											
CZ01	PG&E	3,941	0	0.8	$5,566	$12,616	$8,326	2.3	1.5	$7,050	$2,760
CZ02	PG&E	4,785	0	0.9	$5,566	$12,639	$10,332	2.3	1.9	$7,073	$4,766
CZ03	PG&E	4,733	0	0.9	$5,566	$15,146	$9,991	2.7	1.8	$9,580	$4,425
CZ04	PG&E	4,834	0	1.0	$5,566	$13,266	$10,445	2.4	1.9	$7,700	$4,879
CZ04-2	CPAU	4,834	0	1.0	$5,566	$11,507	$10,445	2.1	1.9	$5,941	$4,879
CZ05	PG&E	5,027	0	1.0	$5,566	$16,048	$10,634	2.9	1.9	$10,482	$5,068
CZ06	SCE	4,769	0	0.9	$5,566	$10,276	$10,559	1.8	1.9	$4,710	$4,993
CZ06-2	LA	4,769	0	0.9	$5,566	$6,307	$10,559	1.1	1.9	$741	$4,993
CZ07	SDG&E	4,960	0	1.0	$5,566	$14,576	$10,861	2.6	2.0	$9,010	$5,295
CZ08	SCE	4,824	0	0.9	$5,566	$10,837	$11,202	1.9	2.0	$5,271	$5,636
CZ08-2	LA	4,824	0	0.9	$5,566	$6,505	$11,202	1.2	2.0	$939	$5,636
CZ09	SCE	4,779	0	0.9	$5,566	$10,298	$10,824	1.9	1.9	$4,732	$5,258
CZ09-2	LA	4,779	0	0.9	$5,566	$6,201	$10,824	1.1	1.9	$635	$5,258
CZ10	SDG&E	4,905	0	1.0	$5,566	$16,302	$10,710	2.9	1.9	$10,736	$5,144
CZ10-2	SCE	4,905	0	1.0	$5,566	$9,468	$10,710	1.7	1.9	$3,902	$5,144
CZ11	PG&E	4,701	0	0.9	$5,566	$14,193	$10,483	2.6	1.9	$8,627	$4,917
CZ12	PG&E	4,770	0	0.9	$5,566	$15,262	$10,596	2.7	1.9	$9,696	$5,030
CZ12-2	SMUD	4,770	0	0.9	$5,566	$7,848	$10,596	1.4	1.9	$2,282	$5,030
CZ13	PG&E	4,633	0	0.9	$5,566	$14,674	$10,105	2.6	1.8	$9,108	$4,539
CZ14	SDG&E	5,377	0	1.1	$5,566	$16,615	$12,375	3.0	2.2	$11,049	$6,809
CZ14-2	SCE	5,377	0	1.1	$5,566	$10,021	$12,375	1.8	2.2	$4,455	$6,809
CZ15	SCE	4,997	0	1.0	$5,566	$9,542	$11,164	1.7	2.0	$3,976	$5,598
CZ16	PG&E	5,240	0	1.0	$5,566	$14,961	$10,975	2.7	2.0	$9,395	$5,409
CZ16-2	LA	5,240	0	1.0	$5,566	$5,670	$10,975	1.0	2.0	$104	$5,409

Figure 71. Cost Effectiveness for Small Hotel – Mixed Fuel + 3kW PV + 5 kWh Battery

CZ	IOU territory	Elec Savings (kWh)	Gas Savings (therms)	GHG savings (tons)	Incremental Package Cost	Lifecycle Energy Cost Savings	$-TDV Savings	B/C Ratio (On-bill)	B/C Ratio (TDV)	NPV (On-bill)	NPV (TDV)
Mixed Fuel + 3kW PV + 5kWh Battery											
CZ01	PG&E	3,941	0	0.8	$9,520	$12,616	$8,326	1.3	0.9	$3,096	($1,194)
CZ02	PG&E	4,785	0	0.9	$9,520	$12,639	$10,332	1.3	1.1	$3,119	$811
CZ03	PG&E	4,733	0	0.9	$9,520	$15,146	$9,991	1.6	1.0	$5,626	$471
CZ04	PG&E	4,834	0	1.0	$9,520	$13,266	$10,445	1.4	1.1	$3,746	$925
CZ04-2	CPAU	4,834	0	1.0	$9,520	$11,507	$10,445	1.2	1.1	$1,987	$925
CZ05	PG&E	5,027	0	1.0	$9,520	$16,048	$10,634	1.7	1.1	$6,528	$1,114
CZ05-2	SCG	5,027	0	1.0	$9,520	$16,048	$10,634	1.7	1.1	$6,528	$1,114
CZ06	SCE	4,769	0	0.9	$9,520	$10,276	$10,559	1.1	1.1	$756	$1,039
CZ06-2	LA	4,769	0	0.9	$9,520	$6,307	$10,559	0.7	1.1	($3,213)	$1,039
CZ07	SDG&E	4,960	0	1.0	$9,520	$14,576	$10,861	1.5	1.1	$5,056	$1,341
CZ08	SCE	4,824	0	0.9	$9,520	$10,837	$11,202	1.1	1.2	$1,317	$1,682
CZ08-2	LA	4,824	0	0.9	$9,520	$6,505	$11,202	0.7	1.2	($3,015)	$1,682
CZ09	SCE	4,779	0	0.9	$9,520	$10,298	$10,824	1.1	1.1	$778	$1,303
CZ09-2	LA	4,779	0	0.9	$9,520	$6,201	$10,824	0.7	1.1	($3,319)	$1,303
CZ10	SDG&E	4,905	0	1.0	$9,520	$16,302	$10,710	1.7	1.1	$6,782	$1,190
CZ10-2	SCE	4,905	0	1.0	$9,520	$9,468	$10,710	0.99	1.1	($52)	$1,190
CZ11	PG&E	4,701	0	0.9	$9,520	$14,193	$10,483	1.5	1.1	$4,673	$963
CZ12	PG&E	4,770	0	0.9	$9,520	$15,262	$10,596	1.6	1.1	$5,742	$1,076
CZ12-2	SMUD	4,770	0	0.9	$9,520	$7,848	$10,596	0.8	1.1	($1,672)	$1,076
CZ13	PG&E	4,633	0	0.9	$9,520	$14,674	$10,105	1.5	1.1	$5,154	$584
CZ14	SDG&E	5,377	0	1.1	$9,520	$16,615	$12,375	1.7	1.3	$7,095	$2,855
CZ14-2	SCE	5,377	0	1.1	$9,520	$10,021	$12,375	1.1	1.3	$501	$2,855
CZ15	SCE	4,997	0	1.0	$9,520	$9,542	$11,164	1.0	1.2	$22	$1,644
CZ16	PG&E	5,240	0	1.0	$9,520	$14,961	$10,975	1.6	1.2	$5,441	$1,455
CZ16-2	LA	5,240	0	1.0	$9,520	$5,670	$10,975	0.6	1.2	($3,851)	$1,455

Figure 72. Cost Effectiveness for Small Hotel - Mixed Fuel +80kW PV

CZ	IOU territory	Elec Savings (kWh)	Gas Savings (therms)	GHG savings (tons)	Incremental Package Cost	Lifecycle Energy Cost Savings	Lifecycle TDV Savings	B/C Ratio (On-bill)	B/C Ratio (TDV)	NPV (On-bill)	NPV (TDV)
Mixed Fuel + 80kW PV											
CZ01	PG&E	105,090	0	20.6	$179,470	$336,440	$221,883	1.9	1.2	$156,970	$42,413
CZ02	PG&E	127,592	0	25.0	$179,470	$320,009	$275,130	1.8	1.5	$140,539	$95,660
CZ03	PG&E	126,206	0	24.8	$179,470	$403,900	$266,426	2.3	1.5	$224,430	$86,956
CZ04	PG&E	128,894	0	25.4	$179,470	$322,782	$278,536	1.8	1.6	$143,312	$99,066
CZ04-2	CPAU	128,894	0	25.4	$179,470	$306,862	$278,536	1.7	1.6	$127,392	$99,066
CZ05	PG&E	134,041	0	26.5	$179,470	$427,935	$283,834	2.4	1.6	$248,465	$104,364
CZ06	SCE	127,168	0	25.0	$179,470	$200,425	$281,488	1.1	1.6	$20,955	$102,018
CZ06-2	LA	127,168	0	25.0	$179,470	$119,357	$281,488	0.7	1.6	($60,113)	$102,018
CZ07	SDG&E	132,258	0	26.1	$179,470	$247,646	$289,700	1.4	1.6	$68,176	$110,230
CZ08	SCE	128,641	0	25.3	$179,470	$207,993	$298,594	1.2	1.7	$28,523	$119,124
CZ08-2	LA	128,641	0	25.3	$179,470	$122,591	$298,594	0.7	1.7	($56,879)	$119,124
CZ09	SCE	127,447	0	25.3	$179,470	$211,567	$288,830	1.2	1.6	$32,096	$109,360
CZ09-2	LA	127,447	0	25.3	$179,470	$123,486	$288,830	0.7	1.6	($55,984)	$109,360
CZ10	SDG&E	130,792	0	25.8	$179,470	$274,832	$285,386	1.5	1.6	$95,361	$105,916
CZ10-2	SCE	130,792	0	25.8	$179,470	$206,865	$285,386	1.2	1.6	$27,395	$105,916
CZ11	PG&E	125,366	0	24.6	$179,470	$316,781	$279,331	1.8	1.6	$137,311	$99,861
CZ12	PG&E	127,203	0	25.0	$179,470	$406,977	$282,358	2.3	1.6	$227,507	$102,888
CZ12-2	SMUD	127,203	0	25.0	$179,470	$198,254	$282,358	1.1	1.6	$18,784	$102,888
CZ13	PG&E	123,535	0	24.4	$179,470	$317,261	$269,908	1.8	1.5	$137,791	$90,437
CZ14	SDG&E	143,387	0	28.1	$179,470	$309,521	$330,345	1.7	1.8	$130,051	$150,875
CZ14-2	SCE	143,387	0	28.1	$179,470	$225,083	$330,345	1.3	1.8	$45,612	$150,875
CZ15	SCE	133,246	0	25.9	$179,470	$207,277	$297,648	1.2	1.7	$27,807	$118,177
CZ16	PG&E	139,738	0	27.3	$179,470	$341,724	$292,728	1.9	1.6	$162,254	$113,258
CZ16-2	LA	139,738	0	27.3	$179,470	$114,215	$292,728	0.6	1.6	($65,255)	$113,258

Figure 73. Cost Effectiveness for Small Hotel – Mixed Fuel + 80kW PV + 50 kWh Battery

CZ	IOU territory	Elec Savings (kWh)	Gas Savings (therms)	GHG savings (tons)	Incremental Package Cost	Lifecycle Energy Cost Savings	Lifecycle TDV Savings	B/C Ratio (On-bill)	B/C Ratio (TDV)	NPV (On-bill)	NPV (TDV)
Mixed Fuel + 80kW PV + 50kWh Battery											
CZ01	PG&E	104,026	0	23.2	$207,370	$332,596	$237,740	1.6	1.1	$125,226	$30,370
CZ02	PG&E	126,332	0	28.1	$207,370	$336,179	$296,058	1.6	1.4	$128,809	$88,688
CZ03	PG&E	124,934	0	28.0	$207,370	$399,220	$289,360	1.9	1.4	$191,850	$81,990
CZ04	PG&E	127,602	0	28.5	$207,370	$332,161	$308,887	1.6	1.5	$124,790	$101,517
CZ04-2	CPAU	127,602	0	28.5	$207,370	$303,828	$308,887	1.5	1.5	$96,458	$101,517
CZ05	PG&E	132,725	0	29.8	$207,370	$423,129	$303,627	2.0	1.5	$215,758	$96,257
CZ06	SCE	125,880	0	28.4	$207,370	$193,814	$297,950	0.9	1.4	($13,556)	$90,580
CZ06-2	LA	125,880	0	28.4	$207,370	$123,083	$297,950	0.6	1.4	($84,287)	$90,580
CZ07	SDG&E	130,940	0	29.5	$207,370	$274,313	$309,682	1.3	1.5	$66,943	$102,312
CZ08	SCE	127,332	0	28.5	$207,370	$199,786	$312,899	1.0	1.5	($7,584)	$105,529
CZ08-2	LA	127,332	0	28.5	$207,370	$124,651	$312,899	0.6	1.5	($82,719)	$105,529
CZ09	SCE	126,232	0	28.2	$207,370	$206,706	$292,804	1.0	1.4	($664)	$85,433
CZ09-2	LA	126,232	0	28.2	$207,370	$126,710	$292,804	0.6	1.4	($80,660)	$85,433
CZ10	SDG&E	129,683	0	28.4	$207,370	$292,202	$287,278	1.4	1.4	$84,832	$79,908
CZ10-2	SCE	129,683	0	28.4	$207,370	$206,171	$287,278	1.0	1.4	($1,199)	$79,908
CZ11	PG&E	124,337	0	26.9	$207,370	$315,330	$283,683	1.5	1.4	$107,960	$76,313
CZ12	PG&E	126,013	0	27.8	$207,370	$403,127	$297,118	1.9	1.4	$195,757	$89,748
CZ12-2	SMUD	126,013	0	27.8	$207,370	$198,007	$297,118	1.0	1.4	($9,363)	$89,748
CZ13	PG&E	122,591	0	26.5	$207,370	$315,541	$280,996	1.5	1.4	$108,171	$73,626
CZ14	SDG&E	142,257	0	30.7	$207,370	$317,565	$334,697	1.5	1.6	$110,195	$127,327
CZ14-2	SCE	142,257	0	30.7	$207,370	$224,195	$334,697	1.1	1.6	$16,824	$127,327
CZ15	SCE	132,418	0	27.8	$207,370	$208,044	$299,199	1.0	1.4	$674	$91,829
CZ16	PG&E	138,402	0	30.7	$207,370	$358,582	$315,699	1.7	1.5	$151,212	$108,329
CZ16-2	LA	138,402	0	30.7	$207,370	$118,770	$315,699	0.6	1.5	($88,600)	$108,329

Figure 74. Cost Effectiveness for Small Hotel – All-Electric + 3kW PV

CZ	IOU territory	Elec Savings (kWh)	Gas Savings (therms)	GHG savings (tons)	Incremental Package Cost*	Lifecycle Energy Cost Savings	Lifecycle TDV Savings	B/C Ratio (On-bill)	B/C Ratio (TDV)	NPV (On-bill)	NPV (TDV)
All-Electric + 3kW PV											
CZ01	PG&E	-155,861	16917	54.7	($1,265,139)	($568,892)	($106,835)	2.2	11.8	$696,246	$1,158,304
CZ02	PG&E	-113,954	12677	40.9	($1,266,111)	($229,433)	($41,288)	5.5	30.7	$1,036,679	$1,224,823
CZ03	PG&E	-105,862	12322	41.4	($1,268,383)	($309,874)	($41,175)	4.1	30.8	$958,510	$1,227,208
CZ04	PG&E	-108,570	11927	37.5	($1,268,218)	($208,239)	($42,689)	6.1	29.7	$1,059,980	$1,225,530
CZ04-2	CPAU	-108,570	11927	37.5	($1,268,218)	($6,261)	($42,689)	202.6	29.7	$1,261,958	$1,225,530
CZ05	PG&E	-103,579	11960	39.3	($1,268,272)	($332,879)	($44,051)	3.8	28.8	$935,393	$1,224,221
CZ06	SCE	-73,524	8912	30.3	($1,268,413)	$48,898	($17,484)	>1	72.5	$1,317,311	$1,250,929
CZ06-2	LA	-64,859	8188	29.0	($1,266,760)	($120,842)	($12,337)	10.5	102.7	$1,145,918	$1,254,423
CZ07	SDG&E	-67,090	8353	29.2	($1,264,731)	($43,964)	($11,618)	28.8	108.9	$1,220,767	$1,253,113
CZ08	SCE	-67,090	8353	29.2	($1,264,731)	$48,736	($11,618)	>1	108.9	$1,313,467	$1,253,113
CZ08-2	LA	-67,483	8402	29.3	($1,266,529)	($35,547)	($11,126)	35.6	113.8	$1,230,982	$1,255,403
CZ09	SCE	-67,483	8402	29.3	($1,266,529)	$52,410	($11,126)	>1	113.8	$1,318,939	$1,255,403
CZ09-2	LA	-75,157	8418	27.2	($1,263,531)	($156,973)	($25,469)	8.0	49.6	$1,106,558	$1,238,061
CZ10	SDG&E	-75,157	8418	27.2	($1,263,531)	($54,711)	($25,469)	23.1	49.6	$1,208,820	$1,238,061
CZ10-2	SCE	-94,783	10252	31.9	($1,264,340)	($169,847)	($38,904)	7.4	32.5	$1,094,493	$1,225,436
CZ11	PG&E	-94,702	10403	33.0	($1,265,779)	($324,908)	($34,968)	3.9	36.2	$940,872	$1,230,811
CZ12	PG&E	-94,297	10403	33.1	($1,265,779)	$13,603	($33,757)	>1	37.5	$1,279,382	$1,232,022
CZ12-2	SMUD	-92,196	10029	31.5	($1,264,152)	($168,358)	($40,229)	7.5	31.4	$1,095,794	$1,223,923
CZ13	PG&E	-96,021	10056	30.7	($1,264,510)	($308,542)	($44,202)	4.1	28.6	$955,969	$1,220,308
CZ14	SDG&E	-96,021	10056	30.7	($1,264,510)	($110,730)	($44,202)	11.4	28.6	$1,153,780	$1,220,308
CZ14-2	SCE	-44,856	5579	19.0	($1,262,631)	$8,996	($10,256)	>1	123.1	$1,271,627	$1,252,375
CZ15	SCE	-211,468	17599	42.9	($1,268,907)	($625,671)	($228,203)	2.0	5.6	$643,236	$1,040,704
CZ16	PG&E	-211,468	17599	42.9	($1,268,907)	$37,142	($228,203)	>1	5.6	$1,306,049	$1,040,704
CZ16-2	LA	-155,861	16917	54.7	($1,265,139)	($568,892)	($106,835)	2.2	11.8	$696,246	$1,158,304

Figure 75. Cost Effectiveness for Small Hotel – All-Electric + 3kW PV + 5 kWh Battery

CZ	IOU territory	Elec Savings (kWh)	Gas Savings (therms)	GHG savings (tons)	Incremental Package Cost	Lifecycle Energy Cost Savings	$-TDV Savings	B/C Ratio (On-bill)	B/C Ratio (TDV)	NPV (On-bill)	NPV (TDV)
All-Electric + 3kW PV + 5kWh Battery											
CZ01	PG&E	-155,861	16917	54.7	($1,288,428)	($568,892)	($106,835)	2.3	12.1	$719,536	$1,181,593
CZ02	PG&E	-113,954	12677	40.9	($1,288,428)	($229,433)	($41,288)	5.6	31.2	$1,058,996	$1,247,140
CZ03	PG&E	-105,862	12322	41.4	($1,288,428)	($309,874)	($41,175)	4.2	31.3	$978,554	$1,247,253
CZ04	PG&E	-108,570	11927	37.5	($1,288,428)	($208,239)	($42,689)	6.2	30.2	$1,080,190	$1,245,740
CZ04-2	CPAU	-108,570	11927	37.5	($1,288,428)	($6,261)	($42,689)	205.8	30.2	$1,282,167	$1,245,740
CZ05	PG&E	-103,579	11960	39.3	($1,288,428)	($332,879)	($44,051)	3.9	29.2	$955,549	$1,244,377
CZ06	SCE	-73,524	8912	30.3	($1,288,428)	($52,341)	($17,484)	24.6	73.7	$1,236,087	$1,270,944
CZ06-2	LA	-73,524	8912	30.3	($1,288,428)	$48,898	($17,484)	>1	73.7	$1,337,326	$1,270,944
CZ07	SDG&E	-64,859	8188	29.0	($1,288,428)	($120,842)	($12,337)	10.7	104.4	$1,167,586	$1,276,091
CZ08	SCE	-67,090	8353	29.2	($1,288,428)	($43,964)	($11,618)	29.3	110.9	$1,244,464	$1,276,810
CZ08-2	LA	-67,090	8353	29.2	($1,288,428)	$48,736	($11,618)	>1	110.9	$1,337,164	$1,276,810
CZ09	SCE	-67,483	8402	29.3	($1,288,428)	($35,547)	($11,126)	36.2	115.8	$1,252,881	$1,277,302
CZ09-2	LA	-67,483	8402	29.3	($1,288,428)	$52,410	($11,126)	>1	115.8	$1,340,838	$1,277,302
CZ10	SDG&E	-75,157	8418	27.2	($1,288,428)	($156,973)	($25,469)	8.2	50.6	$1,131,455	$1,262,959
CZ10-2	SCE	-75,157	8418	27.2	($1,288,428)	($54,711)	($25,469)	23.5	50.6	$1,233,718	$1,262,959
CZ11	PG&E	-94,783	10252	31.9	($1,288,428)	($169,847)	($38,904)	7.6	33.1	$1,118,582	$1,249,524
CZ12	PG&E	-94,702	10403	33.0	($1,288,428)	($324,908)	($34,968)	4.0	36.8	$963,520	$1,253,460
CZ12-2	SMUD	-94,297	10403	33.1	($1,288,428)	$13,603	($33,757)	>1	38.2	$1,302,031	$1,254,671
CZ13	PG&E	-92,196	10029	31.5	($1,288,428)	($168,358)	($40,229)	7.7	32.0	$1,120,071	$1,248,199
CZ14	SDG&E	-96,021	10056	30.7	($1,288,428)	($308,542)	($44,202)	4.2	29.1	$979,887	$1,244,226
CZ14-2	SCE	-96,021	10056	30.7	($1,288,428)	($110,730)	($44,202)	11.6	29.1	$1,177,698	$1,244,226
CZ15	SCE	-44,856	5579	19.0	($1,288,428)	$8,996	($10,256)	>1	125.6	$1,297,425	$1,278,172
CZ16	PG&E	-211,468	17599	42.9	($1,288,428)	($625,671)	($228,203)	2.1	5.6	$662,757	$1,060,225
CZ16-2	LA	-211,468	17599	42.9	($1,288,428)	$37,142	($228,203)	>1	5.6	$1,325,570	$1,060,225

Figure 76. Cost Effectiveness for Small Hotel – All-Electric + 80kW PV

CZ	IOU territory	Elec Savings (kWh)	Gas Savings (therms)	GHG savings (tons)	Incremental Package Cost	Lifecycle Energy Cost Savings	$-TDV Savings	B/C Ratio (On-bill)	B/C Ratio (TDV)	NPV (On-bill)	NPV (TDV)
All-Electric + 80kW PV											
CZ01	PG&E	-54,712	16917	74.6	($1,123,442)	($240,170)	$106,722	4.7	>1	$883,272	$1,230,164
CZ02	PG&E	8,853	12677	65.0	($1,124,415)	$128,649	$223,510	>1	>1	$1,253,063	$1,347,925
CZ03	PG&E	15,612	12322	65.3	($1,126,687)	$44,532	$215,260	>1	>1	$1,171,219	$1,341,947
CZ04	PG&E	15,490	11927	62.0	($1,126,522)	$145,778	$225,402	>1	>1	$1,272,300	$1,351,924
CZ04-2	CPAU	15,490	11927	62.0	($1,126,522)	$289,094	$225,402	>1	>1	$1,415,616	$1,351,924
CZ05	PG&E	25,436	11960	64.8	($1,126,575)	$56,019	$229,149	>1	>1	$1,182,594	$1,355,724
CZ06	SCE	48,875	8912	54.4	($1,126,716)	$163,343	$253,445	>1	>1	$1,290,060	$1,380,161
CZ06-2	LA	62,439	8188	54.1	($1,125,064)	$115,822	$266,502	>1	>1	$1,240,886	$1,391,565
CZ07	SDG&E	56,727	8353	53.5	($1,123,034)	$147,987	$275,773	>1	>1	$1,271,022	$1,398,808
CZ08	SCE	56,727	8353	53.5	($1,123,034)	$163,971	$275,773	>1	>1	$1,287,005	$1,398,808
CZ08-2	LA	55,185	8402	53.7	($1,124,832)	$155,101	$266,880	>1	>1	$1,279,933	$1,391,712
CZ09	SCE	55,185	8402	53.7	($1,124,832)	$169,010	$266,880	>1	>1	$1,293,843	$1,391,712
CZ09-2	LA	50,731	8418	52.0	($1,121,834)	$113,936	$249,207	>1	>1	$1,235,770	$1,371,041
CZ10	SDG&E	50,731	8418	52.0	($1,121,834)	$138,265	$249,207	>1	>1	$1,260,099	$1,371,041
CZ10-2	SCE	25,882	10252	55.6	($1,122,643)	$162,626	$229,944	>1	>1	$1,285,269	$1,352,587
CZ11	PG&E	27,731	10403	57.1	($1,124,083)	$12,954	$236,794	>1	>1	$1,137,037	$1,360,876
CZ12	PG&E	28,136	10403	57.2	($1,124,083)	$206,756	$238,005	>1	>1	$1,330,839	$1,362,087
CZ12-2	SMUD	26,706	10029	55.0	($1,122,455)	$165,991	$219,574	>1	>1	$1,288,446	$1,342,030
CZ13	PG&E	41,989	10056	57.8	($1,122,814)	$22,333	$273,768	>1	>1	$1,145,147	$1,396,582
CZ14	SDG&E	41,989	10056	57.8	($1,122,814)	$120,943	$273,768	>1	>1	$1,243,757	$1,396,582
CZ14-2	SCE	83,393	5579	44.0	($1,120,934)	$210,511	$276,228	>1	>1	$1,331,445	$1,397,162
CZ15	SCE	-76,971	17599	69.2	($1,127,210)	($199,308)	$53,550	5.7	>1	$927,902	$1,180,760
CZ16	PG&E	-76,971	17599	69.2	($1,127,210)	$172,787	$53,550	>1	>1	$1,299,997	$1,180,760
CZ16-2	LA	-54,712	16917	74.6	($1,123,442)	($240,170)	$106,722	4.7	>1	$883,272	$1,230,164

Figure 77. Cost Effectiveness for Small Hotel – All-Electric + 80kW PV + 50 kWh Battery

CZ	IOU territory	Elec Savings (kWh)	Gas Savings (therms)	GHG savings (tons)	Incremental Package Cost	Lifecycle Energy Cost Savings	$-TDV Savings	B/C Ratio (On-bill)	B/C Ratio (TDV)	NPV (On-bill)	NPV (TDV)
All-Electric + 80kW PV + 50kWh Battery											
CZ01	PG&E	-55,323	16917	75.7	($1,095,542)	($238,351)	$118,605	4.6	>1	$857,191	$1,214,147
CZ02	PG&E	7,849	12677	67.4	($1,096,515)	$129,794	$239,632	>1	>1	$1,226,309	$1,336,146
CZ03	PG&E	14,594	12322	67.7	($1,098,787)	$43,166	$235,280	>1	>1	$1,141,953	$1,334,067
CZ04	PG&E	14,459	11927	64.4	($1,098,622)	$148,698	$249,244	>1	>1	$1,247,320	$1,347,866
CZ04-2	CPAU	14,459	11927	64.4	($1,098,622)	$286,573	$249,244	>1	>1	$1,385,195	$1,347,866
CZ05	PG&E	24,292	11960	67.6	($1,098,675)	$53,719	$244,514	>1	>1	$1,152,394	$1,343,189
CZ06	SCE	47,762	8912	57.2	($1,098,816)	$165,763	$267,221	>1	>1	$1,264,579	$1,366,037
CZ06-2	LA	61,252	8188	57.1	($1,097,164)	$138,060	$283,797	>1	>1	$1,235,223	$1,380,960
CZ07	SDG&E	55,588	8353	56.2	($1,095,134)	$138,718	$286,483	>1	>1	$1,233,852	$1,381,618
CZ08	SCE	55,588	8353	56.2	($1,095,134)	$165,932	$286,483	>1	>1	$1,261,066	$1,381,618
CZ08-2	LA	54,162	8402	56.1	($1,096,932)	$149,615	$269,453	>1	>1	$1,246,548	$1,366,386
CZ09	SCE	54,162	8402	56.1	($1,096,932)	$171,168	$269,453	>1	>1	$1,268,101	$1,366,386
CZ09-2	LA	49,832	8418	54.1	($1,093,934)	$120,627	$250,720	>1	>1	$1,214,561	$1,344,654
CZ10	SDG&E	49,832	8418	54.1	($1,093,934)	$136,144	$250,720	>1	>1	$1,230,078	$1,344,654
CZ10-2	SCE	25,148	10252	57.3	($1,094,743)	$160,744	$233,842	>1	>1	$1,255,487	$1,328,585
CZ11	PG&E	26,813	10403	59.2	($1,096,183)	$10,314	$247,504	>1	>1	$1,106,497	$1,343,686
CZ12	PG&E	27,217	10403	59.3	($1,096,183)	$206,749	$248,790	>1	>1	$1,302,931	$1,344,973
CZ12-2	SMUD	26,027	10029	56.5	($1,094,555)	$164,506	$229,300	>1	>1	$1,259,061	$1,323,856
CZ13	PG&E	41,123	10056	59.7	($1,094,914)	$25,707	$276,947	>1	>1	$1,120,621	$1,371,860
CZ14	SDG&E	41,123	10056	59.7	($1,094,914)	$119,382	$276,947	>1	>1	$1,214,296	$1,371,860
CZ14-2	SCE	82,697	5579	45.5	($1,093,034)	$209,837	$277,287	>1	>1	$1,302,871	$1,370,321
CZ15	SCE	-77,815	17599	71.1	($1,099,310)	($193,758)	$65,850	5.7	>1	$905,552	$1,165,160
CZ16	PG&E	-77,815	17599	71.1	($1,099,310)	$175,872	$65,850	>1	>1	$1,275,182	$1,165,160
CZ16-2	LA	-55,323	16917	75.7	($1,095,542)	($238,351)	$118,605	4.6	>1	$857,191	$1,214,147

6.8 List of Relevant Efficiency Measures Explored

The Reach Code Team started with a potential list of energy efficiency measures proposed for 2022 Title 24 codes and standards enhancement measures, as well as measures from the 2018 International Green Construction Code, which is based on ASHRAE Standard 189.1-2017. The team also developed new measures based on their experience. This original list was over 100 measures long. The measures were filtered based on applicability to the prototypes in this study, ability to model in simulation software, previously demonstrated energy savings potential, and market readiness. The list of 28 measures below represent the list of efficiency measures that meet these criteria and were investigated to some degree. The column to the far right indicates whether the measure was ultimately included in analysis or not.

Figure 78. List of Relevant Efficiency Measures Explored

Building Component	Measure Name	Measure Description	Notes	Include?
Water Heating	Drain water Heat Recovery	Add drain water heat recovery in hotel prototype	Requires calculations outside of modeling software.	Y
Envelope	High performance fenestration	Improved fenestration SHGC (reduce to 0.22).		Y
Envelope	High SHGC for cold climates	Raise prescriptive fenestration SHGC (to 0.45) in cold climates where additional heat is beneficial.		Y
Envelope	Allowable fenestration by orientation	Limit amount of fenestration as a function of orientation		Y
Envelope	High Thermal Mass Buildings	Increase building thermal mass. Thermal mass slows the change in internal temperature of buildings with respect to the outdoor temperature, allowing the peak cooling load during summer to be pushed to the evening, resulting in lower overall cooling loads.	Initial energy modeling results showed marginal cooling savings, negative heating savings.	N
Envelope	Opaque Insulation	Increases the insulation requirement for opaque envelopes (i.e., roof and above-grade wall).	Initial energy modeling results showed marginal energy savings at significant costs which would not meet c/e criteria.	N
Envelope	Triple pane windows	U-factor of 0.20 for all windows	Initial energy modeling results showed only marginal energy savings and, in some cases, increased energy use.	N

Building Component	Measure Name	Measure Description	Notes	Include?
Envelope	Duct Leakage Testing	Expand duct leakage testing requirements based on ASHRAE Standard 215-2018: Method of Test to Determine Leakage of Operating HVAC Air Distribution Systems (ANSI Approved).	More research needs to be done on current duct leakage and how it can be addressed.	N
Envelope	Fenestration area	Reduce maximum allowable fenestration area to 30%.	Instead of this measure, analyzed measure which looked at limiting fenestration based on wall orientation.	N
Envelope	Skinny triple pane windows	U-factor of 0.20 for all windows, with no changes to existing framing or building structure.	Market not ready. No commercially-available products for commercial buildings.	N
Envelope	Permanent projections	Detailed prescriptive requirements for shading based on ASHRAE 189. PF >0.50 for first story and >0.25 for other floors. Many exceptions. Corresponding SHGC multipliers to be used.	Title 24 already allows owner to trade off SHGC with permanent projections. Also, adding requirements for permanent projections would raise concerns.	N
Envelope	Reduced infiltration	Reduce infiltration rates by improving building sealing.	Infiltration rates are a fixed ACM input and cannot be changed. A workaround attempt would not be precise, and the practicality of implementation by developers is low given the modeling capabilities and the fact that in-field verification is challenging. Benefits would predominantly be for air quality rather than energy.	N

Building Component	Measure Name	Measure Description	Notes	Include?
HVAC	Heat recovery ventilation	For the hotel, recover and transfer heat from exhausted air to ventilation air.	For small hotels, the ventilation requirement could be met by various approaches, and the most common ones are: a. Exhaust only system, and ventilation is met by infiltration or window operation. b. Through a Z-duct that connects the zone AC unit's intake to an outside air intake louver. c. Centralized ventilation system (DOAS) The prototype developed for the small hotel is using Type 2 above. The major consideration is that currently, HRV + PTACs cannot be modeled at each guest room, only at the rooftop system. Option 1 would require the same type of HRV implementation as Option 2. Option 3 may be pursuable, but would require a significant redesign of the system, with questionable impacts. Previous studies have found heat recovery as cost effective in California only in buildings with high loads or high air exchange rates, given the relatively mild climate.	N
HVAC	Require Economizers in Smaller Capacity Systems	Lower the capacity trigger for air economizers. Previous studies have shown cost effectiveness for systems as low as 3 tons.		Y
HVAC	Reduce VAV minimum flow limit	Current T24 and 90.1 requirements limit VAV minimum flow rates to no more than 20% of maximum flow. Proposal based on ASHRAE Guideline 36 which includes sequences that remove technical barriers that previously existed. Also, most new DDC controllers are now capable of lower limits. The new limit may be as low as the required ventilation rate. A non-energy benefit of this measure is a reduction in over-cooling, thus improving comfort.		Y

Building Component	Measure Name	Measure Description	Notes	Include?
HVAC	Building Automation System (BAS) improvements	With adoption of ASHRAE Guideline 36 (GDL-36), there is now a national consensus standard for the description of high-performance sequences of operation. This measure will update BAS control requirements to improve usability and enforcement and to increase energy efficiency. BAS control requirement language will be improved either by adoption of similar language to GDL-36, or reference to GDL-36. Specific T24 BAS control topics that will be addressed include at a minimum: DCV, demand-based reset of SAT, demand-based reset of SP, dual-maximum zone sequences, and zone groups for scheduling.	In order to realize any savings in the difference, we would need a very detailed energy model with space-by-space load/occupant diversity, etc. We would also need more modeling capability than is currently available in CBECC-Com.	N
HVAC	Fault Detection Devices (FDD)	Expand FDD requirements to a wider range of AHU faults beyond the economizer. Fault requirements will be based on NIST field research, which has consequently been integrated into ASHRAE Guideline 36 Best in Class Sequences of Operations. Costs are solely to develop the sequences, which is likely minimal, and much of the hardware required for economizer FDD is also used to detect other faults.	Market not ready.	N
HVAC	Small circulator pumps ECM, trim to flow rate	Circulator pumps for industry and commercial.	Hot water pump energy use is small already (<1% building electricity usage) so not much savings potential. More savings for CHW pumps. Modeling limitations as well.	N
HVAC	High Performance Ducts to Reduce Static Pressure	Revise requirements for duct sizing to reduce static pressure.	Preliminary energy modeling results showed only marginal energy savings compared to measure cost.	N
HVAC	Parallel fan-powered boxes	Use of parallel fan-powered boxes	Unable to model PFPB with variable speed fans in modeling software.	N
Lighting	Daylight Dimming Plus OFF	Automatic daylight dimming controls requirements include the OFF step.		Y
Lighting	Occupant Sensing in Open Plan Offices	Take the PAF without allowing for increased design wattage		Y
Lighting	Institutional tuning	Take the PAF without allowing for increased design wattage		Y

Building Component	Measure Name	Measure Description	Notes	Include?
Lighting	Reduced Interior Lighting Power Density	Reduced interior LPD values.		Y
Lighting	Shift from general to task illumination	Low levels of general illumination with task and accent lighting added to locations where higher light levels are required. The shift from general to task illumination measure is based on the assumption that proper lighting of a desk surface with high efficacy lighting can allow for the significant reduction of ambient general lighting.	This is a tough measure to require as the LPDs decrease.	N
Lighting	Future-proof lighting controls	Fill any holes in the current code that could lead to the situations where TLEDS or LED fixtures that are not dimmable or upgradable in the future, or any other issues with code that make it hard to transition to ALCS/IoT lighting in the future	Major lighting controls already covered in other measures being considered	N
Lighting	Integrated control of lighting and HVAC systems	Formalize the definition of "lighting and HVAC control integration" by defining the level of data sharing required between systems and the mechanism needed to share such data. The highest savings potential would likely be generated from VAV HVAC systems by closing the damper in unoccupied zones based on the occupancy sensor information from the lighting systems.	Not market ready enough.	N
Other	NR Plug Load Controls	Energy savings opportunities for plug loads, which may include: energy efficient equipment, equipment power management, occupancy sensor control, and occupant awareness programs. The proposal could be extending controlled receptacles requirements in Section 130.5(d) to more occupancy types. It would also consider circuit-level controls.	Office equipment now all have their own standby power modes that use very little power, making plug load controls very difficult to be cost-effective.	N

6.9 Additional Rates Analysis - Healdsburg

After the final version of the report was released, the Reach Code Team provided additional cost effectiveness analysis in Climate Zone 2 using City of Healdsburg electric utility rates and PG&E gas rates. All aspects of the methodology remain the same, and the results for each package and prototype are aggregated below in Figure 79 through Figure 81. Results generally indicate:

- Mixed fuel prototypes achieve positive compliance margins for EE packages and are cost effective.
- All-electric prototypes achieve slightly lower compliance margins than mixed fuel for EE packages and are cost effective.
- All PV and PV+Battery packages are cost effective both using an on-bill and TDV approach.

Figure 79. Healdsburg Utility Rates Analysis – Medium Office, All Packages Cost Effectiveness Summary

Prototype	Package	Elec Savings (kWh)	Gas Savings (therms)	GHG savings (tons)	Comp-liance Margin (%)	Incremental Package Cost	Lifecycle Energy Cost Savings	$-TDV Savings	B/C Ratio (On-bill)	B/C Ratio (TDV)	NPV (On-bill)	NPV (TDV)
Medium Office	Mixed Fuel + EE	40,985	-505	8.1	17%	$66,649	$89,645	$99,181	1.3	1.5	$22,996	$32,532
	Mixed Fuel + EE + PVB	255,787	-505	50.6	17%	$359,648	$510,922	$573,033	1.4	1.6	$151,274	$213,385
	Mixed Fuel + HE	3,795	550	4.3	4%	$68,937	$24,204	$24,676	0.4	0.4	-$44,733	-$44,261
	All-Electric	-49,684	3,868	5.0	-7%	-$73,695	-$7,042	-$41,429	10.5	1.8	$66,653	$32,266
	All-Electric + EE	-11,811	3,868	15.2	10%	-$7,046	$83,285	$58,563	>1	>1	$90,331	$65,609
	All-Electric + EE + PVB	203,026	3,868	57.8	10%	$285,953	$511,954	$532,273	1.8	1.9	$226,001	$246,320
	All-Electric + HE	-45,916	3,868	6.1	-5%	-$22,722	$6,983	-$26,394	>1	0.9	$29,705	-$3,672
	Mixed Fuel + 3kW	4,785	0	0.9	n/a	$5,566	$10,430	$10,500	1.9	1.9	$4,864	$4,934
	Mixed Fuel + 3kW + 5kWh	4,785	0	0.9	n/a	$8,356	$10,430	$10,500	1.2	1.3	$2,074	$2,144
	Mixed Fuel + 135kW	215,311	0	41.5	n/a	$250,470	$424,452	$471,705	1.7	1.9	$173,982	$221,235
	Mixed Fuel + 135kW + 50kWh	214,861	0	42.6	n/a	$278,370	$423,721	$472,898	1.5	1.7	$145,351	$194,528
	All-Electric + 3kW	-44,899	3,868	6.0	n/a	-$68,129	$3,299	-$30,928	>1	2.2	$71,429	$37,201
	All-Electric + 3kW + 5kWh	-44,899	3,868	6.0	n/a	-$65,339	$3,299	-$30,928	>1	2.1	$68,639	$34,411
	All-Electric + 135kW	165,627	3,868	46.6	n/a	$176,775	$424,146	$430,276	2.4	2.4	$247,371	$253,501
	All-Electric + 135kW + 50kWh	165,200	3,868	47.7	n/a	$204,675	$423,466	$431,469	2.1	2.1	$218,792	$226,795
	All-Electric + 80kW + 50kWh	40,985	-505	8.1	17%	$66,649	$89,645	$99,181	1.3	1.5	$22,996	$32,532

Figure 80. Healdsburg Utility Rates Analysis – Medium Retail, All Packages Cost Effectiveness Summary

Prototype	Package	Elec Savings (kWh)	Gas Savings (therms)	GHG savings (tons)	Comp-liance Margin (%)	Incremental Package Cost	Lifecycle Energy Cost Savings	$-TDV Savings	B/C Ratio (On-bill)	B/C Ratio (TDV)	NPV (On-bill)	NPV (TDV)
Medium Retail	Mixed Fuel + EE	18,885	613	8.7	13%	$5,569	$49,546	$59,135	8.9	10.6	$43,977	$53,566
	Mixed Fuel + EE + PVB	189,400	613	43.8	13%	$249,475	$376,219	$465,474	1.5	1.9	$126,744	$215,999
	Mixed Fuel + HE	2,288	229	2.0	3%	$9,726	$13,143	$13,998	1.4	1.4	$3,417	$4,273
	All-Electric	-21,786	2,448	7.5	-1%	-$27,464	$9,228	-$4,483	>1	6.1	$36,692	$22,981
	All-Electric + EE	2,843	2,448	14.6	13%	-$21,895	$61,918	$56,893	>1	>1	$83,813	$78,788
	All-Electric + EE + PVB	173,387	2,448	49.9	13%	$222,012	$391,257	$463,431	1.8	2.1	$169,245	$241,419
	All-Electric + HE	-16,989	2,448	8.9	3%	-$4,211	$23,567	$11,251	>1	>1	$27,779	$15,463
	Mixed Fuel + 3kW	4,685	0	0.9	n/a	$5,566	$10,256	$10,262	1.8	1.8	$4,690	$4,696
	Mixed Fuel + 3kW + 5kWh	4,685	0	0.9	n/a	$8,356	$10,256	$10,262	1.2	1.2	$1,900	$1,906
	Mixed Fuel + 110kW	171,790	0	33.3	n/a	$204,087	$316,293	$376,300	1.5	1.8	$112,206	$172,213
	Mixed Fuel + 110kW + 50kWh	170,542	0	35.1	n/a	$231,987	$320,349	$398,363	1.4	1.7	$88,363	$166,376
	All-Electric + 3kW	-17,101	2,448	8.4	n/a	-$21,898	$19,523	$5,779	>1	>1	$41,421	$27,677
	All-Electric + 3kW + 5kWh	-17,101	2,448	8.4	n/a	-$19,108	$19,523	$5,779	>1	>1	$38,631	$24,887
	All-Electric + 110kW	150,004	2,448	40.8	n/a	$176,623	$332,213	$371,817	1.9	2.1	$155,591	$195,194
	All-Electric + 110kW + 50kWh	148,793	2,448	42.9	n/a	$204,523	$335,043	$394,099	1.6	1.9	$130,520	$189,577

Figure 81. Healdsburg Utility Rates Analysis – Small Hotel, All Packages Cost Effectiveness Summary

Prototype	Package	Elec Savings (kWh)	Gas Savings (therms)	GHG savings (tons)	Comp-liance Margin (%)	Incremental Package Cost	Lifecycle Energy Cost Savings	$-TDV Savings	B/C Ratio (On-bill)	B/C Ratio (TDV)	NPV (On-bill)	NPV (TDV)
Small Hotel	Mixed Fuel + EE	3,802	976	3.9	7%	$20,971	$22,829	$29,353	1.1	1.4	$1,857	$8,381
	Mixed Fuel + EE + PVB	130,144	976	31.1	7%	$205,967	$254,577	$336,575	1.2	1.6	$48,610	$130,608
	Mixed Fuel + HE	981	402	2.7	3%	$23,092	$12,291	$11,808	0.5	0.5	-$10,801	-$11,284
	All-Electric	-118,739	12,677	40.0	-12%	-$1,297,757	-$24,318	-$51,620	53.4	25.1	$1,273,439	$1,246,137
	All-Electric + EE	-88,410	12,677	45.9	5%	-$1,265,064	$45,918	$20,860	>1	>1	$1,310,982	$1,285,924
	All-Electric + EE + PVB	38,115	12,677	73.5	5%	-$1,080,068	$296,233	$317,296	>1	>1	$1,376,301	$1,397,365
	All-Electric + HE	-118,284	12,677	41.2	-11%	-$1,283,243	-$83,994	-$44,505	15.3	28.8	$1,199,249	$1,238,738
	Mixed Fuel + 3kW	4,785	0	0.9	n/a	$5,566	$8,927	$10,332	1.6	1.9	$3,361	$4,766
	Mixed Fuel + 3kW + 5kWh	4,785	0	0.9	n/a	$8,356	$8,927	$10,332	1.1	1.2	$571	$1,976
	Mixed Fuel + 80kW	127,592	0	25.0	n/a	$148,427	$229,794	$275,130	1.5	1.9	$81,367	$126,703
	Mixed Fuel + 80kW + 50kWh	126,332	0	28.1	n/a	$176,327	$236,570	$296,058	1.3	1.7	$60,243	$119,731
	All-Electric + 3kW	-113,954	12,677	40.9	n/a	-$1,292,191	-$14,447	-$41,288	89.4	31.3	$1,277,744	$1,250,902
	All-Electric + 3kW + 5kWh	-113,954	12,677	40.9	n/a	-$1,289,401	-$14,447	-$41,288	89.3	31.2	$1,274,954	$1,248,112
	All-Electric + 80kW	8,853	12,677	65.0	n/a	-$1,149,330	$222,070	$223,510	>1	>1	$1,371,400	$1,372,840
	All-Electric + 80kW + 50kWh	7,849	12,677	67.4	n/a	-$1,121,430	$223,812	$239,632	>1	>1	$1,345,241	$1,361,062