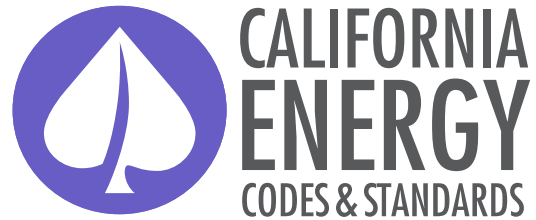


**DOCKETED**

|                         |   |
|-------------------------|---|
| <b>Docket Number:</b>   | 19-BSTD-06  |
| <b>Project Title:</b>   | Local Ordinances Exceeding the 2019 Energy Code                 |
| <b>TN #:</b>            | 242577-7  |
| <b>Document Title:</b>  | City of Encinitas-2019 Nonresidential New Construction CE Study |
| <b>Description:</b>     | Cost effectiveness study for nonresidential new construction    |
| <b>Filer:</b>           | Danuta Drozdowicz   |
| <b>Organization:</b>    | California Energy Commission                                    |
| <b>Submitter Role:</b>  | Commission Staff  |
| <b>Submission Date:</b> | 4/5/2022 4:35:52 PM   |
| <b>Docketed Date:</b>   | 4/5/2022  |



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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## **LEGAL NOTICE**

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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.<sup>1</sup> Since state and local governments are prohibited from adopting

<sup>1</sup> [https://www.ecfr.gov/cgi-bin/retrieveECFR?gp=&SID=8de751f141aaa1c1c9833b36156faf67&mc=true&n=pt10.3.431&r=PART&ty=HTML#se10.3.431\\_197](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.<sup>2</sup>

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.<sup>3</sup>

### 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

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<sup>2</sup> 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](http://www.energy.ca.gov/title24/2016standards/prerulemaking/documents/2014-07-09_workshop/2017_TDV_Documents)

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

<sup>4</sup> 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).<sup>5</sup>

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.<sup>6</sup> 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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<sup>5</sup> 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](http://www.energy.ca.gov/title24/2013standards/prerulemaking/documents/general_cec_documents/2011-01-14_LCC_Methodology_2013.pdf)

<sup>6</sup> 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  |
|----------------------|---|----------------------------|--------------|
| <b>IOUs</b>          |   |                            |              |
| 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         |
| <b>Electric POUs</b> |   |                            |              |
| 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.<sup>7</sup> 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.

<sup>7</sup> 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  $\geq 33,000$  Btu/hr and  $\leq 54,000$  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 daylight 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 daylight 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<sup>2</sup>, 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 |            |                            |             | Incremental Cost  | Sources & Notes   |
|---|--|-----------------------|------------|----------------------------|-------------|---|---|
|   |  | Med Office            | Med Retail | Small Hotel<br>Guest rooms | Comm Spaces |   |   |
| Envelope                                  |  |                       |            |                            |             |   |   |
| Modify SHGC Fenestration                  | SHGC of 0.25   | •                     | •          | •                          | •           | \$1.60 /ft <sup>2</sup> window for SHGC decreases, \$0/ft <sup>2</sup> 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 |            |                            |             | Incremental Cost | Sources & Notes   |
|-------------------------------|---|-----------------------|------------|----------------------------|-------------|------------------|---|
|                               |   | Med Office            | Med Retail | Small Hotel<br>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. <sup>8</sup> 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. |
| <b>Lighting</b>               |   |                       |            |                            |             |                  |   |
| Interior Lighting Reduced LPD | Per Area Category Method, varies by Primary Function Area. Office area 0.60 – 0.70 W/ft <sup>2</sup> depending on area of space. Hotel function area 0.85 W/ft <sup>2</sup> . Retail Merchandise Sales 1.00 W/ft <sup>2</sup> | •                     | •          | –                          | •           | \$0              | Industry report on LED pricing analysis shows that costs are not correlated with efficacy. <sup>9</sup>   |

<sup>8</sup> <http://www.csithermalstats.org/download.html>

<sup>9</sup> [http://calmac.org/publications/LED\\_Pricing\\_Analysis\\_Report\\_-\\_Revised\\_1.19.2018\\_Final.pdf](http://calmac.org/publications/LED_Pricing_Analysis_Report_-_Revised_1.19.2018_Final.pdf)



| Measure                               | Baseline T24 Requirement   | Measure Applicability |            |                            |             | Incremental Cost  | Sources & Notes   |
|---------------------------------------|--|-----------------------|------------|----------------------------|-------------|---|---|
|                                       |  | Med Office            | Med Retail | Small Hotel<br>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 daylight areas. <sup>10</sup> | •                     | •          | –                          | •           | \$0.06/ft <sup>2</sup>  | Industry report on institutional tuning <sup>11</sup>   |
| 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;<br>\$108 /secondary relay | 2 workstations per sensor;<br>1 fixture per workstation;<br>4 workstations per master relay;<br>120 ft <sup>2</sup> /workstation in open office area, which is 53% of total floor area of the medium office |

<sup>10</sup> 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.

<sup>11</sup> <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

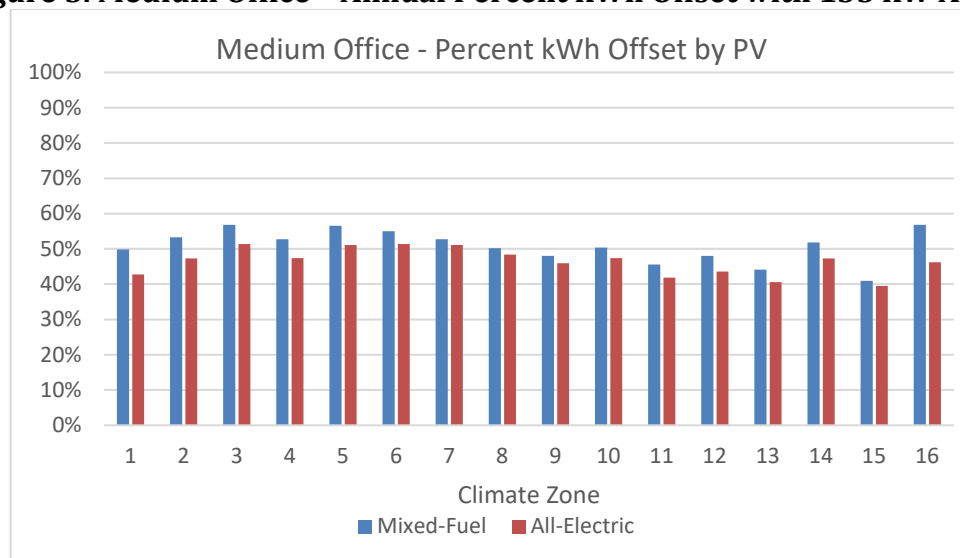
2019 Title 24 requires nonresidential buildings to reserve at least 15 percent of the roof area as a “solar zone,” but does not include any requirements or compliance credits for the installation of photovoltaic systems. The Reach Code Team analyzed a range of PV system sizes to determine cost effectiveness.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

- ◆ 15 W/ft<sup>2</sup> 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.<sup>12</sup>

<sup>12</sup> 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 <sup>13</sup> |
| Inverter Replacement | \$0.15 / Wdc | \$20,250  | 10                 | E3 Rooftop Solar PV System Report <sup>14</sup>                   |
| 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.<sup>15</sup>

### 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.<sup>16,17</sup>

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.<sup>18</sup> 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

<sup>13</sup> Available at: <https://www.nrel.gov/docs/fy16osti/66532.pdf>

<sup>14</sup> Available at: <https://efiling.energy.ca.gov/getdocument.aspx?tn=221366>

<sup>15</sup> More information available at: <https://pvwatts.nrel.gov/downloads/pvwattsv5.pdf>

<sup>16</sup> Battery controls are discussed in Sections 2.1.5.4 and Appendix D of the Residential Alternative Calculation Method Reference Manual, available here: <https://www2.energy.ca.gov/2019publications/CEC-400-2019-005/CEC-400-2019-005-CMF.pdf>

<sup>17</sup> Qualification Requirements for Battery Storage Systems are available in JA12 of the 2019 Reference Appendices: <https://www2.energy.ca.gov/2018publications/CEC-400-2018-021/CEC-400-2018-021-CMF.pdf>

<sup>18</sup> Available at: [http://localenergycodes.com/download/430/file\\_path/fieldList/PV%20Plus%20Battery%20Storage%20Report](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<sup>2</sup> 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   |
|-----------------------------|-----------------------|--|---|
| <b>HVAC System</b>          | Baseline              | Single zone packaged DX with <b>gas</b> furnaces | <u>NonRes</u> : Packaged DX + VAV with HW reheat. Central <b>gas</b> boilers.<br><br><u>Res</u> : Single zone DX AC unit with <b>gas</b> furnaces |
|                             | Proposed All-Electric | Single zone packaged <b>heat pumps</b>           | <u>NonRes</u> : Packaged DX + VAV with electric <b>resistance</b> reheat<br><br><u>Res</u> : Single zone <b>heat pumps</b>                        |
| <b>Water Heating System</b> | Baseline              | Electric <b>resistance</b> with storage          | <u>NonRes</u> : <b>Electric</b> resistance storage<br><br><u>Res</u> : Central <b>gas</b> storage with recirculation                              |
|                             | Proposed All-Electric | Electric <b>resistance</b> with storage          | <u>NonRes</u> : <b>Electric</b> resistance storage<br><br><u>Res</u> : Individual <b>heat pumps</b>   |

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 (PPFB) 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.<sup>19</sup>

<sup>19</sup> 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/3as8f8qx>



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 |
|--------------|---------------------|---------------------|-----------------------------------|
| <b>CZ01</b>  | \$1,202,538         | \$1,106,432         | \$(96,106)                        |
| <b>CZ02</b>  | \$1,261,531         | \$1,178,983         | \$(82,548)                        |
| <b>CZ03</b>  | \$1,205,172         | \$1,113,989         | \$(91,183)                        |
| <b>CZ04</b>  | \$1,283,300         | \$1,205,434         | \$(77,865)                        |
| <b>CZ05</b>  | \$1,207,345         | \$1,113,989         | \$(93,356)                        |
| <b>CZ06</b>  | \$1,216,377         | \$1,131,371         | \$(85,006)                        |
| <b>CZ07</b>  | \$1,227,932         | \$1,148,754         | \$(79,178)                        |
| <b>CZ08</b>  | \$1,250,564         | \$1,172,937         | \$(77,626)                        |
| <b>CZ09</b>  | \$1,268,320         | \$1,196,365         | \$(71,955)                        |
| <b>CZ10</b>  | \$1,313,580         | \$1,256,825         | \$(56,755)                        |
| <b>CZ11</b>  | \$1,294,145         | \$1,221,305         | \$(72,840)                        |
| <b>CZ12</b>  | \$1,274,317         | \$1,197,121         | \$(77,196)                        |
| <b>CZ13</b>  | \$1,292,884         | \$1,221,305         | \$(71,579)                        |
| <b>CZ14</b>  | \$1,286,245         | \$1,212,236         | \$(74,009)                        |
| <b>CZ15</b>  | \$1,357,023         | \$1,311,994         | \$(45,029)                        |
| <b>CZ16</b>  | \$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  $\geq 65,000$  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 |
|--------------|---------------------|---------------------|-----------------------------------|
| <b>CZ01</b>  | \$328,312           | \$333,291           | \$4,978                           |
| <b>CZ02</b>  | \$373,139           | \$373,702           | \$563                             |
| <b>CZ03</b>  | \$322,849           | \$326,764           | \$3,915                           |
| <b>CZ04</b>  | \$329,900           | \$335,031           | \$5,131                           |
| <b>CZ05</b>  | \$359,888           | \$362,408           | \$2,520                           |
| <b>CZ06</b>  | \$335,728           | \$341,992           | \$6,265                           |
| <b>CZ07</b>  | \$345,544           | \$349,808           | \$4,265                           |
| <b>CZ08</b>  | \$368,687           | \$369,792           | \$1,104                           |
| <b>CZ09</b>  | \$415,155           | \$411,069           | \$(4,087)                         |
| <b>CZ10</b>  | \$345,993           | \$346,748           | \$755                             |
| <b>CZ11</b>  | \$418,721           | \$414,546           | \$(4,175)                         |
| <b>CZ12</b>  | \$405,110           | \$400,632           | \$(4,477)                         |
| <b>CZ13</b>  | \$376,003           | \$375,872           | \$(131)                           |
| <b>CZ14</b>  | \$405,381           | \$406,752           | \$1,371                           |
| <b>CZ15</b>  | \$429,123           | \$427,606           | \$(1,517)                         |
| <b>CZ16</b>  | \$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 CBEC-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<sup>2</sup> of conditioned space and has a heating capacity of 5 kW (15 kBtu/hr/ft<sup>2</sup>). 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        |
|   | <b>I + L</b>  | <b>Total electrical infrastructure incremental cost</b> | <b>\$27,802</b> |

### 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        |
| <b>Total Cost</b>       | <b>\$18,949</b> | <b>\$28,027</b> | <b>\$56,020</b> |

### 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.<sup>20</sup>

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<br>11.4-12.9 IEER | 10.5-13 EER<br>15-15.5 IEER | 10-15%                               |
| Single zone heat pump space heating | 7.7 HSPF<br>3.2 COP          | 10 HSPF<br>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 CBEC-Com.<sup>21</sup> 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

<sup>20</sup> Available at: <https://www.ahrifirectory.org/Search/SearchHome?ReturnUrl=%2f>

<sup>21</sup> 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.<sup>22</sup>

## 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                               |

<sup>22</sup> CBEECC-Com documentation does not state which climate zones fall under which region. CBEECC-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 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) |
|------------------------------------|---------|--------------------|----------------------|------------------------|--------------------|--------------------------|--------------------------------|---------------|---------------------|-----------------|---------------|-----------|
| <b>Package 1A: Mixed Fuel + EE</b> |         |                    |                      |                        |                    |                          |                                |               |                     |                 |               |           |
| 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) | 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) |
|----------------------------------|---------|--------------------|----------------------|---------------------|-----------------------|--------------------------|-------------------------------|----------------|---------------------|-----------------|---------------|-----------|
| <b>Mixed Fuel + PV + Battery</b> |         |                    |                      |                     |                       |                          |                               |                |                     |                 |               |           |
| 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) | Compliance Margin | Incremental Package Cost | Lifecycle Utility Cost Savings | \$TDV Savings | B/C Ratio (On-bill) | B/C Ratio (TDV) | NPV (On-bill) | NPV (TDV)  |
|------------------------------------|---------|--------------------|----------------------|------------------------|-------------------|--------------------------|--------------------------------|---------------|---------------------|-----------------|---------------|------------|
| <b>Package 1C: Mixed Fuel + HE</b> |         |                    |                      |                        |                   |                          |                                |               |                     |                 |               |            |
| 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) | Compliance Margin | Incremental Package Cost* | Lifecycle Utility Cost Savings | \$TDV Savings | B/C Ratio (On-bill) | B/C Ratio (TDV) | NPV (On-bill) | NPV (TDV)  |
|---|---------|--------------------|----------------------|------------------------|-------------------|---------------------------|--------------------------------|---------------|---------------------|-----------------|---------------|------------|
| <b>Package 2: All-Electric Federal Code Minimum</b> |         |                    |                      |                        |                   |                           |                                |               |                     |                 |               |            |
| 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) | Compliance Margin | Incremental Package Cost | Lifecycle Utility Cost Savings | \$TDV Savings | B/C Ratio (On-bill) | B/C Ratio (TDV) | NPV (On-bill) | NPV (TDV)  |
|--------------------------------------|---------|--------------------|----------------------|------------------------|-------------------|--------------------------|--------------------------------|---------------|---------------------|-----------------|---------------|------------|
| <b>Package 3A: All-Electric + EE</b> |         |                    |                      |                        |                   |                          |                                |               |                     |                 |               |            |
| 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) |
|------------------------------|---------------|--------------------|----------------------|---------------------|-----------------------|--------------------------|-------------------------------|----------------|---------------------|-----------------|---------------|-----------|
| <b>All-Electric + PV + B</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) | Compliance Margin | Incremental Package Cost | Lifecycle Utility Cost Savings | \$TDV Savings | B/C Ratio (On-bill) | B/C Ratio (TDV) | NPV (On-bill) | NPV (TDV)   |
|--------------------------------------|---------|--------------------|----------------------|------------------------|-------------------|--------------------------|--------------------------------|---------------|---------------------|-----------------|---------------|-------------|
| <b>Package 3C: All-Electric + HE</b> |         |                    |                      |                        |                   |                          |                                |               |                     |                 |               |             |
| 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) | Compliance Margin | Incremental Package Cost | Lifecycle Utility Cost Savings | \$TDV Savings | B/C Ratio (On-bill) | B/C Ratio (TDV) | NPV (On-bill) | NPV (TDV) |
|------------------------------------|---------|--------------------|----------------------|------------------------|-------------------|--------------------------|--------------------------------|---------------|---------------------|-----------------|---------------|-----------|
| <b>Package 1A: Mixed Fuel + EE</b> |         |                    |                      |                        |                   |                          |                                |               |                     |                 |               |           |
| 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) |
|----------------------------------|---------------|--------------------|----------------------|--------------------|-----------------------|--------------------------|-------------------------------|----------------|---------------------|-----------------|---------------|-----------|
| <b>Mixed Fuel + PV + Battery</b> |               |                    |                      |                    |                       |                          |                               |                |                     |                 |               |           |
| 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) | Compliance Margin | Incremental Package Cost | Lifecycle Utility Cost Savings | \$TDV Savings | B/C Ratio (On-bill) | B/C Ratio (TDV) | NPV (On-bill) | NPV (TDV) |
|-----------------------------|---------|--------------------|----------------------|------------------------|-------------------|--------------------------|--------------------------------|---------------|---------------------|-----------------|---------------|-----------|
| 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) | Compliance Margin | Incremental Package Cost* | Lifecycle Utility Cost Savings | \$TDV Savings | B/C Ratio (On-bill) | B/C Ratio (TDV) | NPV (On-bill) | NPV (TDV)  |
|---|---------|--------------------|----------------------|------------------------|-------------------|---------------------------|--------------------------------|---------------|---------------------|-----------------|---------------|------------|
| <b>Package 2: All-Electric Federal Code Minimum</b> |         |                    |                      |                        |                   |                           |                                |               |                     |                 |               |            |
| 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) | Compliance Margin | Incremental Package Cost | Lifecycle Utility Cost Savings | \$TDV Savings | B/C Ratio (On-bill) | B/C Ratio (TDV) | NPV (On-bill) | NPV (TDV) |
|--------------------------------------|---------|--------------------|----------------------|------------------------|-------------------|--------------------------|--------------------------------|---------------|---------------------|-----------------|---------------|-----------|
| <b>Package 3A: All-Electric + EE</b> |         |                    |                      |                        |                   |                          |                                |               |                     |                 |               |           |
| 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) | Compliance Margin | Incremental Package Cost | Lifecycle Utility Cost Savings | \$TDV Savings | B/C Ratio (On-bill) | B/C Ratio (TDV) | NPV (On-bill) | NPV (TDV)  |
|--------------------------------------|---------|--------------------|----------------------|------------------------|-------------------|--------------------------|--------------------------------|---------------|---------------------|-----------------|---------------|------------|
| <b>Package 3C: All-Electric + HE</b> |         |                    |                      |                        |                   |                          |                                |               |                     |                 |               |            |
| 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      | \$11,999   |
| 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.<sup>23</sup> 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.<sup>24</sup>
- ◆ **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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<sup>23</sup> The IOUs and CEC are actively working on including central heat pump water heater modeling with recirculation systems in early 2020.

<sup>24</sup> 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) | Compliance Margin | Incremental Package Cost | Lifecycle Utility Cost Savings | \$TDV Savings | B/C Ratio (On-bill) | B/C Ratio (TDV) | NPV (On-bill) | NPV (TDV) |
|-----------------------------|---------|--------------------|----------------------|------------------------|-------------------|--------------------------|--------------------------------|---------------|---------------------|-----------------|---------------|-----------|
| 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) | Compliance Margin | Incremental Package Cost | Lifecycle Utility Cost Savings | \$TDV Savings | B/C Ratio (On-bill) | B/C Ratio (TDV) | NPV (On-bill) | NPV (TDV)  |
|---|---------|--------------------|----------------------|------------------------|-------------------|--------------------------|--------------------------------|---------------|---------------------|-----------------|---------------|------------|
| <b>Package 1B: Mixed Fuel + EE + PV + B</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) | Compliance Margin | Incremental Package Cost | Lifecycle Utility Cost Savings | \$TDV Savings | B/C Ratio (On-bill) | B/C Ratio (TDV) | NPV (On-bill) | NPV (TDV)  |
|-----------------------------|---------|--------------------|----------------------|------------------------|-------------------|--------------------------|--------------------------------|---------------|---------------------|-----------------|---------------|------------|
| 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) | Compliance Margin | Incremental Package Cost* | Lifecycle Utility Cost Savings | \$TDV Savings | B/C Ratio (On-bill) | B/C Ratio (TDV) | NPV (On-bill) | NPV (TDV)   |
|---|---------|--------------------|----------------------|------------------------|-------------------|---------------------------|--------------------------------|---------------|---------------------|-----------------|---------------|-------------|
| <b>Package 2: All-Electric Federal Code Minimum</b> |         |                    |                      |                        |                   |                           |                                |               |                     |                 |               |             |
| 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) | Compliance Margin | Incremental Package Cost | Lifecycle Utility Cost Savings | \$TDV Savings | B/C Ratio (On-bill) | B/C Ratio (TDV) | NPV (On-bill) | NPV (TDV)   |
|--------------------------------------|---------|--------------------|----------------------|------------------------|-------------------|--------------------------|--------------------------------|---------------|---------------------|-----------------|---------------|-------------|
| <b>Package 3A: All-Electric + EE</b> |         |                    |                      |                        |                   |                          |                                |               |                     |                 |               |             |
| 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) | Compliance Margin | Incremental Package Cost | Lifecycle Utility Cost Savings | \$TDV Savings | B/C Ratio (On-bill) | B/C Ratio (TDV) | NPV (On-bill) | NPV (TDV)   |
|--|---------|--------------------|----------------------|------------------------|-------------------|--------------------------|--------------------------------|---------------|---------------------|-----------------|---------------|-------------|
| 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) | Compliance Margin | Incremental Package Cost | Lifecycle Utility Cost Savings | STDV Savings | B/C Ratio (On-bill) | B/C Ratio (TDV) | NPV (On-bill) | NPV (TDV)   |
|--------|---------|--------------------|----------------------|------------------------|-------------------|--------------------------|--------------------------------|--------------|---------------------|-----------------|---------------|-------------|
|        |         |                    |                      |                        |                   |                          |                                |              |                     |                 |               |             |
| 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.<sup>25</sup>

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.

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<sup>25</sup> 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 39. Cost Effectiveness for Medium Retail - PV and Battery

| CZ     | PV<br>Battery<br>Utility | Mixed Fuel |     |         |     |         |     | All-Electric |     |         |     |         |      |         |     |      |     |
|--------|--------------------------|------------|-----|---------|-----|---------|-----|--------------|-----|---------|-----|---------|------|---------|-----|------|-----|
|        |                          | 3kW        |     | 3kW     |     | 90 kW   |     | 3kW          |     | 3kW     |     | 90 kW   |      | 90 kW   |     |      |     |
|        |                          | 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      | 3.0  | 2.1     | 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      | 2.7  | 2.1     | 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      | 2.4  | 2.1     | 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      | 3.2  | 2.1     | 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      | 3.7  | 1.9     | 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      | 1.7  | 2.2     | 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      | 1.01 | 2.2     | 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      | 2.4  | 2.3     | 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      | 1.7  | 2.4     | 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      | 1.01 | 2.4     | 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      | 1.8  | 2.4     | 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  | 2.4     | 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      | 2.6  | 2.3     | 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      | 1.8  | 2.3     | 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      | 2.7  | 2.3     | 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      | 2.7  | 2.3     | 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      | 1.7  | 2.3     | 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      | 2.7  | 2.2     | 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      | 2.5  | 2.6     | 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      | 1.7  | 2.6     | 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      | 1.7  | 2.4     | 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 | 0.4     | 2.7  | 2.0     | 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 | 0.4     | 1.2  | 2.0     | 2.0 | 1.0  | 1.8 |



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

| CZ     | PV<br>Battery<br>Utility | Mixed Fuel |     |             |      |               |     | All-Electric |     |             |     |         |     |         |     |     |     |    |
|--------|--------------------------|------------|-----|-------------|------|---------------|-----|--------------|-----|-------------|-----|---------|-----|---------|-----|-----|-----|----|
|        |                          | 3kW        |     | 3kW<br>5kWh |      | 80kW<br>50kWh |     | 3kW          |     | 3kW<br>5kWh |     | 80kW    |     | 80kW    |     |     |     |    |
|        |                          | 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 | 1.1          | 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  | >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  | >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  | >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  | >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  | >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  | >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  | >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  | >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  | >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  | >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  | >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  | >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  | >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  | 8.2     | >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  | >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  | >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  | >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  | >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  | >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  | >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  | >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  | >1 |
| CZ16   | PG&E                     | 2.7        | 2.0 | 1.6         | 1.2  | 1.9           | 1.6 | 1.7          | 1.5 | 2.1         | 5.7 | 5.7     | 2.1 | 5.6     | 5.8 | 5.8 | >1  | >1 |
| CZ16-2 | LA                       | 1.02       | 2.0 | 0.6         | 1.2  | 0.6           | 1.6 | 0.6          | 1.5 | >1          | 5.7 | 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 and cost-effective results using both On-Bill and TDV approaches.
- ◆ Cells highlighted in yellow depict a positive compliance and cost-effective results using either the On-Bill or TDV approach.
- ◆ Cells not highlighted either depict a negative compliance margin or a package that was not cost effective using either the On-Bill or TDV approach.

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.



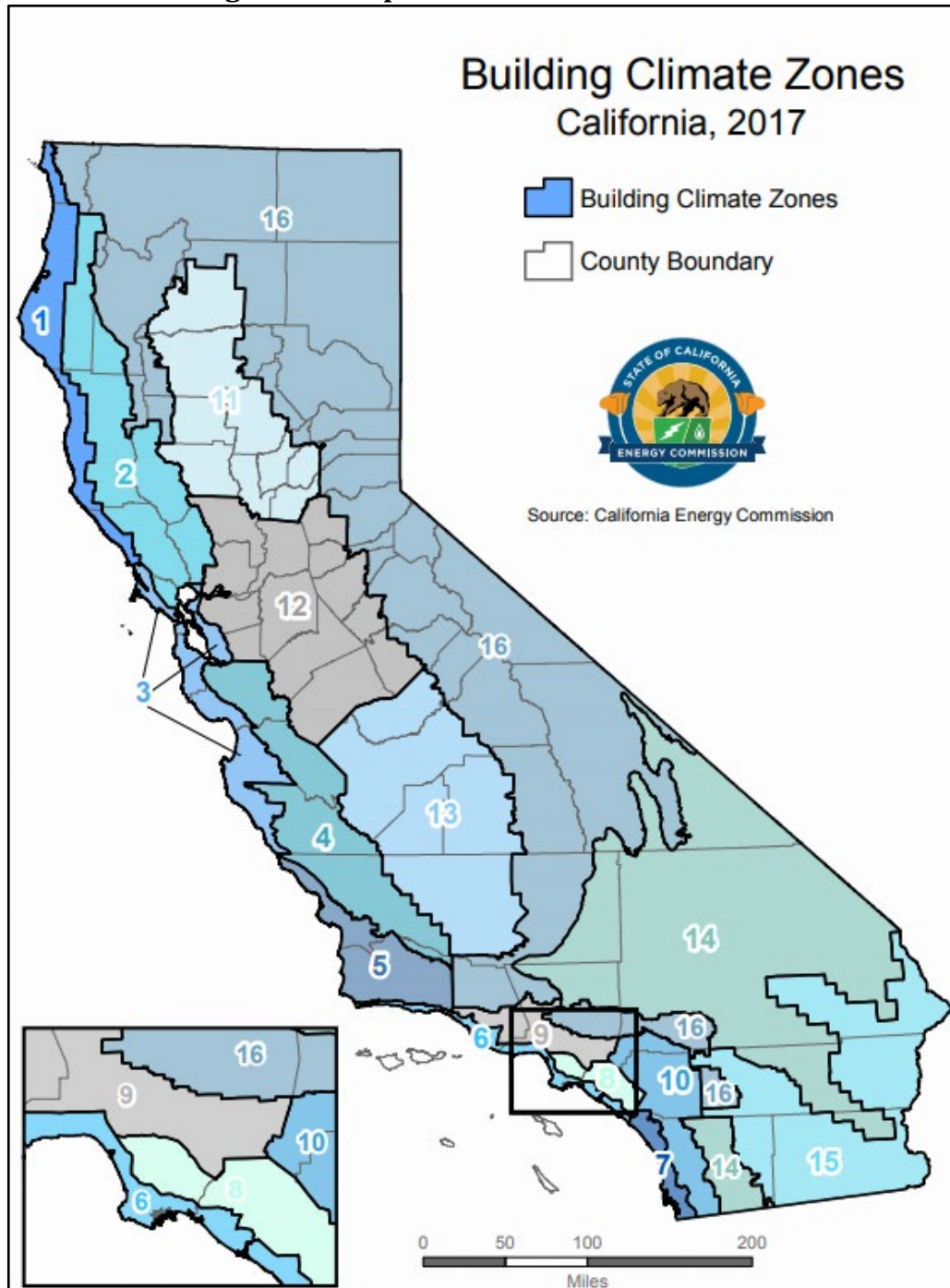
## 6 Appendices

### 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](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**

| Space Function                                    | Baseline                 | Impact                        |                      |                           |                                      | Modeled Proposed         |
|---|--------------------------|-------------------------------|----------------------|---------------------------|--------------------------------------|--------------------------|
|   | LPD (W/ft <sup>2</sup> ) | Interior Lighting Reduced LPD | Institutional Tuning | Daylight Dimming Plus OFF | Occupant Sensing in Open Office Plan | LPD (W/ft <sup>2</sup> ) |
| 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 <sup>2</sup> )               | 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 ft<sup>2</sup> 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          |              |
| 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) |
|--|---------|-------------------------------|----------------------------------|------------------|------------------|----------------|---------------------|
| <b>Medium Office Mixed Fuel Baseline</b> |         |                               |                                  |                  |                  |                |                     |
| 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) |
|--|---------|-------------------------------|----------------------------------|------------------|------------------|----------------|---------------------|
| <b>Medium Retail Mixed Fuel Baseline</b> |         |                               |                                  |                  |                  |                |                     |
| 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) |
|--|---------|-------------------------------|----------------------------------|------------------|------------------|----------------|---------------------|
| <b>Small Hotel Mixed Fuel Baseline</b> |         |                               |                                  |                  |                  |                |                     |
| 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) |
|----------------------------|---------------|--------------------|----------------------|--------------------|--------------------------|-------------------------------|--------------------------|---------------------|-----------------|---------------|-----------|
| <b>Mixed Fuel + 3kW PV</b> |               |                    |                      |                    |                          |                               |                          |                     |                 |               |           |
| 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) |
|---|---------------|--------------------|----------------------|--------------------|--------------------------|-------------------------------|----------------|---------------------|-----------------|---------------|-----------|
| <b>Mixed Fuel + 3kW PV + 5kWh Battery</b> |               |                    |                      |                    |                          |                               |                |                     |                 |               |           |
| 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) |
|-----------------------------|---------------|--------------------|----------------------|--------------------|--------------------------|-------------------------------|-----------------------|---------------------|-----------------|---------------|-----------|
| <b>Mixed Fuel +135kW PV</b> |               |                    |                      |                    |                          |                               |                       |                     |                 |               |           |
| 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) |
|---|---------------|--------------------|----------------------|--------------------|--------------------------|-------------------------------|-----------------------|---------------------|-----------------|---------------|-----------|
| <b>Mixed Fuel + 135kW PV + 50 kWh Battery</b> |               |                    |                      |                    |                          |                               |                       |                     |                 |               |           |
| 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) |
|------------------------------|---------------|--------------------|------|----------------------|--------------------|--------------------------|-------------------------------|-----------------------|---------------------|-----------------|---------------|-----------|
|                              |               |                    |      |                      |                    |                          |                               |                       |                     |                 |               |           |
| <b>All-Electric + 3kW PV</b> |               |                    |      |                      |                    |                          |                               |                       |                     |                 |               |           |
| 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)  |
|--|---------------|--------------------|----------------------|--------------------|--------------------------|-------------------------------|-----------------|---------------------|-----------------|---------------|------------|
| <b>All-Electric + 3kW PV + 5 kWh Battery</b> |               |                    |                      |                    |                          |                               |                 |                     |                 |               |            |
| 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) |
|--------------------------------|---------------|--------------------|----------------------|--------------------|--------------------------|-------------------------------|-----------------------|---------------------|-----------------|---------------|-----------|
| <b>All-Electric + 135kW PV</b> |               |                    |                      |                    |                          |                               |                       |                     |                 |               |           |
| 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) |
|---|---------------|--------------------|----------------------|--------------------|--------------------------|-------------------------------|-----------------------|---------------------|-----------------|---------------|-----------|
| <b>All-Electric + 135kW PV + 50 kWh Battery</b> |               |                    |                      |                    |                          |                               |                       |                     |                 |               |           |
| 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) |
|----------------------------|---------------|--------------------|----------------------|--------------------|--------------------------|-------------------------------|-----------------------|---------------------|-----------------|---------------|-----------|
| <b>Mixed Fuel + 3kW PV</b> |               |                    |                      |                    |                          |                               |                       |                     |                 |               |           |
| 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) |
|--|---------------|--------------------|----------------------|--------------------|--------------------------|-------------------------------|----------------|---------------------|-----------------|---------------|-----------|
| <b>Mixed Fuel + 3kW PV + 5 kWh Battery</b> |               |                    |                      |                    |                          |                               |                |                     |                 |               |           |
| 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) |
|------------------------------|---------------|--------------------|----------------------|--------------------|--------------------------|-------------------------------|-----------------------|---------------------|-----------------|---------------|-----------|
| <b>Mixed Fuel + 110kW PV</b> |               |                    |                      |                    |                          |                               |                       |                     |                 |               |           |
| 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) |
|---|---------------|--------------------|----------------------|--------------------|--------------------------|-------------------------------|-----------------------|---------------------|-----------------|---------------|-----------|
| <b>Mixed Fuel + 110kW PV + 50 kWh Battery</b> |               |                    |                      |                    |                          |                               |                       |                     |                 |               |           |
| 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)  |
|------------------------------|---------------|--------------------|----------------------|--------------------|--------------------------|-------------------------------|-----------------------|---------------------|-----------------|---------------|------------|
| <b>All-Electric + 3kW PV</b> |               |                    |                      |                    |                          |                               |                       |                     |                 |               |            |
| CZ01                         | PG&E          | -25,214            | 3893                 | 14.61              | (\$16,318)               | \$4,288                       | (\$5,450)             | >1                  | >1              | \$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)  |
|--|---------------|--------------------|----------------------|--------------------|--------------------------|-------------------------------|----------------|---------------------|-----------------|---------------|------------|
| <b>All-Electric + 3kW PV + 5 kWh Battery</b> |               |                    |                      |                    |                          |                               |                |                     |                 |               |            |
| 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) |
|--------------------------------|---------------|--------------------|----------------------|--------------------|--------------------------|-------------------------------|-----------------------|---------------------|-----------------|---------------|-----------|
| <b>All-Electric + 110kW PV</b> |               |                    |                      |                    |                          |                               |                       |                     |                 |               |           |
| 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) |
|--|---------------|--------------------|----------------------|--------------------|--------------------------|-------------------------------|-----------------------|---------------------|-----------------|---------------|-----------|
| <b>All-Electric + 90kW PV + 50 kWh Battery</b> |               |                    |                      |                    |                          |                               |                       |                     |                 |               |           |
| 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) |
|----------------------------|---------------|--------------------|----------------------|--------------------|--------------------------|-------------------------------|--------------------------|---------------------|-----------------|---------------|-----------|
| <b>Mixed Fuel + 3kW PV</b> |               |                    |                      |                    |                          |                               |                          |                     |                 |               |           |
| 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) |
|---|---------------|--------------------|----------------------|--------------------|--------------------------|-------------------------------|----------------|---------------------|-----------------|---------------|-----------|
| <b>Mixed Fuel + 3kW PV + 5kWh Battery</b> |               |                    |                      |                    |                          |                               |                |                     |                 |               |           |
| 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) |
|-----------------------------|---------------|--------------------|----------------------|--------------------|--------------------------|-------------------------------|-----------------------|---------------------|-----------------|---------------|-----------|
| <b>Mixed Fuel + 80kW PV</b> |               |                    |                      |                    |                          |                               |                       |                     |                 |               |           |
| 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) |
|---|---------------|--------------------|----------------------|--------------------|--------------------------|-------------------------------|-----------------------|---------------------|-----------------|---------------|-----------|
| <b>Mixed Fuel + 80kW PV + 50kWh Battery</b> |               |                    |                      |                    |                          |                               |                       |                     |                 |               |           |
| 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)   |
|------------------------------|---------------|--------------------|----------------------|--------------------|---------------------------|-------------------------------|-----------------------|---------------------|-----------------|---------------|-------------|
| <b>All-Electric + 3kW PV</b> |               |                    |                      |                    |                           |                               |                       |                     |                 |               |             |
| 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)   |
|---|---------------|--------------------|----------------------|--------------------|--------------------------|-------------------------------|----------------|---------------------|-----------------|---------------|-------------|
| <b>All-Electric + 3kW PV + 5kWh Battery</b> |               |                    |                      |                    |                          |                               |                |                     |                 |               |             |
| 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             |             | NPV (On-bill) | NPV (TDV)   |
|-------------------------------|---------------|--------------------|----------------------|--------------------|--------------------------|-------------------------------|----------------|-----------------|-------------|---------------|-------------|
|                               |               |                    |                      |                    |                          |                               |                | Ratio (On-bill) | Ratio (TDV) |               |             |
| <b>All-Electric + 80kW PV</b> |               |                    |                      |                    |                          |                               |                |                 |             |               |             |
| 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)   |
|---|---------------|--------------------|----------------------|--------------------|--------------------------|-------------------------------|----------------|---------------------|-----------------|---------------|-------------|
| <b>All-Electric + 80kW PV + 50kWh Battery</b> |               |                    |                      |                    |                          |                               |                |                     |                 |               |             |
| 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.   | <p>For small hotels, the ventilation requirement could be met by various approaches, and the most common ones are:</p> <ul style="list-style-type: none"> <li>a. Exhaust only system, and ventilation is met by infiltration or window operation.</li> <li>b. Through a Z-duct that connects the zone AC unit's intake to an outside air intake louver.</li> <li>c. Centralized ventilation system (DOAS)</li> </ul> <p>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.</p> | 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) | 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) |
|-----------------------------|------------------------------|--------------------|----------------------|--------------------|-----------------------|--------------------------|-------------------------------|----------------|---------------------|-----------------|---------------|-----------|
| 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) | 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) |
|------------------------------|----------------------------|--------------------|----------------------|--------------------|-----------------------|--------------------------|-------------------------------|----------------|---------------------|-----------------|---------------|-----------|
| 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) | 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)   |
|-----------------------------|---------------------------|--------------------|----------------------|--------------------|-----------------------|--------------------------|-------------------------------|----------------|---------------------|-----------------|---------------|-------------|
| 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   |             |

