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CALIFORNIA ENERGY CODES & STANDARDS

A STATEWIDE UTILITY PROGRAM

Title 24, Parts 6 and 11
Local Energy Efficiency Ordinances

2019 Nonresidential New Construction Reach Code Cost Effectiveness Study

Prepared for:
Christopher Kuch
Codes and Standards Program
Southern California Edison Company

Prepared by:
TRC Advanced Energy
EnergySoft

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SDGE A Sempra Energy utility
SoCalGas A Sempra Energy utility
Southern California Edison An Edison International Company
PG&E Pacific Gas and Electric Company

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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 documents cost-effective combinations of measures that exceed the minimum state requirements for design including energy efficiency, solar photovoltaics (PV), and battery storage in new construction nonresidential buildings. In addition, the report includes a comparison between a baseline mixed-fuel design and all-electric design for each occupancy type. The following seven packages are compared to 2019 code compliant mixed-fuel design baseline:

- **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 photovoltaics (PV) and batteries.
- **Package 1C – Mixed-fuel + HE**: Alternative design with high efficiency appliances, triggering federal preemption.
- **Package 2 – All-Electric Federal Code-Minimum**: 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 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 Only	EE+ PV + Batt	Pre-empted Equipment	Fed Code Minimum Efficiency	EE Only	EE+ PV + Batt	Pre-empted Equipment
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
Preempted Measures	3.4				X				X

The Department of Energy (DOE) sets minimum efficiency standards for equipment and appliances that are federally regulated under the National Appliance Energy Conservation Act (NAECA), including heating, cooling, and water heating equipment.[1] Since state and local governments are prohibited from adopting 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 a reach code would be limited by federal preemption, 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 nonresidential new construction in the state.

This analysis used both on-bill and time dependent valuation of energy (TDV) based approach 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 such as 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 (Horii et al, 2014).

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

EnergySoft and TRC performed energy simulations using EnergyPro 8.0 software for 2019 Title 24 code compliance analysis, which uses CBECC-Com 2019.0.4 Alpha 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 percent to reflect a prescriptively-built building.[2]

2.1 Building Prototypes

The DOE provides building prototype models which, when modified to comply with the requirement of 2019 Title 24, can be used to evaluate the cost effectiveness of efficiency measures. TRC performed analysis on a medium office, a medium retail, and a small hotel prototype. Figure 2 describes the basic characteristics of each prototype.

At the time of this draft, the Energy Commission is completing its update of the nonresidential HVAC and DHW baseline assumptions. The heating, ventilation, and air-conditioning (HVAC) and domestic hot water (DHW) Standard Design systems are based on the system maps included in the research version of CBECC-Com 2019.0.4 Alpha and may not reflect the final system designs. The Standard Design systems used in this analysis may change because of docketed comments in response to the Energy Commission's February 2019 Alternate Calculation Method (ACM) workshops. The Standard Design is the baseline for all nonresidential projects and assumes a mixed-fuel design using natural gas as the heating source in all cases. Baseline HVAC and DHW system characteristics are described below:

- 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 DHW 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 DHW 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 variable air volume (VAV) terminal boxes with hot water reheat coils. The DHW design include a small electric resistance water heater with 30-gallon storage tank.
  - The residential HVAC design includes one single zone AC unit with gas furnace for each guest room and the DHW design includes one central gas water heater with a recirculation pump for all guest rooms.

[2] 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 compared the package results to that of the proposed design of baseline prototypes (not the standard design).

Figure 2. Prototype Characteristics Summary

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

2.2 Cost Effectiveness

TRC analyzed the cost effectiveness of the packages by applying them to building prototypes (as applicable) using the life cycle cost (LCC) methodology, which is approved and used by the Energy Commission to establish cost effective building energy standards (Title 24, Part 6).[3]

Per Energy Commission's methodology, TRC 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 time dependent valuation (TDV) of energy and typical utility rates for each building type:

- **Time Dependent Valuation (TDV):** 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 over annual electricity and natural gas consumption. The energy bill savings are calculated as the difference in utility costs of baseline and proposed package over 15-year duration accounting for discount rate and energy cost escalation.

In coordination with the IOUs, TRC 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

[3] 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

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. TRC did not attempt to compare or test a variety of tariffs to determine their impact on cost effectiveness.

The applicable time-of–use (TOU) nonresidential rates are applied to both the base and proposed cases with PV systems.[4] 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 6.3 Utility Rate Schedules*.

Figure 3. IOU Utility Tariffs used based on Climate Zone

Climate Zones	Electric / Gas Utility	Electricity (Time-of-use)	Natural Gas
1-5,11-13,16	PG&E	A-1/A-10	G-NR1
6,8-10,14,15	SCE / SoCal Gas	TOU-GS-1/TOU-GS-2/TOU-GS-3	G-10 (GN-10)
7,10,14	SDG&E	A-1/A-10	GN-3

TRC obtained measure costs through interviews with contractors and California distributors and reviewed online sources, such as Home Depot and RS Means. We added taxes and contractor markups, as appropriate. Maintenance costs were not included because there is no assumed maintenance on the envelope measures and for HVAC and DHW measures there should not be any 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.

TRC 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% discount rate and fuel escalation rates of 2.4% and 3.1% for electricity and gas respectively.[5] Cost effectiveness is presented using net present value and benefit-to-cost ratio metrics.

- **Net Present Value (NPV)**: TRC uses net savings (NPV benefits *minus* NPV costs) as the cost effectiveness metric. If the net savings of a measure is positive, the measure or package 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.

[4] 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?).

[5] 2019 TDV Methodology Report, California Energy Commission, Docket number: 16-BSTD-06 https://efiling.energy.ca.gov/GetDocument.aspx?tn=216062

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 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.'

3 Measure Description and Cost Data Collection

Using the 2019 Title 24 code baseline as the starting point, TRC identified potential measure packages to determine the projected energy (therm and kWh) and compliance impacts. TRC 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, electrification and solar PV as outlined 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. Figure 4 gives a summary of the cost of each measure and the applicability of each measure to the prototype buildings. TRC assessed the cost-effectiveness of measures for all climate zones individually and found that the packages did not need to vary by climate zone. 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, refer to *Appendix Section 6.4 Complete List of Efficiency Measures* .

3.1.1 Envelope

- **Lower SHGC fenestration**: Reduce window solar heat gain coefficient (SHGC) from the prescriptive value of 0.25 to 0.20 in climate zone 15 and to 0.22 in all other climate zones. Fenestration VT and U-factor remain the 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 DHW

- **Drain water heat recovery**: Add shower drain heat recovery. Drain water heat recovery captures waste heat from a shower drain line and uses it to preheat domestic hot water. Note that this measure cannot currently be modeled on hotel/motel spaces, and TRC integrated estimated savings outside of modeling software based on DHW savings in residential scenarios. Please see Appendix 6.2 for details on energy savings analysis.
- **VAV box minimum flow**: Reduce Variable Air Volume (VAV) box minimum airflows from the current T24 prescriptive requirement of 20 percent of maximum (design) airflow to the T24 zone ventilation minimums.
- **Economizers on small capacity systems**: Require economizers and staged fan control in units with cooling capacity ≥ 33,000 Btu/hr and ≤ 54,000 Btu/hr, which matches the requirement in the 2018 International Green Construction Code and adopts ANSI/ASHRAE/ICC/USGBC/IES Standard 189.1. This

measure reduces the T24 prescriptive threshold on air handling units that are required to have economizers, which is > 54,000 Btu/hr.

3.1.3 Lighting

- **Interior lighting reduced LPD**: Reduce allowed lighting power density (LPD). Reduce by 15% for Medium Office and by 10% for Medium Retail and by 10% for the nonresidential areas of the Small Hotel.
- **Institutional tuning**: Limit the maximum output or maximum power draw of lighting to 85% of full light output or full power draw.
- **Daylight dimming plus off**: Turn daylight-controlled lights completely off when the daylight available in the daylit zone is greater than 150% of the illuminance received from the general lighting system at full power. There is no associated cost with this measure, as the 2019 T24 Standards already require multilevel lighting and daylight sensors in primary and secondary daylit spaces. This measure is simply a revised control strategy, and does not increase the number of sensors required or labor to install and program a sensor
- **Occupant sensing in open plan offices**: In an open plan office area greater than 250 ft2, 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 Appendix 6.1. The appendix also includes the resulting LPD that is modeled as the proposed by building type and by space function.

Figure 4. Energy Efficiency Measures - Specification and Cost

Measure	Baseline T24 Requirement	Measure Applicability ● Included in Packages 1A, 1B, 3A, 3C ◊ Applicable, but not cost effective – Not applicable				Incremental Cost	Sources & Notes
		Med Office	Med Retail	Small Hotel			
				Guest rooms	Comm Spaces		
Envelope							
Lower SHGC Fenestration	SHGC of 0.25	●	●	◊	◊	$1.60 /ft2 window	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							
Drain Water Heat Recovery	No heat recovery required	–	–	●	–	$841 /unit	Assume 1 heat recovery unit for every 3 guestrooms. Costs from three manufacturers.

Measure	Baseline T24 Requirement	Measure Applicability ● Included in Packages 1A, 1B, 3A, 3C ◊ Applicable, but not cost effective – Not applicable				Incremental Cost	Sources & Notes
				Small Hotel			
		Med Office	Med Retail	Guest rooms	Comm Spaces		
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.
Lighting							
Interior Lighting Reduced LPD	Per Area Category Method, varies by Primary Function Area. Office area 0.60 – 0.70 W/ft2 depending on area of space. Hotel function area 0.85 W/ft2. Retail Merchandise Sales 1.00 W/ft2	●	●	–	●	$0	Industry report on LED pricing analysis shows that costs are not correlated with efficacy.[6]
Institutional Tuning	PAF credit of 0.10 for luminaires in non-daylit areas and 0.05 for luminaires in daylit areas	●	●	–	●	$0.06/ft2	Industry report on institutional tuning[7]
Daylight Dimming Plus Off	PAF credit of 0.10	●	–	–	–	$0	Given the amount of lighting controls already required, this measure is no additional cost.
Occupant Sensing in Open Plan Offices	PAF credit of 0.30	●	–	–	–	$189 /sensor; $74 /powered relay; $108 /secondary relay	2 workstations per sensor; 1 fixture per workstation; 4 workstations per master relay; 120 ft2/workstation in open office area, which is 53% of total floor area of the medium office

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

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

3.2 Solar Photovoltaics and Battery

3.2.1 Solar Photovoltaics

TRC considered the installation of solar photovoltaics (PV) as a measure. To size PV systems, TRC considered the potential for PV on a building determined by a PV generation capacity of 15 W/ft2 of solar zone and 50% of the roof area coverage for the medium office and small hotel, because these prototypes had small roof areas compared to their annual electricity demand. 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 90 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 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 5.

Figure 5. Medium Office PV Costs

	Unit Cost	Cost	Useful Life (yrs.)	Source
Solar PV System	$2.13 / W	$230,239	30	NREL Q1 2016[8]
Inverter Replacement	$0.14 / W	$18,090	10	E3 Rooftop Solar PV System Report[9]
Maintenance Costs	$0.02 / W	$2,680	1	E3 Rooftop Solar PV System Report

3.2.2 Energy Storage

This measure includes installation of batteries to allow energy generated through PV to be used at a later time, providing additional energy cost benefits. This draft report does not focus on optimizing battery sizes for each prototype and climate zone, though TRC ran test simulations to assess the impact of battery sizes on TDV savings and found diminishing returns at larger sizes. Thus, battery sizes for medium office, medium retail and small hotel are all sized to at 50 kWh each. The team set battery control to the Advanced Control method, which represents utility control of charging and discharging periods, to attempt to maximize on-bill savings.

TRC used costs of $443/kWh based on a 2018 IOU Codes and Standards Program report.[10] This report only contains costs for residential systems, and costs for nonresidential systems may be different.

3.3 All Electric Measures

TRC investigated the implementation of all-electric measures and associated infrastructure costs. 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. TRC selected electric systems that would be installed instead of gas-fueled systems in each prototype.

[8] https://www.nrel.gov/docs/fy16osti/66532.pdf

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

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

3.3.1 HVAC and Water Heating

HVAC and water heating are the two end-uses that use natural gas in the mixed-fuel baseline. In the all-electric scenario, gas equipment serving these two end-uses is replaced with electric equipment, described in Figure 6.

Figure 6. All-Electric HVAC and Water Heating Characteristics Summary.

End Use	Medium Office	Medium Retail	Small Hotel
HVAC	- Plant: Packaged heat pump units - VAV Terminal units with electric resistance reheat	Single zone packaged heat pump units	Non-residential: Packaged heat pump units + VAV terminal units with electric resistance reheat
			Guest Rooms: Single zone heat pump unit
Water Heating	Electric resistance water heater with storage	Electric resistance water heater with storage	Non-residential: Electric heater with storage
			Guest Rooms: Individual heat pump water heater with storage

For all scenarios, TRC 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 DHW 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 DHW 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, TRC investigate 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, TRC determined that the most feasible all-electric HVAC system, given the software modeling constraints is a variable air volume (VAV) system with an electric resistance reheat instead of hot water reheat coil. A parallel fan-powered box (PFPB) implementation of electric resistance reheat would further improve efficiency due to reducing ventilation requirements, but an accurate implementation of PFPBs is not currently available in compliance software.

The all-electric DHW 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 7. 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 higher because they require larger size rooftop heat pumps than the other climate zones.

Figure 7. Medium Office HVAC System Costs

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

3.3.1.2 Medium Retail

The baseline HVAC system includes five packaged single zone rooftop air conditioners with gas furnaces. Based on fan control requirements in section 140.4(m), units with cooling capacity ≥ 65,000 Btu/h have variable air volume fans, while smaller units have constant volume fans. The DHW 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, TRC assumed packaged heat pumps instead of the packaged air conditioners.

The all-electric DHW 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 8. Costs for rooftop air-conditioning systems are very similar to rooftop heat pump systems.

Figure 8. Medium Retail HVAC System Costs

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

3.3.1.3 Small Hotel

The small hotel has two different baseline equipment systems, one for the nonresidential spaces and one for the guest rooms. The nonresidential HVAC system includes two gas hot water boilers, four packaged rooftop units and twelve variable air volume (VAV) terminal boxes with hot water reheat coil. The DHW 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 DHW design includes one central gas storage water heater with a recirculation pump for all guest rooms.

For the small hotel all-electric design, TRC assumed the nonresidential HVAC system to be packaged heat pumps with electric resistance VAV terminal units, and the DHW 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 heat pump water heater serving each guest room. This DHW system configuration is uncommon but was selected as the closest system within the software modeling capabilities; current compliance software cannot model central heat pump water heater systems with recirculation serving guest rooms. The only option to allow for heat pump water heating was individual water heaters at each guest room. When developing costs, TRC estimated that one heat pump water heater would be able to serve two guest rooms because heat pump water heater tanks are sized for multi-bedroom residential usage, and because hotels have a high degree of load diversity.

Cost data for small hotel designs are presented in Figure 9. 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 compared to split DX/furnace systems with individual flues.

Figure 9. Small Hotel HVAC and DHW 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

TRC investigated the implementation of all-electric measures and associated infrastructure costs. 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, TRC assumed that on average, a VAV terminal unit serves around 900 ft2 of conditioned space and has a heating capacity of 5 kW (15 kBtu/hr/ft2). The incremental electrical infrastructure costs were determined based on RS Means. Calculations for the medium office shown in Figure 10, include the cost to add electrical panels as well as the cost to add electrical lines to all of the VAV terminal unit electric resistance coils in the medium office prototype. Additionally, TRC 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.

TRC calculated costs to increase electrical capacity for heat pump water heaters in the small hotel similarly.

Figure 10. Medium Office Electrical Infrastructure Costs for All-Electric Design

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

3.3.2.2 Natural Gas

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

TRC 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. TRC 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. TRC assumed 1" corrugated stainless steel tubing (CSST) material is used for the plumbing distribution. TRC included costs for a natural gas plan review, service extension, and a gas meter, as shown in Figure 11 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.

Figure 11. Natural Gas Infrastructure Cost Savings for All-Electric Prototypes

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

3.4 Preempted High Efficiency Appliances

As a comparison to the efficiency measures analyzed, TRC developed a package of high efficiency (HE) space and water heating appliances based on commonly available products. These packages were developed for both the mixed-fuel and all-electric scenarios. TRC reviewed the Air Conditioning, Heating, and Refrigeration Institute (AHRI) certified product database to estimate appropriate efficiencies.[11]

TRC determined the efficiency increases to be appropriate based on equipment type, summarized in . The ranges in efficiency are indicative of varying federal standard requirements based on equipment size:

- Federal standards for heat pump water heating systems are around a UEF = 2.0. TRC increased this efficiency to a UEF=3.3.

Figure 12. High Efficiency Appliance Assumptions

	Federal Minimum Efficiency	Preempted Efficiency
Gas space heating and water heating	80-82%	90-95%
Packaged rooftop cooling	9.8-12 EER 11.4-12.9 IEER	10.5-13 EER 15-15.5 IEER
Heat pump space heating	7.7 HSPF 3.2 COP	10 HSPF 3.5 COP
Heat pump water heating	2.0 UEF	3.3 UEF

3.5 Greenhouse Gas Emissions

The analysis uses the greenhouse gas (GHG) emissions estimates from the built-in GHG multiplier in EnergyPro software, outlined in Figure 13. The cost effectiveness result tables in the subsequent section summarizes the emissions reductions associated with each measure package and prototype.

Figure 13. Greenhouse gas multipliers for electricity and gas

	Electric (lbs/kWh)	Natural Gas (lbs/therm)
PG&E	0.69	11.65
SDG&E	0.807	11.65
SCE	0.807	11.65

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

4 Results

TRC evaluated cost effectiveness of three measure packages over a 2019 code compliant baseline for all climate zones:

- **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 photovoltaics (PV) and batteries.
- **Package 1C – Mixed-fuel + HE**: Alternative design with high efficiency appliances, triggering federal preemption.
- **Package 2 – All-Electric Federal Code-Minimum**: 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.

These packages are reiterated in Figure 14. The application of the efficiency packages (1C and 3C) outlined in Figure 4 are the same across all climate zones. TRC will examine the potential for custom packages to each climate zone in the next draft.

Figure 14. Package Summary

Package	Fuel Type		Energy Efficiency Measures (EE)	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		X			
3A – All-Electric + EE		X	X		
3B – All-Electric + EE + PV + B		X	X	X	
3C – All-Electric + HE		X			X

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 draft 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 below highlight in green the modeling results that are cost effective and have a positive compliance margin.
- 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, TRC 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* TRC coordinated with IOUs to select tariffs for each prototype given the annual energy demand profile and the most prevalent rates in each utility territory. TRC did not attempt to compare or test a variety of tariffs to determine their impact on cost effectiveness.

4.1 Cost Effectiveness Results – Medium Office

Figure 15 through Figure 21 contain the cost-effectiveness findings for the Medium Office packages. Notable findings for each package include:

- **1A – Mixed-Fuel + EE:** Packages achieve 12-20% compliance margins depending on climate zone, and all packages are cost effective in all climate zones.
- **1B – Mixed-Fuel + EE + PV + B:** All packages are cost effective using the On-Bill and TDV approaches. When compared to 1A, the B/C ratio is slightly reduced but overall NPV savings are increased.
- **1C – Mixed-fuel + HE:** Packages achieve 0-5% compliance margins depending on climate zone, and no packages are cost effective in the four climate zones analyzed.
- **2 – All-Electric Federal Code-Minimum:**
    - Packages achieve between -27% and +1% 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 between 0 and +11% GHG emissions savings.
    - Packages achieve savings and are cost effective using the On-Bill approach in CZs 5-10 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 1-4, 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 -13% in CZ16. All packages are cost effective in all climate zones except CZ16.
- **3B – All-Electric + EE + PV +B:** All packages are cost effective using On-Bill approach, but not cost effective using TDV approach in CZ16. Packages reduce in B/C ratio when compared to 3A but increase in magnitude of overall NPV savings.
- **3C – All-Electric + HE:** Packages achieve between -25% and +4% compliance margins depending on climate zone. The only packages that are cost effective are in CZs 6 and 7 using the On-Bill approach.

Note that the actual natural gas consumption for the mixed fuel baseline model 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% of the boiler energy use.[12] If these losses are considered, savings for the all-electric packages, with zero distribution loss, may be higher.

Figure 15. Cost Effectiveness for Medium Office Package 1A – Mixed-Fuel + EE

CZ	IOU territory	Elec Savings (kWh)	Gas Savings (therms)	% GHG Savings	Comp-liance Margin	Incremental Package Cost	Lifecycle Utility Cost Savings	$TDV Savings	B/C Ratio (On-bill)	B/C Ratio (TDV)	NPV (On-bill)	NPV (TDV)
Package 1A: Mixed Fuel + EE												
CZ01	PG&E	32,954	-878	13%	17%	$66,649	$133,241	$67,059	2.0	1.0	$66,592	$410
CZ02	PG&E	40,051	-540	15%	17%	$66,649	$176,510	$96,747	2.6	1.5	$109,861	$30,097
CZ03	PG&E	35,339	-524	15%	20%	$66,649	$154,694	$81,139	2.3	1.2	$88,045	$14,490
CZ04	PG&E	39,885	-566	15%	14%	$66,649	$177,868	$93,931	2.7	1.4	$111,218	$27,281
CZ05	PG&E	38,324	-536	15%	18%	$66,649	$168,827	$89,396	2.5	1.3	$102,178	$22,747
CZ06	SCE	39,177	-360	17%	20%	$66,649	$95,477	$98,942	1.4	1.5	$28,828	$32,293
CZ07	SDG&E	42,005	-35	18%	20%	$66,649	$1,447,948	$112,640	21.7	1.7	$1,381,299	$45,991
CZ08	SCE	41,720	-98	18%	18%	$66,649	$99,478	$113,833	1.5	1.7	$32,829	$47,184
CZ09	SCE	42,556	-235	17%	16%	$66,649	$105,741	$115,552	1.6	1.7	$39,092	$48,903
CZ10	SCE	41,398	-246	17%	17%	$66,649	$100,714	$107,438	1.5	1.6	$34,064	$40,789
CZ10-2	SDG&E	41,408	-246	8%	17%	$66,649	$229,137	$107,438	3.4	1.6	$162,488	$40,789
CZ11	PG&E	41,963	-433	15%	13%	$66,649	$182,981	$102,283	2.7	1.5	$116,332	$35,634
CZ12	PG&E	40,787	-508	15%	14%	$66,649	$174,287	$97,987	2.6	1.5	$107,638	$31,338
CZ13	PG&E	42,401	-460	15%	13%	$66,649	$184,978	$98,608	2.8	1.5	$118,329	$31,959
CZ14	SCE	41,836	-481	15%	18%	$66,649	$105,263	$148,962	1.6	2.2	$38,614	$82,313
CZ14-2	SDG&E	41,836	-481	7%	13%	$66,649	$233,917	$106,006	3.5	1.6	$167,268	$39,357
CZ15	SCE	45,772	-170	16%	12%	$66,649	$115,732	$118,797	1.7	1.8	$49,083	$52,148
CZ16	PG&E	37,259	-773	14%	14%	$66,649	$157,179	$78,085	2.4	1.2	$90,529	$11,435

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

Figure 16. Cost Effectiveness for Medium Office Package 1B – Mixed-Fuel + EE + PV + B

CZ	IOU territory	Elec Savings (kWh)	Gas Savings (therms)	% GHG Savings	Comp-liance Margin	Incremental Package Cost	Lifecycle Utility Cost Savings	$TDV Savings	B/C Ratio (On-bill)	B/C Ratio (TDV)	NPV (On-bill)	NPV (TDV)
Package 1B: Mixed Fuel + EE + PV + B												
CZ01	PG&E	209,040	-878	44%	17%	$373,142	$661,530	$484,926	1.8	1.3	$288,388	$111,784
CZ02	PG&E	192,113	-540	39%	17%	$373,142	$687,858	$430,706	1.8	1.2	$314,716	$57,564
CZ03	PG&E	243,802	-524	56%	20%	$373,142	$817,930	$564,633	2.2	1.5	$444,788	$191,491
CZ04	PG&E	202,369	-566	39%	14%	$373,142	$708,997	$450,752	1.9	1.2	$335,855	$77,610
CZ05	PG&E	199,796	-536	42%	18%	$373,142	$753,710	$437,436	2.0	1.2	$380,568	$64,294
CZ06	SCE	256,311	-360	59%	20%	$373,142	$530,049	$619,903	1.4	1.7	$156,907	$246,761
CZ07	SDG&E	200,291	-35	46%	20%	$373,142	$657,084	$467,887	1.8	1.3	$283,942	$94,745
CZ08	SCE	193,841	-98	43%	18%	$373,142	$398,880	$484,401	1.1	1.3	$25,738	$111,259
CZ09	SCE	197,045	-235	40%	16%	$373,142	$404,131	$481,489	1.1	1.3	$30,989	$108,347
CZ10	SCE	257,292	-246	55%	17%	$373,142	$534,794	$628,017	1.4	1.7	$161,652	$254,875
CZ10-2	SDG&E	257,292	-246	55%	17%	$373,142	$925,986	$628,017	2.5	1.7	$552,844	$254,875
CZ11	PG&E	190,444	-433	36%	13%	$373,142	$695,341	$446,600	1.9	1.2	$322,199	$73,458
CZ12	PG&E	251,358	-508	49%	14%	$373,142	$897,745	$610,692	2.4	1.6	$524,603	$237,550
CZ13	PG&E	187,860	-460	34%	13%	$373,142	$677,943	$422,687	1.8	1.1	$304,801	$49,545
CZ14	SCE	218,371	-481	41%	18%	$373,142	$419,226	$572,031	1.1	1.5	$46,084	$198,889
CZ14-2	SDG&E	218,371	-481	41%	13%	$373,142	$695,038	$529,075	1.9	1.4	$321,896	$155,933
CZ15	SCE	211,547	-170	36%	12%	$373,142	$416,473	$500,724	1.1	1.3	$43,331	$127,582
CZ16	PG&E	200,790	-773	37%	14%	$373,142	$700,728	$425,503	1.9	1.1	$327,586	$52,361

Figure 17. Cost Effectiveness for Medium Office Package 1C – Mixed-Fuel + HE

CZ	IOU territory	Elec Savings (kWh)	Gas Savings (therms)	% GHG Savings	Comp-liance Margin	Incremental Package Cost	Lifecycle Utility Cost Savings	$TDV Savings	B/C Ratio (On-bill)	B/C Ratio (TDV)	NPV (On-bill)	NPV (TDV)
Package 1C: Mixed Fuel + HE												
CZ01	PG&E	268	677	3%	0.04%	$93,570	$18,502	$12,123	0.2	0.1	($75,068)	($81,447)
CZ02	PG&E	3,867	506	3%	4%	$131,778	$38,918	$24,055	0.3	0.2	($92,860)	($107,723)
CZ03	PG&E	1,259	437	2%	3%	$93,025	$22,223	$11,980	0.2	0.1	($70,802)	($81,045)
CZ04	PG&E	5,668	526	3%	5%	$146,044	$49,292	$31,072	0.3	0.2	($96,752)	($114,972)
CZ05	PG&E	3,552	441	2%	0.03%	$95,826	$38,633	$18,185	0.4	0.2	($57,192)	($77,641)
CZ06	SCE	3,416	296	2%	0.03%	$98,404	$21,600	$16,228	0.2	0.2	($76,804)	($82,176)
CZ07	SDG&E	5,354	139	2%	0.03%	$104,234	$46,381	$20,189	0.4	0.2	($57,853)	($84,045)
CZ08	SCE	6,040	173	2%	0.03%	$120,795	$24,919	$24,485	0.2	0.2	($95,875)	($96,310)
CZ09	SCE	7,711	222	2%	0.03%	$131,465	$32,039	$32,265	0.2	0.2	($99,427)	($99,201)
CZ10	SCE	5,809	281	2%	0.03%	$158,277	$26,783	$24,628	0.2	0.2	($131,494)	($133,649)
CZ10-2	SDG&E	5,809	281	2%	0.03%	$158,277	$55,415	$24,628	0.4	0.2	($102,862)	($133,649)
CZ11	PG&E	8,218	404	3%	0.03%	$151,748	$58,432	$37,515	0.4	0.2	($93,316)	($114,233)
CZ12	PG&E	6,583	439	12%	5%	$138,801	$50,879	$34,126	0.4	0.2	($87,922)	($104,675)
CZ13	PG&E	8,561	409	3%	0.03%	$150,122	$57,993	$37,276	0.4	0.2	($92,129)	($112,846)
CZ14	SCE	8,015	429	3%	0.06%	$146,294	$35,512	$79,660	0.2	0.5	($110,782)	($66,635)
CZ14-2	SDG&E	8,015	429	3%	0.03%	$146,294	$69,778	$36,704	0.5	0.3	($76,516)	($109,591)
CZ15	SCE	15,300	197	3%	0.02%	$185,506	$48,702	$52,502	0.3	0.3	($136,804)	($133,004)
CZ16	PG&E	3,193	826	3%	0.04%	$153,048	$37,940	$23,626	0.2	0.2	($115,109)	($129,423)

Figure 18. Cost Effectiveness for Medium Office Package 2 – All-Electric Federal Code Minimum

CZ	IOU territory	Elec Savings (kWh)	Gas Savings (therms)	% GHG Savings	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 2: All-Electric Federal Code Minimum												
CZ01	PG&E	-58,959	4907	5%	-18%	($87,253)	($155,457)	($71,450)	0.6	1.2	($68,204)	$15,803
CZ02	PG&E	-51,461	3798	3%	-8%	($73,695)	($120,176)	($46,583)	0.6	1.6	($46,480)	$27,112
CZ03	PG&E	-39,277	3095	3%	-9%	($82,330)	($94,677)	($37,849)	0.9	2.2	($12,346)	$44,481
CZ04	PG&E	-49,222	3747	3%	-6%	($69,012)	($103,921)	($41,667)	0.7	1.7	($34,909)	$27,345
CZ05	PG&E	-42,259	3203	3%	-9%	($84,503)	($80,794)	($44,579)	1.0	1.9	$3,709	$39,924
CZ06	SCE	-27,693	2080	1%	-5%	($76,153)	$20,075	($24,533)	>1	3.1	$96,227	$51,620
CZ07	SDG&E	-13,473	932	0%	-2%	($70,325)	$46,654	($12,982)	>1	5.4	$116,979	$57,343
CZ08	SCE	-16,535	1193	0%	-2%	($68,774)	$17,393	($14,987)	>1	4.6	$86,166	$53,787
CZ09	SCE	-20,898	1585	0%	-2%	($63,102)	$16,143	($17,278)	>1	3.7	$79,245	$45,824
CZ10	SCE	-27,741	2024	0%	-4%	($47,902)	$18,685	($24,485)	>1	2.0	$66,586	$23,417
CZ10-2	SDG&E	-27,741	2024	0%	-4%	($47,902)	$35,715	($24,485)	>1	2.0	$83,617	$23,417
CZ11	PG&E	-41,526	3003	2%	-5%	($63,987)	($95,000)	($36,894)	0.7	1.7	($31,013)	$27,093
CZ12	PG&E	-44,835	3263	2%	-5%	($68,343)	($104,772)	($39,710)	0.7	1.7	($36,429)	$28,633
CZ13	PG&E	-41,129	3023	2%	-5%	($62,726)	($90,793)	($36,465)	0.7	1.7	($28,067)	$26,261
CZ14	SCE	-44,369	3232	0%	0%	($65,156)	($6,025)	$3,866	10.8	>1	$59,131	$69,022
CZ14-2	SDG&E	-44,369	3232	0%	-5%	($65,156)	($8,000)	($39,090)	8.1	1.7	$57,156	$26,066
CZ15	SCE	-20,092	1504	0%	-2%	($36,176)	$7,150	($16,466)	>1	2.2	$43,325	$19,709
CZ16	PG&E	-92,582	6080	11%	-27%	($64,096)	($247,469)	($146,003)	0.3	0.4	($183,373)	($81,907)

*The Incremental Package Cost is the addition of the incremental HVAC and water heating equipment costs from Figure 7, the electrical infrastructure incremental cost of $27,802 (see section 3.3.2.1), and the natural gas infrastructure incremental cost savings of $18,949 (see section 3.3.2.2).

Figure 19. Cost Effectiveness for Medium Office Package 3A – All-Electric + EE

CZ	IOU territory	Elec Savings (kWh)	Gas Savings (therms)	% GHG Savings	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 3A: All-Electric + EE												
CZ01	PG&E	-22,990	4907	22%	5%	($20,604)	($4,849)	$18,089	4.2	>1	$15,755	$38,693
CZ02	PG&E	-12,193	3798	19%	10%	($7,046)	$46,139	$56,606	>1	>1	$53,185	$63,653
CZ03	PG&E	349	3095	21%	15%	($15,681)	$74,642	$63,241	>1	>1	$90,323	$78,922
CZ04	PG&E	-12,931	3747	19%	9%	($2,363)	$72,225	$60,663	>1	>1	$74,588	$63,026
CZ05	PG&E	-2,809	3203	20%	11%	($17,854)	$91,173	$57,036	>1	>1	$109,027	$74,890
CZ06	SCE	14,599	2080	19%	18%	($9,503)	$118,775	$87,821	>1	>1	$128,278	$97,325
CZ07	SDG&E	33,210	932	19%	20%	($3,676)	$276,760	$111,065	>1	>1	$280,437	$114,742
CZ08	SCE	29,926	1193	19%	18%	($2,124)	$118,175	$111,161	>1	>1	$120,299	$113,285
CZ09	SCE	23,817	1585	18%	14%	$3,547	$122,964	$107,056	34.7	30.2	$119,417	$103,509
CZ10	SCE	12,358	2024	17%	13%	$18,748	$113,190	$82,619	6.0	4.4	$94,443	$63,871
CZ10-2	SDG&E	12,358	2024	17%	13%	$18,748	$248,851	$82,619	13.3	4.4	$230,103	$63,871
CZ11	PG&E	620	3003	18%	9%	$2,662	$87,437	$73,598	32.8	27.6	$84,775	$70,936
CZ12	PG&E	-3,757	3263	19%	9%	($1,694)	$71,582	$67,966	>1	>1	$73,276	$69,660
CZ13	PG&E	1,105	3023	18%	9%	$3,923	$92,195	$70,162	23.5	17.9	$88,271	$66,238
CZ14	SCE	-4,360	3232	17%	14%	$1,493	$97,479	$114,549	65.3	76.7	$95,986	$113,057
CZ14-2	SDG&E	-4,360	3232	17%	9%	$1,493	$221,764	$71,593	148.6	48.0	$220,272	$70,101
CZ15	SCE	26,202	1504	17%	11%	$30,474	$124,263	$106,674	4.1	3.5	$93,790	$76,201
CZ16	PG&E	-62,462	6080	16%	-13%	$2,553	($109,042)	($72,357)	-42.7	-28.3	($111,595)	($74,910)

Figure 20. Cost Effectiveness for Medium Office Package 3B – All-Electric + EE + PV + B

CZ	IOU territory	Elec Savings (kWh)	Gas Savings (therms)	% GHG Savings	Comp-liance Margin	Incremental Package Cost	Lifecycle Utility Cost Savings	$TDV Savings	B/C Ratio (On-bill)	B/C Ratio (TDV)	NPV (On-bill)	NPV (TDV)
Package 3B: All-Electric + EE + PV + B												
CZ01	PG&E	153,097	4907	54%	5%	$285,889	$510,277	$435,956	1.8	1.5	$224,388	$150,067
CZ02	PG&E	139,870	3798	44%	10%	$299,447	$551,077	$390,566	1.8	1.3	$251,630	$91,119
CZ03	PG&E	208,812	3095	62%	15%	$290,812	$719,985	$546,735	2.5	1.9	$429,173	$255,923
CZ04	PG&E	152,553	3747	44%	9%	$304,130	$603,488	$417,485	2.0	1.4	$299,359	$113,355
CZ05	PG&E	158,662	3203	47%	11%	$288,639	$653,001	$405,075	2.3	1.4	$364,362	$116,436
CZ06	SCE	231,733	2080	61%	18%	$296,989	$549,330	$608,782	1.8	2.0	$252,341	$311,793
CZ07	SDG&E	191,496	932	47%	20%	$302,816	$706,334	$466,312	2.3	1.5	$403,518	$163,495
CZ08	SCE	182,047	1193	44%	18%	$304,368	$415,747	$481,728	1.4	1.6	$111,379	$177,360
CZ09	SCE	178,306	1585	42%	14%	$310,040	$420,075	$472,994	1.4	1.5	$110,035	$162,953
CZ10	SCE	228,252	2024	56%	13%	$325,240	$540,861	$603,198	1.7	1.9	$215,620	$277,958
CZ10-2	SDG&E	228,252	2024	56%	13%	$325,240	$938,100	$603,198	2.9	1.9	$612,860	$277,958
CZ11	PG&E	149,102	3003	39%	9%	$309,155	$598,071	$417,914	1.9	1.4	$288,916	$108,760
CZ12	PG&E	197,814	3263	53%	9%	$304,799	$787,827	$580,670	2.6	1.9	$483,028	$275,871
CZ13	PG&E	146,564	3023	38%	9%	$310,416	$583,121	$394,241	1.9	1.3	$272,705	$83,825
CZ14	SCE	172,175	3232	43%	14%	$307,986	$418,447	$537,619	1.4	1.7	$110,461	$229,633
CZ14-2	SDG&E	172,175	3232	43%	9%	$307,986	$691,348	$494,663	2.2	1.6	$383,362	$186,677
CZ15	SCE	191,977	1504	37%	11%	$336,966	$424,691	$488,601	1.3	1.4	$87,725	$151,635
CZ16	PG&E	101,070	6080	40%	-13%	$309,046	$399,822	$275,062	1.3	0.9	$90,777	($33,984)

Figure 21. Cost Effectiveness for Medium Office Package 3C – All-Electric + HE

CZ	IOU territory	Elec Savings (kWh)	Gas Savings (therms)	% GHG Savings	Comp-liance Margin	Incremental Package Cost	Lifecycle Utility Cost Savings	$TDV Savings	B/C Ratio (On-bill)	B/C Ratio (TDV)	NPV (On-bill)	NPV (TDV)
Package 3C: All-Electric + HE												
CZ01	PG&E	-58,686	4907	6%	-18%	($53)	($150,400)	($70,782)	0.0	0.0	($150,347)	($70,729)
CZ02	PG&E	-47,611	3798	4%	-5%	$58,138	($92,556)	($31,358)	-1.6	-0.5	($150,694)	($89,496)
CZ03	PG&E	-38,015	3095	3%	-8%	$9,519	($81,528)	($33,315)	-8.6	-3.5	($91,048)	($42,834)
CZ04	PG&E	-43,553	3747	4%	-3%	$79,094	($66,232)	($18,853)	-0.8	-0.2	($145,325)	($97,947)
CZ05	PG&E	-38,716	3203	3%	-7%	$7,346	($53,219)	($33,935)	-7.2	-4.6	($60,565)	($41,282)
CZ06	SCE	-24,278	2080	1%	-3%	$26,390	$36,659	($13,364)	1.4	-0.5	$10,268	($39,754)
CZ07	SDG&E	-8,121	932	1%	1%	$42,911	$90,471	$4,725	2.1	0.1	$47,560	($38,186)
CZ08	SCE	-10,496	1193	1%	1%	$59,340	$38,855	$6,396	0.7	0.1	($20,485)	($52,945)
CZ09	SCE	-13,189	1585	2%	1%	$79,425	$44,165	$11,025	0.6	0.1	($35,260)	($68,400)
CZ10	SCE	-21,930	2024	2%	-1%	$131,819	$40,653	($4,868)	0.3	0.0	($91,167)	($136,688)
CZ10-2	SDG&E	-21,930	2024	2%	-1%	$131,819	$86,493	($4,868)	0.7	0.0	($45,327)	($136,688)
CZ11	PG&E	-33,315	3003	3%	-1%	$93,882	($45,695)	($6,682)	-0.5	-0.1	($139,577)	($100,564)
CZ12	PG&E	-38,266	3263	3%	-2%	$74,649	($63,334)	($13,412)	-0.8	-0.2	($137,983)	($88,060)
CZ13	PG&E	-32,571	3023	4%	-1%	$95,144	($42,216)	($6,587)	-0.4	-0.1	($137,360)	($101,730)
CZ14	SCE	-36,359	3232	2%	4%	$87,134	$22,859	$32,790	0.3	0.4	($64,275)	($54,344)
CZ14-2	SDG&E	-36,359	3232	2%	-1%	$87,134	$54,676	($10,166)	0.6	-0.1	($32,457)	($97,300)
CZ15	SCE	-4,800	1504	3%	3%	$177,485	$52,246	$32,360	0.3	0.2	($125,239)	($145,125)
CZ16	PG&E	-89,401	6080	3%	-25%	$94,703	($227,137)	($136,982)	-2.4	-1.4	($321,840)	($231,685)

4.2 Cost Effectiveness Results – Medium Retail

Figure 22 through Figure 28 contain the cost-effectiveness findings for the Medium Retail packages. Notable findings for each package include:

- **1A – Mixed-Fuel + EE:**
    - Packages achieve 9-18% 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 higher compliance margins for the package.
- **1B – Mixed-Fuel + EE + PV + B:** All packages are cost effective using both the On-Bill and TDV approach. Adding PV and battery to the efficiency packages reduces the B/C ratio but increases overall NPV savings.
- **1C – Mixed-fuel + HE:** Packages achieve 1-4% compliance margins depending on climate zone, and packages are cost effective in all climate zones analyzed except CZ5.
- **2 – All-Electric Federal Code-Minimum:**
    - 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 (CZ1-4, 12-13, and 16).
    - Packages are cost effective in all climate zones except CZ16.
    - Packages achieve GHG emissions savings between +2% and +15%.
    - All incremental costs are negative 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. 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 in all CZs except CZs 1 and 16.

Figure 22. Cost Effectiveness for Medium Retail Package 1A – Mixed-Fuel + EE

CZ	IOU territory	Elec Savings (kWh)	Gas Savings (therms)	% GHG Savings	Comp-liance Margin	Incremental Package Cost	Lifecycle Utility Cost Savings	$TDV Savings	B/C Ratio (On-bill)	B/C Ratio (TDV)	NPV (On-bill)	NPV (TDV)
Package 1A: Mixed Fuel + EE												
CZ01	PG&E	15,173	1209	14%	18%	$2,712	$74,291	$60,080	27.4	22.2	$71,579	$57,368
CZ02	PG&E	19,663	614	12%	14%	$5,569	$91,143	$63,090	16.4	11.3	$85,574	$57,521
CZ03	PG&E	19,014	463	12%	16%	$5,569	$74,210	$58,431	13.3	10.5	$68,641	$52,863
CZ04	PG&E	19,587	440	19%	15%	$5,569	$88,839	$61,025	16.0	11.0	$83,270	$55,456
CZ05	PG&E	18,274	415	11%	16%	$5,569	$70,487	$55,904	12.7	10.0	$64,918	$50,336
CZ06	SCE	12,337	346	8%	10%	$2,712	$34,892	$40,895	12.9	15.1	$32,180	$38,184
CZ07	SDG&E	17,455	136	14%	13%	$5,569	$35,907	$51,180	15.2	9.2	$78,975	$45,611
CZ08	SCE	12,396	283	7%	10%	$2,712	$33,861	$41,049	12.5	15.1	$31,149	$38,337
CZ09	SCE	13,503	303	7%	9%	$5,569	$35,780	$44,324	6.4	8.0	$30,211	$38,755
CZ10	SCE	20,864	267	10%	12%	$5,569	$47,355	$61,640	8.5	11.1	$41,787	$56,071
CZ10-2	SDG&E	20,864	267	10%	12%	$5,569	$43,358	$61,640	18.2	11.1	$95,795	$56,071
CZ11	PG&E	21,256	575	11%	13%	$5,569	$95,542	$67,859	17.2	12.2	$89,973	$62,290
CZ12	PG&E	21,007	563	11%	13%	$5,569	$93,954	$65,991	16.9	11.9	$88,385	$60,422
CZ13	PG&E	19,676	621	11%	12%	$2,712	$99,483	$67,925	36.7	25.0	$96,771	$65,213
CZ14	SCE	21,650	383	10%	12%	$2,712	$55,269	$68,518	20.4	25.3	$52,557	$65,806
CZ14-2	SDG&E	21,650	383	10%	12%	$2,712	$52,956	$68,518	43.6	25.3	$115,390	$65,806
CZ15	SCE	23,361	169	9%	11%	$2,712	$56,018	$70,122	20.7	25.9	$53,306	$67,410
CZ16	PG&E	16,033	751	10%	13%	$2,712	$80,562	$55,135	29.7	20.3	$77,850	$52,423

Figure 23. Cost Effectiveness for Medium Retail Package 1B – Mixed-Fuel + EE + PV + B

CZ	IOU territory	Elec Savings (kWh)	Gas Savings (therms)	% GHG Savings	Comp-liance Margin	Incremental Package Cost	Lifecycle Utility Cost Savings	$TDV Savings	B/C Ratio (On-bill)	B/C Ratio (TDV)	NPV (On-bill)	NPV (TDV)
Package 1B: Mixed Fuel + EE + PV + B												
CZ01	PG&E	132,147	1209	61%	18%	$214,424	$486,493	$351,226	2.3	1.6	$272,069	$136,803
CZ02	PG&E	158,966	614	77%	14%	$189,562	$538,371	$403,483	2.8	2.1	$348,809	$213,921
CZ03	PG&E	159,743	463	73%	16%	$214,424	$569,926	$396,824	2.7	1.9	$355,502	$182,401
CZ04	PG&E	163,339	440	72%	15%	$189,562	$540,158	$415,525	2.8	2.2	$350,596	$225,963
CZ05	PG&E	164,330	415	76%	16%	$189,562	$582,787	$407,043	3.1	2.1	$393,225	$217,481
CZ06	SCE	154,147	346	71%	10%	$214,424	$300,487	$391,375	1.4	1.8	$86,063	$176,951
CZ07	SDG&E	164,993	136	76%	13%	$189,562	$120,656	$410,317	2.3	2.2	$250,798	$220,755
CZ08	SCE	155,923	283	72%	10%	$189,562	$293,477	$412,536	1.5	2.2	$103,915	$222,975
CZ09	SCE	158,923	303	68%	9%	$189,562	$300,438	$414,316	1.6	2.2	$110,876	$224,755
CZ10	SCE	168,064	267	68%	12%	$189,562	$316,891	$426,710	1.7	2.3	$127,330	$237,148
CZ10-2	SDG&E	168,064	267	68%	12%	$189,562	$155,608	$426,710	2.7	2.3	$314,753	$237,148
CZ11	PG&E	161,535	575	62%	13%	$189,562	$533,861	$427,084	2.8	2.3	$344,299	$237,522
CZ12	PG&E	160,970	563	64%	13%	$214,424	$539,428	$419,525	2.5	2.0	$325,004	$205,101
CZ13	PG&E	163,909	621	63%	12%	$189,562	$538,130	$420,755	2.8	2.2	$348,568	$231,193
CZ14	SCE	178,133	383	65%	12%	$189,562	$323,630	$465,430	1.7	2.5	$134,068	$275,868
CZ14-2	SDG&E	177,552	406	65%	12%	$189,562	$151,195	$464,200	2.7	2.4	$324,634	$274,638
CZ15	SCE	172,009	169	59%	11%	$189,562	$319,010	$443,323	1.7	2.3	$129,448	$253,762
CZ16	PG&E	174,871	751	66%	13%	$189,562	$554,563	$430,029	2.9	2.3	$365,001	$240,467

Figure 24. Cost Effectiveness for Medium Retail Package 1C – Mixed-Fuel + HE

CZ	IOU territory	Elec Savings (kWh)	Gas Savings (therms)	% GHG Savings	Comp-liance Margin	Incremental Package Cost	Lifecycle Utility Cost Savings	$TDV Savings	B/C Ratio (On-bill)	B/C Ratio (TDV)	NPV (On-bill)	NPV (TDV)
Package 1C: Mixed Fuel + HE												
CZ01	PG&E	52	346	2%	2%	$9,006	$6,671	$6,043	0.7	0.7	($2,335)	($2,963)
CZ02	PG&E	2,360	230	2%	3%	$9,726	$26,319	$14,306	2.7	1.5	$16,593	$4,580
CZ03	PG&E	1,001	171	2%	2%	$9,063	$7,033	$7,010	0.8	0.8	($2,031)	($2,053)
CZ04	PG&E	1,722	159	2%	3%	$9,004	$19,025	$10,658	2.1	1.2	$10,021	$1,654
CZ05	PG&E	585	161	1%	1%	$9,454	$5,238	$4,549	0.6	0.5	($4,216)	($4,905)
CZ06	SCE	2,456	90	2%	3%	$8,943	$12,343	$10,966	1.4	1.2	$3,400	$2,023
CZ07	SDG&E	2,124	49	1%	2%	$9,194	$20,752	$9,076	2.3	1.0	$11,558	($118)
CZ08	SCE	2,618	71	2%	3%	$9,645	$12,686	$12,482	1.3	1.3	$3,042	$2,837
CZ09	SCE	4,110	88	2%	4%	$10,446	$18,604	$18,657	1.8	1.8	$8,158	$8,211
CZ10	SCE	4,213	118	2%	4%	$9,514	$19,051	$19,206	2.0	2.0	$9,537	$9,692
CZ10-2	SDG&E	4,213	118	2%	4%	$9,514	$40,818	$19,206	4.3	2.0	$31,304	$9,692
CZ11	PG&E	4,107	225	3%	4%	$10,479	$34,704	$22,305	3.3	2.1	$24,224	$11,825
CZ12	PG&E	3,611	214	3%	4%	$10,409	$32,628	$20,591	3.1	2.0	$22,218	$10,181
CZ13	PG&E	4,814	180	3%	4%	$9,809	$37,964	$23,403	3.9	2.4	$28,156	$13,595
CZ14	SCE	6,514	153	3%	5%	$12,103	$24,691	$26,853	2.0	2.2	$12,588	$14,750
CZ14-2	SDG&E	6,514	153	3%	5%	$12,103	$50,064	$26,853	4.1	2.2	$37,960	$14,750
CZ15	SCE	8,929	48	3%	5%	$12,534	$28,596	$31,930	2.3	2.5	$16,062	$19,396
CZ16	PG&E	2,365	389	3%	3%	$11,999	$24,921	$13,998	2.1	1.2	$12,923	$2,000

Figure 25. Cost Effectiveness for Medium Retail Package 2 – All-Electric Federal Code Minimum

CZ	IOU territory	Elec Savings (kWh)	Gas Savings (therms)	% GHG Savings	Comp-liance Margin	Incremental Package Cost*	Lifecycle Utility Cost Savings	$TDV Savings	B/C Ratio (On-bill)	B/C Ratio (TDV)	NPV (On-bill)	NPV (TDV)
Package 2: All-Electric Federal Code Minimum												
CZ01	PG&E	-29,154	3893	15%	-4.1%	($23,048)	($12,313)	($13,932)	1.9	1.7	$10,735	$9,116
CZ02	PG&E	-21,913	2451	8%	-1.1%	($27,464)	($20,658)	($4,725)	1.3	5.8	$6,806	$22,739
CZ03	PG&E	-14,597	1870	7%	-0.4%	($24,111)	($1,435)	($1,472)	16.8	16.4	$22,676	$22,639
CZ04	PG&E	-14,174	1708	6%	-0.1%	($22,896)	($11,190)	($242)	2.0	94.7	$11,706	$22,654
CZ05	PG&E	-14,339	1746	7%	-1.2%	($25,507)	($3,340)	($4,175)	7.6	6.1	$22,167	$21,331
CZ06	SCE	-7,526	1001	3%	0.5%	($21,762)	$19,645	$1,846	>1	>1	$41,407	$23,608
CZ07	SDG&E	-3,817	522	7%	0.3%	($23,762)	$57,443	$1,297	>1	>1	$81,205	$25,058
CZ08	SCE	-5,808	793	3%	0.4%	($26,922)	$17,633	$1,846	>1	>1	$44,555	$28,768
CZ09	SCE	-7,237	970	3%	0.4%	($32,113)	$19,502	$1,978	>1	>1	$51,615	$34,091
CZ10	SCE	-10,332	1261	3%	0.1%	($27,272)	$22,034	$483	>1	>1	$49,306	$27,755
CZ10-2	SDG&E	-10,332	1261	3%	0.1%	($27,272)	$57,168	$483	>1	>1	$84,440	$27,755
CZ11	PG&E	-19,245	2413	8%	0.5%	($32,202)	($10,909)	$2,549	3.0	>1	$21,292	$34,751
CZ12	PG&E	-19,472	2309	7%	-0.1%	($32,504)	($17,769)	($461)	1.8	70.4	$14,735	$32,042
CZ13	PG&E	-16,817	1983	6%	-0.4%	($28,158)	($13,372)	($2,022)	2.1	13.9	$14,785	$26,136
CZ14	SCE	-13,583	1672	4%	0.5%	($26,656)	$18,191	$2,769	>1	>1	$44,847	$29,425
CZ14-2	SDG&E	-13,583	1672	4%	0.5%	($26,656)	$41,784	$2,769	>1	>1	$68,440	$29,425
CZ15	SCE	-2,541	518	2%	0.9%	($29,544)	$17,378	$5,779	>1	>1	$46,921	$35,323
CZ16	PG&E	-41,416	4304	11%	-12.2%	($25,771)	($58,338)	($52,564)	0.4	0.5	($32,567)	($26,793)

* The Incremental Package Cost is the addition of the incremental HVAC and water heating equipment costs from Figure 8 and the natural gas infrastructure incremental cost savings of $28,027 (see section 3.3.2.2).

Figure 26. Cost Effectiveness for Medium Retail Package 3A – All-Electric + EE

CZ	IOU territory	Elec Savings (kWh)	Gas Savings (therms)	% GHG Savings	Comp-liance Margin	Incremental Package Cost	Lifecycle Utility Cost Savings	$TDV Savings	B/C Ratio (On-bill)	B/C Ratio (TDV)	NPV (On-bill)	NPV (TDV)
Package 3A: All-Electric + EE												
CZ01	PG&E	-5,526	3893	24%	15%	($20,336)	$66,724	$51,092	>1	>1	$87,060	$71,428
CZ02	PG&E	3,705	2451	18%	15%	($21,895)	$88,156	$67,419	>1	>1	$110,051	$89,314
CZ03	PG&E	8,023	1870	17%	16%	($18,542)	$75,193	$57,860	>1	>1	$93,735	$76,402
CZ04	PG&E	9,050	1708	16%	15%	($17,327)	$94,277	$60,893	>1	>1	$111,604	$78,220
CZ05	PG&E	7,045	1746	16%	15%	($19,938)	$68,826	$52,235	>1	>1	$88,763	$72,172
CZ06	SCE	7,397	1001	10%	11%	($19,050)	$50,760	$42,104	>1	>1	$69,810	$61,154
CZ07	SDG&E	14,630	522	15%	13%	($18,193)	$141,641	$52,125	>1	>1	$159,834	$70,318
CZ08	SCE	8,634	793	9%	10%	($24,210)	$48,138	$42,192	>1	>1	$72,349	$66,402
CZ09	SCE	8,438	970	9%	10%	($26,545)	$51,733	$45,554	>1	>1	$78,277	$72,099
CZ10	SCE	12,731	1261	12%	12%	($21,703)	$66,580	$62,101	>1	>1	$88,283	$83,804
CZ10-2	SDG&E	12,731	1261	12%	12%	($21,703)	$158,218	$62,101	>1	>1	$179,921	$83,804
CZ11	PG&E	6,354	2413	17%	12%	($26,633)	$93,324	$66,870	>1	>1	$119,956	$93,503
CZ12	PG&E	6,187	2309	17%	13%	($26,935)	$91,863	$65,463	>1	>1	$118,798	$92,399
CZ13	PG&E	7,741	1983	15%	12%	($25,446)	$98,892	$65,398	>1	>1	$124,338	$90,843
CZ14	SCE	11,760	1672	13%	12%	($23,944)	$75,707	$72,583	>1	>1	$99,651	$96,527
CZ14-2	SDG&E	11,760	1672	13%	12%	($23,944)	$174,544	$72,583	>1	>1	$198,489	$96,527
CZ15	SCE	20,608	518	10%	10%	($26,832)	$64,675	$67,463	>1	>1	$91,507	$94,295
CZ16	PG&E	-18,140	4304	19%	3%	($23,059)	$41,195	$14,525	>1	>1	$64,254	$37,585

Figure 27. Cost Effectiveness for Medium Retail Package 3B – All-Electric + EE + PV + B

CZ	IOU territory	Elec Savings (kWh)	Gas Savings (therms)	% GHG Savings	Comp-liance Margin	Incremental Package Cost	Lifecycle Utility Cost Savings	$TDV Savings	B/C Ratio (On-bill)	B/C Ratio (TDV)	NPV (On-bill)	NPV (TDV)
Package 3B: All-Electric + EE + PV + B												
CZ01	PG&E	111,449	3893	71%	15%	$191,376	$478,926	$342,238	2.5	1.8	$287,550	$150,863
CZ02	PG&E	142,908	2451	72%	15%	$189,562	$534,671	$401,219	2.8	2.1	$345,109	$211,657
CZ03	PG&E	148,752	1870	69%	16%	$193,170	$570,924	$396,253	3.0	2.1	$377,755	$203,083
CZ04	PG&E	152,802	1708	70%	15%	$189,562	$544,094	$415,393	2.9	2.2	$354,532	$225,831
CZ05	PG&E	153,100	1746	68%	15%	$189,562	$581,126	$403,373	3.1	2.1	$391,564	$213,811
CZ06	SCE	149,207	1001	73%	11%	$192,662	$316,087	$392,583	1.6	2.0	$123,425	$199,921
CZ07	SDG&E	162,169	522	73%	13%	$189,562	$497,473	$411,262	2.6	2.2	$307,911	$221,700
CZ08	SCE	152,161	793	72%	10%	$189,562	$307,768	$413,679	1.6	2.2	$118,207	$224,117
CZ09	SCE	153,858	970	74%	10%	$189,562	$316,390	$415,547	1.7	2.2	$126,828	$225,985
CZ10	SCE	159,931	1261	76%	12%	$189,562	$334,584	$427,172	1.8	2.3	$145,022	$237,610
CZ10-2	SDG&E	159,931	1261	76%	12%	$189,562	$558,685	$427,172	2.9	2.3	$369,123	$237,610
CZ11	PG&E	146,633	2413	74%	12%	$189,562	$531,033	$426,095	2.8	2.2	$341,471	$236,533
CZ12	PG&E	146,150	2309	73%	13%	$184,777	$536,058	$418,997	2.9	2.3	$351,281	$234,220
CZ13	PG&E	148,975	1983	74%	12%	$189,562	$537,465	$418,228	2.8	2.2	$347,903	$228,666
CZ14	SCE	168,243	1672	78%	12%	$189,562	$343,086	$469,496	1.8	2.5	$153,524	$279,934
CZ14-2	SDG&E	168,243	1672	78%	12%	$189,562	$565,180	$469,496	3.0	2.5	$375,618	$279,934
CZ15	SCE	169,256	518	79%	10%	$189,562	$327,593	$440,664	1.7	2.3	$138,031	$251,103
CZ16	PG&E	140,699	4304	75%	3%	$189,562	$511,477	$389,419	2.7	2.1	$321,915	$199,857

Figure 28. Cost Effectiveness for Medium Retail Package 3C – All-Electric + HE

CZ	IOU territory	Elec Savings (kWh)	Gas Savings (therms)	% GHG Savings	Comp-liance Margin	Incremental Package Cost	Lifecycle Utility Cost Savings	$TDV Savings	B/C Ratio (On-bill)	B/C Ratio (TDV)	NPV (On-bill)	NPV (TDV)
Package 3C: All-Electric + HE												
CZ01	PG&E	-26,203	3893	16%	-2%	-$587	-$2,750	-$5,801	0.2	0.1	$(2,163)	$(5,214)
CZ02	PG&E	-17,169	2451	9%	2%	($4,211)	$11,275	$11,009	>1	>1	$15,487	$15,221
CZ03	PG&E	-11,802	1870	9%	2%	($2,213)	$8,055	$6,768	>1	>1	$10,268	$8,982
CZ04	PG&E	-10,830	1708	8%	3%	($316)	$13,797	$11,163	>1	>1	$14,114	$11,480
CZ05	PG&E	-12,052	1746	8%	5%	($2,298)	$4,275	$1,626	>1	>1	$6,573	$3,924
CZ06	SCE	-4,110	1001	5%	3%	$1,418	$31,395	$13,273	22.1	9.4	$29,977	$11,855
CZ07	SDG&E	-1,212	522	3%	3%	($710)	$78,295	$10,526	>1	>1	$79,005	$11,236
CZ08	SCE	-2,430	793	4%	4%	($3,719)	$29,636	$14,657	>1	>1	$33,354	$18,376
CZ09	SCE	-2,182	970	5%	4%	($8,268)	$37,306	$21,074	>1	>1	$45,574	$29,342
CZ10	SCE	-4,878	1261	5%	4%	($5,222)	$40,165	$20,239	>1	>1	$45,387	$25,461
CZ10-2	SDG&E	-4,878	1261	5%	4%	($5,222)	$98,338	$20,239	>1	>1	$103,560	$25,461
CZ11	PG&E	-12,726	2413	10%	5%	($8,217)	$29,725	$26,018	>1	>1	$37,942	$34,235
CZ12	PG&E	-13,545	2309	9%	4%	($9,239)	$20,932	$21,272	>1	>1	$30,170	$30,510
CZ13	PG&E	-9,938	1983	9%	4%	-$4,975	$32,111	$23,821	>1	>1	$37,085	$28,796
CZ14	SCE	-5,711	1672	6%	5%	$121	$43,208	$29,776	357	246	$43,087	$29,655
CZ14-2	SDG&E	-5,711	1672	6%	5%	$121	$95,031	$29,776	785	246	$4,910	$29,655
CZ15	SCE	6,832	518	5%	6%	-$2,508	$45,816	$37,929	>1	>1	$48,323	$40,436
CZ16	PG&E	-35,255	4304	13%	-8%	$1,102	-$26,792	$33,710	-24.3	-30.6	$(27,894)	$(34,812)

4.3 Cost Effectiveness Results – Small Hotel

These 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 drastically different occupancy and load profiles than the other prototypes.
- There is a small (19 therms/yr) natural gas laundry load included in the Small Hotel prototype that has not been included in the draft analysis. TRC expects the effect of switching laundry to electric to have very little impact (~500 kWh/yr), and the incremental cost to be minimal if switching to electric resistance. Thus, the impact of this measure should not change the overall cost-effectiveness findings for this prototype.
- Contrary to the office and retail prototypes, the Small Hotel baseline water heater is central gas storage. Current compliance software cannot model central heat pump water heater systems with recirculation serving guest rooms. The only option to allow for heat pump water heating was individual water heaters at each guest room even though this is a very uncommon configuration but was necessary to match modeling capabilities. When developing costs, TRC estimated that one heat pump water heater would be able to serve two guest rooms because heat pump water heater tanks are sized for multi-bedroom residential usage, and because hotel guest rooms have a high degree of load diversity.

Figure 29 through Figure 35 contain the cost-effectiveness findings for the Small Hotel packages. Notable findings for each package include:

- **1A – Mixed-Fuel + EE:**
    - Packages achieve 3-9% compliance margins depending on climate zone.

  - Packages are cost effective using the TDV approach in all CZs except CZ15 (B/C Ratio = 0.9). Packages are cost effective in CZs 1-5, 7, 10-13, and 16 using the On-Bill approach. Packages are not cost effective using the On-Bill approach in SCE territory (CZs 6, 8-10, and 15).
  - The hotel is mostly guest room space with a small proportion of nonresidential floor 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.[13]
- **1B – Mixed-Fuel + EE + PV + B:** Very few packages are cost effective using either the On-Bill or TDV approach, contrary to the Medium Office and Medium Retail. This suggests that the Small Hotel energy demand profiles may not align well with solar PV generation. However, results may vary with a different combination of PV and battery sizes.
- **1C – Mixed-fuel + HE:** Packages achieve 1-5% compliance margins depending on climate zone. The package is cost effective using the On-Bill approach in climate zones 2, 10-11, and 13-16. The package is cost effective only in CZ15 using TDV approach.
- **2 – All-Electric Federal Code-Minimum:**
  - Packages achieve between -78% and -27% negative compliance margins depending on climate zone. This is likely because the modeled DHW system has a low UEF of 2.0, is a non-central design with significant tank losses. and TDV values electricity consumption more heavily than natural gas. This all-electric design does not comply with the Energy Commission's TDV performance budget.
  - All packages are cost effective in all climate zones except CZ16 using the On-Bill approach.
  - Packages achieve GHG emissions savings between -14% and 6%. This is contrary to the Medium Office and Medium Retail, which generally show positive GHG savings in Package 2. The negative GHG savings may be partially due to the heat pump water heater of UEF=2.0 being compared to a central gas water heater.[14] Another potential reason is that the Small Hotel has more late-night heating than the other nonresidential prototypes, meaning that heat pumps operate at lower annual efficiencies because of more runtime during periods of colder outside air.
- **3A – All-Electric + EE:** Packages achieve between -59% and -24% compliance margins depending on climate zone. All packages are cost effective in all climate zones except CZ16 using the On-Bill approach. 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, except in CZ16 using the On-Bill approach. Packages improve in B/C ratio when compared to 3A but increase in magnitude of overall NPV savings. Considering that Package 1B was generally not cost effective, PV appears to

[13] 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.

[14] The office and retail baseline prototypes already contain an electric resistance water heater and thus GHG impacts of Package 2 would only be a result of all-electric space heating systems.

be more cost-effective with higher building electricity loads, with the understanding that this analysis explored only one sizing combination of PV and battery systems.

- **3C – All-Electric + HE:**
  - Packages achieve between -56% and -8% compliance margins depending on climate zone.
  - All packages are cost effective.
  - Packages achieve between +3 and +20% GHG emissions savings in the climate zones analyzed, the highest among small hotel packages not including PV.

Figure 29. Cost Effectiveness for Small Hotel Package 1A – Mixed-Fuel + EE

CZ	IOU territory	Elec Savings (kWh)	Gas Savings (therms)	% GHG Savings	Comp-liance Margin	Incremental Package Cost	Lifecycle Utility Cost Savings	$TDV Savings	B/C Ratio (On-bill)	B/C Ratio (TDV)	NPV (On-bill)	NPV (TDV)
Package 1A: Mixed Fuel + EE												
CZ01	PG&E	4,160	388	0%	7%	$20,971	$23,724	$36,279	1.1	1.7	$2,752	$15,308
CZ02	PG&E	4,928	396	1%	7%	$20,971	$25,226	$35,740	1.2	1.7	$4,255	$14,768
CZ03	PG&E	5,136	415	1%	9%	$20,971	$23,564	$44,144	1.1	2.1	$2,593	$23,173
CZ04	PG&E	4,966	409	1%	7%	$20,971	$23,988	$34,744	1.1	1.7	$3,017	$13,772
CZ05	PG&E	4,823	408	1%	9%	$20,971	$22,370	$44,075	1.1	2.1	$1,398	$23,104
CZ06	SCE	4,958	435	1%	8%	$20,971	$14,857	$39,667	0.7	1.9	($6,114)	$18,695
CZ07	SDG&E	5,123	442	1%	9%	$20,971	$26,921	$41,714	1.3	2.0	$5,950	$20,742
CZ08	SCE	4,937	431	2%	7%	$20,971	$14,055	$33,039	0.7	1.6	($6,916)	$12,068
CZ09	SCE	4,830	418	1%	6%	$20,971	$14,926	$30,035	0.7	1.4	($6,046)	$9,064
CZ10	SCE	4,394	355	1%	5%	$20,971	$11,986	$29,762	0.6	1.4	($8,985)	$8,791
CZ10-2	SDG&E	4,394	355	0%	5%	$20,971	$24,629	$29,762	1.2	1.4	$3,658	$8,791
CZ11	PG&E	4,542	335	1%	4%	$20,971	$22,407	$24,585	1.1	1.2	$1,436	$3,614
CZ12	PG&E	5,050	346	1%	5%	$20,971	$22,295	$28,196	1.1	1.3	$1,323	$7,224
CZ13	PG&E	4,679	312	2%	4%	$20,971	$23,023	$24,432	1.1	1.2	$2,052	$3,461
CZ15	SCE	4,738	287	-2%	3%	$20,971	$12,853	$20,206	0.6	0.9	($8,118)	($765)
CZ16	PG&E	4,630	369	1%	5%	$20,971	$23,350	$30,723	1.1	1.5	$2,379	$9,752

Figure 30. Cost Effectiveness for Small Hotel Package 1B – Mixed-Fuel + EE + PV + B

CZ	IOU territory	Elec Savings (kWh)	Gas Savings (therms)	% GHG Savings	Comp-liance Margin	Incremental Package Cost	Lifecycle Utility Cost Savings	$TDV Savings	B/C Ratio (On-bill)	B/C Ratio (TDV)	NPV (On-bill)	NPV (TDV)
Package 1B: Mixed Fuel + EE + PV + B												
CZ01	PG&E	53,754	388	11%	7%	$211,621	$195,719	$143,001	0.9	0.7	($15,902)	($68,620)
CZ02	PG&E	74,025	396	18%	7%	$211,621	$204,674	$187,686	1.0	0.9	($6,947)	($23,935)
CZ03	PG&E	72,876	415	18%	9%	$211,621	$264,068	$188,900	1.2	0.9	$52,447	($22,721)
CZ04	PG&E	74,603	409	19%	7%	$211,621	$207,526	$189,452	1.0	0.9	($4,095)	($22,169)
CZ05	PG&E	78,519	408	20%	9%	$211,621	$294,456	$203,211	1.4	1.0	$82,835	($8,409)
CZ06	SCE	72,032	435	22%	8%	$211,621	$144,732	$194,262	0.7	0.9	($66,889)	($17,359)
CZ07	SDG&E	77,014	442	25%	9%	$211,621	$190,291	$204,256	0.9	1.0	($21,330)	($7,365)
CZ08	SCE	73,158	431	23%	7%	$211,621	$147,232	$206,594	0.7	1.0	($64,389)	($5,027)
CZ09	SCE	71,789	418	22%	6%	$211,621	$145,812	$194,243	0.7	0.9	($65,809)	($17,378)
CZ10	SCE	74,227	355	22%	5%	$211,621	$142,054	$190,337	0.7	0.9	($69,567)	($21,284)
CZ10-2	SDG&E	74,227	355	21%	5%	$211,621	$187,939	$190,337	0.9	0.9	($23,681)	($21,284)
CZ11	PG&E	71,426	335	18%	4%	$211,621	$201,959	$183,684	1.0	0.9	($9,662)	($27,937)
CZ12	PG&E	73,065	346	19%	5%	$211,621	$263,675	$188,657	1.2	0.9	$52,055	($22,964)
CZ13	PG&E	70,024	322	18%	4%	$211,621	$201,162	$170,588	1.0	0.8	($10,459)	($41,033)
CZ14	SCE	85,947	393	23%	4%	$211,621	$160,223	$226,351	0.8	1.1	($51,398)	$14,730
CZ14-2	SDG&E	86,667	393	23%	4%	$211,621	$205,972	$226,351	1.0	1.1	($5,648)	$14,730
CZ15	SCE	77,323	287	21%	3%	$211,621	$143,204	$191,037	0.7	0.9	($68,417)	($20,584)
CZ16	PG&E	82,501	369	16%	5%	$211,621	$223,383	$194,969	1.1	0.9	$11,762	($16,652)

Figure 31. Cost Effectiveness for Small Hotel Package 1C – Mixed-Fuel + HE

CZ	IOU territory	Elec Savings (kWh)	Gas Savings (therms)	% GHG Savings	Comp-liance Margin	Incremental Package Cost	Lifecycle Utility Cost Savings	$TDV Savings	B/C Ratio (On-bill)	B/C Ratio (TDV)	NPV (On-bill)	NPV (TDV)
Package 1C: Mixed Fuel + HE												
CZ01	PG&E	-3	1148	2%	2%	$22,839	$18,972	$10,407	0.8	0.5	($3,867)	($12,431)
CZ02	PG&E	778	894	2%	2%	$23,092	$23,711	$11,429	1.0	0.5	$619	($11,663)
CZ03	PG&E	-87	869	2%	1%	$20,510	$13,798	$6,244	0.7	0.3	($6,712)	($14,265)
CZ04	PG&E	51	827	2%	1%	$22,164	$14,265	$6,736	0.6	0.3	($7,899)	($15,428)
CZ05	PG&E	-27	845	2%	1%	$21,418	$13,522	$6,017	0.6	0.3	($7,896)	($15,400)
CZ06	SCE	-208	654	1%	1%	$20,941	$6,975	$3,482	0.3	0.2	($13,966)	($17,459)
CZ07	SDG&E	741	606	1%	1%	$19,625	$18,714	$5,866	1.0	0.3	($911)	($13,759)
CZ08	SCE	952	616	1%	2%	$20,678	$12,637	$7,607	0.6	0.4	($8,041)	($13,071)
CZ09	SCE	1,214	617	1%	2%	$20,052	$14,826	$10,407	0.7	0.5	($5,227)	($9,645)
CZ10	SCE	3,041	598	2%	3%	$22,682	$27,874	$19,225	1.2	0.8	$5,193	($3,457)
CZ10-2	SDG&E	3,041	598	1%	3%	$22,682	$43,777	$19,225	1.9	0.8	$21,096	($3,457)
CZ11	PG&E	3,333	696	2%	3%	$23,344	$37,695	$21,004	1.6	0.9	$14,350	($2,341)
CZ12	PG&E	1,578	737	2%	3%	$22,302	$18,006	$15,743	0.8	0.7	($4,296)	($6,559)
CZ13	PG&E	2,943	702	3%	3%	$22,882	$31,533	$17,030	1.4	0.7	$8,651	($5,852)
CZ14	SCE	3,610	765	2%	3%	$23,299	$26,726	$21,647	1.1	0.9	$3,427	($1,652)
CZ14-2	SDG&E	3,610	765	2%	3%	$23,299	$47,377	$21,647	2.0	0.9	$24,078	($1,652)
CZ15	SCE	8,509	402	3%	5%	$20,945	$32,452	$31,827	1.5	1.5	$11,507	$10,882
CZ16	PG&E	703	1196	3%	2%	$24,616	$26,304	$14,381	1.1	0.6	$1,689	($10,235)

Figure 32. Cost Effectiveness for Small Hotel Package 2 – All-Electric Federal Code Minimum

CZ	IOU territory	Elec Savings (kWh)	Gas Savings (therms)	% GHG Savings	Comp-liance Margin	Incremental Package Cost*	Lifecycle Utility Cost Savings	$TDV Savings	B/C Ratio (On-bill)	B/C Ratio (TDV)	NPV (On-bill)	NPV (TDV)
Package 2: All-Electric Federal Code Minimum												
CZ01	PG&E	-240,540	17051	6%	-68%	($1,271,869)	($977,125)	($372,807)	1.3	3.4	$294,744	$899,062
CZ02	PG&E	-199,435	12784	-1%	-52%	($1,272,834)	($776,635)	($283,342)	1.6	4.5	$496,199	$989,491
CZ03	PG&E	-192,155	12412	0%	-58%	($1,275,114)	($791,496)	($286,786)	1.6	4.4	$483,618	$988,327
CZ04	PG&E	-193,633	11906	-2%	-54%	($1,274,933)	($739,354)	($281,034)	1.7	4.5	$535,579	$993,899
CZ05	PG&E	-191,853	12053	-1%	-60%	($1,274,983)	($866,016)	($296,815)	1.5	4.3	$408,967	$978,167
CZ06	SCE	-166,792	8942	-12%	-50%	($1,275,143)	($322,782)	($238,913)	4.0	5.3	$952,361	$1,036,230
CZ07	SDG&E	-144,245	8237	-13%	-50%	($1,273,463)	($205,985)	($231,382)	6.2	5.5	$1,067,478	$1,042,082
CZ08	SCE	-146,537	8402	-12%	-49%	($1,271,430)	($252,696)	($231,306)	5.0	5.5	$1,018,735	$1,040,124
CZ09	SCE	-146,331	8444	-12%	-44%	($1,273,224)	($234,336)	($226,159)	5.4	5.6	$1,038,889	$1,047,065
CZ10	SCE	-154,130	8452	-14%	-40%	($1,270,222)	($324,266)	($235,431)	3.9	5.4	$945,956	$1,034,791
CZ10-2	SDG&E	-154,130	8452	-14%	-40%	($1,270,222)	($270,457)	($235,431)	4.7	5.4	$999,765	$1,034,791
CZ11	PG&E	-174,401	10314	-4%	-42%	($1,271,027)	($638,356)	($260,636)	2.0	4.9	$632,672	$1,010,392
CZ12	PG&E	-176,362	10493	-4%	-47%	($1,272,510)	($824,681)	($262,301)	1.5	4.9	$447,829	$1,010,209
CZ13	PG&E	-171,364	10112	-3%	-41%	($1,270,832)	($641,001)	($258,554)	2.0	4.9	$629,831	$1,012,278
CZ14	SCE	-173,899	10154	-12%	-41%	($1,271,186)	($428,276)	($259,917)	3.0	4.9	$842,910	$1,011,270
CZ14-2	SDG&E	-173,899	10154	-12%	-41%	($1,271,186)	($894,103)	($259,917)	1.4	4.9	$377,083	$1,011,270
CZ15	SCE	-112,082	5628	-11%	-27%	($1,269,303)	($125,311)	($188,239)	10.1	6.7	$1,143,991	$1,081,064
CZ16	PG&E	-274,808	17802	-4%	-78%	($1,275,575)	($1,426,771)	($477,788)	0.9	2.7	($151,196)	$797,787

* The Incremental Package Cost is the addition of the incremental HVAC and water heating equipment costs from Figure 9, 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 33. Cost Effectiveness for Small Hotel Package 3A – All-Electric + EE

CZ	IOU territory	Elec Savings (kWh)	Gas Savings (therms)	% GHG Savings	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 3A: All-Electric + EE												
CZ01	PG&E	-236,038	17051	7%	-51%	($1,250,898)	($960,199)	($278,748)	1.3	4.5	$290,699	$972,150
CZ02	PG&E	-194,428	12784	1%	-39%	($1,251,870)	($759,887)	($211,373)	1.6	5.9	$491,983	$1,040,496
CZ03	PG&E	-186,548	12412	2%	-41%	($1,254,142)	($770,376)	($203,053)	1.6	6.2	$483,766	$1,051,089
CZ04	PG&E	-188,474	11906	-1%	-42%	($1,253,977)	($721,328)	($218,013)	1.7	5.8	$532,650	$1,035,965
CZ05	PG&E	-186,696	12053	0%	-42%	($1,254,031)	($851,202)	($209,392)	1.5	6.0	$402,828	$1,044,638
CZ06	SCE	-161,210	8942	-10%	-37%	($1,254,172)	($313,129)	($178,355)	4.0	7.0	$941,042	$1,075,817
CZ07	SDG&E	-138,668	8237	-11%	-36%	($1,252,519)	($541,467)	($162,725)	2.3	7.7	$711,052	$1,089,794
CZ08	SCE	-140,846	8402	-11%	-41%	($1,250,490)	($242,834)	($192,677)	5.1	6.5	$1,007,655	$1,057,813
CZ09	SCE	-140,755	8444	-10%	-37%	($1,252,288)	($224,950)	($191,657)	5.6	6.5	$1,027,337	$1,060,631
CZ10	SCE	-149,293	8452	-12%	-34%	($1,249,289)	($318,837)	($197,966)	3.9	6.3	$930,453	$1,051,323
CZ10-2	SDG&E	-149,293	8452	-13%	-34%	($1,249,289)	($599,380)	($197,966)	2.1	6.3	$649,909	$1,051,323
CZ11	PG&E	-170,007	10314	-3%	-35%	($1,250,099)	($623,631)	($217,460)	2.0	5.7	$626,468	$1,032,639
CZ12	PG&E	-171,156	10493	-3%	-38%	($1,251,538)	($804,988)	($211,911)	1.6	5.9	$446,550	$1,039,628
CZ13	PG&E	-166,598	10112	-2%	-35%	($1,249,911)	($624,476)	($221,744)	2.0	5.6	$625,434	$1,028,167
CZ14	SCE	-169,354	10154	-11%	-34%	($1,250,269)	($420,289)	($218,502)	3.0	5.7	$829,980	$1,031,767
CZ14-2	SDG&E	-169,354	10154	-11%	-34%	($1,250,269)	($878,293)	($218,502)	1.4	5.7	$371,976	$1,031,767
CZ15	SCE	-107,207	5628	-10%	-24%	($1,248,390)	($116,611)	($168,797)	10.7	7.4	$1,131,779	$1,079,593
CZ16	PG&E	-271,455	17802	-3%	-59%	($1,254,665)	($1,413,712)	($361,018)	0.9	3.5	($159,046)	$893,647

Figure 34. Cost Effectiveness for Small Hotel Package 3B – All-Electric + EE + PV + B

CZ	IOU territory	Elec Savings (kWh)	Gas Savings (therms)	% GHG Savings	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	-186,444	17051	17%	-51%	($1,060,248)	($818,738)	($172,026)	1.3	6.2	$241,510	$888,222
CZ02	PG&E	-125,331	12784	18%	-39%	($1,061,220)	($525,720)	($59,428)	2.0	17.9	$535,500	$1,001,793
CZ03	PG&E	-118,808	12412	19%	-41%	($1,063,493)	($556,585)	($58,297)	1.9	18.2	$506,907	$1,005,195
CZ04	PG&E	-118,838	11906	17%	-42%	($1,063,328)	($499,624)	($63,304)	2.1	16.8	$563,703	$1,000,024
CZ05	PG&E	-113,001	12053	19%	-42%	($1,063,381)	($614,655)	($50,256)	1.7	21.2	$448,726	$1,013,125
CZ06	SCE	-94,136	8942	10%	-37%	($1,063,522)	($197,964)	($23,760)	5.4	44.8	$865,558	$1,039,763
CZ07	SDG&E	-66,777	8237	13%	-36%	($1,061,870)	($391,736)	($183)	2.7	5811.4	$670,133	$1,061,687
CZ08	SCE	-72,624	8402	11%	-41%	($1,059,840)	($115,399)	($19,122)	9.2	55.4	$944,441	$1,040,718
CZ09	SCE	-73,796	8444	11%	-37%	($1,061,638)	($102,230)	($27,449)	10.4	38.7	$959,408	$1,034,189
CZ10	SCE	-79,461	8452	9%	-34%	($1,058,640)	($182,730)	($37,392)	5.8	28.3	$875,910	$1,021,248
CZ10-2	SDG&E	-79,461	8452	8%	-34%	($1,058,640)	($441,365)	($37,392)	2.4	28.3	$617,275	$1,021,248
CZ11	PG&E	-103,124	10314	14%	-35%	($1,059,449)	($402,270)	($58,362)	2.6	18.2	$657,179	$1,001,088
CZ12	PG&E	-103,142	10493	15%	-38%	($1,060,889)	($570,093)	($51,450)	1.9	20.6	$490,796	$1,009,439
CZ13	PG&E	-101,253	10112	14%	-35%	($1,059,261)	($394,236)	($75,588)	2.7	14.0	$665,026	$983,673
CZ14	SCE	-87,982	10154	11%	-34%	($1,059,620)	($257,277)	($18,948)	4.1	55.9	$802,343	$1,040,672
CZ14-2	SDG&E	-87,982	10154	11%	-34%	($1,059,620)	($676,327)	($18,948)	1.6	55.9	$383,293	$1,040,672
CZ15	SCE	-34,623	5628	10%	-24%	($1,057,740)	$10,483	$2,034	>1	>1	$1,068,223	$1,059,774
CZ16	PG&E	-193,584	17802	13%	-59%	($1,064,016)	($1,093,740)	($196,773)	1.0	5.4	($29,724)	$867,243

Figure 35. Cost Effectiveness for Small Hotel Package 3C – All-Electric + HE

CZ	IOU territory	Elec Savings (kWh)	Gas Savings (therms)	% GHG Savings	Comp-liance Margin	Incremental Package Cost	Lifecycle Utility Cost Savings	$TDV Savings	B/C Ratio (On-bill)	B/C Ratio (TDV)	NPV (On-bill)	NPV (TDV)
Package 3C: All-Electric + HE												
CZ01	PG&E	-172,925	17051	20%	-38%	($1,256,423)	(664,218)	-$205,004	1.9	6.1	$592,205	$1,051,419
CZ02	PG&E	-136,527	12784	15%	-25%	($1,258,328)	(471,045)	($133,440)	2.7	9.4	$787,283	$1,124,888
CZ03	PG&E	-130,919	12412	16%	-28%	($1,263,867)	(540,180)	($138,776)	2.3	9.1	$723,687	$1,125,090
CZ04	PG&E	-133,617	11906	13%	-27%	($1,262,963)	(459,570)	($138,435)	2.7	9.1	$803,392	$1,124,527
CZ05	PG&E	-129,920	12053	15%	-29%	($1,263,327)	(597,268)	($146,534)	2.1	8.6	$666,059	$1,116,793
CZ06	SCE	-110,540	8942	5%	-22%	($1,263,779)	(202,545)	($104,338)	6.2	12.1	$1,061,234	$1,159,442
CZ07	SDG&E	-88,821	8237	6%	-21%	($1,260,844)	(369,947)	($94,498)	3.4	13.3	$890,897	$1,166,346
CZ08	SCE	-90,273	8402	6%	-20%	($1,256,326)	(168,869)	($93,514)	7.4	13.4	$1,087,457	$1,162,812
CZ09	SCE	-89,516	8444	6%	-17%	($1,260,223)	(144,247)	($86,967)	8.7	14.5	$1,115,976	$1,173,257
CZ10	SCE	-95,724	8452	4%	-16%	($1,253,181)	(181,674)	($92,416)	6.9	13.6	$1,071,507	$1,160,765
CZ10-2	SDG&E	-95,724	8452	3%	-16%	($1,253,181)	(348,778)	($92,416)	3.6	13.6	$904,404	$1,160,765
CZ11	PG&E	-114,878	10314	11%	-19%	($1,254,613)	(361,561)	($116,713)	3.5	10.7	$893,051	$1,137,900
CZ12	PG&E	-116,042	10493	12%	-21%	($1,257,919)	(556,855)	($116,940)	2.3	10.8	$701,063	$1,140,979
CZ13	PG&E	-112,389	10112	12%	-18%	($1,254,386)	(357,632)	-$115,502	3.5	10.9	$896,754	$1,138,884
CZ14	SCE	-114,724	10154	4%	-18%	($1,254,978)	(243,087)	-$116,675	5.2	10.8	$1,011,890	$1,138,303
CZ14-2	SDG&E	-114,724	10154	4%	-18%	($1,254,978)	(552,966)	-$116,675	2.3	10.8	$702,011	$1,138,303
CZ15	SCE	-60,063	5628	3%	-8%	($1,251,932)	(21,956)	-$59,265	57.0	21.1	$1,229,975	$1,192,667
CZ16	PG&E	-218,246	17802	8%	-56%	($1,263,534)	(905,844)	-$343,629	1.4	3.7	$357,690	$919,906

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, energy escalation rates, or utility tariffs are likely to change results.

5.1 Summary

Figure 36 through Figure 38 summarize results for each prototype across all packages and prototypes 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, TRC highlighted cells meeting these two requirements to help clarify 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.

At the bottom of each of these figures is the average greenhouse gas savings achieved for each package across climate zones.

For more detail on the results in the Figures, please refer to *Section 4 Results*.

Figure 36. Medium Office Summary of Compliance Margin, Cost Effectiveness, and GHG Impacts

CZ	Utility	Mixed Fuel			All Electric			
		EE	EE + PV + B	HE	Fed Code	EE	EE + PV + B	HE
CZ1	PG&E	17%	17%	3%	-18%	5%	5%	-18%
CZ2	PG&E	17%	17%	4%	-8%	10%	10%	-5%
CZ3	PG&E	20%	20%	3%	-9%	15%	15%	-8%
CZ4	PG&E	14%	14%	5%	-6%	9%	9%	-3%
CZ5	PG&E	18%	18%	4%	-9%	11%	11%	-7%
CZ6	SCE/SCG	20%	20%	3%	-5%	18%	18%	-3%
CZ7	SDG&E	20%	20%	4%	-2%	20%	20%	1%
CZ8	SCE/SCG	18%	18%	4%	-2%	18%	18%	1%
CZ9	SCE/SCG	16%	16%	4%	-2%	14%	14%	1%
CZ10	SCE/SCG	17%	17%	4%	-4%	13%	13%	-1%
CZ10-2	SDG&E	17%	17%	4%	-4%	13%	13%	-1%
CZ11	PG&E	13%	13%	5%	-5%	9%	9%	-1%
CZ12	PG&E	14%	14%	5%	-5%	9%	9%	-2%
CZ13	PG&E	13%	13%	5%	-5%	9%	9%	-1%
CZ14	SCE/SCG	18%	18%	10%	0%	14%	14%	4%
CZ14-2	SDG&E	13%	13%	5%	-5%	9%	9%	-1%
CZ15	SCE/SCG	12%	12%	5%	-2%	11%	11%	3%
CZ16	PG&E	14%	14%	4%	-27%	-13%	-13%	-25%
Avg GHG Savings (all CZs)		**15%**	**44%**	**3%**	**2%**	**17%**	**47%**	**3%**

Figure 37. Medium Retail Summary of Compliance Margin, Cost Effectiveness, and GHG Impacts

CZ	Utility	Mixed Fuel			All Electric			
		EE	EE + PV + B	HE	Fed Code	EE	EE + PV + B	HE
CZ1	PG&E	18%	18%	2%	-4.1%	15%	15%	-2%
CZ2	PG&E	14%	14%	3%	-1.1%	15%	15%	2%
CZ3	PG&E	16%	16%	2%	-0.4%	16%	16%	2%
CZ4	PG&E	15%	15%	3%	-0.1%	15%	15%	3%
CZ5	PG&E	16%	16%	1%	-1.2%	15%	15%	0%
CZ6	SCE/SCG	10%	10%	3%	0.5%	11%	11%	3%
CZ7	SDG&E	13%	13%	2%	0.3%	13%	13%	3%
CZ8	SCE/SCG	10%	10%	3%	0.4%	10%	10%	4%
CZ9	SCE/SCG	9%	9%	4%	0.4%	10%	10%	4%
CZ10	SCE/SCG	12%	12%	4%	0.1%	12%	12%	4%
CZ10-2	SDG&E	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%	13%	13%	4%
CZ13	PG&E	12%	12%	4%	-0.4%	12%	12%	4%
CZ14	SCE/SCG	12%	12%	5%	0.5%	12%	12%	5%
CZ14-2	SDG&E	12%	12%	5%	0.5%	12%	12%	5%
CZ15	SCE/SCG	11%	11%	5%	0.9%	10%	10%	6%
CZ16	PG&E	13%	13%	3%	-12%	3%	3%	-8%
Avg GHG Savings (all CZs)		**11%**	**68%**	**2%**	**6%**	**14%**	**71%**	**8%**

Figure 38. Small Hotel Summary of Compliance Margin, Cost Effectiveness, and GHG Impacts

CZ	Utility	Mixed Fuel			All Electric			
		EE	EE + PV + B	HE	Fed Code	EE	EE + PV + B	HE
CZ1	PG&E	7%	7%	2%	-68%	-51%	-51%	-38%
CZ2	PG&E	7%	7%	2%	-52%	-39%	-39%	-25%
CZ3	PG&E	9%	9%	1%	-58%	-41%	-41%	-28%
CZ4	PG&E	7%	7%	1%	-54%	-42%	-42%	-27%
CZ5	PG&E	9%	9%	1%	-60%	-42%	-42%	-29%
CZ6	SCE/SCG	8%	8%	1%	-50%	-37%	-37%	-22%
CZ7	SDG&E	9%	9%	1%	-50%	-36%	-36%	-21%
CZ8	SCE/SCG	7%	7%	2%	-49%	-41%	-41%	-20%
CZ9	SCE/SCG	6%	6%	2%	-44%	-37%	-37%	-17%
CZ10	SCE/SCG	5%	5%	3%	-40%	-34%	-34%	-16%
CZ10-2	SDG&E	5%	5%	3%	-40%	-34%	-34%	-16%
CZ11	PG&E	4%	4%	3%	-42%	-35%	-35%	-19%
CZ12	PG&E	5%	5%	3%	-47%	-38%	-38%	-21%
CZ13	PG&E	4%	4%	3%	-41%	-35%	-35%	-18%
CZ14	SCE/SCG	4%	4%	3%	-41%	-34%	-34%	-18%
CZ14-2	SDG&E	4%	4%	3%	-41%	-34%	-34%	-18%
CZ15	SCE/SCG	3%	3%	5%	-27%	-24%	-24%	-8%
CZ16	PG&E	5%	5%	2%	-78%	-59%	-59%	-56%
Avg GHG Savings (all CZs)		**1%**	**20%**	**2%**	**-7%**	**-6%**	**13%**	**9%**

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. This study assumed that natural gas infrastructure could be eliminated by electrifying space heating and service water heating alone. Avoiding the installation of natural gas infrastructure results in significant cost savings and is a primary factor toward cost-effective outcomes, even with necessary increases in electrical capacity. However, there may be other building types that not examined in this study that do not yet have viable all-electric options where it may not be appropriate to assume that natural gas infrastructure is eliminated.

Draft findings indicate the following overall conclusions:

1. There is ample opportunity for cost effective energy efficiency improvements, as demonstrated by the compliance margins achieved in many 1A and 3A 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.
2. 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 highly dependent on the system type and building type. Specifying high efficiency equipment will

always be a key feature in integrated design but does not appear to be a panacea to achieve higher performance.

3. The Small Hotel presents a challenging prototype to cost-effectively exceed the state's energy performance budget. TRC is uncertain of the precision of the results due to being unable to model either drain water heat recovery or a central heat pump water heater with a recirculation loop. Nonetheless, draft results indicate that an all-electric package with high efficiency appliances yields substantial GHG savings.
4. Many all-electric and solar PV packages demonstrated GHG savings percentages higher than the TDV-based compliance percentage, 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.
5. Changes to the Nonresidential Alternate Calculation Method (ACM) manual can drastically impact results. Three examples include:
    a. 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. If nonresidential buildings were treated in the same way, all-electric cost effectiveness using the TDV approach would improve.
    b. The Energy Commission currently requires solar PV on all new construction residential buildings. If nonresidential buildings were treated in the same way, the cost effectiveness of packages containing solar PV would likely worsen.
    c. The 2019 Nonresidential ACM HVAC and DHW baseline system maps have significantly changed from 2016 and are currently open to public comment. It is possible that the Energy Commission may respond to public comments by further revising the baseline systems assumed in this study within the next few months.
6. All-electric federal code-minimum packages appear to be cost effective, largely due to avoided natural gas infrastructure, but in most cases do not exceed the Energy Commission's minimum performance budget (as described in 5a above). For the Medium Office and Medium Retail, it appears that adding efficiency measures will succeed in exceeding the performance budget.

6 Appendix

6.1 Lighting Efficiency Measures

Figure 39 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 39. Impact of Lighting Measures on Proposed LPDs by Space Function

	Baseline	Impact				Modeled Proposed
Space Function	LPD (W/ft2)	Interior Lighting Reduced LPD	Institutional Tuning	Daylight Dimming Plus OFF	Occupant Sensing in Open Office Plan	LPD (W/ft2)
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 (>250sf)	0.65	10%	5%	-	-	0.557

6.2 Drainwater Heat Recovery Measure Analysis

To support potential DWHR savings in the Small Hotel prototype, TRC modeled the drainwater heat recovery measure in CBECC-Res 2019 in the all-electric and mixed fuel 6,960 ft2 prototype residential buildings. TRC assumed one heat recovery device for every three showers assuming unequal flow to the shower. Based on the average efficiency found for heat recovery in hotel applications, the team assumed a heat recovery efficiency of 50%.

TRC modeled mixed fuel and all-electric residential prototype buildings both with and without heat recovery in each climate zone. Based on these model results, TRC 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. TRC 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 drainwater heat recovery measure in the Small Hotel. TRC applied volumetric energy rates to determine energy cost savings from this measure.

6.3 Utility Rate Schedules

The Reach Codes Team used the IOU rates depicted in Figure 40 to determine the On-Bill savings for each prototype .

Figure 40. IOU Tariffs Analyzed Based on Climate Zone – Detailed View

Climate Zones	Electric / Gas Utility	Electricity (Time-of-use)			Natural Gas
		Medium Office	Medium Retail	Small Hotel	All Prototypes
CZ01	PG&E	A-10	A-1	A-1 or A-10	G-NR1
CZ02	PG&E	A-10	A-10	A-1 or A-10	G-NR1
CZ03	PG&E	A-10	A-1 or A-10	A-1 or A-10	G-NR1
CZ04	PG&E	A-10	A-10	A-1 or A-10	G-NR1
CZ05	PG&E	A-10	A-1	A-1 or A-10	G-NR1
CZ06	SCE/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)
CZ09	SCE/SCG	TOU-GS-2	TOU-GS-2	TOU-GS-2 or TOU-GS-3	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
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

6.4 Complete List of Efficiency Measures Explored

This section will be populated for the final report.