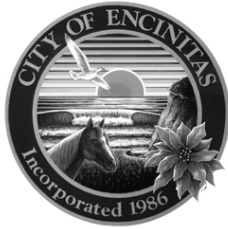


DOCKETED	
Docket Number:	19-BSTD-06
Project Title:	Local Ordinances Exceeding the 2019 Energy Code
TN #:	242577-2
Document Title:	City of Encinitas-2019 Staff Reports
Description:	Staff Report and other documents
Filer:	Danuta Drozdowicz
Organization:	California Energy Commission
Submitter Role:	Commission Staff
Submission Date:	4/5/2022 4:35:52 PM
Docketed Date:	4/5/2022



AGENDA REPORT

City Council

MEETING DATE: October 27, 2021

PREPARED BY: Crystal Najera,
Sustainability Manager

DEPT. DIRECTOR: Lillian Doherty

DEPARTMENT: Infrastructure and
Sustainability

CITY MANAGER: Pamela Antil

SUBJECT:

Adoption of City Council Ordinance No. 2021-13 which proposes Municipal Code amendments to implement the measures in the City's Climate Action Plan related to residential and commercial building energy efficiency, renewable energy, and building decarbonization.

CASE NOS: PLCY-004592-2021; **LOCATION:** Citywide.

RECOMMENDED ACTION:

1. Adopt City Council Ordinance No. 2021-13, titled "An Ordinance of the City Council of Encinitas, Adopting Amendments to Chapter 23.12 (Uniform Codes for Construction) or Title 23 (Building and Construction) of the Encinitas Municipal Code to Adopt the 2019 California Building Code and California Green Building Code with Certain Amendments, Additions, and Deletions related to Energy Efficiency, Solar Energy and Building Decarbonization" (**Attachment 1**).

STRATEGIC PLAN:

This item is related to the Environmental Focus Area of the Strategic Plan.

FISCAL CONSIDERATIONS:

There is no direct fiscal impact associated with the staff recommendation. Costs associated with administering the ordinance will be recovered through plan check, permitting, and inspection fees currently in effect. No fee modifications are proposed.

BACKGROUND:

On November 18, 2020, City Council approved an interim update to the Climate Action Plan which included updates to the following building-related measures:

BE-1: Adopt a Residential Energy Efficiency Ordinance

- BE-2: Require Decarbonization of New Residential Buildings
- BE-3: Adopt Higher Energy Efficiency Standards for Commercial Buildings
- BE-4: Require Decarbonization of New Commercial Buildings
- RE-3: Require Commercial Buildings to Install Solar Photovoltaic Systems

Implementation of these CAP measures requires adoption of an ordinance by City Council to incorporate the building requirements into the Encinitas Municipal Code. In addition to the CAP measures, California Building Energy Efficiency Standards – Title 24, Part 6 and Part 11 (Title 24) contain statewide building codes related to energy efficiency and green building. Local jurisdictions with land use authority are required to incorporate these state codes into their local code and enforce them. In addition to enforcing the state code, local jurisdictions have the authority to adopt local energy efficiency ordinances, or “reach codes,” that exceed the minimum standards defined by Title 24. Local jurisdictions wishing to adopt reach codes must complete a cost effectiveness study to demonstrate that the proposed local regulations would not cost more to implement and abide by than Title 24 (Public Resources Code Section 2502.1(h)2).

The City contracted with the Energy Policy Initiative Center (EPIC) to prepare the draft ordinance, complete the state-required cost-effectiveness studies, and facilitate the gathering of public input. A portion of the draft ordinance was developed beginning in 2019, as it relates to CAP measures BE-3 and RE-3 that were included in the City’s prior version of the CAP. However, in early 2020, completion of the ordinance was put on hold to update the CAP, which was adopted by City Council in November 2020, and until the COVID-19 pandemic economic repercussions subsided.

In January 2021, City staff recommenced development of the draft ordinance. An extensive public outreach component was initiated in tandem with the drafting of the ordinance and gathering of input on the proposed ordinance from January through May 2021. Two public workshops were also held to gather input from the general public on February 25 and May 11, 2021. Registrants for the first workshop were asked to self-identify into various stakeholder groups as to be placed into Zoom breakout rooms, following an initial plenary session. Breakout groups included residents, business owners, developers, environmental advocates, and others. Participants were also requested to identify a spokesperson from their breakout group that would also serve as an advocate to participate in subsequent Green Building Stakeholder Committee meetings. From this initial public workshop, thirteen of the participants were selected to serve on the Committee, including two representatives from the Environmental Commission, Commissioner Adams and Commissioner Morrison, and representatives from various interest groups including residents, business owners, developers, and environmental advocates, as indicated in Table 1.

Table 1. Green Building Stakeholder Committee Members

First Name	Last Name	Affiliation
Dennis	Cook	Other
Dadla	Ponizil	Other
Peter	Davis	Environmental Advocate
William	Morrison	Developer/Environmental Commissioner
Felicia	Gamez-Weinbaum	Resident
John	Gjata	Resident
Warren	Scott	Business Owner
Christian	Adams	Environmental Commissioner
Richard	Williams	Developer
Scott	Grady	Developer
Brian	Grover	Developer
Mike	McSweeney	Developer

Bianca	Martinez	Business Owner

Stakeholder Committee meetings were held on March 18 and April 12, 2021. Participants were provided with a variety of reference materials, including data regarding energy usage of various building types, cost effectiveness studies applicable to the Encinitas climate zone, and third-party research related to building electrification. Participants were asked to review the material and provided input on draft concepts and versions of the ordinance. Various other meeting requests were accommodated by staff to discuss and provide input on the draft ordinance with interested parties, including a meeting with the San Diego chapter of the Building Industry Association, Public Policy Committee on May 26, 2021. Finally, a public comment period on the proposed ordinance was held from May 11 to 31, 2021. All public comments received are included in **Attachment 2**.

On June 20, 2021, the Environmental Commission reviewed and considered proposed Ordinance 2021-13. The commission unanimously recommended that the ordinance be presented to City Council for consideration and adoption with the incorporation of one revision. The commission recommended that the exception that allowed new low-rise multi-family developments to forgo the installation of electric water heaters be removed. Staff considered this request and revised the proposed ordinance accordingly. The commission's action also included a request that staff provide City Council with additional information that characterizes the foregone greenhouse gas emissions reductions for the six remaining exceptions to the electric-only new building requirement. This supplemental information is provided in **Attachment 3** and is summarized in the analysis below.

As part of draft ordinance development, it was determined that existing cost-effectiveness studies developed for use statewide and a study that was completed by the City of Carlsbad includes analysis that the City of Encinitas can rely on for the proposed regulations incorporated into draft Ordinance 2021-13 (**Attachment 4, 5, 6, and 7**). The City of Encinitas is situated in Climate Zone 7 and each of these studies includes analysis for Climate Zone 7 for the various regulations being proposed in Ordinance 2021-13.

On Aug 18, 2021, City Council held a public hearing to consider draft Ordinance 2021-13. At this meeting, City Council voted 5-0 to remove exceptions 1, 3, and 5 from Section 100 (All-Electric New Construction) and directed staff to evaluate how exceptions 2, 4, and 6 could be more narrowly defined. Subsequently, City staff revised the remaining exceptions as follows:

Exception 1: Essential Facilities – Defines the types of facilities exempted and adds allowance for preemption or a requirement to demonstrate public health, safety, or welfare need for natural gas.

Exception 2: For-Profit Restaurants – Adds specific requirements for offsetting greenhouse gas emissions caused by natural gas appliances with other energy efficiency measures.

Exception 3: Utility Upgrade Cost – Defines the cost threshold as a percentage of increased utility upgrade cost. Clarifies that this exception only applies where previous service to the property already exists (e.g., demolition of existing building and new construction).

Additionally, to add clarity for project applicants who may currently have permit applications under review, additional language was added to Section 4 of the ordinance. The following options were considered for inclusion, with the staff recommendation being Option 2 as indicated in Table 2.

Table 2. Project Application Vesting Options

Option	Applicability	Ordinance Language	Project impacts	GHGs
Option 1	Entitlements or Building Permit submittal	Any discretionary project that has been issued project entitlements by the City of Encinitas as of the adoption date of this Ordinance shall be exempt from this Ordinance. Any non-discretionary project that has submitted a building permit application to the City of Encinitas as of the adoption date of this Ordinance shall be exempt from this Ordinance.	Allows projects with any permit application under review to be exempt.	Least amount of emissions reduction.
Option 2*	Building Permit Submittal (Discretionary and non-discretionary)	Any discretionary or non-discretionary project that has submitted a building permit application to the City of Encinitas as of the adoption date of this Ordinance shall be exempt from this Ordinance.	Allows projects with building permits under review to be exempt.	Moderate emissions reduction.
Option 3	Building Permit Issuance	Any discretionary or non-discretionary project that has been issued a current and valid building permit by the City of Encinitas as of the adoption date of this Ordinance shall be exempt from this Ordinance.	Allows projects with an issued and unexpired building permit to be exempt.	Greatest emissions reduction.

* Staff Recommendation & Council Approved Option

On September 22, 2021, City Council held a public hearing to reintroduce Ordinance 2021-13 with the revisions described above, including Staff's vesting recommendation of Option 2, and voted unanimously to move forward with adoption. Since September 22, City staff has received numerous inquiries from concerned developers and property owners undergoing planning review and/or in the process of building design. If so desired, City Council may revise the deadline for building permit application submittal to the "effective date" of the ordinance rather than the "adoption date" to allow more flexibility for project proponents nearing the submittal of their building permit application to the City.

On October 13, 2021, City Council considered adoption of the ordinance and voted instead to revise the vesting language to modify the building permit submittal date as follows:

"Any discretionary or non-discretionary project that has submitted a building permit application to the City of Encinitas as of the ~~adoption date~~ effective date of this Ordinance shall be exempt from this Ordinance."

This date change aligns with the date that the California Energy Commission (CEC) will approve the City's ordinance.

As the Ordinance vesting language was altered by the City Council on October 13, 2021, five additional days of public consideration were required. Therefore, the second reading and adoption of revised Ordinance 2021-13 was agendized for October 27.

If approved by City Council, staff will submit the ordinance and cost-effectiveness studies to the CEC to be filed with the California Building Standards Commission (CBSC) prior to implementation, as required by Public Resources Code Section 2502.l(h)2.

ANALYSIS:

Currently, the City requires building plans for all new and remodeled dwelling units and commercial/office buildings to meet statewide energy efficiency and green building requirements established in Title 24, per state regulation. The proposed ordinance would establish additional energy efficiency, solar photovoltaic, and electrification requirements for certain new and remodeled residential, commercial, multi-unit residential, and hotel/motel buildings. All code amendments proposed by Ordinance 2021-13 are shown in **Attachment 1**, including the removal of Exceptions 1, 3, and 5; revisions to Exceptions 2, 4, and 6; and added clarification for when the ordinance would be applicable to development projects during the permit approval process. ~~Red strike-through~~ font indicates deletions, while red underlined font indicates additions.

The purpose, applicability, and proposed requirements are described below in the order they appear in proposed Ordinance 2021-13. Fact sheets and graphical visualizations of the ordinance requirements can be found in **Attachment 8**.

23.12.080.B Nonresidential Solar Photovoltaic (PV)

The purpose of the nonresidential solar PV provision is to increase the amount of locally generated renewable energy. This is accomplished through the inclusion of cost-effective solar PV systems in new construction and some renovations. This section effectively implements CAP Measure *RE-3: Require Commercial Buildings to Install Solar Photovoltaic Systems*. The solar PV provisions would apply to all new nonresidential, high-rise residential, and hotel/motel buildings as well as existing nonresidential, certain multi-unit residential, and hotel/motel buildings additions that increase total roof area by at least 1,000 square feet or alterations with a permit value of at least \$1,000,000 that affect at least 75% of gross floor area. Applicable projects must install a solar PV system sized based on gross floor area of the building or based on time dependent valuation. Limited exceptions are allowed for building improvements that only included aesthetic exterior alterations, as well as practical challenges, greenhouses, and procurement of renewable electricity. Additionally, ground-mounted solar may be installed as a voluntary option.

23.12.080.C Existing Residential Energy Efficiency

The purpose of the proposed existing residential energy efficiency provision is to increase the energy efficiency of single and multi-family homes. This is accomplished through inclusion of various cost-effective energy efficiency measures, depending on the building type and the year the dwelling was built. This section effectively implements CAP Measure *BE-1: Adopt a Residential Energy Efficiency Ordinance*. According to this provision, multi-family dwellings built before 1978 requesting a building permit would be required to install R-38 attic insulation. Single-family dwellings built before 1978 and multi-family dwellings built between 1978 and 1990 requesting building permits would be required to install duct sealing or a cool roof. Single family homes built in 1978 or later and multi-family dwellings built in 1991 or later requesting building permits would be required to install either a lighting package with LED lamps and vacancy sensors or a water heating package to insulate water heaters and water pipes and install low-flow sink and shower faucets. Dwellings that receive a rating of seven or higher on the U.S. Department of Energy's Home Energy Score rating system would be exempt from this provision.

23.12.080.D-F All-Electric Construction of New Buildings

The purpose of the proposed all-electric provision is to utilize electricity for all appliances in all newly constructed buildings. As opposed to natural gas, electricity is an energy source that is anticipated to be sourced from a greater proportion of renewable energy in the near future, according to City of Encinitas policies, San Diego Community Power goals, and state greenhouse

gas emissions regulations. Electrification of buildings will be accomplished through inclusion of cost-effective electrification measures in both residential and nonresidential buildings. This section effectively implements CAP Measures *BE-2: Require Decarbonization of New Residential Buildings* and *BE-4: Require Decarbonization of New Commercial Buildings*. According to this provision, all new buildings requesting a building permit must either forgo the installation of natural gas infrastructure and install all electric appliances or, if an exception is applicable and requested, shall install electrical appliances except where gas appliances are permitted. Where any exception is utilized, the location must also be pre-wired for future electric appliances. The exceptions to all-electric development that are allowed in the proposed ordinance are summarized in Table 2. Table 3 also summarizes the greenhouse gas emissions reductions that are estimated to be foregone if the exception is fully utilized by applicants (See **Appendix 3** for complete analysis). As discussed above, Exception 5 only applies to high-rise residential, reflecting the recommendation made by the Environmental Commission. Since Encinitas zoning code section 30.16.010B6 effectively limits residential buildings to 3 stories or less, it is not anticipated that any new buildings would utilize Exception 5.

Table 3. Foregone GHG Reductions in 2030 from Ordinance All-Electric Exceptions

Exception ¹	Foregone GHG Reductions in 2030 (MT CO ₂ e)
Exception 1: Essential facilities	Unknown ²
Exception 2: Restaurant cooking equipment	20
Exception 3: Local utility infrastructure design requirements	Unknown ²

¹ Refer to draft ordinance for full exception language

² Limited available data

23.12.110.D Nonresidential Energy Efficiency

The purpose of the nonresidential energy efficiency provision is to increase the energy efficiency of commercial, high-rise residential, and hotel/motel buildings. This is accomplished through inclusion of cost-effective energy efficiency measures in new construction and major renovations. The provisions apply to all new construction of nonresidential buildings, high-rise residential, and hotel/motel buildings as well as all existing nonresidential, high-rise residential, and hotel/motel building additions of 1,000 square feet or alterations with a permit value of at least \$200,000. Applicable projects must meet specific requirements related to energy efficiency, renewable energy, elevator and escalator efficiency, and steel framing that avoids thermal bridging, if applicable to their project.

Subsequent to the completion of the workshops, staff received substantial interest from the environmental community to strengthen the building electrification ordinances to provide for fewer exceptions to the elimination of natural gas use and infrastructure. Staff believes that the ordinances, as proposed, reflect a balance between environmental protection and cost. For example, many comments dealt with the exceptions for natural gas cooking. However, in the public workshops, there was considerable concern that the widespread preference of natural gas stovetops would generate public opposition.

To promote energy efficiency and encourage the transition to electric appliances in existing buildings, staff plans to revise and expand the City's current Green Building Incentive Program to offer additional monetary rebates to residents and commercial property owners wishing to make certain energy efficiency upgrades to their building or swap out natural gas appliances for electric appliances. City staff will bring these proposed revisions to the program to City Council for consideration in the near future.

To support effective implementation of the ordinance, a CAP Consistency Checklist was developed that will be required to be completed by permit applicants to determine applicability of these new requirements to their project (**Attachment 9**). Because the City's CAP is CEQA-qualified, if the project requires discretionary action and the California Environmental Quality Act is applicable to the project, the applicant may utilize the CAP Checklist in lieu of conducting project-specific greenhouse gas emissions analysis.

Next Steps

Upon adoption, Ordinance 2021-13 will be submitted to the CEC for review and approval. The ordinance will become effective upon CEC approval and after filing with the CBSC.

ENVIRONMENTAL CONSIDERATIONS:

The project was previously evaluated in the Final Negative Declaration (ND) for the Climate Action Plan (Case No. 17-224), dated December 5, 2017. The ND evaluated the potential environmental effects of the implementation of the Climate Action Plan including the adoption and enforcement of energy efficiency and renewable energy ordinances. This project is within the scope of the Final Negative Declaration and no further California Environmental Quality Act (CEQA) compliance is required.

This item is related to the Climate Action Plan.

ATTACHMENTS:

1. Proposed Ordinance 2021-13, "An Ordinance of the City Council of Encinitas, Adopting Amendments to Chapter 23.12 (Uniform Codes for Construction) or Title 23 (Building and Construction) of the Encinitas Municipal Code to Adopt the 2019 California Building Code and California Green Building Code with Certain Amendments, Additions, and Deletions related to Energy Efficiency, Solar Energy and Building Decarbonization."
2. Public Comments received as of May 31, 2021
3. Electrification Ordinance Exceptions Greenhouse Gas Analysis
4. California Energy Codes and Standards, 2019 Cost-effectiveness Study: Low-Rise Residential New Construction
5. California Energy Codes and Standards, 2019 Nonresidential New Construction: Reach Code Cost Effectiveness Study
6. City of Carlsbad Energy Conservation Ordinance Cost Effectiveness Analysis, 2019
7. California Energy Codes and Standards, 2019 Cost Effectiveness Study: Existing Low-Rise Residential Building Efficiency Upgrade
8. Proposed Ordinance 2021-13 Fact Sheets
9. Draft CAP Checklist

ORDINANCE 2021-13

AN ORDINANCE OF THE CITY COUNCIL OF ENCINITAS, ADOPTING AMENDMENTS TO CHAPTER 23.12 (UNIFORM CODES FOR CONSTRUCTION) OF TITLE 23 (BUILDING AND CONSTRUCTION) OF THE ENCINITAS MUNICIPAL CODE TO ADOPT THE 2019 CALIFORNIA BUILDING CODE AND CALIFORNIA GREEN BUILDING CODE WITH CERTAIN AMENDMENTS, ADDITIONS, AND DELETIONS RELATED TO ENERGY EFFICIENCY, SOLAR ENERGY, AND BUILDING DECARBONIZATION.

SECTION ONE. The City Council of the City of Encinitas hereby finds and declares as follows:

WHEREAS, the City of Encinitas desires to amend Section 23.12.080 and Section 23.12.110 of Chapter 23.12 (Uniform Codes for Construction) of Title 23 (Building and Construction) of the City of Encinitas Municipal Code to implement goals and objectives set forth in the Climate Action Plan for reducing greenhouse gas (GHG) emissions, conserving water and energy, encouraging green buildings, protecting the natural environment, and protecting the health of residents and visitors;

WHEREAS, the California Global Warming Solutions Act of 2006, known as AB 32, established a statewide goal of reducing greenhouse gas emission to 1990 levels by 2020 and to a level 80 percent below 1990 levels by 2050, and directs the California Air Resources Board to develop a strategy to achieve such reductions;

WHEREAS, the State of California Climate Strategy identifies key strategies for addressing climate change that includes increasing renewable energy usage, doubling energy efficiency savings in existing buildings, making heating fuels cleaner, and reducing emissions from transportation;

WHEREAS, the City Council of the City of Encinitas adopted CEQA-qualified Climate Action Plan on January 17, 2018 aligning local climate action policies with the State of California Climate Strategy including the adoption strategies and goals to procure grid available electricity from 100 percent renewable energy sources, increase energy efficiency in residential and non-residential buildings, and promote the installation of local renewable energy sources at homes and businesses;

WHEREAS, the City of Encinitas Climate Action Plan found that buildings are the second largest contributor to GHG emissions, accounting for 39 percent of its total emissions in 2012;

WHEREAS, the United Nations Intergovernmental Panel on Climate Change (IPCC) has warned that failure to address the causes of global climate change within the next few years will result in sea level rise, increased frequency of wildland fires, and reduced freshwater resources, which will significantly increase the cost of providing local governmental services and protecting public infrastructure;

WHEREAS, the City Council of the City of Encinitas adopted Resolution 2020-90 Declaring a Climate Emergency on December 16, 2020;

WHEREAS, the 2019 California Building Standards Code adopted by the California Building Standards Commission has set minimum Green Building Standards and, within the code, expressly stated that the standards are viewed as “minimal” and that local government entities retain discretion, pursuant to Health and Safety Code Section 17958 to exceed the standards established by the code based on express findings that such changes or modifications are reasonably necessary because of local climatic, topographical, or geological conditions pursuant to Health and Safety Code Section 17985.5, 17958.7, and 18941.5;

WHEREAS, California Green Building Standard Code Section 101.7.1 provides that local climatic, geological, or topographical conditions include environmental conditions established by a city, county, or city and county;

WHEREAS, the local amendments and changes to the California Building Standards Codes are reasonably necessary because of the following climatic, geologic, and topographical conditions:

1. The City has over 6 miles of beaches, several creeks, and other low-lying areas prone to flooding. The City is at risk to coastal storms, erosion, and flooding. There is broad scientific consensus that the earth will continue to warm and sea levels will rise impacting beaches, roads, properties, infrastructure, and environmentally sensitive areas.
2. The City has experienced increases in annual temperature. Annual temperatures have increased more than 1 degree F in many parts of the state, and have exceeded increases of 2 degree F in areas that include the San Diego region. Temperature increases are expected to continue into the future.
3. The City is situated in hilly, inland terrain. Approximately 50% of the City is covered by native vegetation on steep and frequently inaccessible hillsides. The native vegetation includes highly combustible grasses, dense brush and chaparral, and could pose a wildfire risk. Natural firebreaks in these areas are significantly lacking.
4. The City experiences seasonal climatic conditions during the late summer and fall that can result in frequent Santa Ana weather patterns. Dry, hot, strong, and gusty Santa Ana wind conditions produce extreme dryness and some of the highest wind events in San Diego County, resulting in some of the region’s most catastrophic wildfires. These fires impact public health in the populated coastal zone through extreme heat and smoke.
5. The City acts to address environmental conditions that impact public health and welfare. Sustainability and resiliency are core values of the City’s General Plan and Climate Action Plan. Energy Efficiency promotes public health and welfare by enhancing the environmental and economic health of the City through green practices in design, construction, maintenance, and operation of new and existing buildings. Construction of energy efficient buildings and installation of renewable energy systems protects the public health and welfare by reducing air pollution, greenhouse gas emissions, average and peak energy demand, and adverse impacts from power outages.

6. Amendments to the California Green Building Standards Code and Energy Code are reasonably necessary to promote energy efficiency and conservation in the City, increase use of sustainable energy sources, reduce GHG emissions, promote green development patterns, and maintain a long-term balance between environmental, social, and economic impacts that protect public health and welfare.

WHEREAS, Public Resources Code Section 25402.1(h)(2) and Section 10-106 of the Building Energy Efficiency Standards establish a process by which local governments may adopt more stringent energy efficiency standards provided that the more stringent standards are cost effective and the California Energy Commission finds that the standards will require buildings to be designed to consume no more energy than permitted by the California Energy Code;

WHEREAS, the California Energy Codes & Standards 2019 Existing Low-rise Residential Building Efficiency Upgrade, Low-Rise Residential New Construction, and Nonresidential New Construction Reach Code Cost Effectiveness Study prepared by the California Statewide Utility Program and TRC's Cost-Effectiveness Study for Nonresidential New Construction and Alterations for Solar Photovoltaics (PV) demonstrate that the local amendments are cost-effective and do not result in buildings consuming more energy than is permitted by the California Energy Code;

WHEREAS, the City Council finds in its independent judgment that the proposed amendment to the Encinitas Municipal Code to adopt State uniform codes is exempt from environmental review as per Section 15378(b)(5) of the CEQA Guidelines since the activity in question is not considered a "project" as defined therein. The action being considered by the City Council is an administrative activity of government that will not result in the direct or indirect physical change in the environment. This action entails adoption of State mandated Building Codes that are enforceable upon the City. Minor amendments will not have a significant effect on the environment because the strengthened requirements reduce hazards and accommodate features to reduced environmental effects. The City Council therefore finds that there is no possibility that the minor local amendments may have a significant effect on the environment; therefore pursuant to Section 15061(b)(3) of the CEQA Guidelines the activity is exempt from the provisions of CEQA; and

WHEREAS, the City Council of the City of Encinitas adopted Chapter 23.12 (Uniform Codes for Construction) of Title 23 (Building and Construction) of the Encinitas Municipal Code on October 23, 2019 and now seeks to amend Section 23.12.030, Section 23.12.080, and Section 23.12.110 of Chapter 23.12 to reflect its Climate Action Plan.

NOW, THEREFORE, the City Council of the City of Encinitas, California, hereby ordains as follows:

SECTION TWO. Sections 23.12.080 and 23.12.110 of Chapter 23.12 of the Encinitas Municipal Code are hereby amended by repealing in its entirety and adopting a new Section 23.12.080 and Section 23.12.110 to read as follows:

23.12.080 Adoption of the 2019 California Energy Code, Part 6, Title 24 of the California Code of Regulations.

- A. There is adopted and incorporated by reference herein as the City's Energy Code for the purpose of prescribing regulations in the City of Encinitas for the conservation of energy, the 2019 California Energy Code, Part 6, Title 24 of the California Code of Regulations, a portion of the 2019 California Building Standards Code, as defined in the California Health and Safety Code, Section 18901 et seq. Except as otherwise provided by this section of the City of Encinitas Municipal Code, all construction of buildings where energy will be utilized shall be in conformance with 2019 California Energy Code and any rules and regulations promulgated pursuant thereto, including the California Energy Code, 2019 Edition, published by the California Energy Commission.
- B. Section 120.10 is added to the California Energy Code as follows:

**Section 120.10
NONRESIDENTIAL PHOTOVOLTAIC SYSTEM REQUIRED**

All new non-residential construction, high-rise residential, and hotel/motel buildings shall comply with the requirements of Section 120.10(a) or 120.10(b). Additions to existing non-residential, high-rise residential, and hotel/motel buildings where the total roof area is increased by at least 1,000 square feet shall comply with the requirements of Section 120.10(a) or (b). Alterations to existing non-residential, high-rise residential, and hotel/motel buildings with a permit valuation of at least \$1,000,000 that affects at least 75 percent of the gross floor area shall also comply with the requirements of Section 120.10(a) or (b).

The required installation of a photovoltaic (PV) system shall be sized according to one of the following methods:

(a) Based on Gross floor area.

1. Building with greater than or equal to 10,000 square feet of gross floor area shall install a minimum PV system sized at 15 kilowatts direct current (kWdc) per 10,000 square feet of gross floor area.

Note to Section 120.10(a)1: PV system size = 15 kWdc X (Gross Floor Area / 10,000 sq. ft.) where the building size factor shall be rounded to the nearest tenth and the resulting product shall be rounded to the nearest whole number. For example, an applicant with a 126,800 square foot building shall install a minimum 191 kilowatt (kWdc) PV system.

2. Buildings under 10,000 square feet of gross floor area shall install a minimum 5 kilowatt (kWdc) PV system.

Note to Section 120.10(a): Applicants are encouraged to right-size the PV system based on the building's electrical demand to improve the system's cost effectiveness. Applications should also ensure that the PV system meets electrical corporation net energy metering requirements, if applicable.

Note to Section 120.10(a): Where appropriate and where approved by Development Services Director or their designee, a PV system based on gross floor area may be based on the scope of the application where the system size reflects only the gross square footage controlled by the applicant, such as a tenant improvement that only affects the tenant's portion of a building's total gross floor area or a general renovation of a nonresidential building by a property owner or manager that only affects common areas. Applicant specific gross floor area PV systems shall be the minimum requirement unless an applicant can demonstrate to the Development Services Director or their designee that serving applicant specific load is infeasible per Exception 1 to Section 120.10.

(b) Based on Time Dependent Valuation (TDV). Install a solar PV system that will offset 80 percent of the building's TDV energy on an annual basis. The system sizing requirement shall be based upon total building TDV energy use including both conditioned and unconditioned space and calculated using modeling software or other methods approved by the Development Services Director.

Note to Section 120.10(b): Where appropriate and where approved by Development Services Director or their designee, TDV may be based on the scope of the application where the system size reflects only the load controlled by the applicant, such as a tenant improvement that only affects a tenant's portion of a building or a general renovation of a nonresidential building by a property owner that only affects common areas. Applicant specific TDV shall be the minimum requirement unless an applicant can demonstrate to the Development Services Director or their designee that serving common area load is infeasible per Exception 1 to Section 120.10.

Note to Section 120.10(a) and (b): In determining whether additions to existing non-residential, high-rise residential, and hotel/motel buildings increased the total roof area by at least 1,000 square feet, only roof area for new Enclosed Space, defined as space that is substantially surrounded by solid surfaces, including walls, ceilings or roofs, doors, fenestration areas, and floors or ground, is applicable. For sizing of a system, the determination of total roof area shall also be consistent with total roof area under Title 24, Part 6, Section 110.10 (b)1.B.

Exception 1 to Section 120.10: The Development Services Director or their designee may waive or reduce, by the maximum extent necessary, the provision of this Section if the Development Services Director or their designee determines there are sufficient practical challenges to make satisfaction of the requirements infeasible. Practical challenges may be the result of the building site location, structural load limitations, limited rooftop availability, or shading from nearby structures, topography or vegetation. The applicant is responsible for demonstrating requirement infeasibility when applying for an exception.

Exception 2 to Section 120.10: The Development Services Director or their designee may waive or reduce, by the maximum extent necessary, the provisions of this Section if the Development Services Director or their designee determines the building has satisfied the purpose and intent of this provision through the use of alternate on-site renewable generation systems, such as wind energy systems.

Exception 3 to Section 120.10: Greenhouse structures used for commercial cultivation, educational purposes, or the conservancy of plants or animals are exempted from the requirements of Section 120.10. The Development Services Director or their designee may exempt other greenhouse structure uses on a case-by-case basis.

Exception 4 to Section 120.10: If offered by local load serving entity (e.g. local utility provider), new nonresidential buildings including the nonresidential portions of mixed use construction, high-rise residential, and hotel/motel buildings, and alterations thereto having a building permit of at least \$1,000,000 and affecting at least 75 percent of the existing floor area, or additions that increase roof size by at least 1,000 square feet, may instead comply with Section 120.10 by submitting proof to the Development Services Director or their designee that each electrical meter related to the new construction, alteration, or addition is served by a load serving entity's electric tariff, contract, or offered product that provides the greatest available percentage of electrical power from renewable energy sources. To comply with this exception, the applicant must prove that the load serving entity's electric tariff, contract, or offered product is equivalent to the greatest available percentage of electrical power from renewable energy sources for any customer in the City of Encinitas. Proof of enrollment shall be maintained and documented through utility billings and shall be provided upon request to the Development Services Director or their designee. If required, applicant shall consent to disclosure of tariff documentation to the Development Services Director or their designee for verification as authorized under California Public Utilities Code § 8380 (b). Applicant consent and disclosure shall be limited to Development Services Director or their designee accessing tariff information for verification purposes only.

Exception 5 to Section 120.10: An applicant may install a ground-mounted solar PV system that meets the requirements of Section 120.10 as a voluntary alternative to installing rooftop solar PV. The ground-mounted solar photovoltaic system shall comply with all existing health and safety requirements and limitations in the City.

Exception 6 to Section 120.10: Permit valuation shall exclude valuations for aesthetic exterior alterations in determining the \$1,000,000 permit valuation for alterations to existing non-residential, high-rise residential, and hotel/motel buildings.

Note to Exception 6 to Section 120.10: Exclusion of aesthetic exterior alterations is intended to remove façade alterations and other exterior alterations that do not affect internal floor space or are not otherwise required to comply with health and safety requirements.

- C. Section 150.2 of the California Energy Code is amended to add paragraph (d) as follows:

(d) The following requirements shall apply to the entire dwelling unit, not just the addition or altered portion. Where these requirements conflict with other energy code requirements, the stricter requirement shall prevail. All additions and alterations of residential buildings with a building permit valuation of \$50,000 or higher shall include one of the following energy efficiency measures:

1. Additions and alterations of single family residential buildings built before 1978 shall include one of the following:
 - A. Duct sealing pursuant to 2019 Title 24 Section 150.2(b)1E with verification by a Home Energy Rating System (HERS) rater. All exceptions as stated in 2019 Title 24 Section 150.2(b)1E are allowed. Projects that require duct sealing as part of an HVAC alteration or replacement must meet all of the requirements of Title 24, Part 6, including HERS rater verification.
 - B. Cool roof with an aged solar reflectance of greater than or equal to 0.25 and a thermal emittance of greater than or equal to 0.75. All exceptions as stated in 2019 Title 24 Section 150.2(b)1li for steep slope roofs and 150.2(b)1lii for low slope roofs are allowed. Only areas of roof that are to be re-roofed are subject to the cool roof upgrade. Projects that are not installing a new roof as part of the scope are exempt from this cool roof energy efficiency measure.
2. Additions and alterations of single family residential buildings built in 1978 or after shall include one of the following:
 - A. A lighting package consisting of:
 - i. Replacement of all interior and exterior screw-in (A-base) incandescent, compact fluorescent, and halogen lamps with screw-in LED lamps; and,
 - ii. Installation of manual-on automatic-off vacancy sensors that meet Title 24 Section 110.9(b)4 in all bathrooms, bedrooms, offices, laundry rooms, utility rooms, and garages. Spaces which already include vacancy sensors, motions sensors, or dimmers do not need to install new Title 24 Section 110.9(b)4 sensors.
 - B. A water heating package consisting of:
 - i. Addition of exterior insulation meeting a minimum of R-6 to storage water heaters 20 gallons or larger in size, except if insulation installation would void the water heater warranty. Installation must allow for proper venting of the appliance; and,
 - ii. Insulation of all accessible hot water pipes with R-3 pipe insulation. This includes insulating the supply pipe leaving the water heater, piping to faucets underneath sinks, and accessible pipes in attic spaces and crawlspaces; and,
 - iii. Upgrading of fittings in faucets and shower heads to meet current CALGreen (Title 24, Part 11, Sections 4.303.1.3 and 4.303.1.4 of the California Building Code) standards, except for fittings with rated flow rates no more than 10 percent greater than current CALGreen standards.

3. Additions and alterations of multi-family residential buildings built before 1978 shall include attic air sealing and insulation with a minimum of R-38 rating. Buildings without vented attic spaces, buildings with existing attic insulation levels greater than R-5, and buildings that are not currently conditioned for space heating and cooling are exempt from this attic insulation energy efficiency measure.
4. Additions and alterations of multi-family residential buildings built between 1978 and 1990 shall include one of the following:
 - A. Duct sealing pursuant to 2019 Title 24 Section 150.2(b)1E with verification by a HERS rater. All exceptions as stated in 2019 Title 24 Section 150.2(b)1E are allowed. Projects that require duct sealing as part of an HVAC alteration or replacement must meet all of the requirements of Title 24, Part 6, including HERS rater verification.
 - B. Cool roof with an aged solar reflectance of greater than or equal to 0.25 and a thermal emittance of greater than or equal to 0.75. All exceptions as stated in 2019 Title 24 Section 150.2(b)1li for steep slope roofs and 150.2(b)1lii for low slope roofs are allowed. Only areas of roof that are to be re-roofed are subject to the cool roof upgrade. Projects that are not installing a new roof as part of the scope are exempt from this cool roof energy efficiency measure.
5. Additions and alterations of multi-family residential buildings built in or after 1991 shall include one of the following:
 - A. A lighting package consisting of:
 - i. Replacement of all interior and exterior screw-in (A-base) incandescent, compact fluorescent, and halogen lamps with screw-in LED lamps; and,
 - ii. Installation of manual-on automatic-off vacancy sensors that meet Title 24 Section 110.9(b)4 in all bathrooms, bedrooms, offices, laundry rooms, utility rooms, and garages. Spaces which already include vacancy sensors, motions sensors, or dimmers do not need to install new Title 24 Section 110.9(b)4 sensors.
 - B. A water heating package consisting of:
 - i. Addition of exterior insulation meeting a minimum of R-6 to storage water heaters 20 gallons are larger in size, except for buildings with central water heating systems or if insulation installation would void the water heater warranty. Installation must allow for proper venting of the appliance; and,
 - ii. Insulation of all accessible hot water pipes with R-3 pipe insulation. This includes insulating the supply pipe leaving the water heater, piping

to faucets underneath sinks, and accessible pipes in attic spaces and crawlspaces; and,

- iii. Upgrading of fittings in faucets and shower heads to meet current CALGreen (Title 24, Part 11, Sections 4.303.1.3 and 4.303.1.4 of the California Building Code) standards, except for fittings with rated flow rates no more than ten percent greater than current CALGreen standards.

Note: To the extent the provisions of Section 150.2(d) conflict with other provisions of the California Energy Code, then the most energy conserving provisions shall supersede and control.

Exception 1 to Section 150.2(d): The requirement for inclusion of energy efficiency measures does not apply to residential buildings that receive a rating of seven (7) or higher on the U.S. Department of Energy's Home Energy Score rating system based upon an assessment by a Home Energy Score Certified Assessor, to the satisfaction of the Development Services Director or their designee.

D. Section 100.0, subpart (e) of the California Energy Code is amended as follows:

(e) Sections applicable to particular buildings. TABLE 100.0-A and this subsection list the provisions of Part 6 that are applicable to different types of buildings covered by Section 100.0(a).

- 1. All buildings. Sections 100.0 through 110.12 apply to all buildings.

EXCEPTION to Section 100.0(e) 1: Spaces or requirements not listed in TABLE 100.0-A.

- 2. Newly constructed buildings.

A. All newly constructed buildings. Sections 110.0 through 110.12 apply to all newly constructed buildings within the scope of Section 100.0(a). In addition, newly constructed buildings shall meet the requirements of Subsections B, C, D or E, as applicable, and shall be an All-Electric Building as defined in Section 100.1(b) unless one of the following exceptions is applicable:

EXCEPTION 1: "Essential Facilities" as defined by California Health & Safety Code § 16007 built to the standards required by the Essential Services Buildings Seismic Safety Act of 1986 (California Health & Safety Code §§ 16000-16023) and Title 24, Part 1, Chapter 4 are exempt from the all-electric if it is necessary to meet the requirements of other permitting agencies or is demonstrated to be necessary for the purpose of protecting public health, safety, and welfare. "Essential Facilities" as defined by the California Building Code Part 2 Section 202 are included in the definition of "essential services building".

EXCEPTION 2: At the discretion of the Development Services Director or their designee, non-residential buildings containing a for-profit restaurant open to the public may be approved for an exception to install gas-fueled cooking appliances. This request must be based on a business-related reason to cook with a flame that cannot be reasonably achieved with an electric fuel source. Examples include: barbeque-themed restaurants, woks, and pizza ovens. The Development Services Director or their designee shall grant this exception if they find the following:

1. There is a business-related reason to cook with a flame;
2. This need cannot be reasonably achieved with an electric fuel source;
3. The applicant has employed methods to mitigate the greenhouse gas impacts of the gas fueled appliance based on reducing on site energy use that is equal to or greater than the expected annual GHG emissions from the Therms consumed onsite based on new natural gas service request from the utility and equipment installed.

Note: GHG emissions mitigation can include energy efficiency, onsite renewable generation, electric vehicle service equipment, or other action to reduce GHG emissions from this building;

4. The applicant shall comply with the pre-wiring provision of Note 1 below.

EXCEPTION 3: Applies to projects where there is existing electrical service to the property that must be upgraded to serve the all-electric design. The Development Services Director or their designee may exempt the project from this requirement if there is evidence substantiating that meeting the requirements will necessitate a significant alteration of the local utility infrastructure. The alteration is considered significant if it increases the utility side upgrade cost to the project applicant by 20% or more compared to new service for electric and natural gas to serve the same peak load. Applicant shall provide documentation of costs from the utility for both the all-electric new service design and electric and natural gas new service design to Development Services and any other requested documentation.

Note to Exception 3: This exemption does not apply to applications where there is no existing utility service.

Note 1: If natural gas appliances are used in any of the above exceptions 1-3, natural gas appliance locations shall also be Electric-Ready for future electric appliance installation. Electric-Ready shall be specified in the Design Guidelines for Electric-Ready Buildings published by Development Services.

Note 2: Where any of the exceptions 1-3 are granted, the applicant is prohibited from completing any natural gas or propane plumbing rough work or stub out for any appliance or end-use that is required to be electric.

Note 3: If any of the exceptions 1-3 are granted, the Development Services Director or their designee shall have the authority to approve alternative materials, design and methods of construction or equipment per CBC 104.

- E. Section 100.1 (b) of the California Energy Code is hereby amended by adding the following:

For the purposes of interpreting this chapter and the associated standards for compliance, the terms below are defined as follows. These definitions are in addition to those in Section 100.1 (b) of the California Energy Code, as modified in Section 23.12.080 E. of the Encinitas Municipal Code. In the event of a conflict between the definitions in this section and in Section 100.1 (b), the definitions in this section shall control.

ALL ELECTRIC BUILDING: is a building that has no natural gas or propane plumbing installed within the building and there is no gas meter connection, and that uses electricity as the source of energy for its space heating, water heating, cooking appliances, and clothes drying appliances. All Electric Buildings may include solar thermal pool heating.

- F. Sections 110.2, 110.3, 110.4, and 110.5 of the California Energy Code are hereby amended to read as follows:

SECTION 110.2 - MANDATORY REQUIREMENTS FOR SPACE-CONDITIONING EQUIPMENT

Certification by Manufacturers. Any space-conditioning equipment listed in this section, meeting the requirements of section 100.0 (e)(2)(A) may be installed only if the manufacturer has certified to the Commission that the equipment complies with all the applicable requirements of this section.

[SUBPARTS (a)-(f) OF THIS SECTION SHALL BE INCORPORATED WITH NO AMENDMENTS]

SECTION 110.3- MANDATORY REQUIREMENTS FOR SERVICE WATER-HEATING SYSTEMS AND EQUIPMENT

(a) Certification by manufacturers. Any service water-heating system or equipment, meeting the requirements of section 100.0 (e)(2)(A), may be installed only if the manufacturer has certified that the system or equipment complies with all of the requirements of this subsection for that system or equipment.

[SUBPART 1. OF THIS SECTION SHALL BE INCORPORATED WITH NO AMENDMENTS]

SECTION 110.4 - MANDATORY REQUIREMENTS FOR POOL AND SPA SYSTEMS AND EQUIPMENT

(a) Certification by Manufacturers. Any pool or spa heating system or equipment, meeting the requirements of section 100.0 (e)(2)(A), may be installed only if the manufacturer has certified that the system or equipment has all of the following:

[SUBPARTS (a) (1-4) OF THIS SECTION SHALL BE INCORPORATED WITH NO AMENDMENTS]

SECTION 110.5- NATURAL GAS CENTRAL FURNACES, COOKING EQUIPMENT, POOL AND SPA HEATERS, AND FIREPLACES: PILOT LIGHTS PROHIBITED

Any natural gas system or equipment, meeting the requirements of Section 100.0 (e)(2)(A), listed below may be installed only if it does not have a continuously burning pilot light.

[SUBPARTS (a)-(e) OF THIS SECTION SHALL BE INCORPORATED WITH NO AMENDMENTS].

- G. **Applicability:** Any discretionary or non-discretionary project that has submitted a building permit application to the City of Encinitas as of the effective date of Ordinance 2021-13 shall be exempt from Section B-F.

23.12.110 Adoption of the 2019 California Green Building Standards Code, Part 11, Title 24 of the California Code of Regulations.

- A. There is adopted and incorporated by reference herein as the City's Green Building Code for the purpose of prescribing regulations in the City of Encinitas for enhancing the design and construction of buildings through the use of building concepts having a reduced negative impact or positive environmental impact and encouraging sustainable construction practices the 2019 California Green Building Standards Code, Part II, Title 24 of the California Code of Regulations, a portion of the 2019 California Buildings Standards Code, as defined in the California Health and Safety Code, Section 18901 et seq., and the California Green Building Standards Code, 2019 Edition. Except as otherwise provided by this section of the City of Encinitas Municipal Code, all construction of buildings shall be in conformance with the 2019 California Building Standards Code and any rules and regulations promulgated pursuant thereto, including the California Green Building Standards Code, 2019 Edition, published by the California Building Standards Commission.

- B. Section 4.304.2 is hereby added to the 2019 California Green Building Standards Code to read:

4.304.2 Graywater systems. Newly constructed single-family dwelling units shall be pre-plumbed for a graywater system permitted and constructed in accordance with Chapter 15 of the California Plumbing Code and including a stub-out in a convenient location for integration of the graywater system with landscape irrigation systems and

accepting graywater from all sources permissible in conformance with the definition of graywater as per Section 14876 of the California Water Code.

Exception: A graywater system shall not be permitted where a qualified soils engineer determines in a written, stamped report, or a percolation test shows, that the absorption capacity of the soil at the project site is unable to accommodate the discharge of a graywater irrigation system.

- C. Section A4.106.8 is hereby added and amended to the 2019 California Green Building Standards Code to read:

A4.106.8 Electric vehicle (EV) charging for new construction. New construction shall comply with Sections A4.106.8.1 and A4.106.8.2, and A4.106.8.3 to facilitate the future installation and use of electric vehicle chargers. Electric vehicle supply equipment (EVSE) shall be installed in accordance with the *California Electrical Code*, Article 625.

Exceptions: On a case-by case basis, where the local enforcing agency has determined EV charging and infrastructure are not feasible based upon one or more of the following conditions:

1. Where there is no commercial power supply.
2. Where there is evidence substantiating that meeting the requirements will alter the local utility infrastructure design requirements on the utility side of the meter so as to increase the utility side cost to the homeowner or the developer by more than \$400.00 per dwelling unit.
3. Where there will be an impact to existing parking requirements for hotel, motel and nonresidential additions and alterations greater than 10,000 square feet.
4. Or other conditions as determined by the City.

A4.106.8.1 New one- and two-family dwellings and townhouse with attached private garages.

Tier 1. For each dwelling unit, a dedicated 208/240-volt branch circuit shall be installed in the raceway required by Section 4.106.4.1. The branch circuit and associated overcurrent protective device shall be rated to 40 amperes minimum. Other electrical components, including a receptacle or blank cover, related to this section shall be installed in accordance with the *California Electrical Code*.

A4.106.8.1.1 Identification. The service panel or subpanel circuit director shall identify the overcurrent protective device designated for future EV charging purposes as “EV READY” in accordance with the *California Electrical Code*. The receptacle or blank cover shall be identified as “EV READY”.

A4.106.8.2 New multifamily dwellings. For any new multifamily dwelling, at least 15 percent of the total number of parking spaces provided for all types of parking facilities, but in no case less than one, shall be electric vehicle charging spaces (EV spaces).

Each EV space shall be equipped with fully operational electric vehicle supply equipment (EVSE). Calculations for the required number of EV spaces shall be rounded up to the nearest whole number.

A4.106.8.1.2 Technical requirements. The EV spaces required by Section A4.106.8.2 shall be designed and constructed in accordance with Sections 4.106.4.2.1, 4.106.4.2.2, 4.106.4.2.3, 4.106.4.2.4, and 4.106.4.2.5.

4.106.8.3 Hotels and motels. Construction shall comply with Section A4.106.8.3 to facilitate the installation of electric vehicle supply equipment (EVSE). When EVSE(s) is/are installed, it shall be in accordance with the California Building Code and the California Electrical Code and as follows:

A.4.106.8.3.1 For any new hotel or motel, including non-residential portions of mixed use projects, at least eight percent of the total number of parking spaces provided for all types of parking facilities, but in no case less than one, shall be electric vehicle charging spaces (EV spaces). Each EV space shall be equipped with fully operational electric vehicle supply equipment (EVSE). Calculations for the required number of EV spaces shall be rounded up to the nearest whole number. Refer to Section 5.106.5.3 for design requirements.

A.4.106.8.3.2 For any alteration or addition to a hotel or motel that requires a building permit with square footage larger than 10,000 square feet as determined by the City of Encinitas Building Division, at least eight percent of the total number of parking spaces provided for all types of parking facilities, but in no case less than one, shall be electric vehicle charging spaces (EV spaces). Each EV space shall be equipped with fully operational electric vehicle supply equipment (EVSE). Calculations for the required number of EV spaces shall be rounded up to the nearest whole number. Refer to Section 5.106.5.3 for design requirements.

A5.106.5.3 Electric vehicle (EV) charging for non-residential buildings. Construction shall comply with Section A5.106.5.3.1 and A5.106.5.3.2 to facilitate the installation of electric vehicle supply equipment (EVSE). When EVSE(s) is/are installed, it shall be in accordance with the *California Building Code* and the *California Electrical Code* and as follows:

A.5.106.5.3.1 For any new non-residential buildings, including non-residential portions of mixed-use projects, at least eight percent of the total number of parking spaces provided for all types of parking facilities, but in no case less than one, shall be electric vehicle charging spaces (EV spaces). Each EV space shall be equipped with fully operational electric vehicle supply equipment (EVSE). Calculations for the required number of EV spaces shall be rounded up to the nearest whole number. Refer to Section 5.106.5.3 for design requirements. Refer to Section 5.106.5.3 for design requirements.

A.5.106.5.3.2 For any non-residential alteration or addition that requires a building permit with square footage larger than 10,000 sq. ft. as determined by the City of Encinitas Building Division, at least eight percent of the total number of parking spaces provided for all types of parking facilities, but in no case less

than one, shall be electric vehicle charging spaces (EV spaces). Each EV space shall be equipped with fully operational electric vehicle supply equipment (EVSE). Calculations for the required number of EV spaces shall be rounded up to the nearest whole number. Refer to Section 5.106.5.3 for design requirements. Refer to Section 5.106.5.3 for design requirements.

- D. California Sections A5.201, A5.202, Subsections A5.203.1.1 (Tier 1 Prerequisites), and A5.213 are mandatory requirements for alterations thereto having a building permit valuation of at least \$200,000 or additions of at least 1,000 square feet to all existing nonresidential buildings including nonresidential portions of mixed-use construction, high rise residential, hotels/motels. These sections are hereby added and amended to the 2019 California Green Building Standards Code to read:

Section A5.203

PERFORMANCE APPROACH

A5.203.1 Energy efficiency. Nonresidential including the nonresidential portions of mixed-use construction, high-rise residential and hotel/motel buildings that include lighting and/or mechanical systems shall comply with Sections A5.203.1.1. Alterations having a building permit valuation of at least \$200,000 or additions of at least 1,000 square feet are included in the scope of these sections where either the alteration or addition includes Outdoor Lighting.

A5.203.1.1 Tier 1 prerequisites. To comply with Tier 1, ONE of the following efficiency measures is required for all applicable components of the building project.

A5.203.1.1.1 Outdoor Lighting. Newly installed outdoor lighting power shall be no greater than 90 percent of the Allowed Outdoor Lighting Power, and general hardscape lighting within the scope of Title 24, Part 6, Section 140.7(b)(1) shall have a color temperature no higher than 3000K. The Allowed Outdoor Lighting Power calculation is specified in Title 24, Part 6, Section 140.7 Requirements for Outdoor Lighting.

Exception: The color temperature requirement is not applicable to the applications identified in the exceptions to Section 140.7(a) nor to the applications identified as “specific applications” in Section 140.7(b)(2) and Table 140.7.

A5.203.1.1.2 Service water heating in restaurants. Newly constructed restaurants shall comply with California Energy Code Section 140.5.

A5.203.1.1.3 Warehouse dock seal doors. Exterior loading dock doors that are adjacent to conditioned or indirectly conditioned spaces shall have dock seals or dock shelters installed at the time of permitting. This requirement shall apply to newly constructed buildings and to loading dock doors added to existing buildings.

A5.203.1.1.4 Daylight Design Power Adjustment Factors (PAFs). Daylighting devices shall be installed as specified in Title 24, Part 6, Section 140.3(d).

SECTION A5.213 ENERGY EFFICIENT STEEL FRAMING

A5.213.1 Steel framing. Design steel framing for maximum energy efficiency. Techniques for avoiding thermal bridging in the envelope include:

1. Exterior rigid insulation;
2. Punching large holes in the stud web without affecting the structural integrity of the stud;
3. Spacing the studs as far as possible while maintaining the structural integrity of the structure; and
4. Detailed design of intersections of wall openings and building intersections of floors, walls and roofs.

- E. **Applicability:** Any discretionary or non-discretionary project that has submitted a building permit application to the City of Encinitas as of the effective date of Ordinance 2021-13 shall be exempt from Section D.

SECTION THREE SEVERABILITY.

If any section, subsection, sentence, clause, phrase or word of this Ordinance is for any reason held to be invalid by a court of competent jurisdiction, such decision shall not affect the validity of the remaining portions of this Ordinance. The City Council hereby declares that it would have passed and adopted this Ordinance, and each and all provisions hereof, irrespective of the fact that one or more provisions may be declared invalid.

SECTION FOUR: PUBLIC NOTICE AND EFFECTIVE DATE.

The City Clerk is directed to prepare and have published a summary of the Ordinance no less than five days prior to consideration of its adoption, and again within 15 days following adoption, indicating the votes cast.

This ordinance shall take effect and be in force on the 30th day after adoption and following approval by the California Energy Commission and the City Clerk of City of Encinitas is hereby authorized to use summary publication procedures pursuant to Government Code Section 26933 utilizing the Coast News, a newspaper of general circulation published in the City of Encinitas.

SECTION FIVE: INTRODUCTION.

This Ordinance was introduced on August 18, 2021 and reintroduced on September 22, 2021 and October 13, 2021.

PASSED AND ADOPTED this _____ day of _____, 2021, by the following vote to wit:

AYES:

NAYS:

ABSTAIN:
ABSENT:

Catherine S. Blakespear, Mayor, City of Encinitas

ATTESTATION AND CERTIFICATION:

I hereby certify that this is a true and correct copy of Ordinance No. 2021-13 which has been published pursuant to law.

Kathy Hollywood, City Clerk

APPROVED AS TO FORM:

Leslie E. Devaney, City Attorney

Crystal Najera

From: Ann Feeney <feeney@scripps.edu>
Sent: Monday, May 17, 2021 2:28 PM
To: Climate Action
Subject: Comments on the draft building electrification ordinance

Dear Crystal,

I applaud Encinitas for being such a leader in all climate crisis issues. Your city adopted an excellent Climate Emergency Resolution and crafted an excellent CAP update with good targets and goals. I am very pleased that your draft building electrification ordinance is requiring electric water and space heating for all new construction, and also that it requires pre-wiring for future electric appliance installation in the case of the proposed exceptions. However, in order to address the climate emergency situation that we are in, and also to reduce GHG emissions to meet your CAP goals, I have a few comments about the proposed exceptions.

Cooking

An exception is proposed for residences to have non-electric cooking for any reason (exception #1), yet restaurants can only have an exception (#4) for gas cooking stoves if they restaurant provides the city with a “reason that they need to cook with a flame that cannot be reasonably achieved with an electric fuel source” such as BBQ or pizza ovens. Why therefore not use the same logic to prohibit gas cooking in most residential homes?

Available technology. Induction cooktops are just as good, and in my opinion are better, than gas cooktops. I cook a lot and loved my gas cooktop. However, after trying an induction cooktop, I am very impressed. There is as much immediate control of temperature as gas, and they are much safer than gas, in that when you remove your pan, the cooktop turns off so there is no danger from leaving a burner on, or danger of young children getting burned from touching it. The quality of cooking is superb, and many top restaurants use induction cooking. The main resistance comes from people who are not familiar with induction cooktops. Encinitas now has a loaner program for induction cooktops. If this is promoted well, perhaps there will be less resistance to this superior form of cooking.

Health reasons. The burning of natural gas in gas cooktops is associated with high levels of indoor air pollution, especially when stove vents are not used (which is usually the case). There is increased incidence of asthma and other chronic respiratory diseases in individuals, especially children, from households with gas cooktops.

If cooking is the main reason why residents want natural gas, building a kitchen with an induction cooktop will save the residents all the money of laying the gas infrastructure just for a stove.

Outdoor BBQ (#1). Outdoor BBQ could easily use propane rather than piped in natural gas, so I see no need for this exception.

ADU (#3) ADU’s need their own electrical panel, so there is no need to also provide natural gas infrastructure to extend natural gas to the ADU. This is a simple and ideal place to go all-electric. In addition, it is cheaper to build new construction as all-electric, which will make ADUs more affordable.

Pools (#1). It is very expensive to heat a pool with gas, and in southern California, one does not need to do so. Solar heating and pool covers are the smartest option.

Multi-family central water heating (#5). I see no reason why heat pump water heaters (HPWH) (maybe a few per building) could not be utilized. HPWH are so much more efficient than gas water heaters that the residents will realize the savings from the use of HPWH. Gas water heaters are a major source of GHG emissions from buildings, so requiring HPWH would be a major way to achieve the GHG reduction targets in your CAP.

California has committed to a zero carbon future, and we must quickly wean ourselves off of burning fossil fuels. Not only are there GHG emissions associated with burning natural gas, but there is much leakage from the site of extraction of the natural gas to the home. Natural gas pipelines are also a hazard in earthquakes, gas line ruptures. Recall Aliso Canyon, San Bruno. Allowing more gas infrastructure will just place these homeowners in a situation of adapting to electric appliances in the future, and paying the cost of those retrofits. Now that Encinitas has 100% clean energy from San Diego Community Power, the energy in all-electric homes can help to save our planet.

Thank you, and good luck with your building electrification ordinance. I appreciate all of the public workshops and outreach that you are doing.

Sincerely,

Ann Feeney

Vice Chair, City of Del Mar's Sustainability Advisory Board

Co-chair, Building Electrification team, SanDiego350

Co-chair, Steering Committee and Campaign Strategy working group, San Diego Building Electrification Coalition

Crystal Najera

From: Ann Feeney <feeney@scripps.edu>
Sent: Tuesday, May 18, 2021 12:22 PM
To: Climate Action
Subject: Re: Comments on the draft building electrification ordinance

Underscoring the urgent nature of the climate crisis. Please keep this in mind when drafting the building electrification ordinance.

Thanks for your efforts.

<https://www.nytimes.com/2021/05/18/climate/climate-change-emissions-IEA.html?referringSource=articleShare>

First few paragraphs of the article:

Nations around the world would need to immediately stop approving new coal-fired power plants and new oil and gas fields and quickly phase out gasoline-powered vehicles if they want to avert the most catastrophic effects of climate change, the world's leading energy agency said Tuesday.

In a sweeping new report, the International Energy Agency [issued a detailed road map](#) of what it would take for the world's nations to slash carbon dioxide emissions to net zero by 2050. That would very likely keep the average global temperature from increasing [1.5 Celsius above preindustrial levels](#) — the threshold beyond which scientists say the Earth faces irreversible damage.

While academics and environmentalists have made similar recommendations before, this is the first time the International Energy Agency has outlined ways to accomplish such drastic cuts in emissions.

That's significant, given the fact that the influential agency is not an environmental group but an international organization that advises world capitals on energy policy. Formed after the oil crises of the 1970s, the agency's reports and forecasts are frequently cited by energy companies and investors as a basis for long-term planning.

"It's a huge shift in messaging if they're saying there's no need to invest in new fossil fuel supply," said Kelly Trout, senior research analyst at Oil Change International, an environmental advocacy group.

From: Barbara Diamond <diamondbarb@gmail.com>
Sent: Friday, May 28, 2021 7:45 PM
To: Climate Action
Subject: Why consider exceptions to building electrification

[NOTICE: Caution: External Email]

Council members,
I learned that there are several requests to make exceptions so that various items even private pools can have gas. These requests should be ignored. If you grant one it will embolden those who want more exceptions. Remember the overall goal of reducing carbon to save our environment and these requests will clearly show themselves as destructive distractions.

Sincerely,
Barbara C. Diamond
3808 Skyline Rd. Carlsbad, CA 92008

--

~Barbara Diamond~

Crystal Najera

From: Christina <csimokat.encinitas@gmail.com>
Sent: Monday, May 31, 2021 1:47 PM
To: Climate Action
Subject: Green Building ordinance input

[NOTICE: Caution: External Email]

I support all efforts to create all-renewable energy usage in existing and new buildings, and all efforts to reduce energy use overall. I support all de-carbonization efforts.

Thank you,

Christina Simokat
1964 Circle Park Ln, Encinitas, CA 92024

Crystal Najera

From: Courtney Meltvedt <askthedoc@olivebranchchiropractic.com>
Sent: Monday, May 24, 2021 7:15 AM
To: Climate Action
Subject: Cost Upgrading Parking Lots

[NOTICE: Caution: External Email]

Won't this cost get transferred to the tenants via triple net ? Another blow to small business.

Dr. Leo Meltvedt

--

Creating Community Wellness~

Dr. Courtney Meltvedt, DC

619-992-5592

Crystal Najera

From: Dadla Ponizil <dadlaponizil@gmail.com>
Sent: Sunday, May 30, 2021 3:06 PM
To: Crystal Najera
Subject: My input for Green Building Ordinance

[NOTICE: Caution: External Email]

Hi Crystal:

I don't know what happened to it, but I could not find where I put the proposed Ordinance set of files you sent out. So this is based on my general primary goal from the outset, and not specific to any particular provision(s) proposed. Hope it's useful.

1. We should prioritize efficiency in all our buildings, retrofits, new,--residential or commercial. A properly built or remodeled building will need less energy where it counts: the conditioning of the living spaces.
2. By doing a good job on (1) less energy is needed. I can't say this enough times: energy, whether it comes from renewables or fossil fuel-- is still energy and we do not have an unlimited amount of clean energy. Solar panels, wind turbines, hydro, etc. all have a carbon footprint, spacial footprints, off-shore ecosystem limitations, etc. So the only prudent and realistic loading order is: energy demand reduction, then energy source conversion.
3. I applaud the move to electrification. The more the better. I would prioritize it as follows due to highest demand and existing technologies as well as public uptake:
 - o space conditioning (retrofitting gas furnaces with heat pumps)
 - o water heating (and here I would love to see more effort at incentivising solar thermal which I think we have totally missed the opportunities on and should revisit).
 - o I think taking stoves away from people is not worth it now. That will take care of itself.
4. All the feedback I've provided on incentives I will not repeat except to say the resources should be aimed at efficiency. Again, the Green Genie program does a wonderful job of utilizing these resources to the greatest benefit.
5. Finally (for now) check out this holistic solution for space conditioning using existing infrastructure. See <https://heet.org/>. If you don't have time to study this now, the idea is to use NG infrastructure (the lines already in the ground) to set up a ground source heat pump system--geothermal micro grids. Think heat pumps for a whole neighborhood or university campus. All sharing and running off the same ground-sourced heating/cooling system. I think this is the future because maintaining gas infrastructure is a waste and using what is already in place toward electrification economically superior.

Thanks for all you're doing on this and let me know how I can help further.
Dadla.

Crystal Najera

From: Emmy Garnica <emmygarnica@cox.net>
Sent: Saturday, May 15, 2021 1:33 PM
To: Climate Action
Subject: green building ordinance

[NOTICE: Caution: External Email]

Are there going to be similar rules for residential development? I hope so.
Thank you,
Emmy Garnica

Sent from my iPad

Crystal Najera

From: Frank Grant <fwgrant@gmail.com>
Sent: Tuesday, May 11, 2021 9:21 AM
To: Climate Action
Subject: Green Energy Program

[NOTICE: Caution: External Email]

Hi,

All I'm going to say is that taking the choice of gas ranges and stoves away from homes takes all the JOY away from cooking.

Why so mean? So sad.

--

Frank Grant
Encinitas, California
760-533-1520

Crystal Najera

From: Gary Jahns <lorenjahns@gmail.com>
Sent: Saturday, May 29, 2021 10:31 AM
To: Climate Action
Subject: Public Comment on the Green Building Ordinance

[NOTICE: Caution: External Email]

Thank you for asking my opinion of your draft Green Building Ordinance. My only concerns are for the six Exceptions of Section D.2. This section predominantly deals with minimizing the use of natural gas (i.e., “decarbonization”) in new construction, and implements ordinances required in the Encinitas Climate Action Plan (ref: Table 3-3 on page 3-5 of the CAP, Measures BE-2, 3, and 4). The Exceptions are so broad that it is not clear to me that the decarbonization goals of the CAP would be achieved. I have reviewed the supporting documents (e.g. New Residential All-Electric CES), but they do not quantify how much GHG reduction would be undermined by each of these Exceptions. I get the impression that the city doesn’t want to upset our citizens who fear their comfort may be compromised. Unfortunately, decarbonization (which, as a physicist I support) may require some sacrifices. Think about what it means to allow natural gas to be piped to new construction: maybe GHG reductions for 2030 could still be achieved, but gas usage would be baked into the cake for 50 years, so how do we then get to 100% decarbonization by 2050? Then consider that studies show that decarbonization will drive UP natural gas prices (<https://ww2.energy.ca.gov/2019publications/CEC-500-2019-055/index.html>). Do builders a favor and give them a reason to forego plumbing in gas lines and save the money it would cost. Do owners a favor and save them from getting blindsided by the high cost of gas 20 years from now. Do them all a favor and make new construction all-electric.

Exception 1 is the most onerous because it excepts almost anything that gets built. It guarantees that new gas infrastructure will be de facto, so it should be struck from this ordinance. As for Exception 2, I do not see the justification of treating “Essential Facilities” differently. Similarly, there is absolutely no reason why an ADU needs to have gas (Exception 3). As for multi-family buildings with a central water heater, Exception 5 is a total backtrack from the technology improvement in the 2020 CAP update due to using heat-pump water heaters’ UEF ratings as the standard for water heating. Why Exception 6 (utility-side costs) is here may have been discussed in the second workshop (which I missed), but I don’t understand how this would even happen: no gas lines installed means no cost of installing gas lines.

Exception 4 (restaurant use of gas for cooking) is the only one that I do not totally reject, but it should have one additional requirement: that the restaurateur get a projection of how much their cooking gas will cost them now and in 10 years, so they understand that their gas usage cost will escalate and affect their bottom line.

To sum up, my opinion is that the Exceptions in Section D.2 of the proposed ordinance are antithetical to the city’s building decarbonization goals and are problematic for its Climate Action Plan. The only Exception that has any justification is for restaurant cooking, and then only under stringent restrictions. Thank you for allowing me to express my thoughts on the subject.

Gary Jahns
1926 Skyknoll Way, 92024
lorenjahns@gmail.com

From: James Wang <tc4312@gmail.com>
Sent: Sunday, May 30, 2021 3:11 PM
To: Climate Action
Subject: Proposed Building Electrification Ordinance - All-electric, no exceptions

[NOTICE: Caution: External Email]

Green Building Council:

Our City Council has declared a **Climate Emergency**. Councilmembers were unequivocal when they spoke about the need to declare an Emergency. Councilmembers statements include:

- *"Dire threat demands our action"*
- *"We need to make sure that we're doing everything we can to reduce GHGs"*
- *"We have not seen enough progress globally, so it's time for local governments to act"*
- *"Our actions are for future generations"*

Building electrification is a climate issue, so all of these comments are pertinent to the proposed ordinance.

When we have an Emergency, then Emergency Action is required. "Emergency" means that time is of the essence - we have run out of time and need to act with alacrity (*"Dire threat demands our action"*).

Emergency Action means that we do not settle for half-hearted, compromised measures. Such halfway measures include preferences ("Cook with gas is preferable"), exceptions (gas in ADUs produce GHGs too), or specific-appliance loopholes (why?).

We have recognized, acknowledged, and declared a Climate Emergency. **Emergency Action has no room for preferences, exceptions, and loopholes.** (*"We need to make sure that we're doing everything we can to reduce GHGs"*)

Our emergency is happening now. Building infrastructure lasts for decades. *We do not have decades: we need action now. ("it's time for local governments to act")*

Fittingly, we have the technology and the reasons to replace 1950's appliances with 21st-century equipment that is:

- Less expensive to install and operate
- Yields better performance
- Is safer for both the homeowner and for the public, and
- Saves the planet (*this is not a minor point*)

How can we say no? The only reasonable ordinance is for all-electric construction with NO exceptions.

Encinitas may be the first city in our county to consider a climate-related ordinance under Emergency

conditions. What our city does sets a precedent for the entire County. If we ignore our Emergency, then what will other cities do?

Thank you!

James Wang
Cardiff

Crystal Najera

From: James Wang <tc4312@gmail.com>
Sent: Monday, May 31, 2021 8:52 PM
To: Climate Action
Subject: Proposed BE Ordinance - All-Electric Buildings are Cost-Effective
Attachments: AllElectricCostEffectiveness.pdf

[NOTICE: Caution: External Email]

Green Building Council:

Please see the attached PDF document.

Thank you,

James Wang
Cardiff

May 31, 2021

Encinitas Green Building Council:

You may have seen my other message regarding how our Climate Emergency militates for halting further natural gas installations.

The Climate Emergency is reason enough to mandate all-electric buildings. But the 2019 Cost-Effectiveness Study¹ conducted for PG&E adds further impetus for all-electric buildings: they win substantial cost-savings for both the developer and the owner.

Background

First, some explanation of some of the terms used in the report.

The study used two means for evaluating costs: On-Bill and Time-Dependent Valuation (TDV). The On-Bill cost is the customer Lifecycle Cost (LCC). It includes a predicted inflation adjustment, but does not include the cost of carbon emission. On the other hand, TDV includes not only societal costs such as GHG emissions, but it also includes the cost impact of electricity use due to varying demand.

Since the TDV method includes consideration of carbon emissions, it is more relevant to our proposed ordinance since it addresses our CAP Measures. The CEC also uses TDV (and not On-Bill) for Title 24.

Federal law sets minimum efficiency standards for appliances and equipment: local ordinances are not allowed to mandate higher efficiency. However, builders may install higher efficiency equipment if they wish. As the report states, such options "are the simplest and most affordable measures to increase energy performance" (p4). If a builder chooses to install equipment that exceeds federal minimums, it is "non-preempted".

Study Findings

The study is comprehensive and covers single-family and multifamily residences, with varying degrees of efficiency and electrification in all California Climate Zones. Encinitas only needs to consider Climate Zone 7 and not surprisingly, the results are similar for single and multifamily buildings.

Quoting from the Summary (page 41):

The analysis found cost-effective packages across the state for both single family and low-rise multifamily buildings. For the building types and climate zones where cost-effective packages were identified, the results of this analysis can be used by local jurisdictions to support the adoption of reach codes.

Therefore, all packages presented are cost-effective based on TDV, and may or may not be cost-effective based on the On-Bill method.

This analysis also looked at the GHG emissions impacts of the various packages. An all-electric design reduces GHG emissions 40-50% in most cases relative to a comparable mixed fuel design.

¹ <https://encinitasca.gov/Portals/0/City%20Documents/Documents/City%20Manager/Climate%20Action/Residential%20Retrofit%20CES.pdf?ver=2021-05-07-165738-600>

Based on lifetime equipment cost savings (the difference in first cost for equipment and infrastructure combined with incremental replacement costs) of \$5,349 for an all-electric single family home this analysis found that the all-electric code compliant option is cost-effective in all climate zones except 1 and 16 based on TDV. (page 42)

Adding efficiency and PV [ie, non-preempted designs] to the code compliant all-electric buildings increases the cost-effectiveness in all climate zones. The Efficiency & PV Package is cost-effective when compared to a mixed fuel code compliant building in all climate zones for both single family and multifamily buildings based on both the On-Bill and TDV methodologies.

Conclusion

The PG&E-sponsored study found that all-electric buildings are cost effective when compared to mixed-use buildings, and became even more so for non-preempted designs.

Combined with our imperative need to address our Climate Emergency, the cost advantages of all-electric buildings combine to show that an ordinance with no exceptions will be favorable to the developer, the owner, and most importantly, the climate.

Thank you for your consideration.

James Wang

Cardiff

PS Another reason that an ordinance without exceptions is that the burning of natural gas, especially in stoves that are indoors, emits large quantities of hazardous (but odorless and virtually undetectable) gases. It's demonstrated in this two-minute video:

<https://youtu.be/1ws8KSewOsk>

Health safety is yet another reason that natural gas should not be used.

Crystal Najera

From: JP Bruner <jp@surfridersd.org>
Sent: Friday, May 28, 2021 12:20 PM
To: Climate Action
Cc: Laura Walsh
Subject: Proposed Green Building Ordinance
Attachments: Proposed Green Building Ordinance Surfrider Comments.pdf

[NOTICE: Caution: External Email]

Hello,

Please see the attachment with comments related to the Green Building Ordinance from the Surfrider Foundation San Diego County Chapter.

Thank you,

--

J.P. Bruner | Climate Change Committee Co-Lead | [Surfrider Foundation San Diego](#) |
he/ him/ his
M: 949.547.6933 | jp@surfridersd.org



To: The City of Encinitas
505 S Vulcan Ave, Encinitas, CA 92024

Re: Proposed Green Building Ordinance

The Surfrider Foundation San Diego County is a non-profit organization dedicated to the protection of our ocean, waves, and beaches. We recognize the climate crisis as one of the greatest threats to the ocean today and host a climate committee currently focused on regional mitigation opportunities. We support the City's move towards all electric new construction. However, in line with the climate emergency declaration from the City of Encinitas, **we recommend removing the below 'exceptions' for new natural gas infrastructure installation from the Green Building Ordinance.**

We commend the City's effort to seek to ensure affordable housing within the community, and we do not believe that the below exceptions will result in any measurable cost tradeoffs to low income residents. Many of the exceptions as currently proposed run the risk of increasing housing costs due to the high price of installing new fossil fuel infrastructure, the increasing price of gas prices, and the high cost of retrofitting in the future.

The following 'exceptions' should be removed from the ordinance:

Residential Gas Stoves: Homes with gas stoves can contain [up to 4 times the amount of nitrous oxide](#) than homes with electric stoves, often resulting in levels of indoor air pollution that would be illegal outdoors. 12 million Californians regularly breathe indoor air that [fails to meet EPA standards](#) for outdoor air quality due to the burning of natural gas. On top of the climate impacts of burning gas, the pollution from cooking with gas indoors is unregulated and poses a great health risk to occupants. These impacts are often more common for lower income and smaller dwelling units with less open air and space. As the City seeks to achieve its affordable housing goals, it should not be facilitating unsafe and unhealthy housing.

Central Water Heating in Multi Family Homes: Electric water heating is cheaper upfront and over the life of the equipment. In new construction, more infrastructure must be installed to incorporate gas, which ultimately raises the price of the home.

Phone: 858.800.2282 | info@surfridersd.org | surfridersd.org
3900 Cleveland Ave., Ste 201, San Diego, CA 92103



An electric home constructed today compared to a home using natural gas **results in additional annual cost savings** every year. Highly efficient all-electric equipment, such as heat pumps, are 3-5 times more efficient than conventional gas and water heaters. Therefore, electrification results in **savings** for multifamily and single family homes. Again, the City should be seeking to create affordable housing that supports low-income individuals through long-term utilities cost-savings.

Accessory Dwelling Units: For the reasons stated above, using natural gas in a newly constructed ADU will likely result in increased cost to the occupant, expose them to health risks related to burning gas, and contribute to the climate crisis.

Pools & Outdoor Fireplaces: In light of the climate emergency, the heating of recreational pools and outdoor fireplaces should not be exempt as they are in no way essential and suitable electric alternatives exist for both.

In summary, limiting new gas infrastructure as much as possible is an effective and necessary measure to address the climate crisis, improve building occupants health, and will ultimately save Encinitas residents money. We would be happy to work with the City to discuss and address this important issue and applaud your commitments to date.

Thank you,
J.P. Bruner
Climate Change Committee Chair
Surfrider Foundation San Diego County

Laura Walsh
Policy Coordinator
Surfrider Foundation San Diego County

Crystal Najera

From: Judy Berlfein <judyberlfein@gmail.com>
Sent: Monday, May 31, 2021 3:36 PM
To: Climate Action
Subject: green building ordinance

[NOTICE: Caution: External Email]

Thank you for your work on the green building ordinances. Here is my feedback.

1. Electrification is good.
2. Most natural gas usage is from space and water heating -- focus on those areas when promoting electrification.
3. Move slowly on gas ranges, since gas cooking doesn't use that much gas and if you push too hard, there will be a big backlash.
4. Finally, and most importantly --
 - educate homeowners and contractors about the value of green building (comfort, **health, safety**, decreased emissions)
 - implement and enforce current codes for improved insulation, proper heater sizing, proper duct installment, air sealing, etc. There is very little understanding on the part of the contractors and the inspectors about all of these issues. There is no point in having a great code if no one enforces it.
5. Don't let the perfect be the enemy of the good. Our city is better off with 100 pretty good homes than with 5 perfect zero energy, expensive, large homes. Keep the focus on the "average" homeowner and not on the few homeowners who can afford things like LEED ratings.
6. Offer substantial incentives for heat pumps and other items you want to encourage.
7. Learn more about existing programs in the Bay Area that are making this stuff happen already.

Thank you again for your great work!

Judy Berlfein
760-944-3761

Crystal Najera

From: Karl Aldinger <karl.alddinger@sierraclub.org>
Sent: Wednesday, May 26, 2021 6:18 PM
To: Climate Action; Crystal Najera
Cc: Harold Standerfer; Sally Prendergast
Subject: Comments for Proposed Building Electrification Ordinance
Attachments: Encinitas_MyGen_Sierra_Club_Building_Ordinanace_Comment.pdf

[NOTICE: Caution: External Email]

Hello,

Please find attached, our comments about the draft ordinance for Building Electrification from MyGen Encinitas Sierra Club and Sierra Club North County Coastal Group. Thank you for your consideration.

Sincerely,

Karl Aldinger
Conservation Organizer

Sierra Club San Diego
760-331-7885

Pronouns: He, him, his



Explore, Enjoy &
Protect the Planet

May 26, 2021

CAP Program Manager Crystal Najera
City of Encinitas

Re: Proposed Building Electrification Ordinance

Dear Ms. Najera and Encinitas city staff,

We thank the city of Encinitas for undertaking the introduction of a building electrification ordinance for new commercial and residential construction and major renovations as part of the ongoing efforts to limit greenhouse gas (GHG) emissions. This should be one of the critical steps in combating the Climate Crisis. This is also an opportunity for the city to take bold action since the declaration of a *Climate Emergency* in December of 2020 by the Encinitas city council.

We understand that these proposed changes are designed to implement certain elements of the city's award winning Climate Action Plan. This letter is offered as comment on the proposed ordinance regarding energy efficiency, building electrification and solar energy; ordinance 2021-TBD, amendments to Chapter 23.12 of the Encinitas Municipal Code.

Our comments will be limited to the proposed exceptions that permit the use of methane gas. We have concerns with a number of the exceptions in new construction projects. These exceptions serve to gut the proposed ordinance in a way that may significantly limit its positive impact. We see the move away from combustion of fossil fuels as inevitable and necessary for the survival of the planet. We strongly object to the continued development of the gas infrastructure and the hazards associated with it. This infrastructure will undoubtedly become a stranded asset, wasting money and shackling the homeowner and renter with higher energy costs in the future. We will address some of the six exceptions listed in Section D.

Exception 1 allows all residential buildings to utilize non-electric cooking appliances (including outdoor BBQs), gas for heating of pools, spas, fire pits and outdoor fireplaces. This broad exception is counter to the reductions of GHGs, and it should not be included. Electric grills can take the place of combustion grills, and homeowners still have the option of using removable propane tank combustion for grills and firepits, beyond the oversight of the city's permitting. Electric heat pump spa heaters are available by the major manufacturers and are less expensive to operate, especially when paired with solar PV, now required by Title 24. The heating of swimming pools with gas is impractical and prohibitively expensive. Finally, the impact on health from gas burning cooktops has been well documented. The release of carbon monoxide, NOx, and fine particulates in the indoor setting are particularly harmful to children, leading to increased rates of asthma and many other long term exposure health consequences. Modern induction cooktops are safe, easy to use, and provide better performance than gas. [Effects of Residential Gas Appliances on Indoor and Outdoor Air Quality and Public Health in California - UCLA Fielding School of Public Health](#) (pdf)
[Professional Chef on Her Love of Cooking with Induction](#)

Exception 3 is for Accessory Dwelling Units. This exception is not needed. ADUs are a great example of infill housing, a positive addition to the community. But there is no reason why ADUs should not be all-electric. Heat pump space heaters provide a heating and cooling solution in one unit, simplifying the build and eliminating the extra expense and maintenance of a furnace. They also provide much better comfort regulation as they operate continuously, keeping temperatures very steady, while consuming far less energy. Detached ADUs will generally require rooftop solar under Title 24, and powering the ADU's air and water heating and cooktops with this solar just makes sense. It is a mistake to saddle the landlord, renter, or family member with a fuel source that will soon go away. Future retrofitting of ADUs built today, to all-electric will be more costly than doing it right, the first time. [Consider Going All-Electric for your ADU](#)

Exception 5 permits low and high rise residential multi-family buildings to utilize central water heaters powered by gas. With water heating being the primary source of GHG in the city's buildings, especially so in MFU's because they have shared interior walls, it is antithetical to the ordinance to carve out an exception for this case. Heat pump water heaters have been used in multi-family dwelling very successfully. Encinitas should not encourage construction of MFU's with a shared hot water gas boiler system. Instead careful design that makes better use of resources with heat pump water heating should be the direction taken. Gas should not be an option in this application. [A Zero Emissions All-Electric Multifamily Construction Guide 2019 - Redwood Energy](#) (pdf)

Exception 6 indicates that "significantly" higher expense to the builder for electrification of a project is a sufficient reason to permit the installation of gas appliances. However, significantly is not defined in the code and is left to the discretion of the Developmental Services Director or designee to make a determination of the cost impact. We are concerned that this exception language could be used to skirt the intended requirements of this ordinance.

We applaud the city of Encinitas for considering an additional rebate program to incentivize the transition to electric appliances, particularly for cooktops, space heating and water heating. We understand that this would be in addition to the existing incentive programs offered by the city. Rebate programs have proven to be successful tools in the transition to electrical appliances in the home and commercial setting.

We recognize and appreciate the strong actions taken by the city in combating the climate crisis. Encinitas has taken a leadership position in creation of a large Community Choice Energy Program, development and implementation of a highly regarded Climate Action Plan, creation of safe pedestrian and bicycle transit, adoption of ordinances requiring installation of energy generating solar panels and the declaration of a *Climate Emergency*. We ask that the city continue to lead in combating the crisis through the adoption of meaningful building electrification ordinance.

Thank you,

Harold Standerfer
MyGen Encinitas - Sierra Club
haroldloyd99@gmail.com

Sally Prentergast
Chairperson North County Coastal Group, Sierra Club
sallyp123@mac.com

From: kelly.a.lyndon@gmail.com
Sent: Sunday, May 23, 2021 3:09 PM
To: Climate Action
Subject: Reduce Exceptions in the Green Building Ordinance

[NOTICE: Caution: External Email]

I applaud the city of Encinitas for its efforts to address the climate emergency by reducing natural gas usage in new buildings. However, the number of exceptions that are proposed are not consistent with the urgency of the situation. I urge you to reduce any exceptions to truly critical needs.

Residential gas stoves don't make sense to exclude. Numerous studies have shown the negative impact burning fossil gas has on health, which increases asthma rates in children. Modern induction stoves are easy to use and efficient, and are safe if children accidentally touch them.

Accessory Dwelling Units don't make sense to exclude. Running gas in addition to electricity to an ADU is more expensive. ADUs have smaller internal space, increasing the health risks of gas cooktops, and are well-suited for cost effective mini split heat pumps that provide heating and cooling in one unit.

Pools are used primarily for recreation, and shouldn't be excluded given the severity of the climate emergency. Solar thermal heating is a sustainable solution.

Any new gas infrastructure installed in buildings will lead to future stranded assets which is a waste of money, a source of potential leaks and maintenance, and will leave remaining gas customers footing the bill.

We are in a climate emergency and we need Encinitas to move quickly to stop increasing the use of fossil fuels.

Thank you,
Kelly Lyndon

Crystal Najera

From: kelly.a.lyndon@gmail.com
Sent: Monday, May 31, 2021 9:21 PM
To: Climate Action
Subject: Green Building Ordinances comment
Attachments: SDBEC Letter to Encinitas GBO.pdf

[NOTICE: Caution: External Email]

Please see attached, thank you!



31 May 2021

To: Crystal Najera, Climate Action Plan Program Administrator at the City of Encinitas

Re: Proposed Encinitas Green Building Ordinance

As members of The San Diego Building Electrification Coalition (SDBEC), we are writing to thank you for leadership in considering building electrification ordinances for new construction in Encinitas. Encinitas has always been a leader in addressing the climate crisis, which we appreciate. It is essential that we stop the use of fossil fuels in buildings as soon as possible, and starting by restricting installation of gas infrastructure in new construction is the simplest path. We urge you to minimize the number of exceptions allowing new gas connections to truly critical needs, and not just preferences.

In order to address the existential threat from the climate emergency and meet local and state greenhouse gas (GHG) reduction mandates, building electrification must begin immediately. The switch from GHG-producing natural gas¹ to increasingly clean electricity to power our buildings has already been adopted by over 40 cities across the state² who recognize that this is a cost effective solution that exists today. We are in a climate emergency and rapid urgent action is required.

Unfortunately, SDG&E and its parent company Sempra Energy, threatened by the urgent need to transition off fossil fuels in the buildings we live and work in, have launched a campaign of misinformation to sway governing bodies such as yourselves to delay the action that is needed now. SDG&E has sent letters to a few cities already, and may have sent one to you in your open comment period. We therefore want to respond to some of their false claims in case you did receive a letter from them.

SDG&E says they recognize the urgency of climate change, yet their proposed solutions, renewable natural gas³ and green hydrogen⁴, have serious issues with implementation, are expensive and are not able to scale up to meet our energy needs. Importantly, they would not be able to significantly reduce emissions. Large investments in natural gas infrastructure would be necessary to support these fuels, resulting in even more ratepayer-funded stranded assets. It should be noted that Sempra recently sold all of its remaining renewable energy projects⁵, which

¹ <https://www.eia.gov/tools/faqs/faq.php?id=73&t=11>

² <https://www.sierraclub.org/articles/2021/05/californias-cities-lead-way-gas-free-future>

³ <https://www.vox.com/energy-and-environment/2020/2/14/21131109/california-natural-gas-renewable-social-gas>

⁴ <https://www.greentechmedia.com/articles/read/green-hydrogen-in-natural-gas-pipelines-decarbonization-solution-or-pipe-dream>

⁵ <https://www.sempra.com/sempra-energy-completes-25-billion-divestiture-us-renewables-and-non-utility-natural-gas-storage>



is not the action of a company that claims to recognize the urgency to address climate change and its impacts.

SDG&E accurately states that GHG emissions reductions from the transportation sector need to be a priority. We agree that transportation emission reductions are a priority, but we need to do that in addition to building electrification. Emissions from buildings are the second highest source of GHG emissions in California⁶. GHG reduction targets will never be met if we only focus on one sector at a time.

SDG&E claims to be worried that communities of concern will be adversely affected by building electrification. The irony of that claim is that fossil fuel extraction and processing already disproportionately harm these communities⁷ and the continued use of fossil fuel in our buildings will only make this reality worse. Furthermore, the use of fossil fuels, especially from the use of gas on cooktops, produces high levels of indoor air pollution, resulting in health risks such as increases in asthma and other respiratory diseases⁸. The concentration of these air pollutants is higher in places with smaller living spaces as may be found in communities of concern.

The climate emergency demands that our communities eventually transition nearly all of our buildings to all-electric appliances. Not only is it less expensive to build all electric homes by eliminating the cost of installing gas infrastructure, it avoids additional costs to retrofit later. This is especially important for working families and communities of concern.

We encourage you to address implications to working families and unions jobs by considering policies that create clean energy jobs in long duration pump storage, geothermal, district energy systems and water recycling/reuse. These fossil-free technologies are a valuable part of our future.

We urge you to not be swayed by SDG&E's misleading claims. As a for-profit investor-owned utility, SDG&E's motive in their campaign to delay building electrification ordinances is to drive profitability for Sempra's shareholders⁹. The required solutions to the climate emergency are a threat to their business model, so they are highly motivated to slow down anything that will reduce their fossil fuel-based profits. They will not voluntarily prioritize building electrification, and must be held accountable to do the morally and fiscally responsible thing.

In closing, we urge you to support solutions that are available today. All-electric construction is cost effective and is feasible right now for new construction, with minimal exceptions. We are in a climate emergency and we need to act like it, with the help of your leadership.

⁶ <https://ww2.arb.ca.gov/research/research-green-buildings>

⁷ <https://www.latimes.com/business/story/2020-11-23/clean-energy-fossil-fuels-racial-justice>

⁸ <https://academic.oup.com/ije/article/42/6/1724/737113>

⁹ <https://www.sempra.com/sempra-energy-delivers-strong-full-year-2020-financial-and-operational-results>



Sincerely,

 Ann Feeney Strategy Committee Chair San Diego Building Electrification Coalition info@sdbec.org	 Adam Cooper Political Action Team Leader Sunrise Movement San Diego	 HAMMOND CLIMATE SOLUTIONS <i>Dynamic Action for a Sustainable Planet</i> Tara Hammond Founder & CEO Hammond Climate Solutions
 Kelly Lyndon Co-chair Building Electrification San Diego 350	 Interfaith Coalition FOR EARTH JUSTICE Philip Petrie Acting Coordinator Interfaith Coalition for Earth Justice	 Matthew Vasilakis Co-Director of Policy Climate Action Campaign
 Luke Stroth Green New Deal at UCSD	 CLIMATE JUSTICE Climate Change is a Moral Issue First Unitarian Universalist Church of San Diego Rhea and Armin Kuhlman Co-Chair, Climate Justice Team First Unitarian Universalist Church of San Diego	 Tyson Siegele Energy Analyst The Protect Our Communities Foundation
 North County NCCCA Climate Change Alliance Marian Sedio	 Susan Wayo	 SAN DIEGO COASTKEEPER Lucero Sanchez



Board Member North County Climate Change Alliance	Board Member & Secretary Center for Community Energy	Community Policy Coordinator San Diego Coastkeeper
 The Climate Reality Project® SAN DIEGO CHAPTER Marie Chen Climate Policy Team Lead The Climate Reality Project San Diego Chapter	 Maleeka Marsden Chair San Diego Green New Deal Alliance	 Suzanne Hume Educational Director & Founder CleanEarth4Kids.org
	 Peter Zahn CEO Futures Unbound	



Crystal Najera

From: Lynda Daniels <lynda6367@yahoo.com>
Sent: Saturday, May 15, 2021 11:14 AM
To: Climate Action
Subject: CLIMATE EMERGENCY

[NOTICE: Caution: External Email]

As a resident of North County for over 20 years, a member of the Sierra Club MyGen, a member of the San Diego Building Electrification Coalition (SDBEC) and an active environmentalist in my own home with an all-electric car, rooftop solar and a new electric furnace, I wish to state emphatically that Building Electrification must be a priority for all cities.

We have declared a Climate Emergency! That means **Climate Emergency Action!** We must do everything we can to reduce Green House Gases (GHG's)! Making exceptions due to comments from the plumbers, electricians, gas pipe fitters, etc. is not going to help us reduce the pollutants. We cannot please everyone and every industry. There needs to be No Exceptions! No half way measures!

For instance, ADU's (Accessory Dwelling Units) require their own electrical panel meaning it is simple to size that panel appropriately when the building is constructed – and as they require solar panels when constructed it is the best way to match usage with the solar panels and the electrical panel. The internal space is much smaller and having gas in the home is unhealthy and risky.

To help homeowners, we need rebates for those replacing gas stoves with induction stoves when we need to upgrade! Induction cooking means you will not only have Climate Benefits, but also Health Benefits, and public safety is increased (gas leaks – one explosion every day in the US), and also induction cooking increases energy efficiency!

We have ten short years – maybe less since the ice caps are melting faster than previously thought.

We have a climate emergency – let's act like it by having Climate emergency action!

Thank you

Lynda Daniels

Crystal Najera

From: Mike Harp <mikeyharp@gmail.com>
Sent: Monday, May 31, 2021 10:14 PM
To: Climate Action
Subject: Comments to the Green Building Ordinance
Attachments: COMMENTS-Encinitas.Ordinance.21-TBD_Redline.5.6.21-1-mdh.docx

[NOTICE: Caution: External Email]

My comments are attached.

Please let me know if you have any questions.

Thank You
Mike Harp
1850 Tennis Pl, Encinitas, CA 92024

Mike Harp

1850 Tennis Pl, Encinitas

Comments regarding "ORDINANCE 2021-TBD "ADOPTING AMENDMENTS TO CHAPTER 23.12 (UNIFORM CODES FOR CONSTRUCTION) OF TITLE 23 (BUILDING AND CONSTRUCTION) OF THE ENCINITAS MUNICIPAL CODE TO ADOPT THE 2019 CALIFORNIA BUILDING CODE AND CALIFORNIA GREEN BUILDING CODE WITH CERTAIN AMENDMENTS, ADDITIONS, AND DELETIONS RELATED TO ENERGY EFFICIENCY AND SOLAR ENERGY"

I am strongly opposed to this draft/proposed ordinance, as written, as it amounts to loss of freedom of choice and unnecessary risks to Encinitas Residents and businesses serviced by utilities and under the California Code. If implemented as written, it may greatly affect the quality of life of families, the businesses that are in the city and stability of our infrastructure.

California Energy code Section 110.5 states "Any natural gas system or equipment listed below may be installed" (without continuously burning pilot light). The city must make no alteration to this code to restrict the freedom of its residents.

Section D.2 of the proposed ordinance should not restrict the rights under California Energy code 110.5 or 101 "NATURAL GAS AVAILABILITY. For newly constructed buildings, natural gas is available if a gas service line can be connected to the site without a gas main extension. For addition and alteration, natural gas is available if a gas service line is connected to the existing building."

Section D and entire ordinance must have a sunset (no more than 3 years without a renewal) AND a tripwire for automatic suspension in the event of escalating electrical rates (>25%/kWh cost from 2019 (your cost study) baseline) or instability in the electric grid (evidenced by > 4 hours / year of blackouts/brownouts).

Section D.2 of the proposed ordinance must not have "Exceptions" that are adjudicated by a city employee without any metric or due process stated in the code. Make Section D.1 and D.2 exceptions permanent without city employee/director determination and fully conform to California Code 110.5. Remove "At the discretion of the Development Services Director or their designee." This is the slippery slope (likely designed into the draft) where the city employee can simply decide to no longer grant "exceptions", thereby removing any freedom of choice from residents and businesses, and making a de facto ban permanent. There must be no city employee determining what kind of house, business, food or restaurant is worthy of an exception in an undefined ordinance and at their "sole discretion" (this is fraught with all sorts of potential ethics, influence, abuse, discrimination, manipulation and bribery).

Remove Section E. The city has no business defining a term that is not in the California Energy code definition (101.1(b) (Strike "ALL ELECTRIC BUILDING" definition). The city does not have enough data (cost or energy analysis, etc.) to support this novel definition from the code, nor has the city had sufficient public comment or input for this assertion, and may invite litigation.

This is a thinly veiled slippery slope, seemingly intended to be on a full ban of natural gas service (start now with new construction, extend to all residents soon). This is evidenced in the February 25th "Green Building Workshop" slides wherein slides 32-34, presented by the Entergy Policy Initiatives Center,

counts scenarios where the city could realize a number of household/commercial categories in a “Natural Gas Ban.” Let’s be honest, the ordinance targets “new construction” and “renovation”, but we all know most groups involved in this process want a total ban on gas service. If the city choses to move forward with this misguided BAN, they should at least call the ordinance for what it is, an= “Natural Gas Ban”, instead of ‘Amendments to code’.

The city did no real work in cost benefit analysis, instead presenting city of Carlsbad analysis (February 2019).

The work does not seem to study work underway for Green hydrogen mix/ replacement of gas. If the city really wants to be in a leadership position, it should pursue this. There are pilots globally.

<https://www.greentechmedia.com/articles/read/green-hydrogen-in-natural-gas-pipelines-decarbonization-solution-or-pipe-dream>, including one by SDG&E. This supply-side change would require no expensive changes from the public and businesses in the city. SDG&E’s pilot “test pipeline injection of green hydrogen blends from 1 percent to 20 percent, starting next year”, presumably with the goal of replacement in the future. The ordinance assumes Natural Gas served through SDG&E will not be replaced by a renewable. The unintended consequence is residents could go “off grid” to propane and other freely available source outside of city jurisdiction.

This flawed proposed draft ordinance does not consider actual availability of electricity, delivered through a single channel (SDG&E infrastructure). What happens (like Texas, California during Enron) when there are blackouts/brownouts as massive new loads (millions of EVs, rapid industry decarbonization, household and commercial electrification of previous gas services) come online? Where do we get these massive quantities of new electrical generation from? Of course, the city is not concerned with this as shown there is no study on the increase in electrical supply needed from this ordinance or full city-wide electrification.

The only outcome to “banning” natural gas energy, without a resilient and capable electric grid will be rationing (as happens in Spain, Central America and other countries that do not have enough supply). Can the city guarantee electricity will be available to cook dinner or heat our homes and water in the winter? Can the city guarantee that residents will not be impacted by hyper-escalation of electric rates when electricity becomes scarce?

In this dystopia, Encinitas will be labeled an energy and electric-challenged city. Businesses and Investment will go to other cities with diversified energy and home values will go down. Restaurants will not be able to fully operate or compete with other cities that can run traditional kitchens and offer superior food from commercial quality kitchens. What about “time of day”, when everyone needs to eat dinner at 5-8pm, when solar and wind go offline?

When the city enacts law to reduce energy choice to a single channel (electric through a utility monopoly), without regard to other emerging technology choice, this also comes with single-channel risks from cyber, blackouts, brownouts and unintended consequences (residents and businesses acquiring generators, propane systems, etc.). Does the city have a plan to ensure sufficient and affordable energy its residents will all the other demands on the grid? I haven’t seen the studies or data.

To the contrary, the state seems to be on the path to implement AB 1139 (Gonzalez), a toxic bill that will destroy net metering for solar, removing any incentive on residents to convert to solar. Under AB 1139,

there equation for residents going solar will be a 45 year payback, which will stall any sort of renewable progress in Encinitas.

https://www.reddit.com/r/solar/comments/mw8850/ab_1139_gonzalez_and_destroying_net_metering_in/.

Let's be honest, this is not the environment to enact this ordinance or be in the lead on the issue and put your residents at risk.

Crystal Najera

From: Paige DeCino <pdecino@hotmail.com>
Sent: Friday, May 28, 2021 9:29 AM
To: Climate Action
Subject: Building electrification ordinances

[NOTICE: Caution: External Email]

To whom it may concern,

I'm writing to encourage the city of Encinitas to eliminate some of the exceptions under consideration in their building electrification ordinances as they will slow the progress in reaching greenhouse gas reduction goals. The ones I am most concerned about are listed below:

- Allowing natural gas (NG) to be used for heating pools and spas: Heating pools with natural gas is very expensive so why even allow it as a possibility? Solar thermal is the best option for pools. As for spas, I personally have heated my spa with electricity for over 30 years with reasonable costs.
- The ADU exemption doesn't make sense. These are smaller units easily accommodated by efficient electric space heating/AC (e.g., heat pump space heaters).
- Residential cooking allowing for NG as the sole exception (possibly) means plumbing NG lines to the house for a single function when there is a viable alternative - induction cooking - which is much more efficient, cleaner, and healthier than NG. Allowing this exception could also incur significant (>\$6000) cost to construction.

I encourage the city to work toward their strong climate action goals and climate emergency declaration by seriously considering the need of most of the exceptions to the proposed ordinances. At the workshop earlier in the month, I think a request to look at the effect of these exceptions on GHG emissions was put forward. I hope that data is available when council has a chance to consider the ordinances.

Best regards, 
Paige DeCino

Crystal Najera

From: Peter Davis <peterdca@me.com>
Sent: Monday, May 31, 2021 2:17 PM
To: Climate Action
Subject: Comments on Draft Green Building Ordinance

[NOTICE: Caution: External Email]

I am writing to express my appreciation to Crystal Najera, city staff, and EPIC consultants for their hard work on developing ordinances requiring solar PV for non-residential buildings, energy efficiency retrofits of residential and non-residential buildings, and electrification of new construction of residential and non-residential buildings. However, I have concerns regarding exceptions 1, 3, 5, and 6, as detailed in the comments from Harold Standerfer of the Encinitas Sierra Club MyGen team and Sally Prendergast, Chairperson of the Sierra Club North County Coastal Group.

During my participation in the Green Building Stakeholder Committee, I was impressed by the documents from Redwood Energy shared by city staff that addressed: 1) the significant negative public health effects of cooking with natural gas, 2) the cost savings associated with avoidance of natural gas infrastructure in new construction, 3) the significant greenhouse gas emissions arising from natural gas usage (both operational and related to methane leakage within the gas delivery system), 4) the public safety risks associated with natural gas usage (i.e., fires from gas line rupture), and 5) the reduced operational costs associated with all-electric buildings. In addition, these documents highlighted the available technology for single family (SF), multi-family (MF), and commercial buildings. Specifically, these All-Electric Product Guides included heat pump water heaters (HPWH), HVAC systems, radiant ranges, induction cooktops, induction ranges and ovens (both residential and commercial), fryers, laundry dryers, landscaping tools, fireplaces, barbecues, and swimming pool and hot tub heaters. Finally, these SF, MF, and commercial electrification guides also provide all-electric building case studies ranging from large commercial buildings to small single family homes.

My views are also informed by the work of the Building Decarbonization Coalition (BDC), which is well summarized in their January 2021 Recommendations for Gas Transition Regulatory Proceedings at the California Public Utilities Commission (<https://drive.google.com/file/d/13bmk0GcEyZ3tOwk3S13YW5D8Ue3QIRfA/view>). In this document one finds support for the argument that the transition to all-electric construction of SF, MF, and commercial buildings has already begun, and that declining gas throughput will leave those least able to transition to all-electric appliances (i.e., renters and low-income homeowners) burdened by rising gas prices required to maintain the safety and reliability of the remaining gas system infrastructure.

Expanding the current gas infrastructure system does not seem to make sense on a number of levels. As this ordinance development process moves forward, I strongly encourage the Environmental Commission and the City Council to critically examine the need for any and all exceptions. Failure to build new buildings, especially the MF developments needed to comply with the most recent Housing Element Update, using currently available all-electric technology would seem to be a missed opportunity that would likely lead to future regret. This is especially true given the fact that Encinitas is less than one year away from complete execution of its 100% renewable energy offering through its participation with San Diego Community Power.

Finally, I am very supportive of all efforts to provide incentives for building electrification. I very much appreciate the efforts by staff in this regard.

Thank-you for your dedicated public service.

Sincerely,

Peter Davis

Crystal Najera

From: Peter Zahn <peterezahn@gmail.com>
Sent: Monday, May 31, 2021 1:04 PM
To: Climate Action
Subject: Draft Ordinance 2021-TBD Rev 5-7-21

[NOTICE: Caution: External Email]

Dear Sir/Madam --

I commend city staff and the stakeholder committee for its work on the draft ordinance.

It represents a great advance toward addressing the reduction of GHG's from Encinitas's built environment, and improving indoor health and wellness.

I urge the city to move forward to consideration of a final draft ordinance at the earliest possible time.

Best wishes,
Peter Zahn

Peter Zahn
Member, Solana Beach Climate Action Commission

Electrification Ordinance Exceptions – Greenhouse Gas Analysis

A draft local ordinance for the City of Encinitas was developed to require all-electric construction of new residential and non-residential buildings with some exceptions for natural gas. This document summarizes the foregone greenhouse gas (GHG) emissions reductions¹ associated with those exceptions included in the draft ordinance.²

Table 1 provides the estimated foregone GHG emissions reductions in year 2030 for the six exceptions to all-electric construction. These emissions are the result of natural gas consumption in new residential and non-residential projects that meet one or more of the exceptions listed.³

Table 1. Foregone GHG Reductions in 2030 from Ordinance All-Electric Exceptions

Exception *	Foregone GHG Reductions in 2030 (MT CO ₂ e)
Exception 1: Residential cooking appliances, pool and spa water heaters, and outdoor fireplaces	45
Exception 2: Essential facilities	Unknown
Exception 3: Accessory dwelling units	654
Exception 4: Restaurant cooking equipment	20
Exception 5: High-rise residential central water heater	0
Exception 6: Local utility infrastructure design requirements	Unknown

* Refer to draft ordinance for full exception language

A breakdown of how foregone reductions were calculated for each exception is provided below, including: data sources, assumptions, and constraints.

Exception 1. Exception 1 to the all-electric requirements permit natural gas consumption for select residential end uses including: cooking appliances (including outdoor BBQs), pool and spa heaters, and outdoor fireplaces (including common area fireplaces and fire rings).

Table 2 documents the expected number of new single- and multi-family residential units to be built by 2030 with a qualifying exempted end-use and the associated natural gas consumption and foregone GHG reductions in 2030 as a result of the exception.

¹ Estimated foregone GHG emissions reductions are those emissions that would likely occur as a result of one or more exception.

² Based on the June 21, 2021 draft ordinance, which incorporates feedback on exceptions from the City's Environmental Commission provided during the June 10, 2021 Environmental Commission Meeting.

³ These estimates assume a natural gas emission factor of 0.005472 MT CO₂e/therm for natural gas and zero emissions from electricity consumption, consistent with the City's 2020 CAP update.

Table 2. Foregone GHG Reductions in 2030 for Select Residential End-Uses Exception

Residential End-Use	# of Units with Exception	Natural Gas Consumption (therm/unit-year)	Foregone GHG Reductions in 2030 (MT CO ₂ e/unit)	Total Foregone GHG Reductions in 2030 (MT CO ₂ e)
Single-Family Residential Units				
Cooking Appliances	23	18	0.10	2.3
Pool Heater	1	134	0.73	1.1
Spa Heater	3	37	0.20	0.5
Outdoor Fireplaces*	NA	NA	NA	NA
Multi-Family Residential Units				
Cooking Appliances	667	28	0.15	41
Pool Heater*	NA	NA	NA	NA
Spa Heater*	NA	NA	NA	NA
Outdoor Fireplaces*	NA	NA	NA	NA

* Insufficient data were available on (1) the number of single- and/or multi-family units that would trigger the exception for the particular appliance and/or (2) the natural gas consumption associated with the appliance for the particular residential unit type.

An estimated 34 new single family and 1,449 new multi-family units are expected to be built by 2030.⁴ The number of units that would likely use natural gas for each end-use and the average annual natural gas consumption per unit by end use are based current appliance saturations in the SDG&E territory.⁵

For single-family residential units, 69% are likely to use natural gas for cooking, 4% for pool heating, and 7% for spa heating. It is unclear how many units typically install a plumbed gas outdoor fireplace and the foregone GHG reductions are expected to be low for this end-use, as residential users would likely switch to propane instead of electricity if the exception were removed.

Multi-family units are likely to use natural gas for cooking in 35% of units. Data for other exempted end uses were insufficient to determine the number of multi-family buildings with a pool, spa, and/or outdoor fireplace, as well as the average annual natural gas consumption. For this reason, foregone GHG emissions from multi-family units are not estimated except for cooking equipment. However, anecdotal evidence suggests that foregone emissions from these end uses are likely minimal relative to those associated with cooking equipment.

Exception 2. Exception 2 to the all-electric requirements permits Essential Facilities⁶ to use mixed-fuel consumption, including natural gas.

It is unknown how many newly constructed buildings will qualify as an Essential Facility for the purposes of this ordinance. As such, foregone GHG emissions reductions cannot be estimated at this time. It is

⁴ Based on data included in the 2020 CAP update and the [City of Encinitas Housing Update 2021-2029](#)

⁵ [2019 CA Residential Appliance Saturation Survey](#). Additional data was provided to EPIC by California Energy Commission staff.

⁶ Essential Facilities as defined by CBC, Part 2, Section 202 that include public agency owned and operated emergency centers.

anticipated, however, that few buildings would trigger this exception between adoption of the ordinance and 2030.

Exception 3. Exception 3 to the all-electric requirements exempts accessory dwelling units (ADUs) from the all-electric requirement and permits mixed-fuel development for both attached and detached ADUs.

Table 3 documents the expected number of new attached and detached accessory dwelling units to be built by 2030 and the associated natural gas consumption and foregone GHG reductions in 2030 as a result of the exception.

Table 3. Foregone GHG Reductions in 2030 by ADU Type

Accessory Dwelling Unit (ADU) Type	# of Units with Exception	Natural Gas Consumption (therm/unit-year)	Foregone GHG Reductions in 2030 (MT CO ₂ e/unit)	Total Foregone GHG Reductions in 2030 (MT CO ₂ e)
Attached ADUs	328	119	0.65	214
Detached ADUs	676	119	0.65	440

Historic building permit data⁷ were used to determine the average annual number of new ADUs built in Encinitas and the proportion of attached and detached units. A total of 1,004 new ADUs are expected to be built by 2030, with 33% of those units attached and 67% detached. A statewide cost-effectiveness study for ADUs was used to determine the annual natural gas consumption per unit for ADUs in Climate Zone 7 and SDG&E territory.⁸

Exception 4. Exception 4 to the all-electric requirements permits for-profit restaurants that demonstrate a business-related need to cook with flame that cannot be reasonably achieved with an electric fuel source to use natural gas. This applies to restaurant cooking equipment only and does not permit natural gas consumption for non-cooking related end-uses.

Table 4 documents the expected number of new restaurants to be built by 2030 that would qualify for this exception and the associated natural gas consumption and foregone GHG reductions in 2030 as a result of the exception.

Table 4. Foregone GHG Reductions in 2030 for Restaurant Exception

Restaurant Type	# of Units with Exception	Natural Gas Consumption (therm/unit-year)	Foregone GHG Reductions in 2030 (MT CO ₂ e/unit)	Total Foregone GHG Reductions in 2030 (MT CO ₂ e)
Restaurants with exception	1	3,593	20	20

Historic building permit⁹ and restaurant licensing data¹⁰ were used to determine the average number of new restaurants built per year in Encinitas and to estimate the proportion of restaurants that require a

⁷ Provided by City staff. Average annual number of new ADUs built are based on last three years (2019-2020) of data. Building permits were reviewed to determine the proportion of attached to detached ADUs.

⁸ [2020 Reach Code Cost-Effectiveness Analysis: Detached Accessory Dwelling Units](#)

⁹ Provided by City staff. Average annual number of new restaurants built are based on last ten years (2011-2020) of data.

¹⁰ Provided by City staff. City staff estimated the number of currently licensed restaurants that require a flame for cooking.

flame for cooking. Eight new restaurants are expected to be built by 2030 and 15%, or 1 restaurant, are anticipated to qualify for the exception. Annual natural gas consumption for cooking in restaurants was estimated using the average restaurant size¹¹ and average cooking energy intensity¹² (kBtu/ft²) in the SDG&E territory.

Exception 5. Exception 5 to the all-electric requirements permits new high-rise (four stories or greater) residential multi-family buildings served by a common, central water heater to use natural gas for water heating.

As noted under Exception 1, the City anticipates building 1,449 new multi-family units by 2030 as identified in the recently adopted Housing Element. However, all projects identified in the Housing Element are expected to be low-rise (three stories or fewer) multi-family residential buildings consistent with current zoning requirements.¹³ As a result, no future projects are not anticipated to qualify for this exception, resulting in zero foregone emissions reductions.

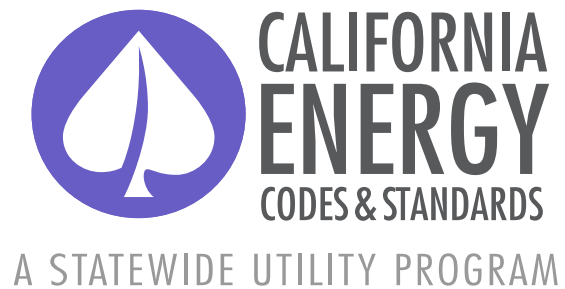
Exception 6. Exception 6 to the all-electric requirements allows the Development Services Director to exempt new construction projects from the all-electric requirement if there is a documented significant cost to the project applicant resulting from utility infrastructure upgrades.

It is unclear how many newly constructed residential and nonresidential buildings will qualify for this exception because of significant project costs resulting from local utility infrastructure limitations. As such, foregone GHG emissions reductions cannot be estimated at this time. It is anticipated, however, that few buildings would trigger this exception between adoption of the ordinance and 2030.

¹¹ [2014 CA Commercial Saturation Survey Report](#)

¹² [2006 CA Commercial End Use Survey](#)

¹³ Some projects may apply for a density bonus that will permit high-rise development, however, it is may unknown if any will do so.



Title 24, Parts 6 and 11
Local Energy Efficiency Ordinances

2019 Cost-effectiveness Study: Low-Rise Residential New Construction

Prepared for:
Kelly Cunningham
Codes and Standards Program
Pacific Gas and Electric Company

Prepared by:
Frontier Energy, Inc.
Misti Bruceri & Associates, LLC

Last Modified: August 01, 2019

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Acronyms

2020 PV\$	Present value costs in 2020
ACH50	Air Changes per Hour at 50 pascals pressure differential
ACM	Alternative Calculation Method
AFUE	Annual Fuel Utilization Efficiency
B/C	Lifecycle Benefit-to-Cost Ratio
BEopt	Building Energy Optimization Tool
BSC	Building Standards Commission
CAHP	California Advanced Homes Program
CBECC-Res	Computer program developed by the California Energy Commission for use in demonstrating compliance with the California Residential Building Energy Efficiency Standards
CFI	California Flexible Installation
CFM	Cubic Feet per Minute
CMFNH	California Multifamily New Homes
CO ₂	Carbon Dioxide
CPC	California Plumbing Code
CZ	California Climate Zone
DHW	Domestic Hot Water
DOE	Department of Energy
DWHR	Drain Water Heat Recovery
EDR	Energy Design Rating
EER	Energy Efficiency Ratio
EF	Energy Factor
GHG	Greenhouse Gas
HERS Rater	Home Energy Rating System Rater
HPA	High Performance Attic
HPWH	Heat Pump Water Heater
HSPF	Heating Seasonal Performance Factor
HVAC	Heating, Ventilation, and Air Conditioning
IECC	International Energy Conservation Code
IOU	Investor Owned Utility
kBtu	kilo-British thermal unit
kWh	Kilowatt Hour
LBNL	Lawrence Berkeley National Laboratory

LCC	Lifecycle Cost
LLAHU	Low Leakage Air Handler Unit
VLLDCS	Verified Low Leakage Ducts in Conditioned Space
MF	Multifamily
NAECA	National Appliance Energy Conservation Act
NEEA	Northwest Energy Efficiency Alliance
NEM	Net Energy Metering
NPV	Net Present Value
NREL	National Renewable Energy Laboratory
PG&E	Pacific Gas and Electric Company
PV	Photovoltaic
SCE	Southern California Edison
SDG&E	San Diego Gas and Electric
SEER	Seasonal Energy Efficiency Ratio
SF	Single Family
CASE	Codes and Standards Enhancement
TDV	Time Dependent Valuation
Therm	Unit for quantity of heat that equals 100,000 British thermal units
Title 24	Title 24, Part 6
TOU	Time-Of-Use
UEF	Uniform Energy Factor
ZNE	Zero-net Energy

1 Introduction

The California Building Energy Efficiency Standards Title 24, Part 6 (Title 24) (Energy Commission, 2018b) is maintained and updated every three years by two state agencies, the California Energy Commission (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, the 2019 Building Energy Efficiency Standards, effective January 1, 2020, for new single family and low-rise (one- to three-story) multifamily residential construction. The analysis includes evaluation of both mixed fuel and all-electric homes, documenting that the performance requirements can be met by either type of building design. Compliance package options and cost-effectiveness analysis in all sixteen California climate zones (CZs) are presented (see Appendix A – California Climate Zone Map for a graphical depiction of Climate Zone locations). All proposed package options include a combination of efficiency measures and on-site renewable energy.

2 Methodology and Assumptions

This analysis uses two different metrics to assess cost-effectiveness. Both methodologies require estimating and quantifying the incremental costs and energy savings associated with energy efficiency measures. The main difference between the methodologies is the manner in which they value energy and thus the cost savings of reduced or avoided energy use.

- **Utility Bill Impacts (On-Bill):** Customer-based Lifecycle Cost (LCC) approach that values energy based upon estimated site energy usage and customer on-bill savings using electricity and natural gas utility rate schedules over a 30-year duration accounting for discount rate and energy cost inflation.
- **Time Dependent Valuation (TDV):** Energy Commission LCC methodology, which is intended to capture the “societal value or cost” of energy use including long-term projected costs such as the cost of providing energy during peak periods of demand and other societal costs such as projected costs for carbon emissions, as well as grid transmission and distribution impacts. This metric values energy use differently depending on the fuel source (gas, electricity, and propane), time of day, and season. Electricity used (or saved) during peak periods has a much higher value than electricity used (or saved) during off-peak periods (Horie et al., 2014). This is the methodology used by the Energy Commission in evaluating cost-effectiveness for efficiency measures in Title 24, Part 6.

2.1 Building Prototypes

The Energy Commission defines building prototypes which it uses to evaluate the cost-effectiveness of proposed changes to Title 24 requirements. At the time that this report was written, there are two single family prototypes and one low-rise multifamily prototype. All three are used in this analysis in development of the above-code packages. Table 1 describes the basic characteristics of each prototype. Additional details on the prototypes can be found in the Alternative Calculation Method (ACM) Approval Manual (Energy Commission, 2018a). The prototypes have equal geometry on all walls, windows and roof to be orientation neutral.



Table 1: Prototype Characteristics

Characteristic	Single Family One-Story	Single Family Two-Story	Multifamily
Conditioned Floor Area	2,100 ft ²	2,700 ft ²	6,960 ft ² : (4) 780 ft ² & (4) 960 ft ² units
Num. of Stories	1	2	2
Num. of Bedrooms	3	3	(4) 1-bed & (4) 2-bed units
Window-to-Floor Area Ratio	20%	20%	15%

Source: 2019 Alternative Calculation Method Approval Manual (California Energy Commission, 2018a).

The Energy Commission's protocol for single family prototypes is to weight the simulated energy impacts by a factor that represents the distribution of single-story and two-story homes being built statewide, assuming 45 percent single-story and 55 percent two-story. Simulation results in this study are characterized according to this ratio, which is approximately equivalent to a 2,430-square foot (ft²) house.¹

The methodology used in the analyses for each of the prototypical building types begins with a design that precisely meets the minimum 2019 prescriptive requirements (zero compliance margin). Table 150.1-A in the 2019 Standards (Energy Commission, 2018b) lists the prescriptive measures that determine the baseline design in each climate zone. Other features are consistent with the Standard Design in the ACM Reference Manual (Energy Commission, 2019), and are designed to meet, but not exceed, the minimum requirements. Each prototype building has the following features:

- Slab-on-grade foundation.
- Vented attic.
- High performance attic in climate zones where prescriptively required (CZ 4, 8-16) with insulation installed at the ceiling and below the roof deck per Option B. (Refer to Table 150.1-A in the 2019 Standards.)
- Ductwork located in the attic for single family and within conditioned space for multifamily.

Both mixed fuel and all-electric prototypes are evaluated in this study. While in past code cycles an all-electric home was compared to a home with gas for certain end-uses, the 2019 code includes separate prescriptive and performance paths for mixed-fuel and all-electric homes. The fuel specific characteristics of the mixed fuel and all-electric prototypes are defined according to the 2019 ACM Reference Manual and described in Table 2.²

¹ 2,430 ft² = (45% x 2,100 ft²) + (55% x 2,700 ft²)

² Standards Section 150.1(c)8.A.iv.a specifies that compact hot water distribution design and a drain water heat recovery system or extra PV capacity are required when a heat pump water heater is installed prescriptively. The efficiency of the distribution and the drain water heat recovery systems as well as the location of the water heater applied in this analysis are based on the Standard Design assumptions in CBECC-Res which result in a zero-compliance margin for the 2019 basecase model.



Table 2: Characteristics of the Mixed Fuel vs All-Electric Prototype

Characteristic	Mixed Fuel	All-Electric
Space Heating/Cooling¹	Gas furnace 80 AFUE Split A/C 14 SEER, 11.7 EER	Split heat pump 8.2 HSPF, 14 SEER, 11.7 EER
Water Heater^{1,2, 3, 4}	Gas tankless UEF = 0.81	50gal HPWH UEF = 2.0 SF: located in the garage MF CZ 2,4,6-16: located in living space MF CZ 1,3,5: located in exterior closet
Hot Water Distribution	Code minimum. All hot water lines insulated	Basic compact distribution credit, (CZ 6-8,15) Expanded compact distribution credit, compactness factor = 0.6 (CZ 1-5,9-14,16)
Drain Water Heat Recovery Efficiency	None	CZ 1: unequal flow to shower = 42% CZ 16: equal flow to shower & water heater = 65% None in other CZs
Cooking	Gas	Electric
Clothes Drying	Gas	Electric

¹Equipment efficiencies are equal to minimum federal appliance efficiency standards.

²The multifamily prototype is evaluated with individual water heaters. HPWHs located in the living space do not have ducting for either inlet or exhaust air; CBECC-Res does not have the capability to model ducted HPWHs.

³UEF = uniform energy factor. HPWH = heat pump water heater. SF = single family. MF = multifamily.

⁴CBECC-Res applies a 50gal water heater when specifying a storage water heater. Hot water draws differ between the prototypes based on number of bedrooms.

2.2 Measure Analysis

The California Building Energy Code Compliance simulation tool, CBECC-RES 2019.1.0, was used to evaluate energy impacts using the 2019 Title 24 prescriptive standards as the benchmark, and the 2019 TDV values. TDV is the energy metric used by the Energy Commission since the 2005 Title 24 energy code to evaluate compliance with the Title 24 standards.

Using the 2019 baseline as the starting point, prospective energy efficiency measures were identified and modeled in each of the prototypes to determine the projected energy (Therm and kWh) and compliance impacts. A large set of parametric runs were conducted to evaluate various options and develop packages of measures that exceed minimum code performance. The analysis utilizes a parametric tool based on Micropas³ to automate and manage the generation of CBECC-Res input files. This allows for quick evaluation of various efficiency measures across multiple climate zones and prototypes and improves quality control. The batch process functionality of CBECC-Res is utilized to simulate large groups of input files at once. Annual utility costs were calculated using hourly data output from CBECC-Res and electricity and natural gas tariffs for each of the investor owned utilities (IOUs).

³ Developed by Ken Nittler of Enercomp, Inc.



The Reach Codes Team selected packages and measures based on cost-effectiveness as well as decades of experience with residential architects, builders, and engineers along with general knowledge of the relative acceptance of many measures.

2.2.1 Federal Preemption

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. Since state and local governments are prohibited from adopting policies that mandate 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. While this study is limited by federal preemption, in practice builders may use any package of compliant measures to achieve the performance goals, including high efficiency appliances. Often, these measures are the simplest and most affordable measures to increase energy performance.

2.2.2 Energy Design Rating

The 2019 Title 24 code introduces California's Energy Design Rating (EDR) as the primary metric to demonstrate compliance with the energy code. EDR is still based on TDV but it uses a building that is compliant with the 2006 International Energy Conservation Code (IECC) as the reference building. The reference building has an EDR score of 100 while a zero-net energy (ZNE) home has an EDR score of zero (Energy Commission, 2018d). See Figure 1 for a graphical representation of this. While the Reference Building is used to determine the rating, the Proposed Design is still compared to the Standard Design based on the prescriptive baseline assumptions to determine compliance.

The EDR is calculated by CBECC-Res and has two components:

1. An "Efficiency EDR" which represents the building's energy use without solar generation.⁴
2. A "Total EDR" that represents the final energy use of the building based on the combined impact of efficiency measures, PV generation and demand flexibility.

For a building to comply, two criteria are required:

- (1) the proposed Efficiency EDR must be equal to or less than the Efficiency EDR of the Standard Design, and
- (2) the proposed Total EDR must be equal to or less than the Total EDR of the Standard Design.

Single family prototypes used in this analysis that are minimally compliant with the 2019 Title 24 code achieve a Total EDR between 20 and 35 in most climates.

This concept, consistent with California's "loading order" which prioritizes energy efficiency ahead of renewable generation, requires projects meet a minimum Efficiency EDR before PV is credited but allows for PV to be traded off with additional efficiency when meeting the Total EDR. A project may improve on building efficiency beyond the minimum required and subsequently reduce the PV generation capacity required to achieve the required Total EDR but may not increase the size of the PV system and trade this off with a reduction of efficiency measures. Figure 1 graphically summarizes how both Efficiency EDR and PV / demand flexibility EDR are used to calculate the Total EDR used in the 2019 code and in this analysis.

⁴ While there is no compliance credit for solar PV as there is under the 2016 Standards, the credit for installing electric storage battery systems that meet minimum qualifications can be applied to the Efficiency EDR.



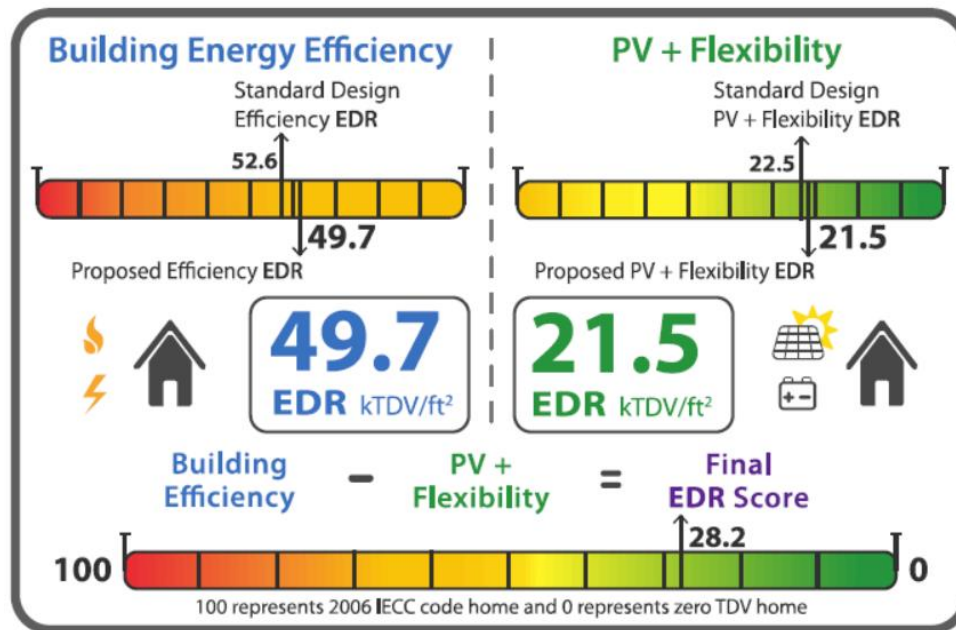


Figure 1: Graphical description of EDR scores (courtesy of Energy Code Ace⁵)

Results from this analysis are presented as EDR Margin, a reduction in the EDR score relative to the Standard Design. EDR Margin is a better metric to use than absolute EDR in the context of a reach code because absolute values vary, based on the home design and characteristics such as size and orientation. This approach aligns with how compliance is determined for the 2019 Title 24 code, as well as utility incentive programs, such as the California Advanced Homes Program (CAHP) & California Multifamily New Homes (CMFNH), which require minimum performance criteria based on an EDR Margin for low-rise residential projects. The EDR Margin is calculated according to Equation 1 for the two efficiency packages and Equation 2 for the Efficiency & PV and Efficiency & PV/Battery packages (see Section 2.3).

Equation 1

$$EDR\ Margin_{efficiency} = Standard\ Design\ \textbf{Efficiency}\ EDR - Proposed\ Design\ \textbf{Efficiency}\ EDR$$

Equation 2

$$EDR\ Margin_{efficiency\ \&\ PV} = Standard\ Design\ \textbf{Total}\ EDR - Proposed\ Design\ \textbf{Total}\ EDR$$

2.2.3 Energy Efficiency Measures

Following are descriptions of each of the efficiency measures evaluated under this analysis. Because not all of the measures described below were found to be cost-effective and cost-effectiveness varied by climate zone, not all measures are included in all packages and some of the measures listed are not included in any final package. For a list of measures included in each efficiency package by climate zone, see Appendix D – Single Family Measure Summary and Appendix F – Multifamily Measure Summary.

Reduced Infiltration (ACH50): Reduce infiltration in single family homes from the default infiltration assumption of five (5) air changes per hour at 50 Pascals (ACH50)⁶ by 40 to 60 percent to either 3 ACH50 or 2 ACH50. HERS

⁵ <https://energycodeace.com/>

⁶ Whole house leakage tested at a pressure difference of 50 Pascals between indoors and outdoors.



rater field verification and diagnostic testing of building air leakage according to the procedures outlined in the 2019 Reference Appendices RA3.8 (Energy Commission, 2018c). This measure was not applied to multifamily homes because CBECC-Res does not allow reduced infiltration credit for multifamily buildings.

Improved Fenestration: Reduce window U-factor to 0.24. The prescriptive U-factor is 0.30 in all climates. In climate zones 1, 3, 5, and 16 where heating loads dominate, an increase in solar heat gain coefficient (SHGC) from the default assumption of 0.35 to 0.50 was evaluated in addition to the reduction in U-factor.

Cool Roof: Install a roofing product that's rated by the Cool Roof Rating Council to have an aged solar reflectance (ASR) equal to or greater than 0.25. Steep-sloped roofs were assumed in all cases. Title 24 specifies a prescriptive ASR of 0.20 for Climate Zones 10 through 15 and assumes 0.10 in other climate zones.

Exterior Wall Insulation: Decrease wall U-factor in 2x6 walls to 0.043 from the prescriptive requirement of 0.048 by increasing exterior insulation from one-inch R-5 to 1-1/2 inch R-7.5. This was evaluated for single family buildings only in all climate zones except 6 and 7 where the prescriptive requirement is higher (U-factor of 0.065) and improving beyond the prescriptive value has little impact.

High Performance Attics (HPA): HPA with R-38 ceiling insulation and R-30 insulation under the roof deck. In climates where HPA is already required prescriptively this measure requires an incremental increase in roof insulation from R-19 or R-13 to R-30. In climates where HPA is not currently required (Climate Zones 1 through 3, and 5 through 7), this measure adds roof insulation to an uninsulated roof as well as increasing ceiling insulation from R-30 to R-38 in Climate Zones 3, 5, 6 and 7.

Slab Insulation: Install R-10 perimeter slab insulation at a depth of 16-inches. For climate zone 16, where slab insulation is required, prescriptively this measure increases that insulation from R-7 to R-10.

Duct Location (Ducts in Conditioned Space): Move the ductwork and equipment from the attic to inside the conditioned space in one of the three following ways.

1. Locate ductwork in conditioned space. The air handler may remain in the attic provided that 12 linear feet or less of duct is located outside the conditioned space including the air handler and plenum. Meet the requirements of 2019 Reference Appendices RA3.1.4.1.2. (Energy Commission, 2018c)
2. All ductwork and equipment located entirely in conditioned space meeting the requirements of 2019 Reference Appendices RA3.1.4.1.3. (Energy Commission, 2018c)
3. All ductwork and equipment located entirely in conditioned space with ducts tested to have less than or equal to 25 cfm leakage to outside. Meet the requirements of Verified Low Leakage Ducts in Conditioned Space (VLLDCS) in the 2019 Reference Appendices RA3.1.4.3.8. (Energy Commission, 2018c)

Option 1 and 2 above apply to single family only since the basecase for multifamily assumes ducts are within conditioned space. Option 3 applies to both single family and multifamily cases.

Reduced Distribution System (Duct) Leakage: Reduce duct leakage from 5% to 2% and install a low leakage air handler unit (LLAHU). This is only applicable to single family homes since the basecase for multifamily assumes ducts are within conditioned space and additional duct leakage credit is not available.

Low Pressure Drop Ducts: Upgrade the duct distribution system to reduce external static pressure and meet a maximum fan efficacy of 0.35 Watts per cfm for gas furnaces and 0.45 Watts per cfm for heat pumps operating at full speed. This may involve upsizing ductwork, reducing the total effective length of ducts, and/or selecting low pressure drop components such as filters. Fan watt draw must be verified by a HERS rater according to the procedures outlined in the 2019 Reference Appendices RA3.3 (Energy Commission, 2018c). New federal regulations that went into effect July 3, 2019 require higher fan efficiency for gas furnaces than for heat pumps and air handlers, which is why the recommended specification is different for mixed fuel and all-electric homes.



HERS Verification of Hot Water Pipe Insulation: The California Plumbing Code (CPC) requires pipe insulation on all hot water lines. This measure provides credit for HERS rater verification of pipe insulation requirements according to the procedures outlined in the 2019 Reference Appendices RA3.6.3. (Energy Commission, 2018c)

Compact Hot Water Distribution: Two credits for compact hot water distribution were evaluated.

1. **Basic Credit:** Design the hot water distribution system to meet minimum requirements for the basic compact hot water distribution credit according to the procedures outlined in the 2019 Reference Appendices RA4.4.6 (Energy Commission, 2018c). In many single family homes this may require moving the water heater from an exterior to an interior garage wall. Multifamily homes with individual water heaters are expected to easily meet this credit with little or no alteration to plumbing design. CBECC-Res software assumes a 30% reduction in distribution losses for the basic credit.
2. **Expanded Credit:** Design the hot water distribution system to meet minimum requirements for the expanded compact hot water distribution credit according to the procedures outlined in the 2019 Reference Appendices RA3.6.5 (Energy Commission, 2018c). In addition to requiring HERS verification that the minimum requirements for the basic compact distribution credit are met, this credit also imposes limitations on pipe location, maximum pipe diameter, and recirculation system controls allowed.

Drain Water Heat Recovery (DWHR): For multifamily buildings add DWHR that serves the showers in an unequal flow configuration (pre-heated water is piped directly to the shower) with 50% efficiency. This upgrade assumes all apartments are served by a DWHR with one unit serving each apartment individually. For a slab-on-grade building this requires a horizontal unit for the first-floor apartments.

Federally Preempted Measures:

The following additional measures were evaluated. Because these measures require upgrading appliances that are federally regulated to high efficiency models, they cannot be used to show cost-effectiveness in a local ordinance. The measures and packages are presented here to show that there are several options for builders to meet the performance targets. Heating and cooling capacities are autosized by CBECC-Res in all cases.

High Efficiency Furnace: For the mixed-fuel prototypes, upgrade natural gas furnace to one of two condensing furnace options with an efficiency of 92% or 96% AFUE.

High Efficiency Air Conditioner: For the mixed-fuel prototypes, upgrade the air conditioner to either single-stage SEER 16 / EER 13 or two-stage SEER 18 / EER 14 equipment.

High Efficiency Heat Pump: For the all-electric prototypes, upgrade the heat pump to either single-stage SEER 16 / EER 13 / HSPF 9 or two-stage SEER 18 / EER 14 / HSPF 10 equipment.

High Efficiency Tankless Water Heater: For the mixed-fuel prototype, upgrade tankless water heater to a condensing unit with a rated Uniform Energy Factor (UEF) of 0.96.

High Efficiency Heat Pump Water Heater (HPWH): For the all-electric prototypes, upgrade the federal minimum heat pump water heater to a HPWH that meets the Northwest Energy Efficiency Alliance (NEEA)⁷ Tier 3 rating. The evaluated NEEA water heater is an 80gal unit and is applied to all three building prototypes. Using the same

⁷ Based on operational challenges experienced in the past, NEEA established rating test criteria to ensure newly installed HPWHs perform adequately, especially in colder climates. The NEEA rating requires an Energy Factor equal to the ENERGY STAR performance level and includes requirements regarding noise and prioritizing heat pump use over supplemental electric resistance heating.



water heater provides consistency in performance across all the equipment upgrade cases, even though hot water draws differ across the prototypes.

2.3 Package Development

Three to four packages were evaluated for each prototype and climate zone, as described below.

- 1) **Efficiency – Non-Preempted**: This package uses only efficiency measures that don't trigger federal preemption issues including envelope, and water heating and duct distribution efficiency measures.
- 2) **Efficiency – Equipment, Preempted**: This package shows an alternative design that applies HVAC and water heating equipment that are more efficient than federal standards. The Reach Code Team considers this more reflective of how builders meet above code requirements in practice.
- 3) **Efficiency & PV**: Using the Efficiency – Non-Preempted Package as a starting point⁸, PV capacity is added to offset most of the estimated electricity use. This only applies to the all-electric case, since for the mixed fuel cases, 100% of the projected electricity use is already being offset as required by 2019 Title 24, Part 6.
- 4) **Efficiency & PV/Battery**: Using the Efficiency & PV Package as a starting point, PV capacity is added as well as a battery system.

2.3.1 Solar Photovoltaics (PV)

Installation of on-site PV is required in the 2019 residential code. The PV sizing methodology in each package was developed to offset annual building electricity use and avoid oversizing which would violate net energy metering (NEM) rules.⁹ In all cases, PV is evaluated in CBECC-Res according to the California Flexible Installation (CFI) assumptions.

The Reach Code Team used two options within the CBECC-Res software for sizing the PV system, described below. Analysis was conducted to determine the most appropriate sizing method for each package which is described in the results.

- Standard Design PV – the same PV capacity as is required for the Standard Design case¹⁰
- Specify PV System Scaling – a PV system sized to offset a specified percentage of the estimated electricity use of the Proposed Design case

2.3.2 Energy Storage (Batteries)

A battery system was evaluated in CBECC-Res with control type set to "Time of Use" and with default efficiencies of 95% for both charging and discharging. The "Time of Use" option assumes batteries are charged anytime PV generation is greater than the house load but controls when the battery storage system discharges. During the summer months (July – September) the battery begins to discharge at the beginning of the peak period at a maximum rate until fully discharged. During discharge the battery first serves the house load but will

⁸ In cases where there was no cost-effective Efficiency – Non-Preempted Package, the most cost-effective efficiency measures for that climate zone were also included in the Efficiency & PV Package in order to provide a combination of both efficiency and PV beyond code minimum.

⁹ NEM rules apply to the IOU territories only.

¹⁰ The Standard Design PV system is sized to offset the electricity use of the building loads which are typically electric in a mixed fuel home, which includes all loads except space heating, water heating, clothes drying, and cooking.



discharge to the electric grid if there is excess energy available. During other months the battery discharges whenever the PV system does not cover the entire house load and does not discharge to the electric grid. This control option is considered to be most reflective of the current products on the market. This control option requires an input for the “First Hour of the Summer Peak” and the Statewide CASE Team applied the default hour in CBECC-Res which differs by climate zone (either a 6pm or 7pm start). The Self Utilization Credit was taken when the battery system was modeled.

2.4 Incremental Costs

Table 4 below summarizes the incremental cost assumptions for measures evaluated in this study. Incremental costs represent the equipment, installation, replacement, and maintenance costs of the proposed measures relative to the base case.¹¹ Replacement costs are applied to HVAC and DHW equipment, PV inverters, and battery systems over the 30-year evaluation period. There is no assumed maintenance on the envelope, HVAC, or DHW measures since there should not be any additional maintenance cost for a more efficient version of the same system type as the baseline. Costs were estimated to reflect costs to the building owner. When costs were obtained from a source that didn’t already include builder overhead and profit, a markup of ten percent was added. All costs are provided as present value in 2020 (2020 PV\$). Costs due to variations in furnace, air conditioner, and heat pump capacity by climate zone were not accounted for in the analysis.

Equipment lifetimes applied in this analysis for the water heating and space conditioning measures are summarized in Table 3.

Table 3: Lifetime of Water Heating & Space Conditioning Equipment Measures

Measure	Lifetime
Gas Furnace	20
Air Conditioner	20
Heat Pump	15
Gas Tankless Water Heater	20
Heat Pump Water Heater	15

Source: City of Palo Alto 2019 Title 24 Energy Reach Code Cost-effectiveness Analysis Draft (TRC, 2018) which is based on the Database of Energy Efficiency Resources (DEER).¹²

¹¹ Interest costs due to financing are not included in the incremental costs presented in the Table 4 but are accounted for in the lifetime cost analysis. All first costs are assumed to be financed in a mortgage, see Section 2.5 for details.

¹² <http://www.deeresources.com>



Table 4: Incremental Cost Assumptions

Measure	Performance Level	Incremental Cost (2020 PV\$)		Source & Notes
		Single Family	Multifamily (Per Dwelling Unit)	
Non-Preempted Measures				
Reduced Infiltration	3.0 vs 5.0 ACH50	\$391	n/a	NREL’s BEopt cost database (\$0.115/ft² for 3 ACH50 & \$0.207/ft² for 2 ACH50) + \$100 HERS rater verification.
	2.0 vs 5.0 ACH50	\$613	n/a	
Window U-factor	0.24 vs 0.30	\$2,261	\$607	\$4.23/ft² window area based on analysis conducted for the 2019 and 2022 Title 24 cycles (Statewide CASE Team, 2018).
Window SHGC	0.50 vs 0.35	\$0	\$0	Data from CASE Report along with direct feedback from Statewide CASE Team that higher SHGC does not necessarily have any incremental cost (Statewide CASE Team, 2017d). Applies to CZ 1,3,5,16.
Cool Roof - Aged Solar Reflectance	0.25 vs 0.20	\$237	\$58	Costs based on 2016 Cost-effectiveness Study for Cool Roofs reach code analysis for 0.28 solar reflectance product. (Statewide Reach Codes Team, 2017b).
	0.20 vs 0.10	\$0	\$0	
Exterior Wall Insulation	R-7.5 vs R-5	\$818	n/a	Based on increasing exterior insulation from 1” R-5 to 1.5” R-7.5 in a 2x6 wall (Statewide CASE Team, 2017c). Applies to single family only in all climates except CZ 6, 7.
Under-Deck Roof Insulation (HPA)	R-13 vs R-0	\$1,338	\$334	Costs for R-13 (\$0.64/ft²), R-19 (\$0.78/ft²) and R-30 (\$1.61/ft²) based on data presented in the 2019 HPA CASE Report (Statewide CASE Team, 2017b) along with data collected directly from builders during the 2019 CASE process. The R-30 costs include additional labor costs for cabling. Costs for R-38 from NREL’s BEopt cost database.
	R-19 vs R-13	\$282	\$70	
	R-30 vs R-19	\$1,831	\$457	
	R-38 vs R-30	\$585	\$146	
Attic Floor Insulation	R-38 vs R-30	\$584	\$146	NREL’s BEopt cost database: \$0.34/ft² ceiling area
Slab Edge Insulation	R-10 vs R-0	\$553	\$121	\$4/linear foot of slab perimeter based on internet research. Assumes 16in depth.
	R-10 vs R-7	\$157	\$21	\$1.58/linear foot of slab perimeter based on NREL’s BEopt cost database. This applies to CZ 16 only where R-7 slab edge insulation is required prescriptively. Assumes 16in depth.
Duct Location	<12 feet in attic	\$358	n/a	Costs based on a 2015 report on the Evaluation of Ducts in Conditioned Space for New California Homes (Davis Energy Group, 2015). HERS verification cost of \$100 for the Verified Low Leakage Ducts in Conditioned Space credit.
	Ducts in Conditioned Space	\$658	n/a	
	Verified Low Leakage Ducts in Conditioned Space	\$768	\$110	



Table 4: Incremental Cost Assumptions

Measure	Performance Level	Incremental Cost (2020 PV\$)		Source & Notes
		Single Family	Multifamily (Per Dwelling Unit)	
Distribution System Leakage	2% vs 5%	\$96	n/a	1-hour labor. Labor rate of \$96 per hour is from 2019 RSMeans for sheet metal workers and includes an average City Cost Index for labor for California cities & 10% for overhead and profit. Applies to single family only since ducts are assumed to be in conditioned space for multifamily
	Low Leakage Air Handler	\$0	n/a	Negligible cost based on review of available products. There are more than 6,000 Energy Commission certified units and the list includes many furnace and heat pump air handler product lines from the major manufacturers, including minimum efficiency, low cost product lines.
Low Pressure Drop Ducts (Fan W/cfm)	0.35 vs 0.45	\$96	\$48	Costs assume one-hour labor for single family and half-hour per multifamily apartment. Labor rate of \$96 per hour is from 2019 RSMeans for sheet metal workers and includes an average City Cost Index for labor for California cities.
	0.45 vs 0.58	\$96	\$48	
Hot Water Pipe Insulation	HERS verified	\$110	\$83	Cost for HERS verification only, based on feedback from HERS raters. \$100 per single family home and \$75 per multifamily unit before markup.
Compact Hot Water Distribution	Basic credit	\$150	\$0	For single family add 20-feet venting at \$12/ft to locate water heater on interior garage wall, less 20-feet savings for less PEX and pipe insulation at \$4.88/ft. Costs from online retailers. Many multifamily buildings are expected to meet this credit without any changes to distribution design.
	Expanded credit	n/a	\$83	Cost for HERS verification only. \$75 per multifamily unit before markup. This was only evaluated for multifamily buildings.
Drain Water Heat Recovery	50% efficiency	n/a	\$690	Cost from the 2019 DWHR CASE Report assuming a 2-inch DWHR unit. The CASE Report multifamily costs were based on one unit serving 4 dwelling units with a central water heater. Since individual water heaters serve each dwelling unit in this analysis, the Reach Code Team used single family costs from the CASE Report. Costs in the CASE Report were based on a 46.1% efficient unit, a DWHR device that meets the 50% efficiency assumed in this analysis may cost a little more. (Statewide CASE Team, 2017a).
Federally Pre-empted Measures				
Furnace AFUE	92% vs 80%	\$139	\$139	Equipment costs from online retailers for 40-kBtu/h unit. Cost saving for 6-feet of venting at \$26/foot due to lower cost venting requirements for condensing (PVC) vs non-condensing (stainless) furnaces. Replacement at year 20 assumes a 50% reduction in first cost. Value at year 30 based on remaining useful life is included.
	96% vs 80%	\$244	\$244	
Air Conditioner SEER/EER	16/13 vs 14/11.7	\$111	\$111	Costs from online retailers for 2-ton unit. Replacement at year 20 assumes a 50% reduction in first cost. Value at year 30 based on remaining useful life is included.
	18/14 vs 14/11.7	\$1,148	\$1,148	



Table 4: Incremental Cost Assumptions

Measure	Performance Level	Incremental Cost (2020 PV\$)		Source & Notes
		Single Family	Multifamily (Per Dwelling Unit)	
Heat Pump SEER/EER /HSPF	16/13/9 vs 14/11.7/8.2	\$411	\$411	Costs from online retailers for 2-ton unit. Replacement at year 15 assumes a 50% reduction in first cost.
	18/14/10 vs 14/11.7/8.2	\$1,511	\$1,511	
Tankless Water Heater Energy Factor	0.96 vs 0.81	\$203	\$203	Equipment costs from online retailers for 40-kBtu/h unit. Cost saving for 6-feet of venting at \$26/foot due to lower cost venting requirements for condensing (PVC) vs non-condensing (stainless) furnaces. Replacement at year 15 assumes a 50% reduction in first cost.
HPWH	NEEA Tier 3 vs 2.0 EF	\$294	\$294	Equipment costs from online retailers. Replacement at year 15 assumes a 50% reduction in first cost.
PV + Battery				
PV System	System size varies	\$3.72/W-DC	\$3.17/W-DC	First costs are from LBNL's Tracking the Sun 2018 costs (Barbose et al., 2018) and represent costs for the first half of 2018 of \$3.50/W-DC for residential system and \$2.90/W-DC for non-residential system ≤500 kW-DC. These costs were reduced by 16% for the solar investment tax credit, which is the average credit over years 2020-2022. Inverter replacement cost of \$0.14/W-DC present value includes replacements at year 11 at \$0.15/W-DC (nominal) and at year 21 at \$0.12/W-DC (nominal) per the 2019 PV CASE Report (California Energy Commission, 2017). System maintenance costs of \$0.31/W-DC present value assume \$0.02/W-DC (nominal) annually per the 2019 PV CASE Report (California Energy Commission, 2017). 10% overhead and profit added to all costs
Battery	System size varies by building type	\$656/kWh	\$656/kWh	\$633/kWh first cost based on the PV Plus Battery Study report (Statewide Reach Codes Team, 2018) as the average cost of the three systems that were analyzed. This cost was reduced by 16% for the solar investment tax credit, which is the average credit over years 2020-2022. Replacement cost at year 15 of \$100/kWh based on target price reductions (Penn, 2018).



2.5 Cost-effectiveness

Cost-effectiveness was evaluated for all sixteen climate zones and is presented based on both TDV energy, using the Energy Commission's LCC methodology, and an On-Bill approach using residential customer utility rates. Both methodologies require estimating and quantifying the value of the energy impact associated with energy efficiency measures over the life of the measures (30 years) as compared to the prescriptive Title 24 requirements.

Results are presented as a lifecycle benefit-to-cost (B/C) ratio, a net present value (NPV) metric which represents the cost-effectiveness of a measure over a 30-year lifetime taking into account discounting of future savings and costs and financing of incremental first costs. A value of one indicates the NPV of the savings over the life of the measure is equivalent to the NPV of the lifetime incremental cost of that measure. A value greater than one represents a positive return on investment. The B/C ratio is calculated according to Equation 3.

Equation 3

$$\text{Benefit-to-Cost Ratio} = \frac{\text{NPV of lifetime benefit}}{\text{NPV of lifetime cost}}$$

In most cases the benefit is represented by annual utility savings or TDV savings and the cost by incremental first cost and replacement costs. However, in some cases a measure may have incremental cost savings but with increased energy related costs. In this case, the benefit is the lower first cost and the cost is the increase in utility bills. The lifetime costs or benefits are calculated according to Equation 4.

Equation 4

$$\text{NPV of lifetime cost/benefit} = \sum_{t=1}^n \text{Annual cost/benefit}_t * (1 + r)^t$$

Where:

- n = analysis term
- r = discount rate

The following summarizes the assumptions applied in this analysis to both methodologies.

- Analysis term of 30-years
- Real discount rate of 3 percent
- Inflation rate of 2 percent
- First incremental costs are financed into a 30-year mortgage
- Mortgage interest rate of 4.5 percent
- Average tax rate of 20 percent (to account for tax savings due to loan interest deductions)

2.5.1 On-Bill Customer Lifecycle Cost

Residential utility rates were used to calculate utility costs for all cases and determine On-Bill customer cost-effectiveness for the proposed packages. The Reach Codes Team obtained the recommended utility rates from each IOU based on the assumption that the reach codes go into effect January of 2020. Annual utility costs were calculated using hourly electricity and gas output from CBECC-Res and applying the utility tariffs summarized in Table 5. Appendix B – Utility Tariff Details includes the utility rate schedules used for this study. The applicable residential time-of-use (TOU) rate was applied to all cases.¹³ Annual electricity production in excess of annual electricity consumption is credited to the utility account at the applicable wholesale rate based on the approved

¹³ 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. <https://www.cpuc.ca.gov/General.aspx?id=3800>



NEM2 tariffs for that utility. Minimum daily use billing and mandatory non-bypassable charges have been applied. Future change to the NEM tariffs are likely; however, there is a lot of uncertainty about what those changes will be and if they will become effective during the 2019 code cycle (2020-2022).

The net surplus compensation rates for each utility are as follows:¹⁴

- PG&E: \$0.0287 / kWh
- SCE: \$0.0301 / kWh
- SDG&E: \$0.0355 / kWh

Utility rates were applied to each climate zone based on the predominant IOU serving the population of each zone according to Two SCE tariff options were evaluated: TOU-D-4-9 and TOU-D-PRIME. The TOU-D-PRIME rate is only available to customers with heat pumps for either space or water heating, a battery storage system, or an electric vehicle and therefore was only evaluated for the all-electric cases and the Efficiency & PV/Battery packages. The rate which resulted in the lowest annual cost to the customer was used for this analysis, which was TOU-D-4-9 in all cases with the exception of the single family all-electric cases in Climate Zone 14.

Table 5. Climate Zones 10 and 14 are evaluated with both SCE/SoCalGas and SDG&E tariffs since each utility has customers within these climate zones. Climate Zone 5 is evaluated under both PG&E and SoCalGas natural gas rates.

Two SCE tariff options were evaluated: TOU-D-4-9 and TOU-D-PRIME. The TOU-D-PRIME rate is only available to customers with heat pumps for either space or water heating, a battery storage system, or an electric vehicle and therefore was only evaluated for the all-electric cases and the Efficiency & PV/Battery packages. The rate which resulted in the lowest annual cost to the customer was used for this analysis, which was TOU-D-4-9 in all cases with the exception of the single family all-electric cases in Climate Zone 14.

Table 5: IOU Utility Tariffs Applied Based on Climate Zone

Climate Zones	Electric / Gas Utility	Electricity (Time-of-use)	Natural Gas
1-5, 11-13, 16	PG&E	E-TOU, Option B	G1
5	PG&E / SoCalGas	E-TOU, Option B	GR
6, 8-10, 14, 15	SCE / SoCal Gas	TOU-D-4-9 or TOU-D-PRIME	GR
7, 10, 14	SDG&E	TOU-DR1	GR

Source: Utility websites, See Appendix B – Utility Tariff Details for details on the tariffs applied.

Utility rates are assumed to escalate over time, using assumptions from research conducted by Energy and Environmental Economics (E3) in the 2019 study Residential Building Electrification in California study (Energy & Environmental Economics, 2019). Escalation of natural gas rates between 2019 and 2022 is based on the currently filed General Rate Cases (GRCs) for PG&E, SoCalGas and SDG&E. From 2023 through 2025, gas rates are assumed to escalate at 4% per year above inflation, which reflects historical rate increases between 2013 and 2018. Escalation of electricity rates from 2019 through 2025 is assumed to be 2% per year above inflation, based on electric utility estimates. After 2025, escalation rates for both natural gas and electric rates are assumed to drop to a more conservative 1% escalation per year above inflation for long-term rate trajectories beginning in 2026 through 2050. See Appendix B – Utility Tariff Details for additional details.

¹⁴ Net surplus compensation rates based on 1-year average February 2018 – January 2019.



2.5.2 *TDV Lifecycle Cost*

Cost-effectiveness was also assessed using the Energy Commission's TDV LCC methodology. 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. The 2019 TDV values are based on long term discounted costs of 30 years for all residential measures. The CBECC-Res simulation software outputs are in terms of TDV kBTUs. The present value of the energy cost savings in dollars is calculated by multiplying the TDV kBTU savings by a net present value (NPV) factor, also developed by the Energy Commission. The NPV factor is \$0.173/TDV kBTU for residential buildings.

Like the customer B/C ratio, a TDV B/C ratio value of one indicates the savings over the life of the measure are equivalent to the incremental cost of that measure. A value greater than one represents a positive return on investment. The ratio is calculated according to Equation 5.

Equation 5

$$TDV \text{ Benefit} - to - Cost \text{ Ratio} = \frac{TDV \text{ energy savings} * NPV \text{ factor}}{NPV \text{ of lifetime incremental cost}}$$

2.6 *Electrification Evaluation*

In addition to evaluating upgrades to mixed fuel and all-electric buildings independently that do not result in fuel switching, the Reach Code Team also analyzed the impact on construction costs, utility costs, and TDV when a builder specifies and installs electric appliances instead of the gas appliances typically found in a mixed fuel building. This analysis compared the code compliant mixed fuel prototype, which uses gas for space heating, water heating, cooking, and clothes drying, with the code compliant all-electric prototype. It also compared the all-electric Efficiency & PV Package with the code compliance mixed fuel prototype. In these cases, the relative costs between natural gas and electric appliances, differences between in-house electricity and gas infrastructure and the associated infrastructure costs for providing gas to the building were also included.

A variety of sources were reviewed when determining incremental costs. The sources are listed below.

- SMUD All-Electric Homes Electrification Case Study (EPRI, 2016)
- City of Palo Alto 2019 Title 24 Energy Reach Code Cost-effectiveness Analysis (TRC, 2018)
- Building Electrification Market Assessment (E3, 2019)
- Decarbonization of Heating Energy Use in California Buildings (Hopkins et al., 2018)
- Analysis of the Role of Gas for a Low-Carbon California Future (Navigant, 2008)
- Rulemaking No. 15-03-010 An Order Instituting Rulemaking to Identify Disadvantaged Communities in the San Joaquin Valley and Analyze Economically Feasible Options to Increase Access to Affordable Energy in Those Disadvantaged Communities (California Public Utilities Commission, 2016)
- 2010-2012 WO017 Ex Ante Measure Cost Study: Final Report (Itron, 2014)
- Natural gas infrastructure costs provided by utility staff through the Reach Code subprogram
- Costs obtained from builders, contractors and developers

Incremental costs are presented in Table 6. Values in parentheses represent a lower cost or cost reduction in the electric option relative to mixed fuel. The costs from the available sources varied widely, making it difficult to develop narrow cost estimates for each component. For certain components data is provided with a low to high range as well as what were determined to be typical costs and ultimately applied in this analysis. Two sets of typical costs are presented, one which is applied in the On-Bill cost effectiveness methodology and another applied in the TDV methodology. Details of these differences are explained in the discussion of site gas infrastructure costs in the following pages.



Table 6: Incremental Costs – All-Electric Code Compliant Home Compared to a Mixed Fuel Code Compliant Home

Measure	Incremental Cost (2020 PV\$) Single Family ¹				Incremental Cost (2020 PV\$) Multifamily ¹ (Per Dwelling Unit)			
	Low	High	Typical (On-Bill)	Typical (TDV)	Low	High	Typical (On-Bill)	Typical (TDV)
Heat Pump vs Gas Furnace/Split AC	(\$2,770)	\$620	(\$221)		Same as Single Family			
Heat Pump Water Heater vs Gas Tankless	(\$1,120)	\$1,120	\$0					
Electric vs Gas Clothes Dryer ²	(\$428)	\$820	\$0					
Electric vs Gas Cooking ²	\$0	\$1,800	\$0					
Electric Service Upgrade	\$200	\$800	\$600		\$150	\$600	\$600	
In-House Gas Infrastructure	(\$1,670)	(\$550)	(\$800)		(\$600)	(\$150)	(\$600)	
Site Gas Infrastructure	(\$25,000)	(\$900)	(\$5,750)	(\$11,836)	(\$16,250)	(\$310)	(\$3,140)	(\$6,463)
Total First Cost	(\$30,788)	\$3,710	(\$6,171)	(\$12,257)	(\$20,918)	\$4,500	(\$3,361)	(\$6,684)
Present Value of Equipment Replacement Cost			\$1,266				\$1,266	
Lifetime Cost Including Replacement & Financing of First Cost			(\$5,349)	(\$11,872)			(\$2,337)	(\$5,899)

¹Low and high costs represent the potential range of costs and typical represents the costs used in this analysis and determined to be most representative of the conditions described in this report. Two sets of typical costs are presented, one which is applied in the On-Bill cost effectiveness methodology and another applied in the TDV methodology.

²Typical costs assume electric resistance technology. The high range represents higher end induction cooktops and heat pump clothes dryers. Lower cost induction cooktops are available.

Typical incremental costs for switching from a mixed fuel design to an all-electric design are based on the following assumptions:

Appliances: The Reach Code Team determined that the typical first installed cost for electric appliances is very similar to that for natural gas appliances. This was based on information provided by HVAC contractors, plumbers and builders as well as a review of other studies. After review of various sources, the Reach Code Team concluded that the cost difference between gas and electric resistance options for clothes dryers and stoves is negligible and that the lifetimes of the two technologies are also similar.

HVAC: Typical HVAC incremental costs were based on the City of Palo Alto 2019 Title 24 Energy Reach Code Cost-effectiveness Analysis (TRC, 2018) which assumes approximately \$200 first cost savings for the heat pump relative to the gas furnace and air conditioner. Table 6 also includes the present value of the incremental replacement costs for the heat pump based on a 15-year lifetime and a 20-year lifetime for the gas furnace in the mixed fuel home.

DHW: Typical costs for the water heating system were based on equivalent installed first costs for the HPWH and tankless gas water heater. This accounts for slightly higher equipment cost but lower installation labor due to the elimination of the gas flue. Incremental replacement costs for the HPWH are based on a 15-year lifetime and a 20-year lifetime for the tankless water heater.

For multifamily, less data was available and therefore a range of low and high costs is not provided. The typical first cost for multifamily similarly is expected to be close to the same for the mixed fuel and all-electric designs. However, there are additional considerations with multifamily such as greater complexity for venting of natural gas appliances as well as for locating the HPWH within the conditioned space (all climates except Climate Zones 1, 3, and 5, see Table 2) that may impact the total costs.

Electric service upgrade: The study assumes an incremental cost to run 220V service to each appliance of \$200 per appliance for single family homes and \$150 per appliance per multifamily apartment based on cost estimates from builders and contractors. The Reach Code Team reviewed production builder utility plans for



mixed-fuel homes and consulted with contractors to estimate which electricity and/or natural gas services are usually provided to the dryer and oven. Typical practice varied, with some builders providing both gas and electric service to both appliances, others providing both services to only one of the appliances, and some only providing gas. For this study, the Reach Code Team determined that for single family homes the typical cost is best qualified by the practice of providing 220V service and gas to either the dryer and the oven and only gas service to the other. For multifamily buildings it's assumed that only gas is provided to the dryer and oven in the mixed fuel home.

It is assumed that no upgrades to the electrical panel are required and that a 200 Amp panel is typically installed for both mixed fuel and all-electric new construction homes. There are no incremental electrical site infrastructure requirements.

In-house gas infrastructure (from meter to appliances): Installation cost to run a gas line from the meter to the appliance location is \$200 per appliance for single family and \$150 per appliance per multifamily apartment based on cost estimates from builders and contractors. The cost estimate includes providing gas to the water heater, furnace, dryer and cooktop.

Site gas infrastructure: The cost-effective analysis components with the highest degree of variability are the costs for on-site gas infrastructure. These costs can be project dependent and may be significantly impacted by such factors as utility territory, site characteristics, distance to the nearest gas main and main location, joint trenching, whether work is conducted by the utility or a private contractor, and number of dwelling units per development. All gas utilities participating in this study were solicited for cost information. The typical infrastructure costs for single family homes presented in Table 6 are based on cost data provided by PG&E and reflect those for a new subdivision in an undeveloped area requiring the installation of natural gas infrastructure, including a main line. Infrastructure costs for infill development can also be highly variable and may be higher than in an undeveloped area. The additional costs associated with disruption of existing roads, sidewalks, and other structures can be significant. Total typical costs in Table 6 assume \$10,000 for extension of a gas main, \$1,686 for a service lateral, and \$150 for the meter.

Utility Gas Main Extensions rules¹⁵ specify that the developer has the option to only pay 50% of the total cost for a main extension after subtraction of allowances for installation of gas appliances. This 50% refund and the appliance allowance deductions are accounted for in the site gas infrastructure costs under the On-Bill cost-effectiveness methodology. The net costs to the utility after partial reimbursement from the developer are included in utility ratebase and recovered via rates to all customers. The total cost of \$5,750 presented in Table 6 reflects a 50% refund on the \$10,000 extension and appliance deductions of \$1,086 for a furnace, water heater, cooktop, and dryer. Under the On-Bill methodology this analysis assumes this developer option will remain available through 2022 and that the cost savings are passed along to the customer.

The 50% refund and appliance deductions were not applied to the site gas infrastructure costs under the TDV cost-effectiveness methodology based on input received from the Energy Commission and agreement from the Reach Code technical advisory team that the approach is appropriate. TDV cost savings impacts extend beyond the customer and account for societal impacts of energy use. Accounting for the full cost of the infrastructure upgrades was determined to be justified when evaluating under the TDV methodology.

¹⁵ PG&E Rule 15: https://www.pge.com/tariffs/tm2/pdf/GAS_RULES_15.pdf

SoCalGas Rule 20: <https://www.socalgas.com/regulatory/tariffs/tm2/pdf/20.pdf>

SDG&E Rule 15: http://regarchive.sdge.com/tm2/pdf/GAS_GAS-RULES_GRULE15.pdf



Less information was available for the costs associated with gas infrastructure for low-rise multifamily development. The typical cost in Table 6 for the On-Bill methodology is based on TRC's City of Palo Alto 2019 Title 24 Energy Reach Code Cost-effectiveness Analysis (TRC, 2018). These costs, provided by the City of Palo Alto, are approximately \$25,100 for an 8-unit new construction building and reflect connection to an existing main for infill development. Specific costs include plan review, connection charges, meter and manifold, plumbing distribution, and street cut fees. While these costs are specifically based on infill development and from one municipal utility, the estimates are less than those provided by PG&E reflecting the average cost differences charged to the developer between single family and multifamily in an undeveloped area (after accounting for deductions per the Gas Main Extensions rule). To convert costs charged to the developer to account for the full infrastructure upgrade cost (costs applied in the TDV methodology analysis), a factor of 2.06¹⁶ was calculated based on the single family analysis. This same factor was applied to the multifamily cost of \$3,140 to arrive at \$6,463 (see Table 6).

2.7 Greenhouse Gas Emissions

Equivalent CO₂ emission savings were calculated based on outputs from the CBECC-Res simulation software. Electricity emissions vary by region and by hour of the year. CBECC-Res applies two distinct hourly profiles, one for Climate Zones 1 through 5 and 11 through 13 and another for Climate Zones 6 through 10 and 14 through 16. For natural gas a fixed factor of 0.005307 metric tons/therm is used. To compare the mixed fuel and all-electric cases side-by-side, greenhouse gas (GHG) emissions are presented as CO₂-equivalent emissions per square foot of conditioned floor area.

3 Results

The primary objective of the evaluation is to identify cost-effective, non-preempted performance targets for both single family and low-rise multifamily prototypes, under both mixed fuel and all-electric cases, to support the design of local ordinances requiring new low-rise residential buildings to exceed the minimum state requirements. The packages presented are representative examples of designs and measures that can be used to meet the requirements. In practice, a builder can use any combination of non-preempted or preempted compliant measures to meet the requirements.

This analysis covered all sixteen climate zones and evaluated two efficiency packages, including a non-preempted package and a preempted package that includes upgrades to federally regulated equipment, an Efficiency & PV Package for the all-electric scenario only, and an Efficiency & PV/Battery Package. For the efficiency-only packages, measures were refined to ensure that the non-preempted package was cost-effective based on one of the two metrics applied in this study, TDV or On-Bill. The preempted equipment package, which the Reach Code Team considers to be a package of upgrades most reflective of what builders commonly apply to exceed code requirements, was designed to be cost-effective based on the On-Bill cost-effectiveness approach.

Results are presented as EDR Margin instead of compliance margin. EDR is the metric used to determine code compliance in the 2019 cycle. Target EDR Margin is based on taking the calculated EDR Margin for the case and rounding down to the next half of a whole number. Target EDR Margin for the Efficiency Package are defined based on the lower of the EDR Margin of the non-preempted package and the equipment, preempted package. For example, if for a particular case the cost-effective non-preempted package has an EDR Margin of 3 and the preempted package an EDR Margin of 4, the Target EDR Margin is set at 3.

¹⁶ This factor includes the elimination of the 50% refund for the main extension and adding back in the appliance allowance deductions.



For a package to qualify, a minimum EDR Margin of 0.5 was required. This is to say that a package that only achieved an EDR Margin of 0.4, for example, was not considered. An EDR Margin less than 0.5 generally corresponds to a compliance margin lower than 5% and was considered too small to ensure repeatable results. In certain cases, the Reach Code Team did not identify a cost-effective package that achieved the minimum EDR Margin of 0.5.

Although some of the efficiency measures evaluated were not cost-effective and were eliminated, the following measures are included in at least one package:

- Reduced infiltration
- Improved fenestration
- Improved cool roofs
- High performance attics
- Slab insulation
- Reduced duct leakage
- Verified low leakage ducts in conditioned space
- Low pressure-drop distribution system
- Compact hot water distribution system, basic and expanded
- High efficiency furnace, air conditioner & heat pump (*preempted*)
- High efficiency tankless water heater & heat pump water heater (*preempted*)

3.1 PV and Battery System Sizing

The approach to determining the size of the PV and battery systems varied based on each package and the source fuel. Table 7 describes the PV and battery sizing approaches applied to each of the four packages. For the **Efficiency Non-preempted and Efficiency – Equipment, Preempted packages** a different method was applied to each the two fuel scenarios. In all **mixed fuel cases**, the PV was sized to offset 100% of the estimated electrical load and any electricity savings from efficiency measures were traded off with a smaller PV system. Not downsizing the PV system after adding efficiency measures runs the risk of producing more electricity than is consumed, reducing cost-effectiveness and violating NEM rules. While the impact of this in most cases is minor, analysis confirmed that cost-effectiveness improved when reducing the system size to offset 100% of the electricity usage as opposed to keeping the PV system the same size as the Standard Design.

In the **all-electric Efficiency cases**, the PV system size was left to match the Standard Design (Std Design PV), and the inclusion of energy efficiency measures was not traded off with a reduced capacity PV system. Because the PV system is sized to meet the electricity load of a mixed fuel home, it is cost-effective to keep the PV system the same size and offset a greater percentage of the electrical load.

For the **Efficiency & PV case on the all-electric home**, the Reach Code Team evaluated PV system sizing to offset 100%, 90% and 80% of the total calculated electricity use. Of these three, sizing to 90% proved to be the most cost-effective based on customer utility bills. This is a result of the impact of the annual minimum bill which is around \$120 across all the utilities. The “sweet spot” is a PV system that reduces electricity bills just enough to match the annual minimum bill; increasing the PV size beyond this adds first cost but does not result in utility bill savings.

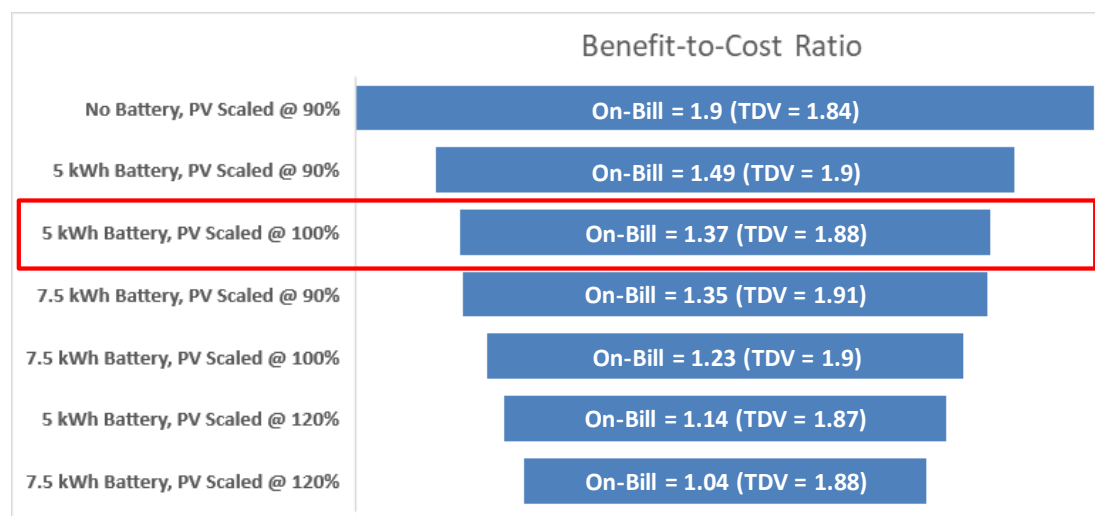
Table 7: PV & Battery Sizing Details by Package Type

Package	Mixed Fuel	All-Electric
Efficiency (Envelope & Equipment)	PV Scaled @ 100% electricity	Std Design PV
Efficiency & PV	n/a	PV Scaled @ 90%
Efficiency & PV/Battery	PV Scaled @ 100% electricity 5kWh / SF home 2.75kWh/ MF apt	PV Scaled @ 100% 5kWh / SF home 2.75kWh/ MF apt

A sensitivity analysis was conducted to determine the appropriate battery and PV capacity for the Efficiency & PV/Battery Packages using the 1-story 2,100 square foot prototype in Climate Zone 12. Results are shown in Figure 2. The current version of CBECC-Res requires a minimum battery size of 5 kWh to qualify for the self-utilization credit. CBECC-Res allows for PV oversizing up to 160% of the building's estimated electricity load when battery storage systems are installed; however, the Reach Code Team considered this high, potentially problematic from a grid perspective, and likely not acceptable to the utilities or customers. The Reach Code Team compared cost-effectiveness of 5kWh and 7.5kWh battery systems as well as of PV systems sized to offset 90%, 100%, or 120% of the estimated electrical load.

Results show that from an on-bill perspective a smaller battery size is more cost-effective. The sensitivity analysis also showed that increasing the PV capacity from 90% to 120% of the electricity use reduced cost-effectiveness. From the TDV perspective there was little difference in results across all the scenarios, with the larger battery size being marginally more cost-effective. Based on these results, the Reach Code Team applied to the Efficiency & PV/Battery Package a 5kWh battery system for single family homes with PV sized to offset 100% of the electricity load. Even though PV scaled to 90% was the most cost-effective, sizing was increased to 100% to evaluate greater generation beyond the Efficiency & PV Package and to achieve zero net electricity. These results also show that in isolation, the inclusion of a battery system reduces cost-effectiveness compared to the same size PV system without batteries.

For multifamily buildings the battery capacity was scaled to reflect the average ratio of battery size to PV system capacity (kWh/kW) for the single family Efficiency & PV Package. This resulted in a 22kWh battery for the multifamily building, or 2.75kWh per apartment.

**Figure 2: B/C ratio comparison for PV and battery sizing**

3.2 Single Family Results

Table 8 through Table 10 contain cost effectiveness findings for the single family packages. Table 8 summarizes the package costs for all of the mixed fuel and all-electric efficiency, PV and battery packages. The mixed fuel results are evaluated and presented relative to a mixed fuel code compliant basecase while the all-electric results are relative to an all-electric code compliant basecase.

Table 9 and Table 10 present the B/C ratios for all the single family packages according to both the On-Bill and TDV methodologies for the mixed fuel and the all-electric cases, respectively. Results are cost-effective based on TDV for all cases except for Climate Zone 7 where no cost-effective combination of non-preempted efficiency measures was found that met the minimum 0.5 EDR Margin threshold. Cases where the B/C ratio is indicated as “>1” refer to instances where there are incremental cost savings in addition to annual utility bill savings. In these cases, there is no cost associated with the upgrade and benefits are realized immediately.

Figure 3 presents a comparison of Total EDRs for single family buildings and Figure 4 presents the EDR Margin results. Each graph compares the mixed fuel and all-electric cases as well as the various packages. The EDR Margin for the **Efficiency Package** for most climates is between 1.0 and 5.5 for mixed fuel cases and slightly higher, between 1.5 and 6.5, for the all-electric design. No cost-effective **mixed fuel or all-electric non-preempted Efficiency package** was found Climate Zone 7.

For the **mixed fuel case, the Efficiency & PV/Battery Package** increased the EDR Margin to values between 7.0 and 10.5. Because of the limitations on oversizing PV systems to offset natural gas use it is not feasible to achieve higher EDR Margins by increasing PV system capacity.

For the **all-electric case, the Efficiency & PV Package** resulted in EDR Margins of 11.0 to 19.0 for most climates; adding a battery system increased the EDR Margin by an additional 7 to 13 points. Climate zones 1 and 16, which have high heating loads, have much higher EDR Margins for the Efficiency & PV package (26.5-31.0). The Standard Design PV, which is what is applied in the all-electric Efficiency Package, is not sized to offset any of the heating load. When the PV system is sized to offset 90% of the total electricity use, the increase is substantial as a result. In contrast, in Climate Zone 15 the Standard Design PV system is already sized to cover the cooling electricity load, which represents 40% of whole building electricity use. Therefore, increasing the PV size to offset 90% of the electric load in this climate only results in adding approximately 120 Watts of PV capacity and subsequently a negligible impact on the EDR.

Additional results details can be found in Appendix C – Single Family Detailed Results with summaries of measures included in each of the packages in Appendix D – Single Family Measure Summary. A summary of results by climate zone is presented in Appendix G – Results by Climate Zone.

Table 8: Single Family Package Lifetime Incremental Costs

Climate Zone	Mixed Fuel			All-Electric			
	Non-Preempted	Equipment - Preempted	Efficiency & PV/Battery	Non-Preempted	Equipment - Preempted	Efficiency & PV	Efficiency & PV/Battery
CZ01	+\$1,355	+\$1,280	+\$5,311	+\$7,642	+\$2,108	+\$18,192	+\$24,770
CZ02	+\$1,504	+\$724	+\$5,393	+\$3,943	+\$2,108	+\$12,106	+\$18,132
CZ03	+\$1,552	+\$1,448	+\$5,438	+\$1,519	+\$2,108	+\$8,517	+\$14,380
CZ04	+\$1,556	+\$758	+\$5,434	+\$1,519	+\$2,108	+\$8,786	+\$14,664
CZ05	+\$1,571	+\$772	+\$5,433	+\$1,519	+\$2,108	+\$8,307	+\$14,047
CZ06	+\$1,003	+\$581	+\$4,889	+\$926	+\$846	+\$6,341	+\$12,036
CZ07	n/a	+\$606	+\$4,028	n/a	+\$846	+\$4,436	+\$9,936
CZ08	+\$581	+\$586	+\$4,466	+\$926	+\$412	+\$5,373	+\$11,016
CZ09	+\$912	+\$574	+\$4,785	+\$1,180	+\$846	+\$5,778	+\$11,454
CZ10	+\$1,648	+\$593	+\$5,522	+\$1,773	+\$949	+\$6,405	+\$12,129
CZ11	+\$3,143	+\$1,222	+\$7,026	+\$3,735	+\$2,108	+\$10,827	+\$17,077
CZ12	+\$1,679	+\$654	+\$5,568	+\$3,735	+\$2,108	+\$11,520	+\$17,586
CZ13	+\$3,060	+\$611	+\$6,954	+\$4,154	+\$2,108	+\$10,532	+\$16,806
CZ14	+\$1,662	+\$799	+\$5,526	+\$4,154	+\$2,108	+\$10,459	+\$16,394
CZ15	+\$2,179	-\$936	+\$6,043	+\$4,612	+\$2,108	+\$5,085	+\$11,382
CZ16	+\$3,542	+\$2,441	+\$7,399	+\$5,731	+\$2,108	+\$16,582	+\$22,838



Table 9: Single Family Package Cost-Effectiveness Results for the Mixed Fuel Case ^{1,2}

CZ	Utility	Efficiency							Efficiency & PV/Battery			
		Non-Preempted			Equipment - Preempted			Target				Target
		Efficiency	On-Bill	TDV	Efficiency	On-Bill	TDV	Efficiency	Total	On-Bill	TDV	Total
		EDR	B/C	B/C	EDR	B/C	B/C	EDR	EDR	B/C	B/C	EDR
		Margin	Ratio	Ratio	Margin	Ratio	Ratio	Margin	Margin	Ratio	Ratio	Margin
01	PG&E	5.3	3.4	2.8	6.9	4.9	4.1	5.0	10.6	0.9	1.6	10.5
02	PG&E	3.3	1.6	1.7	3.3	3.8	3.6	3.0	10.1	0.5	1.6	10.0
03	PG&E	3.0	1.3	1.3	4.1	1.9	2.0	2.5	10.0	0.4	1.4	10.0
04	PG&E	2.5	0.9	1.2	2.7	2.4	2.7	2.5	10.1	0.3	1.5	10.0
05	PG&E	2.7	1.1	1.2	2.6	2.3	2.5	2.5	9.4	0.4	1.3	9.0
05	PG&E/SoCalGas	2.7	0.9	1.2	2.6	2.0	2.5	2.5	9.4	0.3	1.3	9.0
06	SCE/SoCalGas	2.0	0.7	1.2	2.0	1.6	2.0	1.5	9.8	0.8	1.3	9.5
07	SDG&E	0.0	-	-	1.5	1.5	1.4	0.0	9.2	0.1	1.3	9.0
08	SCE/SoCalGas	1.3	0.6	1.4	1.6	1.3	1.8	1.0	8.4	0.9	1.3	8.0
09	SCE/SoCalGas	2.6	0.7	2.0	2.9	1.8	3.7	2.5	8.8	1.0	1.5	8.5
10	SCE/SoCalGas	3.2	0.6	1.3	3.2	2.0	3.8	3.0	9.6	1.0	1.5	9.5
10	SDG&E	3.2	0.8	1.3	3.2	2.6	3.8	3.0	9.6	0.6	1.5	9.5
11	PG&E	4.3	0.8	1.2	5.1	2.5	3.7	4.0	9.2	0.4	1.5	9.0
12	PG&E	3.5	1.2	1.8	3.4	3.3	4.6	3.0	9.6	0.4	1.7	9.5
13	PG&E	4.6	0.8	1.3	5.8	5.3	8.4	4.5	9.7	0.4	1.6	9.5
14	SCE/SoCalGas	5.0	1.6	2.5	5.8	4.0	6.1	4.5	9.0	1.3	1.7	9.0
14	SDG&E	5.0	1.9	2.5	5.8	4.9	6.1	4.5	9.0	1.2	1.7	9.0
15	SCE/SoCalGas	4.8	1.0	1.6	5.0	>1	>1	4.5	7.1	1.1	1.5	7.0
16	PG&E	5.4	1.6	1.5	6.2	2.2	2.2	5.0	10.5	0.9	1.4	10.5

¹">1" indicates cases where there are both first cost savings and annual utility bill savings.

²Information about the measures included for each climate zone are described in Appendix D – Single Family Measure Summary.



Table 10: Single Family Package Cost-Effectiveness Results for the All-Electric Case^{1,2}

CZ	Utility	Efficiency							Efficiency & PV				Efficiency & PV/Battery			
		Non-Preempted			Equipment - Preempted			Target Efficiency				Target Total				Target Total
		Efficiency EDR Margin	On-Bill B/C Ratio	TDV B/C Ratio	Efficiency EDR Margin	On-Bill B/C Ratio	TDV B/C Ratio		Total EDR Margin	On-Bill B/C Ratio	TDV B/C Ratio		Total EDR Margin	On-Bill B/C Ratio	TDV B/C Ratio	
01	PG&E	15.2	1.8	1.7	6.9	2.9	2.7	6.5	31.4	1.8	1.5	31.0	41.2	1.4	1.4	41.0
02	PG&E	4.9	1.2	1.1	5.1	2.3	2.1	4.5	19.4	1.8	1.4	19.0	30.1	1.4	1.4	30.0
03	PG&E	4.7	2.6	2.4	4.4	1.8	1.6	4.0	18.5	2.2	1.7	18.0	29.3	1.5	1.6	29.0
04	PG&E	3.4	1.9	1.8	3.9	1.5	1.5	3.0	17.2	2.1	1.6	17.0	28.6	1.5	1.6	28.5
05	PG&E	4.4	2.6	2.3	4.4	1.9	1.7	4.0	18.2	2.3	1.8	18.0	28.7	1.6	1.6	28.5
05	PG&E/SoCalGas	4.4	2.6	2.3	4.4	1.9	1.7	4.0	18.2	2.3	1.8	18.0	28.7	1.6	1.6	28.5
06	SCE/SoCalGas	2.0	1.3	1.4	2.9	2.2	2.3	2.0	14.3	1.2	1.5	14.0	26.1	1.2	1.4	26.0
07	SDG&E	0.0	-	-	2.2	1.6	1.7	0.0	11.3	1.9	1.5	11.0	24.2	1.3	1.5	24.0
08	SCE/SoCalGas	1.6	0.6	1.2	1.8	2.8	3.0	1.5	10.9	1.0	1.5	10.5	21.6	1.1	1.4	21.5
09	SCE/SoCalGas	2.8	0.8	2.0	3.3	2.1	3.2	2.5	11.5	1.1	1.6	11.5	21.3	1.1	1.5	21.0
10	SCE/SoCalGas	3.1	0.9	1.5	3.4	2.3	3.2	3.0	11.1	1.1	1.5	11.0	21.2	1.1	1.5	21.0
10	SDG&E	3.1	1.1	1.5	3.4	2.6	3.2	3.0	11.1	1.7	1.5	11.0	21.2	1.4	1.5	21.0
11	PG&E	4.6	1.2	1.5	5.9	3.0	3.3	4.5	14.2	1.8	1.6	14.0	23.2	1.5	1.6	23.0
12	PG&E	3.8	0.8	1.1	5.1	2.0	2.5	3.5	15.7	1.7	1.4	15.5	25.4	1.3	1.5	25.0
13	PG&E	5.1	1.1	1.4	6.0	2.9	3.3	5.0	13.4	1.7	1.5	13.0	22.5	1.4	1.5	22.0
14	SCE/SoCalGas	5.6	1.0	1.5	6.0	2.3	3.1	5.5	15.5	1.2	1.6	15.5	23.9	1.4	1.6	23.5
14	SDG&E	5.6	1.3	1.5	6.0	2.9	3.1	5.5	15.5	1.8	1.6	15.5	23.9	1.7	1.6	23.5
15	SCE/SoCalGas	5.6	1.1	1.6	7.3	3.3	4.5	5.5	6.2	1.1	1.6	6.0	13.5	1.2	1.5	13.0
16	PG&E	9.7	1.7	1.7	4.9	2.4	2.3	4.5	27.0	2.1	1.6	26.5	35.4	1.7	1.5	35.0

¹">1" indicates cases where there are both first cost savings and annual utility bill savings.

²Information about the measures included for each climate zone are described in Appendix D – Single Family Measure Summary



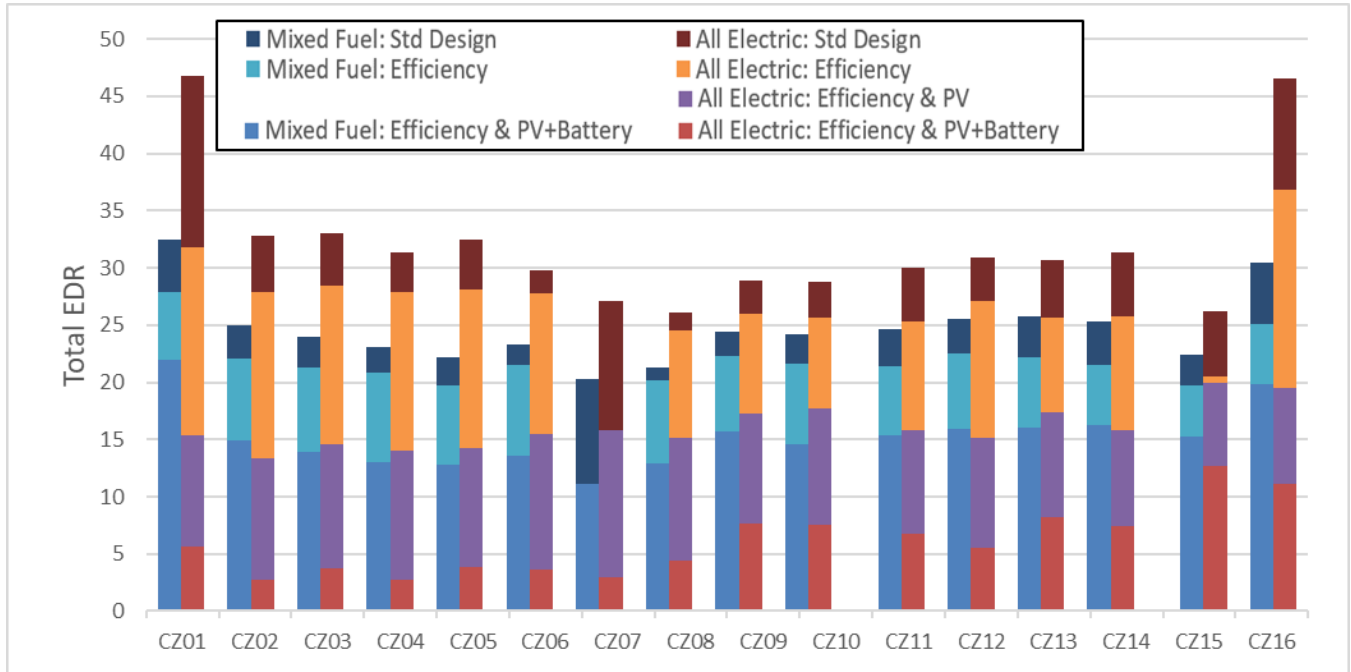


Figure 3: Single family Total EDR comparison

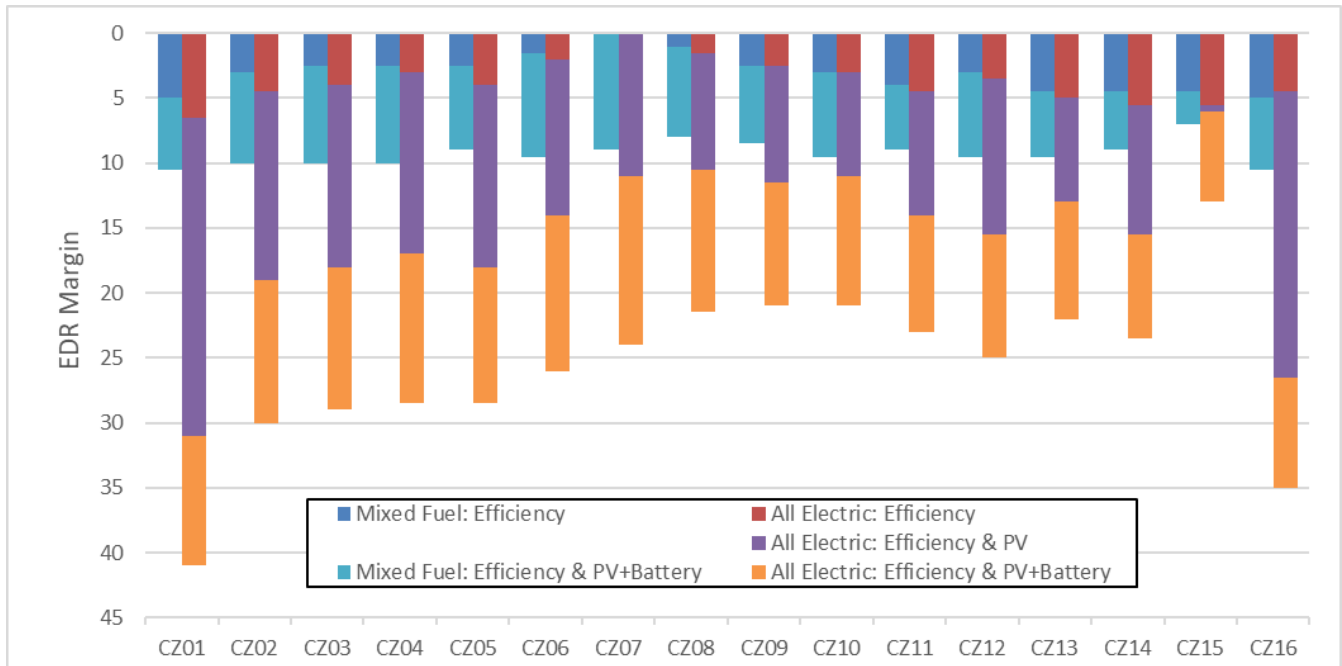


Figure 4: Single family EDR Margin comparison (based on Efficiency EDR Margin for the Efficiency packages and the Total EDR Margin for the Efficiency & PV and Efficiency & PV/Battery packages)



3.2.1 GHG Emission Reductions

Figure 5 compares annual GHG emissions for both mixed fuel and all-electric single family 2019 code compliant cases with Efficiency, Efficiency & PV and Efficiency & PV/Battery packages. GHG emissions vary by climate but are consistently higher in mixed fuel cases than all-electric. Standard Design mixed fuel emissions range from 1.3 (CZ 7) to 3.3 (CZ 16) lbs CO₂e/square foot of floor area, where all-electric Standard Design emissions range from 0.7 to 1.7 lbs CO₂e/ ft². Adding efficiency, PV and batteries to the mixed fuel code compliant prototype reduces GHG emissions by 20% on average to between 1.0 and 1.8 lbs CO₂e/ft², with the exception of Climate Zones 1 and 16. Adding efficiency, PV and batteries to the all-electric code compliant prototype reduces annual GHG emissions by 65% on average to 0.8 lbs CO₂e/ft² or less. None of the cases completely eliminate GHG emissions. Because of the time value of emissions calculation for electricity in CBECC-Res, there is always some amount of GHG impacts with using electricity from the grid.

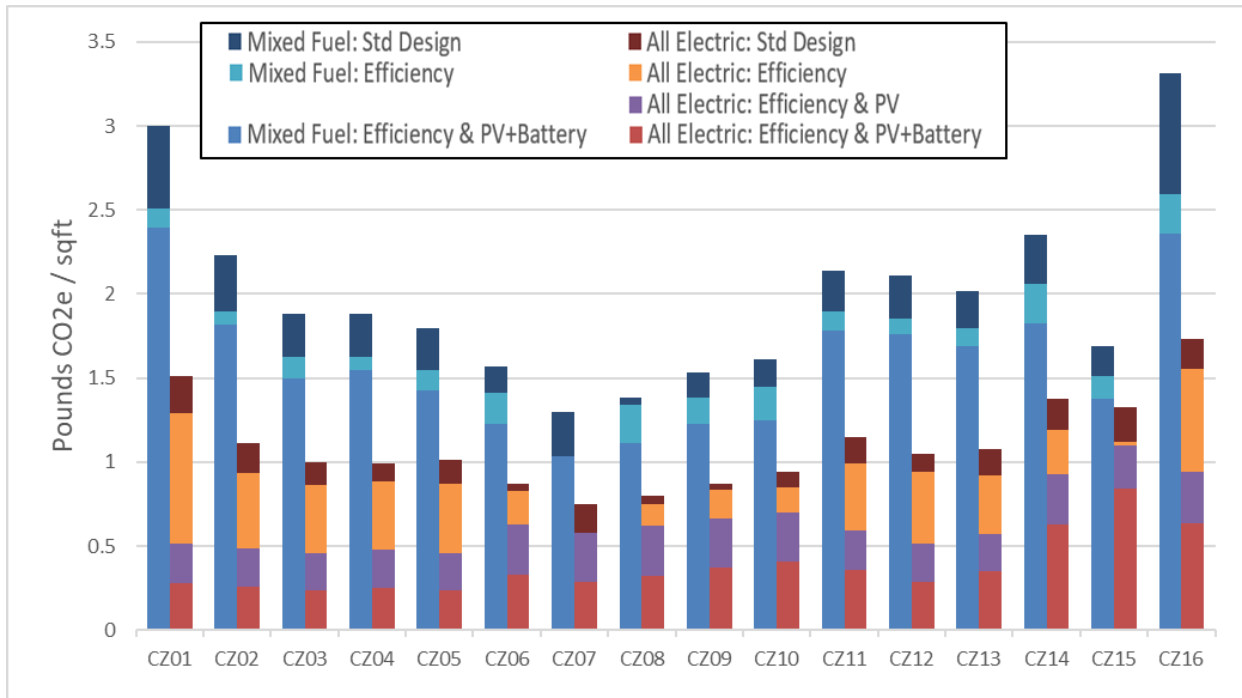


Figure 5: Single family greenhouse gas emissions comparison

3.3 Multifamily Results

Table 11 through Table 13 contain cost effectiveness findings for the multifamily packages. Table 11 summarizes the package costs for all the mixed fuel and all-electric efficiency, PV and battery packages.

Table 12 and Table 13 present the B/C ratios for all the packages according to both the On-Bill and TDV methodologies for the mixed fuel and the all-electric cases, respectively. All the packages are cost-effective based on TDV except Climate Zone 3 for the all-electric cases where no cost-effective combination of non-preempted efficiency measures was found that met the minimum 0.5 EDR Margin threshold. Cases where the B/C ratio is indicated as ">1" refer to instances where there are incremental cost savings in addition to annual utility bill savings. In these cases, there is no cost associated with this upgrade and benefits are realized immediately.

It is generally more challenging to achieve equivalent savings targets cost-effectively for the multifamily cases than for the single family cases. With less exterior surface area per floor area the impact of envelope measures



is diminished in multifamily buildings. Ducts are already assumed to be within conditioned space and therefore only one of the duct measures found to be cost-effective in single family homes can be applied.

Figure 6 presents a comparison of Total EDRs for the multifamily cases and Figure 7 presents the EDR Margin results. Each graph compares the mixed fuel and all-electric cases as well as the various packages. Cost-effective efficiency packages were found for all **mixed fuel cases**. The Target EDR Margins for the **mixed fuel Efficiency Package** are 0.5 for Climate Zones 3, 5 and 7, between 1.0 and 2.5 for Climate Zones 1, 2, 4, 6, 8 through 12 and 16, and between 3.0 and 4.0 in Climate Zones 13 through 15. For the **all-electric case, no cost-effective non-preempted efficiency packages** were found in Climate Zone 3. The Target EDR Margins are between 0.5 and 2.5 for Climate Zones 2, 4 through 10 and 12, and between 3.0 and 4.0 in Climate Zones 1, 11, and 13 through 16.

For the **mixed fuel case, the Efficiency & PV/Battery Package** results in an EDR Margin of between 8.5 and 11.5 across all climate zones. Most of these packages were not found to be cost-effective based on utility bill savings alone, but they all are cost-effective based on TDV energy savings. For the **all-electric case, the Efficiency & PV Package** resulted in EDR Margins of 10.5 to 17.5 for most climates; adding a battery system increased the EDR Margin by an additional 10 to 15 points. Climate zones 1 and 16, which have high heating loads, have much higher EDR Margins for the **Efficiency & PV package** (19.5-22.5). The Standard Design PV, which is what is applied in the **Efficiency Package**, is not sized to offset any of the heating load. When the PV system is sized to offset 90% of the total electricity use, the increase is substantial as a result. In Climate Zone 15 the Standard Design PV system is already sized to cover the cooling electricity load, which represents 30% of whole building electricity use. Therefore, increasing the PV size to offset 90% of the electric load in this climate only results in adding approximately 240 Watts of PV capacity per apartment and subsequently a much smaller impact on the EDR than in other climate zones. Because of the limitations on oversizing PV systems to offset natural gas use it is not feasible to achieve comparable EDR Margins for the mixed fuel case as in the all-electric case.

Additional results details can be found in Appendix E – Multifamily Detailed Results with summaries of measures included in each of the packages in Appendix F – Multifamily Measure Summary. A summary of results by climate zone is presented in Appendix G – Results by Climate Zone.

Table 11: Multifamily Package Incremental Costs per Dwelling Unit

Climate Zone	Mixed Fuel			All-Electric			
	Non-Preempted	Equipment - Preempted	Efficiency & PV/Battery	Non-Preempted	Equipment - Preempted	Efficiency & PV	Efficiency & PV/Battery
CZ01	+\$960	+\$507	+\$3,094	+\$949	+\$795	+\$5,538	+\$8,919
CZ02	+\$309	+\$497	+\$2,413	+\$361	+\$795	+\$3,711	+\$6,833
CZ03	+\$175	+\$403	+\$2,279	n/a	+\$795	+\$3,272	+\$6,344
CZ04	+\$329	+\$351	+\$2,429	+\$361	+\$795	+\$3,158	+\$6,201
CZ05	+\$180	+\$358	+\$2,273	+\$247	+\$795	+\$3,293	+\$6,314
CZ06	+\$190	+\$213	+\$2,294	+\$231	+\$361	+\$2,580	+\$5,590
CZ07	+\$90	+\$366	+\$2,188	+\$202	+\$361	+\$2,261	+\$5,203
CZ08	+\$250	+\$213	+\$2,353	+\$231	+\$361	+\$2,240	+\$5,249
CZ09	+\$136	+\$274	+\$2,234	+\$231	+\$361	+\$2,232	+\$5,236
CZ10	+\$278	+\$250	+\$2,376	+\$361	+\$361	+\$2,371	+\$5,395
CZ11	+\$850	+\$317	+\$2,950	+\$1,011	+\$795	+\$3,601	+\$6,759
CZ12	+\$291	+\$434	+\$2,394	+\$1,011	+\$795	+\$3,835	+\$6,943
CZ13	+\$831	+\$290	+\$2,936	+\$1,011	+\$795	+\$3,462	+\$6,650
CZ14	+\$874	+\$347	+\$2,957	+\$1,011	+\$795	+\$3,356	+\$6,380
CZ15	+\$510	-\$157	+\$2,604	+\$1,011	+\$1,954	+\$1,826	+\$5,020
CZ16	+\$937	+\$453	+\$3,028	+\$843	+\$795	+\$4,423	+\$7,533



Table 12: Multifamily Package Cost-Effectiveness Results for the Mixed Fuel Case^{1,2}

CZ	Utility	Efficiency							Efficiency & PV/Battery			
		Non-Preempted			Equipment - Preempted			Target				Target
		Efficiency	On-Bill	TDV	Efficiency	On-Bill	TDV	Efficiency	Total	On-Bill	TDV	Total
		EDR	B/C	B/C	EDR	B/C	B/C	EDR	EDR	B/C	B/C	EDR
		Margin	Ratio	Ratio	Margin	Ratio	Ratio	Margin	Margin	Ratio	Ratio	Margin
01	PG&E	3.4	1.1	1.2	2.3	1.3	1.4	2.0	11.5	0.4	1.2	11.5
02	PG&E	1.8	1.0	1.7	2.3	1.1	1.5	1.5	10.9	0.2	1.6	10.5
03	PG&E	0.6	1.0	1.1	1.6	1.1	1.2	0.5	10.3	0.1	1.4	10.0
04	PG&E	1.3	0.8	1.2	1.9	1.1	1.7	1.0	11.2	0.2	1.6	11.0
05	PG&E	0.5	1.0	1.0	1.5	1.2	1.3	0.5	9.9	0.2	1.4	9.5
05	PG&E/SoCalGas	0.5	0.8	1.0	1.5	1.1	1.3	0.5	9.9	0.1	1.4	9.5
06	SCE/SoCalGas	1.3	0.6	1.5	1.3	1.4	1.7	1.0	10.7	0.6	1.4	10.5
07	SDG&E	0.9	0.7	2.2	2.0	1.1	1.4	0.5	11.0	0.0	1.4	11.0
08	SCE/SoCalGas	1.5	0.7	1.4	1.1	1.4	1.7	1.0	9.9	0.7	1.3	9.5
09	SCE/SoCalGas	1.8	1.5	3.3	2.8	1.7	2.9	1.5	9.7	0.9	1.5	9.5
10	SCE/SoCalGas	1.7	0.8	1.7	2.9	2.0	3.3	1.5	10.4	1.0	1.6	10.0
10	SDG&E	1.7	1.1	1.7	2.9	2.6	3.3	1.5	10.4	0.2	1.6	10.0
11	PG&E	2.9	0.7	1.2	3.2	1.8	3.3	2.5	10.5	0.4	1.6	10.5
12	PG&E	1.9	1.1	2.2	2.8	1.2	2.2	1.5	10.3	0.3	1.7	10.0
13	PG&E	3.1	0.6	1.3	3.4	2.0	3.8	3.0	10.7	0.4	1.6	10.5
14	SCE/SoCalGas	3.1	0.7	1.2	3.3	2.0	3.0	3.0	9.6	1.1	1.4	9.5
14	SDG&E	3.1	0.9	1.2	3.3	2.5	3.0	3.0	9.6	0.5	1.4	9.5
15	SCE/SoCalGas	4.2	1.4	2.3	4.4	>1	>1	4.0	8.8	1.3	1.7	8.5
16	PG&E	2.4	1.1	1.2	2.9	1.8	2.1	2.0	9.9	0.5	1.3	9.5

¹">1" indicates cases where there are both first cost savings and annual utility bill savings.

²Information about the measures included for each climate zone are described in Appendix F – Multifamily Measure Summary.



Table 13: Multifamily Package Cost-effectiveness Results for the All-Electric Case^{1,2}

CZ	Utility	Efficiency							Efficiency & PV				Efficiency & PV/Battery			
		Non-Preempted			Equipment - Preempted			Target Efficiency EDR Margin				Target Total EDR Margin				Target Total EDR Margin
		Efficiency EDR Margin	On-Bill B/C Ratio	TDV B/C Ratio	Efficiency EDR Margin	On-Bill B/C Ratio	TDV B/C Ratio		Total EDR Margin	On-Bill B/C Ratio	TDV B/C Ratio		Total EDR Margin	On-Bill B/C Ratio	TDV B/C Ratio	
01	PG&E	3.6	1.6	1.4	3.3	2.4	2.3	3.0	22.5	2.0	1.5	22.5	34.5	1.3	1.4	34.5
02	PG&E	1.9	1.7	2.1	3.2	1.6	1.6	1.5	17.5	2.4	1.8	17.5	30.9	1.4	1.7	30.5
03	PG&E	0.0	-	-	2.7	1.7	1.6	0.0	16.1	2.4	1.7	16.0	29.5	1.3	1.6	29.5
04	PG&E	1.4	1.4	1.5	2.2	1.2	1.1	1.0	15.0	2.4	1.8	15.0	28.9	1.3	1.8	28.5
05	PG&E	0.6	1.1	0.9	3.6	2.1	2.0	0.5	17.1	2.5	1.8	17.0	30.3	1.4	1.7	30.0
05	PG&E/SoCalGas	0.6	1.1	0.9	3.6	2.1	2.0	0.5	17.1	2.5	1.8	17.0	30.3	1.4	1.7	30.0
06	SCE/SoCalGas	1.0	0.7	1.3	2.2	1.6	1.9	1.0	13.8	1.2	1.7	13.5	27.5	1.2	1.6	27.5
07	SDG&E	0.6	0.6	1.0	1.9	1.6	1.7	0.5	12.8	2.1	1.8	12.5	27.1	1.2	1.6	27.0
08	SCE/SoCalGas	1.2	0.9	1.7	1.9	1.6	1.8	1.0	11.6	1.3	1.8	11.5	24.2	1.2	1.6	24.0
09	SCE/SoCalGas	1.6	1.3	2.7	1.5	1.6	1.6	1.5	11.3	1.3	1.9	11.0	23.3	1.3	1.7	23.0
10	SCE/SoCalGas	1.8	1.2	2.0	1.8	1.7	2.0	1.5	10.8	1.3	1.8	10.5	23.3	1.3	1.7	23.0
10	SDG&E	1.8	1.5	2.0	1.8	2.0	2.0	1.5	10.8	2.1	1.8	10.5	23.3	1.4	1.7	23.0
11	PG&E	3.5	1.4	1.6	3.9	2.0	2.3	3.5	13.4	2.2	1.8	13.0	25.3	1.4	1.8	25.0
12	PG&E	2.6	0.9	1.1	2.9	1.6	1.6	2.5	14.4	2.1	1.6	14.0	26.6	1.3	1.7	26.5
13	PG&E	3.3	1.3	1.6	3.8	2.0	2.3	3.0	12.2	2.1	1.7	12.0	23.9	1.4	1.7	23.5
14	SCE/SoCalGas	3.7	1.2	1.6	3.8	1.6	2.2	3.5	14.0	1.4	1.9	14.0	24.8	1.4	1.8	24.5
14	SDG&E	3.7	1.5	1.6	3.8	2.0	2.2	3.5	14.0	2.2	1.9	14.0	24.8	1.7	1.8	24.5
15	SCE/SoCalGas	4.4	1.5	2.3	6.4	1.2	1.7	4.0	7.1	1.4	2.1	7.0	16.9	1.3	1.8	16.5
16	PG&E	4.1	2.1	2.1	3.2	1.6	1.7	3.0	19.6	2.6	1.9	19.5	29.9	1.6	1.7	29.5

¹">1" indicates cases where there are both first cost savings and annual utility bill savings.

²Information about the measures included for each climate zone are described in Appendix F – Multifamily Measure Summary.



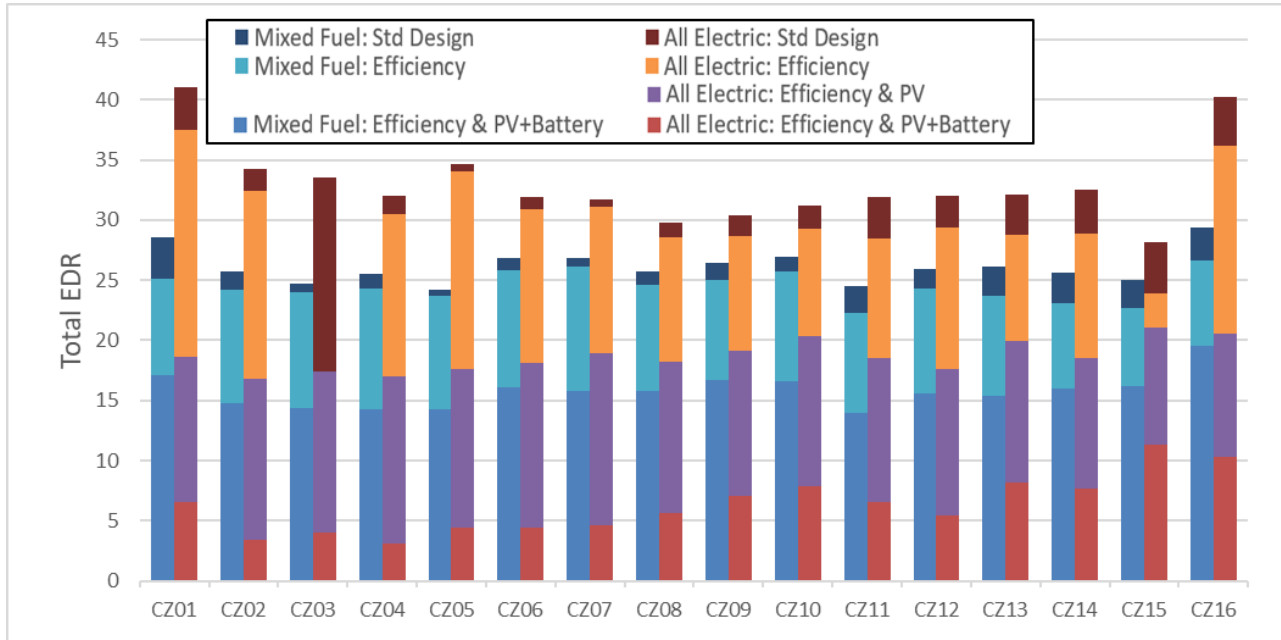


Figure 6: Multifamily Total EDR comparison

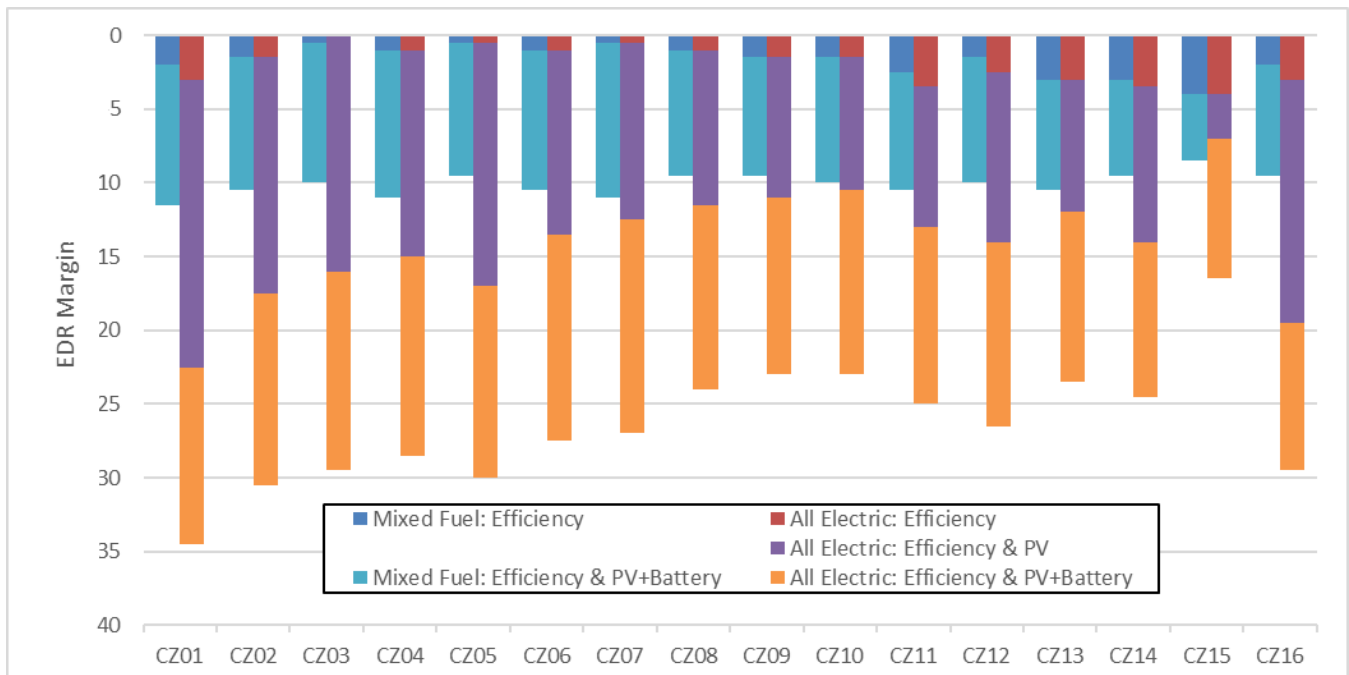


Figure 7: Multifamily EDR Margin comparison (based on Efficiency EDR Margin for the Efficiency packages and the Total EDR Margin for the Efficiency & PV and Efficiency & PV/Battery packages)

3.3.1 GHG Emission Reductions

Figure 8 compares annual GHG emissions for both mixed fuel and all-electric multifamily 2019 code compliant cases with Efficiency, Efficiency & PV and Efficiency & PV/Battery packages. GHG emissions vary by climate but are consistently higher in mixed fuel cases than all-electric. Standard design mixed fuel emissions range from 2.0 to 3.0 lbs CO₂e/square foot of floor area, where all-electric standard design emissions range from 1.2 to 1.7 lbs CO₂e/ft². Adding PV, batteries and efficiency to the mixed fuel code compliant prototype reduces annual GHG emissions by 17% on average to between 1.7 and 2.2 lbs CO₂e/ft², except Climate Zone 16. Adding PV, batteries and efficiency to the all-electric code compliant prototype reduces annual GHG emissions by 64% on average to 0.6 lbs CO₂e/ft² or less with the exception of Climate Zones 14, 15 and 16. As in the single family case, none of the cases completely eliminate GHG emissions because of the time value of emissions calculation for electricity in CBECC-Res.

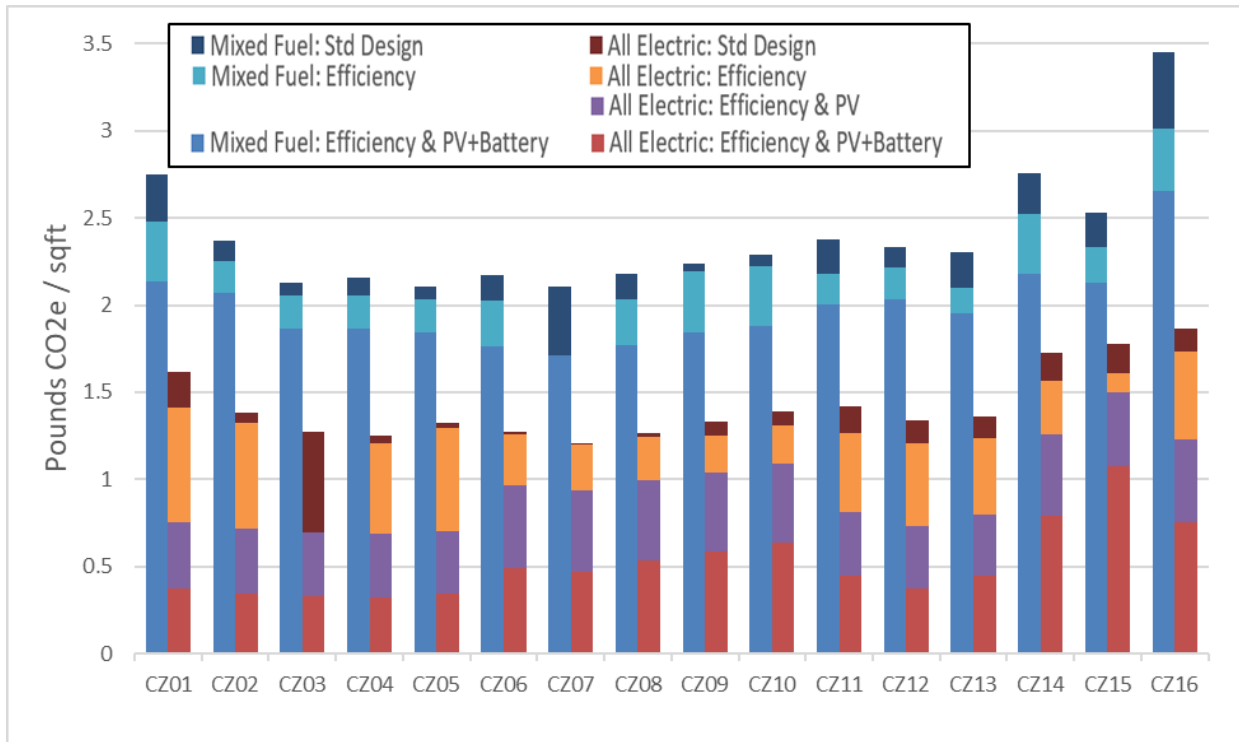


Figure 8: Multifamily greenhouse gas emissions comparison

3.4 Electrification Results

Cost-effectiveness results comparing mixed fuel and all-electric cases are summarized below. The tables show average annual utility bill impacts and lifetime utility bill impacts, which account for fuel escalation for electricity and natural gas (see Section 2.5), lifetime equipment cost savings, and both On-Bill and TDV cost-effectiveness (B/C ratio). Positive utility bill values indicate lower utility costs for the all-electric home relative to the mixed fuel case while negative values in red and parenthesis indicate higher utility costs for the all-electric case. Lifetime equipment cost savings include savings due to eliminating natural gas infrastructure and replacement costs for appliances based on equipment life. Positive values for the lifetime equipment cost savings indicate lower installed costs for the all-electric and negative values indicate higher costs. B/C ratios 1.0 or greater indicate positive cost-effectiveness. Cases where the B/C ratio is indicated as ">1" refer to instances where there was incremental cost savings in addition to annual utility bill savings. In these cases, there is no cost associated with this upgrade and benefits are realized immediately.



Three scenarios were evaluated:

1. **2019 Code Compliant:** Compares a 2019 code compliant all-electric home with a 2019 code compliant mixed fuel home.
2. **Efficiency & PV Package:** Compares an all-electric home with efficiency and PV sized to 90% of the annual electricity use to a 2019 code compliant mixed fuel home. The first cost savings in the code compliant all-electric house is invested in above code efficiency and PV reflective of the Efficiency & PV packages described above.
3. **Neutral Cost Package:** Compares an all-electric home with PV beyond code minimum with a 2019 code compliant mixed fuel home. The PV system for the all-electric case is sized to result in a zero lifetime incremental cost relative to a mixed fuel home.

3.4.1 Single Family

Table 14, Table 15, Figure 9, Figure 10, and Figure 11 present results of cost-effectiveness analysis for electrification of single family buildings, according to both the On-Bill and TDV methodologies. Based on typical cost assumptions arrived at for this analysis, the lifetime equipment costs for the single family code compliant all-electric option are approximately \$5,350 less than the mixed fuel code compliant option. Cost savings are entirely due to the elimination of gas infrastructure, which was assumed to be a savings of \$5,750. When evaluating cost-effectiveness based on TDV, the Utility Gas Main Extensions rules 50% refund and appliance allowance deduction are not applied and therefore the cost savings are twice as much.

Under the Efficiency & PV Package and the On-Bill analysis, the incremental cost of the efficiency and PV is typically more than the cost savings seen in the code compliant case, which results in a net cost increase in most climate zones for the all-electric case. In climates with small heating loads (7 and 15) there continues to be an incremental cost savings for the all-electric home. With the TDV analysis, there is still an incremental cost savings in all climates except 1 and 16 for single family.

Utility impacts differ by climate zone and utility, but utility costs for the code compliant all-electric option are typically higher than for the compliant mixed fuel design. There are utility cost savings across all climate zones and building types for the all-electric Efficiency & PV Package, resulting in a more cost-effective option.

The all-electric code compliant option is cost-effective based on the On-Bill approach for single family homes in Climate Zones 6 through 9, 10 (SCE/SoCalGas territory only), and 15. The code compliant option is cost-effective based on the TDV methodology in all climate zones except 1 and 16. If the same costs used for the On-Bill approach are also used for the TDV approach (incorporating the Utility Gas Main Extensions rules 50% refund and appliance allowance deduction), the all-electric code compliant option is cost-effective in Climate Zones 6 through 10. The Efficiency & PV all-electric option is cost-effective in all climate zones based on both the On-Bill and TDV methodologies. In many cases it is cost-effective immediately with lower equipment and utility costs.

The last set of results in Table 14 shows the neutral cost case where the cost savings for the all-electric code compliant home is invested in a larger PV system, resulting in a lifetime incremental cost of zero based on the On-Bill approach. This package results in utility cost savings in all cases except Climate Zones 1, 14 (SCE/SoCalGas territory only), and 16. For these three cases the Reach Code Team evaluated how much additional PV would be required to result in a cost-effective package. These results are presented in Table 15 and show that an additional 1.6kW in Climate Zone 1 results in a B/C ratio of 1.1. For Climate Zone 14 and 16 adding 0.25kW and 1.2kW, respectively, results in a B/C ratio of 1.2. Neutral cost cases are cost-effective based on the TDV methodology in all climate zones except 16.

3.4.2 Multifamily

Multifamily results are found in Table 16, Table 17, Figure 12, Figure 13, and Figure 14. Lifetime costs for the multifamily code compliant all-electric option are approximately \$2,300 less than the mixed fuel code compliant option, entirely due to the elimination of gas infrastructure. When evaluating cost-effectiveness based on TDV,



the Utility Gas Main Extensions rules 50% refund and appliance allowance deduction are not applied and therefore the cost savings are approximately 2.5 times higher.

With the Efficiency & PV Package and the On-Bill analysis, due to the added cost of the efficiency and PV there is a net cost increase for the all-electric case in all climate zones for except 7, 8, 9, and 15. With the TDV analysis, there is still an incremental cost savings in all climates. Like the single family results, utility costs are typically higher for the code compliant all-electric option but lower than the code compliant mixed fuel option with the Efficiency & PV Package.

The all-electric code compliant option is cost-effective based on the On-Bill approach for multifamily in Climate Zones 6 through 9, 10 and 14 (SCE/SoCalGas territory only), and 15. Based on the TDV methodology, the code compliant option for multifamily is cost-effective for all climate zones. If the same costs used for the On-Bill approach are also used for the TDV approach (incorporating the Utility Gas Main Extensions rules 50% refund and appliance allowance deduction), the all-electric code compliant option is cost-effective in Climate Zones 8 and 9. Like the single family cases, the Efficiency & PV all-electric option is cost-effective in all climate zones based on both the On-Bill and TDV methodologies.

The last set of results in Table 16 show the neutral cost case where the cost savings for the all-electric code compliant home is invested in a larger PV system, resulting in a lifetime incremental cost of zero based on the On-Bill approach. This package results in utility cost savings in all cases except Climate Zone 1. For this case the Reach Code Team evaluated how much additional PV would be required to result in a cost-effective package. These results are presented in Table 17 and show that an additional 0.3kW per apartment results in a B/C ratio of 1.1. Neutral cost cases are cost-effective based on the TDV methodology in all climate zones except 16.

Table 14: Single Family Electrification Results

		On-Bill Cost-effectiveness ¹						TDV Cost-effectiveness		
		Average Annual Utility Bill Savings			Lifetime NPV			Lifetime NPV		
			Natural Gas	Net Utility Savings	Utility Bill Savings	Equipment Cost Savings	On-Bill B/C Ratio ²	TDV Cost Savings	Equipment Cost Savings	TDV B/C Ratio
CZ	Utility	Electricity	Gas	Savings	Savings	Savings	Ratio ²	Savings	Savings	Ratio
	2019 Code Compliant Home									
01	PG&E	-\$(\$1,194)	+\$712	-\$(\$482)	-\$(\$14,464)	+\$5,349	0.4	-\$(\$13,081)	+\$11,872	0.9
02	PG&E	-\$(\$825)	+\$486	-\$(\$340)	-\$(\$10,194)	+\$5,349	0.5	-\$(\$7,456)	+\$11,872	1.6
03	PG&E	-\$(\$717)	+\$391	-\$(\$326)	-\$(\$9,779)	+\$5,349	0.5	-\$(\$7,766)	+\$11,872	1.5
04	PG&E	-\$(\$710)	+\$387	-\$(\$322)	-\$(\$9,671)	+\$5,349	0.6	-\$(\$7,447)	+\$11,872	1.6
05	PG&E	-\$(\$738)	+\$367	-\$(\$371)	-\$(\$11,128)	+\$5,349	0.5	-\$(\$8,969)	+\$11,872	1.3
05	PG&E/SoCalGas	-\$(\$738)	+\$370	-\$(\$368)	-\$(\$11,034)	+\$5,349	0.5	-\$(\$8,969)	+\$11,872	1.3
06	SCE/SoCalGas	-\$(\$439)	+\$289	-\$(\$149)	-\$(\$4,476)	+\$5,349	1.2	-\$(\$4,826)	+\$11,872	2.5
07	SDG&E	-\$(\$414)	+\$243	-\$(\$171)	-\$(\$5,134)	+\$5,349	1.0	-\$(\$4,678)	+\$11,872	2.5
08	SCE/SoCalGas	-\$(\$347)	+\$249	-\$(\$97)	-\$(\$2,921)	+\$5,349	1.8	-\$(\$3,971)	+\$11,872	3.0
09	SCE/SoCalGas	-\$(\$377)	+\$271	-\$(\$107)	-\$(\$3,199)	+\$5,349	1.7	-\$(\$4,089)	+\$11,872	2.9
10	SCE/SoCalGas	-\$(\$403)	+\$280	-\$(\$123)	-\$(\$3,684)	+\$5,349	1.5	-\$(\$4,458)	+\$11,872	2.7
10	SDG&E	-\$(\$496)	+\$297	-\$(\$198)	-\$(\$5,950)	+\$5,349	0.9	-\$(\$4,458)	+\$11,872	2.7
11	PG&E	-\$(\$810)	+\$447	-\$(\$364)	-\$(\$10,917)	+\$5,349	0.5	-\$(\$7,024)	+\$11,872	1.7
12	PG&E	-\$(\$740)	+\$456	-\$(\$284)	-\$(\$8,533)	+\$5,349	0.6	-\$(\$6,281)	+\$11,872	1.9
13	PG&E	-\$(\$742)	+\$413	-\$(\$329)	-\$(\$9,870)	+\$5,349	0.5	-\$(\$6,480)	+\$11,872	1.8
14	SCE/SoCalGas	-\$(\$661)	+\$413	-\$(\$248)	-\$(\$7,454)	+\$5,349	0.7	-\$(\$7,126)	+\$11,872	1.7
14	SDG&E	-\$(\$765)	+\$469	-\$(\$296)	-\$(\$8,868)	+\$5,349	0.6	-\$(\$7,126)	+\$11,872	1.7
15	SCE/SoCalGas	-\$(\$297)	+\$194	-\$(\$103)	-\$(\$3,090)	+\$5,349	1.7	-\$(\$5,364)	+\$11,872	2.2
16	PG&E	-\$(\$1,287)	+\$712	-\$(\$575)	-\$(\$17,250)	+\$5,349	0.3	-\$(\$17,391)	+\$11,872	0.7



		On-Bill Cost-effectiveness ¹						TDV Cost-effectiveness		
		Average Annual Utility Bill Savings			Lifetime NPV			Lifetime NPV		
				Net Utility Savings		Equipment Cost Savings	On-Bill B/C Ratio ²		Equipment Cost Savings	TDV B/C Ratio
CZ	Utility	Electricity	Gas		Utility Bill Savings			TDV Cost Savings		
	Efficiency & PV Package									
01	PG&E	-\$99	+\$712	+\$613	+\$18,398	-\$12,844	1.4	+\$13,364	-\$6,321	2.1
02	PG&E	-\$89	+\$486	+\$397	+\$11,910	-\$6,758	1.8	+\$9,307	-\$234	39.7
03	PG&E	-\$87	+\$391	+\$304	+\$9,119	-\$3,169	2.9	+\$6,516	+\$3,355	>1
04	PG&E	-\$85	+\$387	+\$302	+\$9,074	-\$3,438	2.6	+\$6,804	+\$3,086	>1
05	PG&E	-\$98	+\$367	+\$268	+\$8,054	-\$2,959	2.7	+\$5,625	+\$3,564	>1
05	PG&E/SoCalGas	-\$98	+\$370	+\$272	+\$8,148	-\$2,959	2.8	+\$5,625	+\$3,564	>1
06	SCE/SoCalGas	-\$188	+\$289	+\$102	+\$3,049	-\$992	3.1	+\$4,585	+\$5,531	>1
07	SDG&E	-\$137	+\$243	+\$106	+\$3,174	+\$912	>1	+\$2,176	+\$7,436	>1
08	SCE/SoCalGas	-\$160	+\$249	+\$89	+\$2,664	-\$25	107.9	+\$3,965	+\$6,499	>1
09	SCE/SoCalGas	-\$169	+\$271	+\$102	+\$3,067	-\$429	7.1	+\$5,368	+\$6,094	>1
10	SCE/SoCalGas	-\$173	+\$280	+\$107	+\$3,216	-\$1,057	3.0	+\$5,165	+\$5,466	>1
10	SDG&E	-\$137	+\$297	+\$160	+\$4,805	-\$1,057	4.5	+\$5,165	+\$5,466	>1
11	PG&E	-\$147	+\$447	+\$300	+\$8,988	-\$5,478	1.6	+\$9,776	+\$1,045	>1
12	PG&E	-\$92	+\$456	+\$364	+\$10,918	-\$6,172	1.8	+\$9,913	+\$352	>1
13	PG&E	-\$144	+\$413	+\$269	+\$8,077	-\$5,184	1.6	+\$8,960	+\$1,339	>1
14	SCE/SoCalGas	-\$241	+\$413	+\$172	+\$5,164	-\$5,111	1.0	+\$9,850	+\$1,412	>1
14	SDG&E	-\$139	+\$469	+\$330	+\$9,910	-\$5,111	1.9	+\$9,850	+\$1,412	>1
15	SCE/SoCalGas	-\$107	+\$194	+\$87	+\$2,603	+\$264	>1	+\$2,598	+\$6,787	>1
16	PG&E	-\$130	+\$712	+\$582	+\$17,457	-\$11,234	1.6	+\$9,536	-\$4,710	2.0
	Neutral Cost Package									
01	PG&E	-\$869	+\$712	-\$157	-\$4,704	+\$0	0	-\$6,033	+\$6,549	1.1
02	PG&E	-\$445	+\$486	+\$40	+\$1,213	+\$0	>1	+\$868	+\$6,505	>1
03	PG&E	-\$335	+\$391	+\$56	+\$1,671	+\$0	>1	+\$483	+\$6,520	>1
04	PG&E	-\$321	+\$387	+\$66	+\$1,984	+\$0	>1	+\$1,062	+\$6,521	>1
05	PG&E	-\$335	+\$367	+\$31	+\$938	+\$0	>1	-\$163	+\$6,519	40.1
05	PG&E/SoCalGas	-\$335	+\$370	+\$34	+\$1,031	+\$0	>1	-\$163	+\$6,519	40.1
06	SCE/SoCalGas	-\$227	+\$289	+\$63	+\$1,886	+\$0	>1	+\$3,258	+\$6,499	>1
07	SDG&E	-\$72	+\$243	+\$171	+\$5,132	+\$0	>1	+\$3,741	+\$6,519	>1
08	SCE/SoCalGas	-\$144	+\$249	+\$105	+\$3,162	+\$0	>1	+\$4,252	+\$6,515	>1
09	SCE/SoCalGas	-\$170	+\$271	+\$100	+\$3,014	+\$0	>1	+\$4,271	+\$6,513	>1
10	SCE/SoCalGas	-\$199	+\$280	+\$81	+\$2,440	+\$0	>1	+\$3,629	+\$6,494	>1
10	SDG&E	-\$155	+\$297	+\$143	+\$4,287	+\$0	>1	+\$3,629	+\$6,494	>1
11	PG&E	-\$426	+\$447	+\$21	+\$630	+\$0	>1	+\$1,623	+\$6,504	>1
12	PG&E	-\$362	+\$456	+\$94	+\$2,828	+\$0	>1	+\$2,196	+\$6,525	>1
13	PG&E	-\$370	+\$413	+\$43	+\$1,280	+\$0	>1	+\$1,677	+\$6,509	>1
14	SCE/SoCalGas	-\$416	+\$413	-\$4	-\$107	+\$0	0	+\$2,198	+\$6,520	>1
14	SDG&E	-\$391	+\$469	+\$79	+\$2,356	+\$0	>1	+\$2,198	+\$6,520	>1
15	SCE/SoCalGas	-\$98	+\$194	+\$97	+\$2,900	+\$0	>1	+\$2,456	+\$6,483	>1
16	PG&E	-\$878	+\$712	-\$166	-\$4,969	+\$0	0	-\$8,805	+\$6,529	0.7

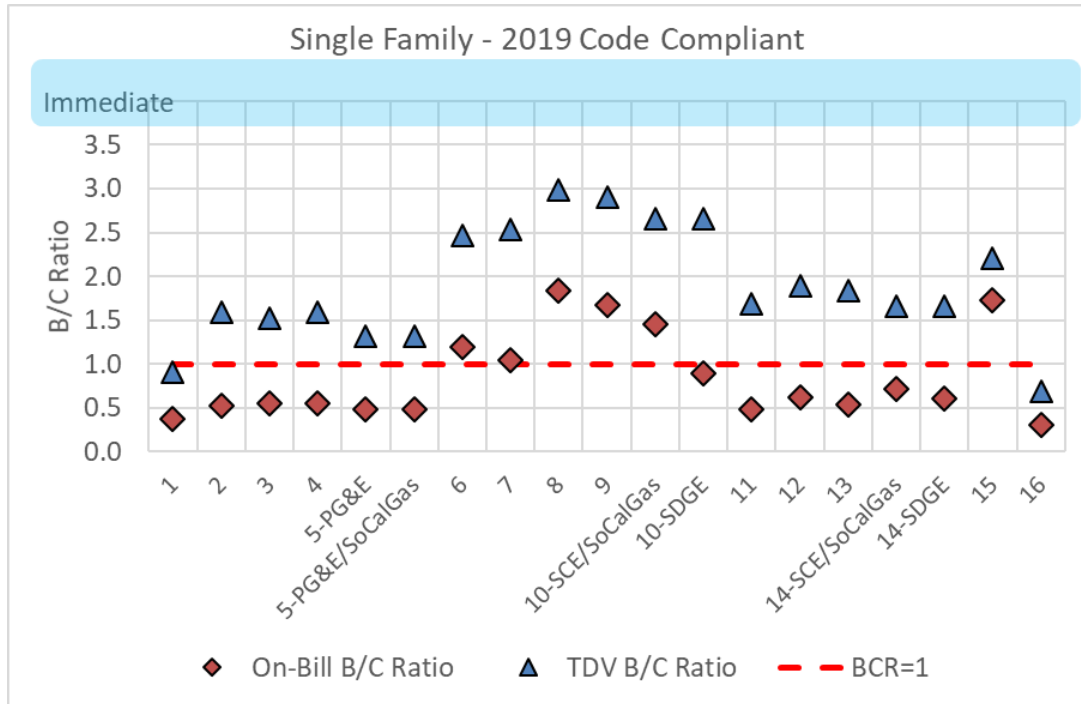
¹Red values in parentheses indicate an increase in utility bill costs or an incremental first cost for the all-electric home.

²>1" indicates cases where there are both first cost savings and annual utility bill savings.



Table 15: Comparison of Single Family On-Bill Cost Effectiveness Results with Additional PV

CZ	Utility	Neutral Cost				Min. Cost Effectiveness			
		PV Capacity (kW)	Utility Bill Savings	Equipment Cost Savings	On-Bill B/C Ratio	PV Capacity (kW)	Utility Bill Savings	Equipment Cost Savings	On-Bill B/C Ratio
01	PG&E	4.7	-\$4,704	+\$0	0	6.3	+\$6,898	-\$6,372	1.1
14	SCE/SoCalGas	4.5	-\$107	+\$0	0	4.8	+\$1,238	-\$1,000	1.2
16	PG&E	4.1	-\$4,969	+\$0	0	5.3	+\$5,883	-\$4,753	1.2

**Figure 9: B/C ratio results for a single family all-electric code compliant home versus a mixed fuel code compliant home**

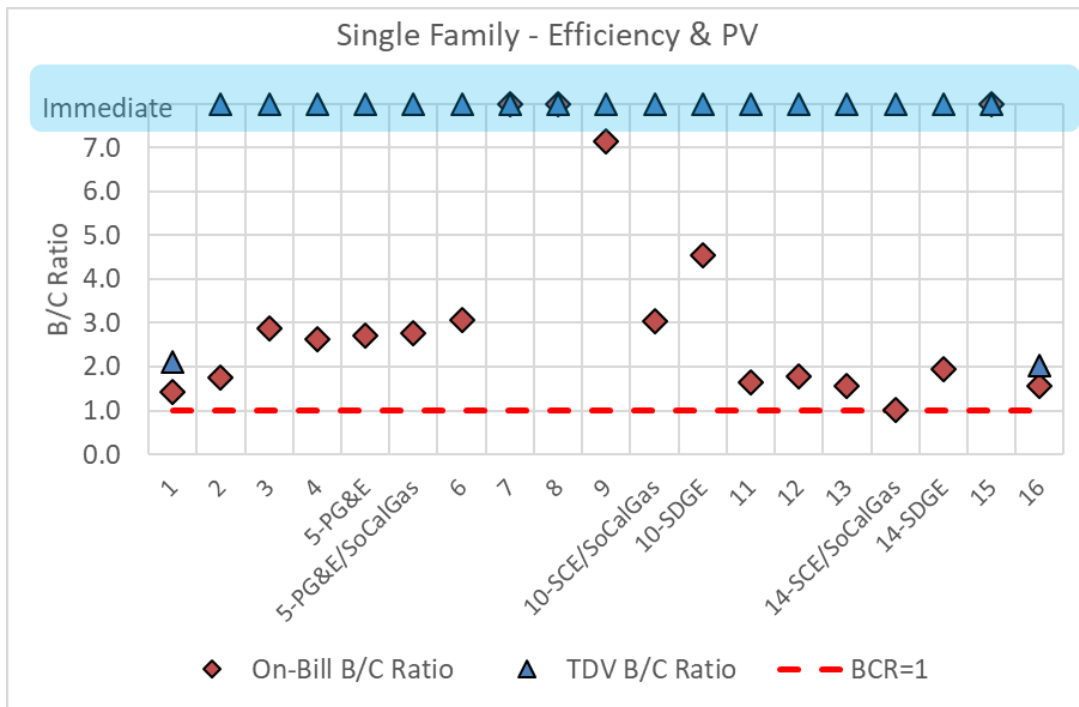


Figure 10: B/C ratio results for the single family Efficiency & PV all-electric home versus a mixed fuel code compliant home

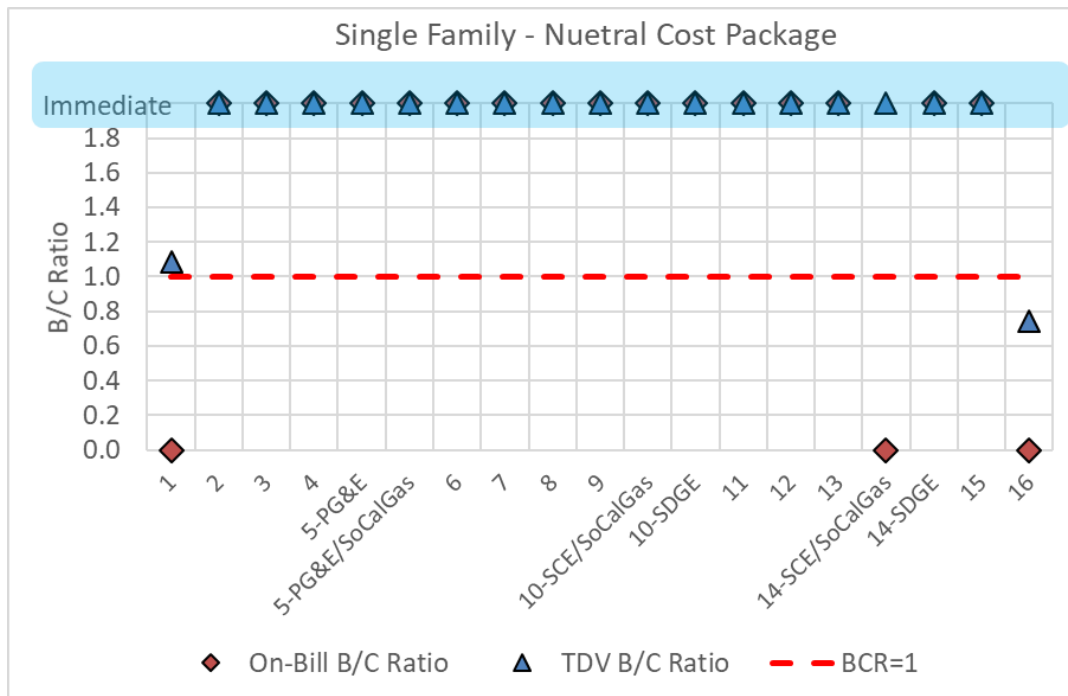


Figure 11: B/C ratio results for the single family neutral cost package all-electric home versus a mixed fuel code compliant home



Table 16: Multifamily Electrification Results (Per Dwelling Unit)

		On-Bill Cost-effectiveness ¹						TDV Cost-effectiveness		
		Average Annual Utility Bill Savings			Lifetime NPV			Lifetime NPV		
				Net		Equipment	On-Bill		Equipment	TDV
CZ	Utility	Electricity	Natural Gas	Utility Savings	Utility Bill Savings	Cost Savings	B/C Ratio ²	TDV Cost Savings	Cost Savings	B/C Ratio
	2019 Code Compliant Home									
01	PG&E	-\$(\$396)	+\$193	-\$(\$203)	-\$(\$6,079)	+\$2,337	0.4	-\$(\$5,838)	+\$5,899	1.0
02	PG&E	-\$(\$310)	+\$162	-\$(\$148)	-\$(\$4,450)	+\$2,337	0.5	-\$(\$4,144)	+\$5,899	1.4
03	PG&E	-\$(\$277)	+\$142	-\$(\$135)	-\$(\$4,041)	+\$2,337	0.6	-\$(\$4,035)	+\$5,899	1.5
04	PG&E	-\$(\$264)	+\$144	-\$(\$120)	-\$(\$3,595)	+\$2,337	0.6	-\$(\$3,329)	+\$5,899	1.8
05	PG&E	-\$(\$297)	+\$140	-\$(\$157)	-\$(\$4,703)	+\$2,337	0.5	-\$(\$4,604)	+\$5,899	1.3
05	PG&E/SoCalGas	-\$(\$297)	+\$178	-\$(\$119)	-\$(\$3,573)	+\$2,337	0.7	-\$(\$4,604)	+\$5,899	1.3
06	SCE/SoCalGas	-\$(\$191)	+\$161	-\$(\$30)	-\$(\$902)	+\$2,337	2.6	-\$(\$2,477)	+\$5,899	2.4
07	SDG&E	-\$(\$206)	+\$136	-\$(\$70)	-\$(\$2,094)	+\$2,337	1.1	-\$(\$2,390)	+\$5,899	2.5
08	SCE/SoCalGas	-\$(\$169)	+\$157	-\$(\$12)	-\$(\$349)	+\$2,337	6.7	-\$(\$2,211)	+\$5,899	2.7
09	SCE/SoCalGas	-\$(\$177)	+\$159	-\$(\$18)	-\$(\$533)	+\$2,337	4.4	-\$(\$2,315)	+\$5,899	2.5
10	SCE/SoCalGas	-\$(\$183)	+\$159	-\$(\$23)	-\$(\$697)	+\$2,337	3.4	-\$(\$2,495)	+\$5,899	2.4
10	SDG&E	-\$(\$245)	+\$139	-\$(\$106)	-\$(\$3,192)	+\$2,337	0.7	-\$(\$2,495)	+\$5,899	2.4
11	PG&E	-\$(\$291)	+\$153	-\$(\$138)	-\$(\$4,149)	+\$2,337	0.6	-\$(\$4,420)	+\$5,899	1.3
12	PG&E	-\$(\$277)	+\$155	-\$(\$122)	-\$(\$3,665)	+\$2,337	0.6	-\$(\$3,557)	+\$5,899	1.7
13	PG&E	-\$(\$270)	+\$146	-\$(\$124)	-\$(\$3,707)	+\$2,337	0.6	-\$(\$3,821)	+\$5,899	1.5
14	SCE/SoCalGas	-\$(\$255)	+\$187	-\$(\$69)	-\$(\$2,062)	+\$2,337	1.1	-\$(\$3,976)	+\$5,899	1.5
14	SDG&E	-\$(\$328)	+\$175	-\$(\$154)	-\$(\$4,607)	+\$2,337	0.5	-\$(\$3,976)	+\$5,899	1.5
15	SCE/SoCalGas	-\$(\$154)	+\$142	-\$(\$12)	-\$(\$367)	+\$2,337	6.4	-\$(\$2,509)	+\$5,899	2.4
16	PG&E	-\$(\$404)	+\$224	-\$(\$180)	-\$(\$5,411)	+\$2,337	0.4	-\$(\$5,719)	+\$5,899	1.0
	Efficiency & PV Package									
01	PG&E	-\$(\$19)	+\$193	+\$174	+\$5,230	-\$(\$3,202)	1.6	+\$2,467	+\$361	>1
02	PG&E	-\$(\$10)	+\$162	+\$152	+\$4,549	-\$(\$1,375)	3.3	+\$2,605	+\$2,187	>1
03	PG&E	-\$(\$12)	+\$142	+\$130	+\$3,910	-\$(\$936)	4.2	+\$1,632	+\$2,626	>1
04	PG&E	-\$(\$8)	+\$144	+\$136	+\$4,080	-\$(\$822)	5.0	+\$2,381	+\$2,740	>1
05	PG&E	-\$(\$19)	+\$140	+\$121	+\$3,635	-\$(\$956)	3.8	+\$1,403	+\$2,606	>1
05	PG&E/SoCalGas	-\$(\$19)	+\$178	+\$159	+\$4,765	-\$(\$956)	5.0	+\$1,403	+\$2,606	>1
06	SCE/SoCalGas	-\$(\$84)	+\$161	+\$77	+\$2,309	-\$(\$243)	9.5	+\$1,940	+\$3,319	>1
07	SDG&E	-\$(\$49)	+\$136	+\$87	+\$2,611	+\$75	>1	+\$1,583	+\$3,638	>1
08	SCE/SoCalGas	-\$(\$74)	+\$157	+\$83	+\$2,480	+\$96	>1	+\$1,772	+\$3,658	>1
09	SCE/SoCalGas	-\$(\$76)	+\$159	+\$82	+\$2,469	+\$104	>1	+\$1,939	+\$3,667	>1
10	SCE/SoCalGas	-\$(\$79)	+\$159	+\$80	+\$2,411	-\$(\$34)	70.9	+\$1,737	+\$3,528	>1
10	SDG&E	-\$(\$77)	+\$139	+\$61	+\$1,842	-\$(\$34)	54.2	+\$1,737	+\$3,528	>1
11	PG&E	-\$(\$25)	+\$153	+\$128	+\$3,834	-\$(\$1,264)	3.0	+\$2,080	+\$2,298	>1
12	PG&E	-\$(\$11)	+\$155	+\$144	+\$4,316	-\$(\$1,498)	2.9	+\$2,759	+\$2,064	>1
13	PG&E	-\$(\$26)	+\$146	+\$121	+\$3,625	-\$(\$1,125)	3.2	+\$2,083	+\$2,437	>1
14	SCE/SoCalGas	-\$(\$99)	+\$187	+\$87	+\$2,616	-\$(\$1,019)	2.6	+\$2,422	+\$2,543	>1
14	SDG&E	-\$(\$86)	+\$175	+\$88	+\$2,647	-\$(\$1,019)	2.6	+\$2,422	+\$2,543	>1
15	SCE/SoCalGas	-\$(\$67)	+\$142	+\$75	+\$2,247	+\$511	>1	+\$1,276	+\$4,073	>1
16	PG&E	-\$(\$24)	+\$224	+\$200	+\$5,992	-\$(\$2,087)	2.9	+\$2,629	+\$1,476	>1



		On-Bill Cost-effectiveness ¹						TDV Cost-effectiveness		
		Average Annual Utility Bill Savings			Lifetime NPV			Lifetime NPV		
		Electricity	Natural Gas	Net Utility Savings	Utility Bill Savings	Equipment Cost Savings	On-Bill B/C Ratio ²	TDV Cost Savings	Equipment Cost Savings	TDV B/C Ratio
CZ	Utility									
	Neutral Cost Package									
01	PG&E	-\$228	+\$193	-\$35	-\$1,057	+\$0	0	-\$2,267	+\$3,564	1.6
02	PG&E	-\$115	+\$162	+\$47	+\$1,399	+\$0	>1	+\$59	+\$3,563	>1
03	PG&E	-\$81	+\$142	+\$61	+\$1,843	+\$0	>1	+\$138	+\$3,562	>1
04	PG&E	-\$64	+\$144	+\$80	+\$2,402	+\$0	>1	+\$983	+\$3,563	>1
05	PG&E	-\$90	+\$140	+\$50	+\$1,490	+\$0	>1	-\$152	+\$3,564	23.4
05	PG&E/SoCalGas	-\$90	+\$178	+\$87	+\$2,620	+\$0	>1	-\$152	+\$3,564	23.4
06	SCE/SoCalGas	-\$90	+\$161	+\$71	+\$2,144	+\$0	>1	+\$1,612	+\$3,562	>1
07	SDG&E	-\$32	+\$136	+\$105	+\$3,135	+\$0	>1	+\$1,886	+\$3,560	>1
08	SCE/SoCalGas	-\$67	+\$157	+\$90	+\$2,705	+\$0	>1	+\$1,955	+\$3,564	>1
09	SCE/SoCalGas	-\$71	+\$159	+\$87	+\$2,623	+\$0	>1	+\$1,924	+\$3,561	>1
10	SCE/SoCalGas	-\$78	+\$159	+\$81	+\$2,431	+\$0	>1	+\$1,588	+\$3,561	>1
10	SDG&E	-\$71	+\$139	+\$68	+\$2,033	+\$0	>1	+\$1,588	+\$3,561	>1
11	PG&E	-\$93	+\$153	+\$59	+\$1,783	+\$0	>1	-\$48	+\$3,562	74.0
12	PG&E	-\$82	+\$155	+\$73	+\$2,184	+\$0	>1	+\$739	+\$3,564	>1
13	PG&E	-\$79	+\$146	+\$68	+\$2,034	+\$0	>1	+\$310	+\$3,560	>1
14	SCE/SoCalGas	-\$141	+\$187	+\$45	+\$1,359	+\$0	>1	+\$747	+\$3,562	>1
14	SDG&E	-\$137	+\$175	+\$38	+\$1,131	+\$0	>1	+\$747	+\$3,562	>1
15	SCE/SoCalGas	-\$50	+\$142	+\$92	+\$2,771	+\$0	>1	+\$1,738	+\$3,560	>1
16	PG&E	-\$194	+\$224	+\$30	+\$900	+\$0	>1	-\$1,382	+\$3,564	2.6

¹Red values in parentheses indicate an increase in utility bill costs or an incremental first cost for the all-electric home.

²">1" indicates cases where there are both first cost savings and annual utility bill savings.

Table 17: Comparison of Multifamily On-Bill Cost Effectiveness Results with Additional PV (Per Dwelling Unit)

CZ	Utility	Neutral Cost				Min. Cost Effectiveness			
		PV Capacity (kW)	Utility Bill Savings	Equipment Cost Savings	On-Bill B/C Ratio	PV Capacity (kW)	Utility Bill Savings	Equipment Cost Savings	On-Bill B/C Ratio
01	PG&E	2.7	-(\$1,057)	+\$0	0	3.0	+\$1,198	-(\$1,052)	1.1



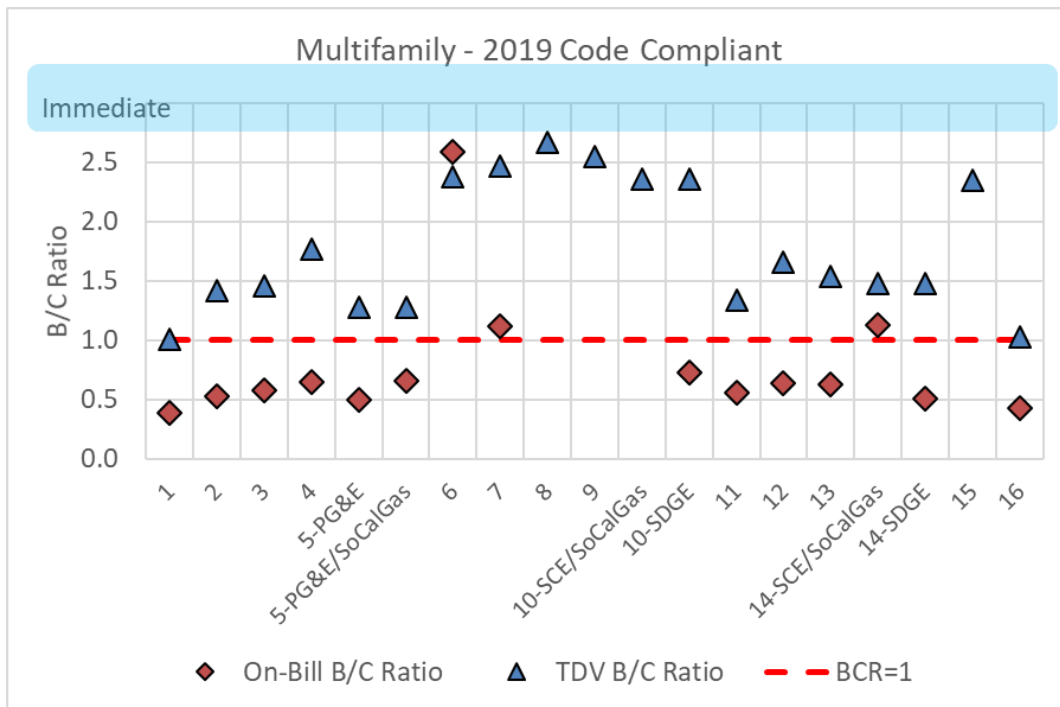


Figure 12: B/C ratio results for a multifamily all-electric code compliant home versus a mixed fuel code compliant home

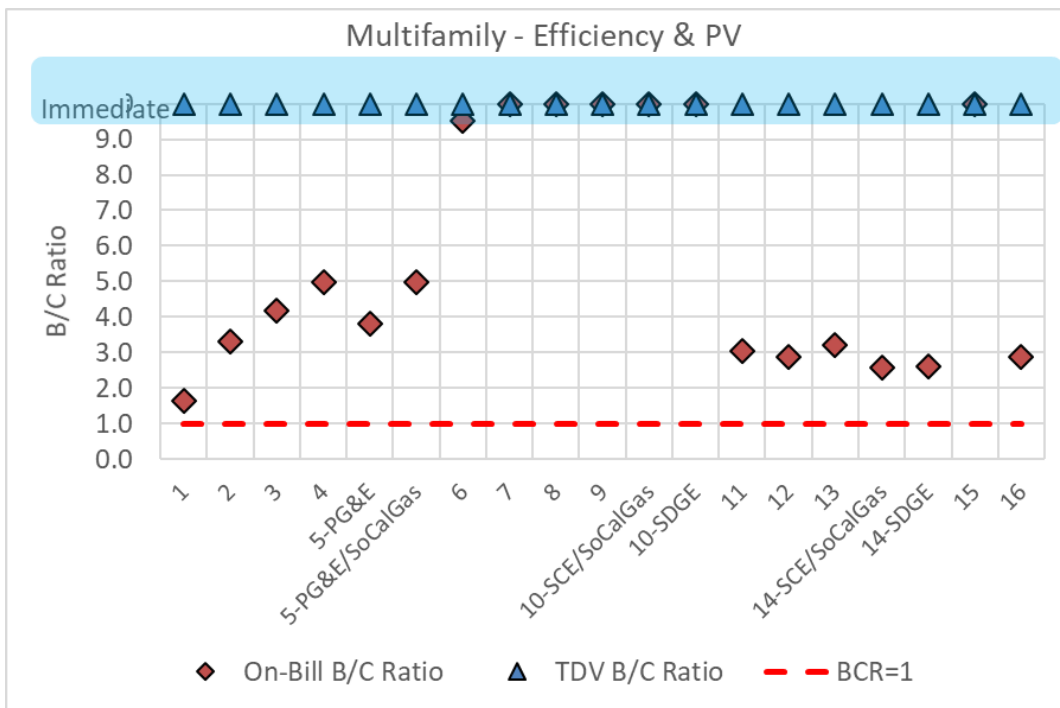


Figure 13: B/C ratio results for the multifamily Efficiency & PV all-electric home versus a mixed fuel code compliant home



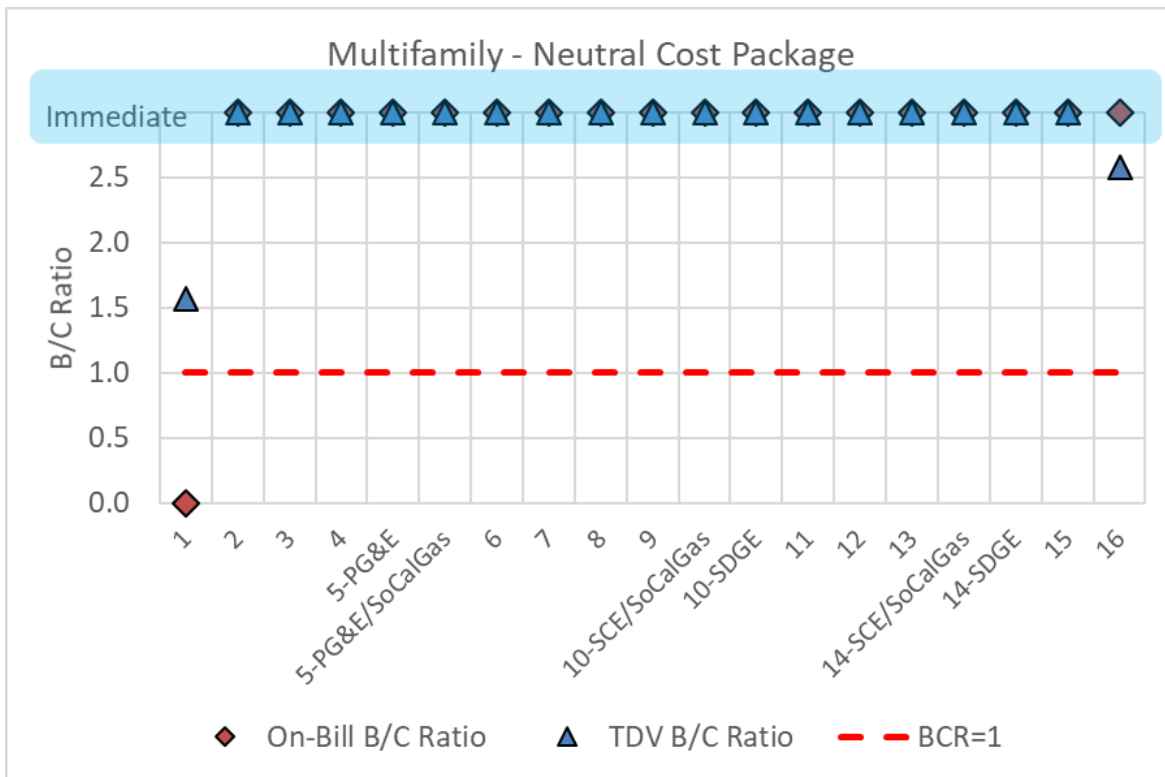


Figure 14: B/C ratio results for the multifamily neutral cost package all-electric home versus a mixed fuel code compliant home

4 Conclusions & Summary

This report evaluated the feasibility and cost-effectiveness of “above code” performance specifications through the application of efficiency measures, PV, and electric battery storage in all 16 California climate zones. The analysis found cost-effective packages across the state for both single family and low-rise multifamily buildings. For the building types and climate zones where cost-effective packages were identified, the results of this analysis can be used by local jurisdictions to support the adoption of reach codes. Cost-effectiveness was evaluated according to two metrics: On-Bill customer lifecycle benefit-to-cost and TDV lifecycle benefit-to-cost. While all the above code targets presented are based on packages that are cost-effective under at least one of these metrics, they are not all cost-effective under both metrics. Generally, the test for being cost-effective under the TDV methodology is less challenging than under the On-Bill methodology. Therefore, all packages presented are cost-effective based on TDV, and may or may not be cost-effective based on the On-Bill method. It is up to each jurisdiction to determine what metric is most appropriate for their application. A summary of results by climate zone are presented in Appendix G – Results by Climate Zone.

Above code targets are presented as Target EDR Margin, which have been defined for each scenario where a cost-effective package was identified. Target EDR Margins represent the maximum “reach” values that meet the requirements. Jurisdictions may adopt less stringent requirements. For the Efficiency Package the Target EDR Margin was defined based on the lower EDR Margin of the Efficiency – Non-Preempted Package and the Efficiency – Equipment, Preempted Package. For example, if the cost-effective Non-Preempted package has an EDR Margin of 3 and the Preempted package an EDR Margin of 4, the Target EDR Margin is set at 3.

The average incremental cost for the single family Efficiency packages is ~\$1,750. The Efficiency & PV Package average incremental cost is \$9,180 and for the Efficiency & PV/Battery Package it is approximately \$5,600 for the



mixed fuel cases and \$15,100 for the all-electric cases. The incremental costs for each multifamily apartment are approximately 30-40% lower. See Table 8 and Table 11 for a summary of package costs by case.

Table 18 and Table 19 summarize the maximum Target EDR Margins determined to be cost effective for each package for single family and multifamily, respectively. Cases labeled as “n/a” in the tables indicate where no cost-effective package was identified under either On-Bill or TDV methodology.

This analysis also looked at the GHG emissions impacts of the various packages. An all-electric design reduces GHG emissions 40-50% in most cases relative to a comparable mixed fuel design.

There is significant interest throughout California on electrification of new buildings. The Reach Code Team assembled data on the cost differences between a code compliant mixed fuel building and a code compliant all-electric building. Based on lifetime equipment cost savings (the difference in first cost for equipment and infrastructure combined with incremental replacement costs) of \$5,349 for an all-electric single family home this analysis found that from a customer on-bill perspective, the all-electric code compliant option is cost-effective in Climates Zones 6 through 9, 10 (SCE/SoCalGas territory only), and 15, and cost-effective in all climate zones except 1 and 16 based on TDV. For multifamily buildings, based on a cost savings of \$2,337 per apartment, the code compliant option is cost-effective in Climates Zones 6 through 9, 10 & 14 (SCE/SoCalGas territory only), and 15, and cost-effective based on TDV.

Adding efficiency and PV to the code compliant all-electric buildings increases the cost-effectiveness in all climate zones. The Efficiency & PV Package is cost-effective when compared to a mixed fuel code compliant building in all climate zones for both single family and multifamily buildings based on both the On-Bill and TDV methodologies. The Efficiency & PV package adds PV to offset 90% of the electricity use of the home. While this results in higher installed costs, the reduced lifetime utility costs are larger (\$0 to \$6,000 lifetime incremental equipment costs in many climates for single family homes and an associated \$4,500 to \$13,500 lifetime utility cost savings across the same cases), resulting in positive B/C ratios for all cases.

The Reach Code Team also evaluated a neutral cost electrification scenario where the cost savings for the all-electric code compliant home is invested in a larger PV system, resulting in a lifetime incremental cost of zero based on the On-Bill approach. This package results in utility cost savings and positive on-bill B/C ratio in all cases except Climate Zones 1 and 16 for single family, and Climate Zone 1 for low-rise multifamily. Increasing the PV sizes in those climates by approximately 30% resulted in positive on-bill B/C ratios, while still not resulting in oversizing of PV systems.

Other studies have shown that cost-effectiveness of electrification increases with high efficiency space conditioning and water heating equipment in the all-electric home. This was not directly evaluated in this analysis but based on the favorable cost-effectiveness results of the Equipment, Preempted package for the individual mixed fuel and all-electric upgrades it's expected that applying similar packages to the electrification analysis would result in increased cost-effectiveness.

The Reach Code Team found there can be substantial variability in first costs, particularly related to natural gas infrastructure. Costs are project-dependent and will be impacted by such factors as site characteristics, distance to the nearest gas main, joint trenching, whether work is conducted by the utility or a private contractor, and number of homes per development among other things. While the best cost data available to the Reach Code Team was applied in this analysis, individual projects may experience different costs, either higher or lower than the estimates presented here.

Table 18: Summary of Single Family Target EDR Margins

Climate Zone	Mixed Fuel		All-Electric		
	Efficiency	Efficiency & PV/Battery	Efficiency	Efficiency & PV	Efficiency & PV/Battery
01	5.0	10.5	6.5	31.0	41.0
02	3.0	10.0	4.5	19.0	30.0
03	2.5	10.0	4.0	18.0	29.0
04	2.5	10.0	3.0	17.0	28.5
05	2.5	9.0	4.0	18.0	28.5
06	1.5	9.5	2.0	14.0	26.0
07	n/a	9.0	n/a	11.0	24.0
08	1.0	8.0	1.5	10.5	21.5
09	2.5	8.5	2.5	11.5	21.0
10	3.0	9.5	3.0	11.0	21.0
11	4.0	9.0	4.5	14.0	23.0
12	3.0	9.5	3.5	15.5	25.0
13	4.5	9.5	5.0	13.0	22.0
14	4.5	9.0	5.5	15.5	23.5
15	4.5	7.0	5.5	6.0	13.0
16	5.0	10.5	4.5	26.5	35.0

Table 19: Summary of Multifamily Target EDR Margins

Climate Zone	Mixed Fuel		All-Electric		
	Efficiency	Efficiency & PV/Battery	Efficiency	Efficiency & PV	Efficiency & PV/Battery
01	2.0	11.5	3.0	22.5	34.5
02	1.5	10.5	1.5	17.5	30.5
03	0.5	10.0	n/a	16.0	29.5
04	1.0	11.0	1.0	15.0	28.5
05	0.5	9.5	0.5	17.0	30.0
06	1.0	10.5	1.0	13.5	27.5
07	0.5	11.0	0.5	12.5	27.0
08	1.0	9.5	1.0	11.5	24.0
09	1.5	9.5	1.5	11.0	23.0
10	1.5	10.0	1.5	10.5	23.0
11	2.5	10.5	3.5	13.0	25.0
12	1.5	10.0	2.5	14.0	26.5
13	3.0	10.5	3.0	12.0	23.5
14	3.0	9.5	3.5	14.0	24.5
15	4.0	8.5	4.0	7.0	16.5
16	2.0	9.5	3.0	19.5	29.5



5 References

- California Energy Commission. 2017. Rooftop Solar PV System. Measure number: 2019-Res-PV-D Prepared by Energy and Environmental Economics, Inc. <https://efiling.energy.ca.gov/getdocument.aspx?tn=221366>
- California Energy Commission. 2018a. 2019 Alternative Calculation Method Approval Manual. CEC-400-2018-023-CMF. December 2018. California Energy Commission. [https://www.energy.ca.gov/2018publications/CEC-400-2018-023-CMF.pdf](https://www.energy.ca.gov/2018publications/CEC-400-2018-023/CEC-400-2018-023-CMF.pdf)
- California Energy Commission. 2018b. 2019 Building Energy Efficiency Standards for Residential and Nonresidential Buildings. CEC-400-2018-020-CMF. December 2018. California Energy Commission. <https://www.energy.ca.gov/2018publications/CEC-400-2018-020/CEC-400-2018-020-CMF.pdf>
- California Energy Commission. 2018c. 2019 Reference Appendices. CEC-400-2018-021-CMF. December 2018. California Energy Commission. <https://www.energy.ca.gov/2018publications/CEC-400-2018-021/CEC-400-2018-021-CMF.pdf>
- California Energy Commission. 2018d. 2019 Residential Compliance Manual. CEC-400-2018-017-CMF. December 2018. California Energy Commission. <https://www.energy.ca.gov/2018publications/CEC-400-2018-017/CEC-400-2018-017-CMF.pdf>
- California Energy Commission. 2019. 2019 Residential Alternative Calculation Method Reference Manual. CEC-400-2019-005-CMF. May 2019. California Energy Commission. <https://www.energy.ca.gov/2019publications/CEC-400-2019-005/CEC-400-2019-005-CMF.pdf>
- California Public Utilities Commission. 2016. Rulemaking No. 15-03-010 An Order Instituting Rulemaking to Identify Disadvantaged Communities in the San Joaquin Valley and Analyze Economically Feasible Options to Increase Access to Affordable Energy in Those Disadvantaged Communities. Proposed Decision of Commissioner Guzman Aceves. April 07, 2017. <http://docs.cpuc.ca.gov/PublishedDocs/Efile/G000/M183/K389/183389022.PDF>
- Davis Energy Group. 2015. Evaluation of Ducts in Conditioned Space for New California Homes. Prepared for Pacific Gas and Electric Company. March 2015. <https://www.etcc-ca.com/reports/evaluation-ducts-conditioned-space-new-california-homes>
- Energy & Environmental Economics. 2019. Residential Building Electrification in California. April 2019. https://www.ethree.com/wp-content/uploads/2019/04/E3_Residential_Building_Electrification_in_California_April_2019.pdf
- EPRI. 2016. SMUD All-Electric Homes Electrification Case Study: Summary for the Three-Prong Test Discussion. Electric Power Research Institute, Inc. September. 2016. Presentation to Sacramento Municipal Utility District.
- Horii, B., E. Cutter, N. Kapur, J. Arent, and D. Conotyannis. 2014. "Time Dependent Valuation of Energy for Developing Building Energy Efficiency Standards." http://www.energy.ca.gov/title24/2016standards/prerulemaking/documents/2014-07-09_workshop/2017_TDV_Documents/
- Itron. 2014. 2010-2012 WO017 Ex Ante Measure Cost Study: Final Report. Itron. May 2014. Presented to California Public Utilities Commission.
- Barbose, Galen and Darghouth, Naim. 2018. Tracking the Sun. Installed Price Trends for Distributed Photovoltaic Systems in the United States – 2018 Edition. Lawrence Berkeley National Laboratory. September 2018. https://emp.lbl.gov/sites/default/files/tracking_the_sun_2018_edition_final_0.pdf
- Navigant. 2018. Analysis of the Role of Gas for a Low-Carbon California Future. July 24, 2018. Prepared for Southern California Gas Company. https://www.socalgas.com/1443741887279/SoCalGas_Renewable_Gas_Final-Report.pdf



- Penn, Ivan. 2018. Cheaper Battery Is Unveiled as a Step to a Carbon-Free Grid. The New York Times. September 2018. <https://www.nytimes.com/2018/09/26/business/energy-environment/zinc-battery-solar-power.html>. Accessed January 29, 2019.
- Statewide CASE Team. 2017a. Codes and Standards Enhancement (CASE) Initiative Drain Water Heat Recovery – Final Report. July 2017. http://title24stakeholders.com/wp-content/uploads/2017/09/2019-T24-CASE-Report_DWHR_Final_September-2017.pdf
- Statewide CASE Team. 2017b. Codes and Standards Enhancement (CASE) Initiative High Performance Attics – Final Report. September 2017. http://title24stakeholders.com/wp-content/uploads/2017/09/2019-T24-CASE-Report_HPA_Final_September-2017.pdf
- Statewide CASE Team. 2017c. Codes and Standards Enhancement (CASE) Initiative High Performance Walls – Final Report. September 2017. http://title24stakeholders.com/wp-content/uploads/2017/09/2019-T24-CASE-Report_HPW_Final_September-2017.pdf
- Statewide CASE Team. 2017d. Codes and Standards Enhancement (CASE) Initiative Residential High Performance Windows & Doors – Final Report. August 2017. http://title24stakeholders.com/wp-content/uploads/2017/09/2019-T24-CASE-Report_Res-Windows-and-Doors_Final_September-2017.pdf
- Statewide CASE Team. 2018. Energy Savings Potential and Cost-Effectiveness Analysis of High Efficiency Windows in California. Prepared by Frontier Energy. May 2018. <https://www.etcc-ca.com/reports/energy-savings-potential-and-cost-effectiveness-analysis-high-efficiency-windows-california>
- Statewide Reach Codes Team. 2016. CALGreen Cost-Effectiveness Study. Prepared for Pacific Gas and Electric Company. Prepared by Davis Energy Group. November 2016. http://localenergycodes.com/download/50/file_path/fieldList/2016%20RNC%20Tiers%201-2%20Cost-Eff%20Report
- Statewide Reach Codes Team. 2017a. CALGreen All-Electric Cost-Effectiveness Study. Prepared for Pacific Gas and Electric Company. Prepared by Davis Energy Group. October 2017. http://localenergycodes.com/download/276/file_path/fieldList/2016%20RNC%20All-Electric%20Cost-Eff%20Report
- Statewide Reach Codes Team. 2017b. 2016 Title 24 Residential Reach Code Recommendations: Cost-effectiveness Analysis for All California Climate Zones. Prepared for Southern California Edison. Prepared by TRC Energy Services. August 2017. http://localenergycodes.com/download/283/file_path/fieldList/2016%20RNC%20Reach%20Code%20Tier%203%20Cost-Eff%20Report
- Statewide Reach Codes Team. 2018. PV + Battery Storage Study. Prepared for Pacific Gas and Electric Company. Prepared by EnergySoft. July, 2018. http://localenergycodes.com/download/430/file_path/fieldList/PV%20Plus%20Battery%20Storage%20Report
- Hopkins, Asa, Takahashi, Kenji, Glick, Devi, Whited, Melissa. 2018. Decarbonization of Heating Energy Use in California Buildings. Synapse Energy Economics, Inc. October 2018. <http://www.synapse-energy.com/sites/default/files/Decarbonization-Heating-CA-Buildings-17-092-1.pdf>
- TRC. 2018. City of Palo Alto 2019 Title 24 Energy Reach Code Cost-effectiveness Analysis Draft. September 2018. <https://cityofpaloalto.org/civicax/filebank/documents/66742>



Appendix A – California Climate Zone Map

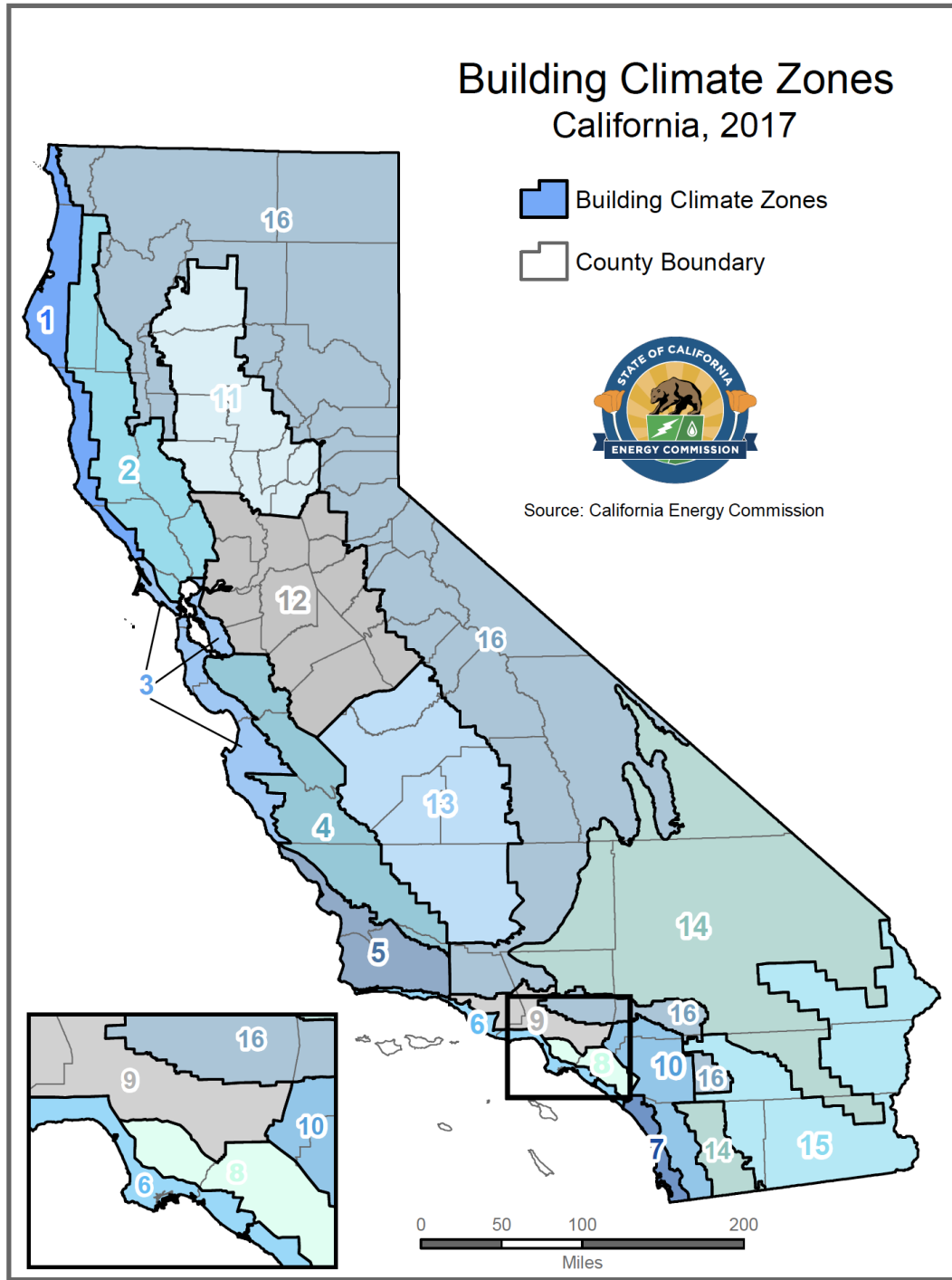


Figure 15: Map of California Climate Zones (courtesy of the California Energy Commission¹⁷)

¹⁷ https://ww2.energy.ca.gov/maps/renewable/building_climate_zones.html

Appendix B – Utility Tariff Details

PG&E 48

SCE 51

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Escalation Assumptions 56



PG&E

The following pages provide details on the PG&E electricity and natural gas tariffs applied in this study. Table 20 describes the baseline territories that were assumed for each climate zone.

Table 20: PG&E Baseline Territory by Climate Zone

	Baseline Territory
CZ01	V
CZ02	X
CZ03	T
CZ04	X
CZ05	T
CZ11	R
CZ12	S
CZ13	R
CZ16	Y

The PG&E monthly gas rate in \$/therm was applied on a monthly basis for the 12-month period ending January 2019 according to the rates shown below.

Pacific Gas and Electric Company							
Residential Non-CARE and CARE Gas Tariff Rates							
January 1, 2018, to Present							
(\$/therm) ^{1/}							
Effective Date	Advice Letter Number	Minimum Transportation Charge ^{2/} (per day)	Procurement Charge	Transportation Charge ^{2/}		TOTAL Residential Non-CARE Schedules Charge ^{3/}	
				Baseline	Excess	Baseline	Excess
01/01/18	3918-G	\$0.09863	\$0.37310	\$0.91828	\$1.46925	\$1.29138	\$1.84235
02/01/18	3931-G	\$0.09863	\$0.40635	\$0.91828	\$1.46925	\$1.32463	\$1.87560
03/01/18	3941-G	\$0.09863	\$0.32103	\$0.91828	\$1.46925	\$1.23931	\$1.79028
04/01/18	3959-G	\$0.09863	\$0.34783	\$0.91828	\$1.46925	\$1.26611	\$1.81708
05/01/18	3969-G	\$0.09863	\$0.26995	\$0.91828	\$1.46925	\$1.18823	\$1.73920
06/01/18	3980-G	\$0.09863	\$0.21571	\$0.91828	\$1.46925	\$1.13399	\$1.68496
07/01/18	3984-G	\$0.09863	\$0.22488	\$0.93438	\$1.49502	\$1.15926	\$1.71990
08/01/18	3995-G	\$0.09863	\$0.28814	\$0.93438	\$1.49502	\$1.22252	\$1.78316
09/01/18	4008-G	\$0.09863	\$0.25597	\$0.93438	\$1.49502	\$1.19035	\$1.75099
10/01/18	4018-G	\$0.09863	\$0.27383	\$0.93438	\$1.49502	\$1.20821	\$1.76885
11/01/18	4034-G	\$0.09863	\$0.35368	\$0.93438	\$1.49502	\$1.28806	\$1.84870
12/01/18	4046-G	\$0.09863	\$0.42932	\$0.93438	\$1.49502	\$1.36370	\$1.92434
01/01/19	4052-G	\$0.09863	\$0.43394 ^{7/}	\$0.99414	\$1.59063	\$1.42808	\$2.02457

^{1/} Unless otherwise noted

^{2/} Effective July 1, 2005, the Transportation Charge will be no less than the Minimum Transportation Charge of \$0.09863 (per day). Applicable to Rate Schedule G-1 only and does not apply to submetered tenants of master-metered customers served under gas Rate Schedule GS and GT.

^{3/} Schedule G-PPPS (Public Purpose Program Surcharge) needs to be added to the TOTAL Non-CARE Charge and TOTAL CARE Charge for bill calculation. See Schedule G-PPPS for details and exempt customers.

^{4/} CARE Schedules include California Solar Initiative (CSI) Exemption in accordance with Advice Letter 3257-G-A.

^{5/} Per dwelling unit per day (Multifamily Service)

^{6/} Per installed space per day (Mobilehome Park Service)

^{7/} This procurement rate includes a charge of \$0.03686 per therm to reflect account balance amortizations in accordance with Advice Letter 3157-G.

^{8/} Residential bill credit of (\$29.85) per household, annual bill credit occurring in the October 2018 bill cycle, thereafter in the April bill cycle.

Seasons: Winter = Nov-Mar Summer = April-Oct





**Pacific Gas and
Electric Company**
U 39 San Francisco, California

Cancelling

Revised
RevisedCal. P.U.C. Sheet No. 43533-E
Cal. P.U.C. Sheet No. 42728-E

**ELECTRIC SCHEDULE E-TOU
RESIDENTIAL TIME-OF-USE SERVICE**

Sheet 4

RATES:
(Cont'd.)

OPTION B TOTAL RATES

Total Energy Rates (\$ per kWh)	PEAK	OFF-PEAK
Summer (all usage)	\$0.37188 (R)	\$0.26882 (R)
Winter (all usage)	\$0.23441 (R)	\$0.21561 (R)

Delivery Minimum Bill Amount (\$ per meter per day) \$0.32854

California Climate Credit (per household, per semi-annual payment occurring in the April and October bill cycles) (\$39.42)

Total bundled service charges shown on customer's bills are unbundled according to the component rates shown below. Where the delivery minimum bill amount applies, the customer's bill will equal the sum of (1) the delivery minimum bill amount plus (2) for bundled service, the generation rate times the number of kWh used. For revenue accounting purposes, the revenues from the delivery minimum bill amount will be assigned to the Transmission, Transmission Rate Adjustments, Reliability Services, Public Purpose Programs, Nuclear Decommissioning, Competition Transition Charges, Energy Cost Recovery Amount, DWR Bond, and New System Generation Charges based on kWh usage times the corresponding unbundled rate component per kWh, with any residual revenue assigned to Distribution.***

UNBUNDLING OF OPTION B TOTAL RATES

Generation	PEAK	OFF-PEAK
Summer (all usage)	\$0.21238	\$0.10932
Winter (all usage)	\$0.10554	\$0.08674
Distribution**		
Summer (all usage)	\$0.10716 (R)	\$0.10716 (R)
Winter (all usage)	\$0.07653 (R)	\$0.07653 (R)
Transmission* (all usage)	\$0.02469 (R)	
Transmission Rate Adjustments* (all usage)	\$0.00214	
Reliability Services* (all usage)	\$0.00260	
Public Purpose Programs (all usage)	\$0.01413	
Nuclear Decommissioning (all usage)	\$0.00020	
Competition Transition Charges (all usage)	\$0.00132	
Energy Cost Recovery Amount (all usage)	(\$0.00005)	
DWR Bond (all usage)	\$0.00503 (R)	
New System Generation Charge (all usage)**	\$0.00228	

* Transmission, Transmission Rate Adjustments and Reliability Service charges are combined for presentation on customer bills.

** Distribution and New System Generation Charges are combined for presentation on customer bills.

*** This same assignment of revenues applies to direct access and community choice aggregation customers.

(Continued)

Advice	5444-E	Issued by	Submitted	December 18, 2018
Decision	18-08-013	Robert S. Kenney	Effective	January 1, 2019
		Vice President, Regulatory Affairs	Resolution	





**Pacific Gas and
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U 39

San Francisco, California

Cancelling Revised
Revised

Cal. P.U.C. Sheet No. 34735-G
Cal. P.U.C. Sheet No. 34691-G

**GAS SCHEDULE G-1
RESIDENTIAL SERVICE**

Sheet 1

APPLICABILITY: This rate schedule¹ applies to natural gas service to Core End-Use Customers on PG&E's Transmission and/or Distribution Systems. To qualify, service must be to individually-metered single family premises for residential use, including those in a multifamily complex, and to separately-metered common areas in a multifamily complex where Schedules GM, GS, or GT are not applicable. Common area accounts that are separately metered by PG&E have an option of switching to a core commercial rate schedule. Common area accounts are those accounts that provide gas service to common use areas as defined in Rule 1.

Per D.15-10-032 and D.18-03-017, transportation rates include GHG Compliance Cost for non-covered entities. Customers who are directly billed by the Air Resources Board (ARB), i.e., covered entities, are exempt from paying AB 32 GHG Compliance Costs through PG&E's rates.² A "Cap-and-Trade Cost Exemption" credit for these costs will be shown as a line item on exempt customers' bills.^{3,4}

TERRITORY: Schedule G-1 applies everywhere within PG&E's natural gas Service Territory.

RATES: Customers on this schedule pay a Procurement Charge and a Transportation Charge, per meter, as shown below. The Transportation Charge will be no less than the Minimum Transportation Charge, as follows:

<u>Minimum Transportation Charge:</u> ⁵		<u>Per Day</u>	
		\$0.09863	
		<u>Per Therm</u>	
	<u>Baseline</u>		<u>Excess</u>
<u>Procurement:</u>	\$0.43394	(l)	\$0.43394 (l)
<u>Transportation Charge:</u>	\$0.99414	(l)	\$1.59063 (l)
<u>Total:</u>	\$1.42808	(l)	\$2.02457 (l)
California Natural Gas Climate Credit (per Household, annual payment occurring in October 2018 bill cycle, and thereafter in the April bill cycle)	(\$25.45)	(l)	

Public Purpose Program Surcharge:

Customers served under this schedule are subject to a gas Public Purpose Program (PPP) Surcharge under Schedule G-PPPS.

See Preliminary Statement, Part B for the Default Tariff Rate Components.

The Procurement Charge on this schedule is equivalent to the rate shown on informational Schedule G-CP—Gas Procurement Service to Core End-Use Customers.

¹ PG&E's gas tariffs are available online at www.pge.com.

² Covered entities are not exempt from paying costs associated with LUAF Gas and Gas used by Company Facilities.

³ The exemption credit will be equal to the effective non-exempt AB 32 GHG Compliance Cost Rate (\$ per therm) included in Preliminary Statement – Part B, multiplied by the customer's billed volumes (therms) for each billing period.

⁴ PG&E will update its billing system annually to reflect newly exempt or newly excluded customers to conform with lists of Directly Billed Customers provided annually by the ARB.

⁵ The Minimum Transportation charge does not apply to submetered tenants of master-metered customers served under gas rate Schedules GS and GT.

(Continued)

<i>Advice</i>	4052-G	<i>Issued by</i>	<i>Submitted</i>	<i>December 21, 2018</i>
<i>Decision</i>	97-10-065 & 98-07-025	<i>Robert S. Kenney</i>	<i>Effective</i>	<i>January 1, 2019</i>
		<i>Vice President, Regulatory Affairs</i>	<i>Resolution</i>	



SCE

The following pages provide details on are the SCE electricity tariffs applied in this study. Table 21 describes the baseline territories that were assumed for each climate zone.

Table 21: SCE Baseline Territory by Climate Zone

	Baseline Territory
CZ06	6
CZ08	8
CZ09	9
CZ10	10
CZ14	14
CZ15	15

	Delivery	Generation	Total Rate
TOU-Default-Rate-1 (On-Peak 4:00 pm - 9:00 pm)			
Energy Charge - \$/kWh			
Summer Season - On-Peak	0.19880	0.20072	0.39952
Mid-Peak	0.19880	0.05948	0.25828
Off-Peak	0.15574	0.06023	0.21597
Winter Season - Mid-Peak	0.19880	0.08308	0.28188
Off-Peak	0.15574	0.11309	0.26883
Super-Off-Peak	0.15062	0.01344	0.16406
Basic Charge - \$/day			
Single-Family Residence	0.031	0.000	0.031
Multi-Family Residence	0.024	0.000	0.024
Minimum Charge - \$/day			
Single Family Residence	0.338	0.000	0.338
Multi-Family Residence	0.338	0.000	0.338
Baseline Credit - \$/kWh	(0.06512)	0.00000	(0.06512)



	Delivery	Generation	Total Rate
TOU-D-Rate PRIME			
Energy Charge - \$/kWh			
Summer Season - On-Peak	0.15926	0.19811	0.35737
Mid-Peak	0.15926	0.10092	0.26018
Off-Peak	0.08308	0.04687	0.12995
Winter Season - Mid-Peak	0.16268	0.16761	0.33029
Off-Peak	0.08081	0.04331	0.12412
Super-Off-Peak	0.08081	0.04331	0.12412
Customer Charge - \$/day	0.395	0.000	0.395

TOU Period	Weekdays		Weekends and Holidays	
	Summer	Winter	Summer	Winter
On-Peak	4 p.m. - 9 p.m.			
Mid-Peak		4 p.m. - 9 p.m.	4 p.m. - 9 p.m.	4 p.m. - 9 p.m.
Off-Peak	All other hours	9 p.m. - 8 a.m.	All other hours	9 p.m. - 8 a.m.
Super-Off-Peak		8 a.m. - 4 p.m.		8 a.m. - 4 p.m.

PROPOSED
(7 Year Average 2010-2016)

Summer kWh per Day			Winter kWh per Day		
Baseline Region	Basic	All Electric	Baseline Region	Basic	All Electric
05	17.2	17.9	05	18.7	29.1
06	11.4	8.8	06	11.3	13.0
08	12.6	9.8	08	10.6	12.7
09	16.5	12.4	09	12.3	14.3
10	18.9	15.8	10	12.5	17.0
13	22.0	24.6	13	12.6	24.3
14	18.7	18.3	14	12.0	21.3
15	46.4	24.1	15	9.9	18.2
16	14.4	13.5	16	12.6	23.1



SoCalGas

Following are the SoCalGas natural gas tariffs applied in this study. Table 22 describes the baseline territories that were assumed for each climate zone.

Table 22: SoCalGas Baseline Territory by Climate Zone

	Baseline Territory
CZ05	2
CZ06	1
CZ08	1
CZ09	1
CZ10	1
CZ14	2
CZ15	1

SOUTHERN CALIFORNIA GAS COMPANY Revised CAL P.U.C. SHEET NO. 55854-G
LOS ANGELES, CALIFORNIA CANCELING Revised CAL P.U.C. SHEET NO. 55828-G

Schedule No. GR <u>RESIDENTIAL SERVICE</u> (Includes GR, GR-C and GT-R Rates)				Sheet 1
APPLICABILITY				
The GR rate is applicable to natural gas procurement service to individually metered residential customers.				
The GR-C, cross-over rate, is a core procurement option for individually metered residential core transportation customers with annual consumption over 50,000 therms, as set forth in Special Condition 10.				
The GT-R rate is applicable to Core Aggregation Transportation (CAT) service to individually metered residential customers, as set forth in Special Condition 11.				
The California Alternate Rates for Energy (CARE) discount of 20%, reflected as a separate line item on the bill, is applicable to income-qualified households that meet the requirements for the CARE program as set forth in Schedule No. G-CARE.				
TERRITORY				
Applicable throughout the service territory.				
RATES				
<u>Customer Charge</u> , per meter per day:	<u>GR</u> 16.438¢	<u>GR-C</u> 16.438¢	<u>GT-R</u> 16.438¢	
For "Space Heating Only" customers, a daily Customer Charge applies during the winter period from November 1 through April 30 ^{1/} :				
	33.149¢	33.149¢	33.149¢	
<u>Baseline Rate</u> , per therm (baseline usage defined in Special Conditions 3 and 4):				
Procurement Charge: ^{2/}	41.589¢	42.676¢	N/A	R
<u>Transmission Charge</u> :	<u>63.566¢</u>	<u>63.566¢</u>	<u>63.566¢</u>	R
Total Baseline Charge:	105.155¢	106.242¢	63.566¢	R
<u>Non-Baseline Rate</u> , per therm (usage in excess of baseline usage):				
Procurement Charge: ^{2/}	41.589¢	42.676¢	N/A	R
<u>Transmission Charge</u> :	<u>96.806¢</u>	<u>96.806¢</u>	<u>96.806¢</u>	R
Total Non-Baseline Charge:	138.395¢	139.482¢	96.806¢	R
^{1/} For the summer period beginning May 1 through October 31, with some exceptions, usage will be accumulated to at least 20 Ccf (100 cubic feet) before billing.				
(Footnotes continue next page.)				
(Continued)				
(TO BE INSERTED BY UTILITY)		ISSUED BY		(TO BE INSERTED BY CAL. PUC)
ADVICE LETTER NO. 5410		Dan Skopec		SUBMITTED <u>Jan 7, 2019</u>
DECISION NO.		Vice President		EFFECTIVE <u>Jan 10, 2019</u>
106		Regulatory Affairs		RESOLUTION NO. <u>G-3351</u>



SDG&E

Following are the SDG&E electricity and natural gas tariffs applied in this study. Table 23 describes the baseline territories that were assumed for each climate zone.

Table 23: SDG&E Baseline Territory by Climate Zone

	Baseline Territory
CZ07	Coastal
CZ10	Inland
CZ14	Mountain



San Diego Gas & Electric Company
San Diego, California

Revised Cal. P.U.C. Sheet No. 31320-E

Canceling Revised Cal. P.U.C. Sheet No. 31103-E

SCHEDULE TOU-DR1
RESIDENTIAL TIME-OF-USE

Sheet 2

RATES

Total Rates:

Description – TOU DR1	UDC Total Rate	DWR-BC Rate	EECC Rate + DWR Credit	Total Rate
Summer:				
On-Peak	0.29562	R 0.00503	R 0.35013	R 0.65078
Off-Peak	0.29562	R 0.00503	R 0.11235	R 0.41300
Super Off-Peak	0.29562	R 0.00503	R 0.05739	R 0.35804
Winter:				
On-Peak	0.32037	R 0.00503	R 0.07618	R 0.40158
Off-Peak	0.32037	R 0.00503	R 0.06762	R 0.39302
Super Off-Peak	0.32037	R 0.00503	R 0.05812	R 0.38352
Summer Baseline Adjustment Credit up to 130% of Baseline	(0.19921)	I		(0.19921)
Winter Baseline Adjustment Credit up to 130% of Baseline	(0.16853)	I		(0.16853)
Minimum Bill (\$/day)	0.329			0.329

Description – TOU DR1	UDC Total Rate	DWR-BC Rate	EECC Rate + DWR Credit	Total Rate	Total Effective Care Rate
Summer – CARE					
Rates:					
On-Peak	0.29494	R 0.00000	R 0.35013	R 0.64507	R 0.41628
Off-Peak	0.29494	R 0.00000	R 0.11235	R 0.40729	R 0.26077
Super Off-Peak	0.29494	R 0.00000	R 0.05739	R 0.35233	R 0.22483
Winter – CARE					
Rates:					
On-Peak	0.31969	R 0.00000	R 0.07618	R 0.39587	R 0.25330
Off-Peak	0.31969	R 0.00000	R 0.06762	R 0.38731	R 0.24770
Super Off-Peak	0.31969	R 0.00000	R 0.05812	R 0.37781	R 0.24149
Summer Baseline Adjustment Credit up to 130% of Baseline	(0.19921)	I		(0.19921)	(0.13028)
Winter Baseline Adjustment Credit up to 130% of Baseline	(0.16853)	I		(0.16853)	(0.11022)
Minimum Bill (\$/day)	0.164			0.164	0.164

Note:

- (1) Total Rates consist of UDC, Schedule DWR-BC (Department of Water Resources Bond Charge), and Schedule EECC (Electric Energy Commodity Cost) rates, with the EECC rates reflecting a DWR Credit.
- (2) Total Rates presented are for customers that receive commodity supply and delivery service from Utility.
- (3) DWR-BC charges do not apply to CARE customers.
- (4) As identified in the rates tables, customer bills will also include line-item summer and winter credits for usage up to 130% of baseline to provide the rate capping benefits adopted by Assembly Bill 1X and Senate Bill 695.

(Continued)

2C11

Advice Ltr. No. 3326-E

Decision No. _____

Issued by
Dan Skopec
Vice President
Regulatory Affairs

Submitted Dec 28, 2018

Effective Jan 1, 2019

Resolution No. _____





San Diego Gas & Electric Company
San Diego, California

Revised Cal. P.U.C. Sheet No. 23614-G

Canceling Revised Cal. P.U.C. Sheet No. 23601-G

SCHEDULE GR

Sheet 1

RESIDENTIAL NATURAL GAS SERVICE (Includes Rates for GR, GR-C, GTC/GTCA)

APPLICABILITY

The GR rate is applicable to natural gas procurement service for individually metered residential customers.

The GR-C, cross-over rate, is a core procurement option for individually metered residential core transportation customers with annual consumption over 50,000 therms, as set forth in Special Condition 10.

The GTC/GTCA rate is applicable to intrastate gas transportation-only services to individually metered residential customers, as set forth in Special Condition 11.

Customers taking service under this schedule may be eligible for a 20% California Alternate Rate for Energy (CARE) program discount, reflected as a separate line item on the bill, if they qualify to receive service under the terms and conditions of Schedule G-CARE.

TERRITORY

Within the entire territory served natural gas by the utility.

RATES

	<u>GR</u>	<u>GR-C</u>	<u>GTC/GTCA^{1/}</u>
<u>Baseline Rate</u> , per therm (baseline usage defined in Special Conditions 3 and 4):			
Procurement Charge: ^{2/}	\$0.41614	\$0.41614 R	N/A
Transmission Charge:	\$1.01230	\$1.01230	\$1.01230
Total Baseline Charge:	\$1.42844	\$1.42844 R	\$1.01230
<u>Non-Baseline Rate</u> , per therm (usage in excess of baseline usage):			
Procurement Charge: ^{2/}	\$0.41614	\$0.41614 R	N/A
Transmission Charge:	\$1.19980	\$1.19980	\$1.19980
Total Non-Baseline Charge:	\$1.61594	\$1.61594 R	\$1.19980
<u>Minimum Bill</u> , per day: ^{3/}			
Non-CARE customers:	\$0.09863	\$0.09863	\$0.09863
CARE customers:	\$0.07890	\$0.07890	\$0.07890

^{1/} The rates for core transportation-only customers, with the exception of customers taking service under Schedule GT-NGV, include any FERC Settlement Proceeds Memorandum Account (FSPMA) credit adjustments.

^{2/} This charge is applicable to Utility Procurement Customers and includes the GPC and GPC-A Procurement Charges shown in Schedule GPC which are subject to change monthly as set forth in Special Condition 7.

^{3/} Effective starting May 1, 2017, the minimum bill is calculated as the minimum bill charge of \$0.09863 per day times the number of days in the billing cycle (approximately \$3 per month) with a 20% discount applied for CARE customer resulting in a minimum bill charge of \$0.07890 per day (approximately \$2.40 per month).

(Continued)

1C5
Advice Ltr. No. 2735-G
Decision No.

Issued by
Dan Skopec
Vice President
Regulatory Affairs

Submitted Jan 7, 2019
Effective Jan 10, 2019
Resolution No.



Escalation Assumptions

The average annual escalation rates in the following table were used in this study and are from E3's 2019 study Residential Building Electrification in California (Energy & Environmental Economics, 2019). These rates are applied to the 2019 rate schedules over a thirty-year period beginning in 2020. SDG&E was not covered in the E3 study. The Reach Code Team reviewed SDG&E's GRC filing and applied the same approach that E3 applied for PG&E and SoCalGas to arrive at average escalation rates between 2020 and 2022.

Table 24: Real Utility Rate Escalation Rate Assumptions

	Statewide Electric Residential Average Rate (%/year, real)	Natural Gas Residential Core Rate (%/yr escalation, real)		
		PG&E	SoCalGas	SDG&E
2020	2.0%	1.48%	6.37%	5.00%
2021	2.0%	5.69%	4.12%	3.14%
2022	2.0%	1.11%	4.12%	2.94%
2023	2.0%	4.0%	4.0%	4.0%
2024	2.0%	4.0%	4.0%	4.0%
2025	2.0%	4.0%	4.0%	4.0%
2026	1.0%	1.0%	1.0%	1.0%
2027	1.0%	1.0%	1.0%	1.0%
2028	1.0%	1.0%	1.0%	1.0%
2029	1.0%	1.0%	1.0%	1.0%
2030	1.0%	1.0%	1.0%	1.0%
2031	1.0%	1.0%	1.0%	1.0%
2032	1.0%	1.0%	1.0%	1.0%
2033	1.0%	1.0%	1.0%	1.0%
2034	1.0%	1.0%	1.0%	1.0%
2035	1.0%	1.0%	1.0%	1.0%
2036	1.0%	1.0%	1.0%	1.0%
2037	1.0%	1.0%	1.0%	1.0%
2038	1.0%	1.0%	1.0%	1.0%
2039	1.0%	1.0%	1.0%	1.0%
2040	1.0%	1.0%	1.0%	1.0%
2041	1.0%	1.0%	1.0%	1.0%
2042	1.0%	1.0%	1.0%	1.0%
2043	1.0%	1.0%	1.0%	1.0%
2044	1.0%	1.0%	1.0%	1.0%
2045	1.0%	1.0%	1.0%	1.0%
2046	1.0%	1.0%	1.0%	1.0%
2047	1.0%	1.0%	1.0%	1.0%
2048	1.0%	1.0%	1.0%	1.0%
2049	1.0%	1.0%	1.0%	1.0%



Appendix C – Single Family Detailed Results

Table 25: Single Family Mixed Fuel Efficiency Package Cost-Effectiveness Results

CZ	Utility	BASECASE						Non-Preempted								Equipment - Preempted							
		Total EDR	Efficiency EDR	CALGreen Tier 1 EDR Target	lbs CO2 per sqft	PV kW	Total EDR	Efficiency EDR	Efficiency EDR Margin	% Comp Margin	lbs CO2 per sqft	PV kW	On-Bill B/C Ratio	TDV B/C Ratio	Total EDR	Efficiency EDR	Efficiency EDR Margin	% Comp Margin	lbs CO2 per sqft	PV kW	On-Bill B/C Ratio	TDV B/C Ratio	
1	PG&E	32.5	54.2	23	3.0	3.3	27.9	49.0	5.3	18.8%	2.5	3.2	3.4	2.8	26.0	47.3	6.9	25.1%	2.3	3.2	4.9	4.1	
2	PG&E	25.0	46.0	12	2.2	2.8	22.0	42.7	3.3	16.3%	1.9	2.8	1.6	1.7	21.8	42.6	3.3	16.4%	1.9	2.8	3.8	3.6	
3	PG&E	23.9	46.9	10	1.9	2.7	21.3	43.9	3.0	16.7%	1.6	2.7	1.3	1.3	20.1	42.8	4.1	22.8%	1.5	2.7	1.9	2.0	
4	PG&E	23.1	44.9	8	1.9	2.7	20.8	42.4	2.5	13.9%	1.7	2.7	0.9	1.2	20.5	42.2	2.7	14.9%	1.6	2.7	2.4	2.7	
5	PG&E	22.2	44.4	10	1.8	2.6	19.7	41.7	2.7	16.7%	1.6	2.5	1.1	1.2	19.7	41.7	2.6	16.2%	1.5	2.5	2.3	2.5	
5	PG&E/SoCalGas	22.2	44.4	10	1.8	2.6	19.7	41.7	2.7	16.7%	1.6	2.5	0.9	1.2	19.7	41.7	2.6	16.2%	1.5	2.5	2.0	2.5	
6	SCE/SoCalGas	23.3	49.9	10	1.6	2.7	21.5	47.8	2.0	12.1%	1.5	2.7	0.7	1.2	21.5	47.9	2.0	11.8%	1.4	2.7	1.6	2.0	
7	SDG&E	20.3	49.1	5	1.3	2.6	20.3	49.1	0.0	0.0%	1.3	2.6	-	-	18.8	47.6	1.5	12.4%	1.2	2.6	1.5	1.4	
8	SCE/SoCalGas	21.3	46.9	10	1.4	2.9	20.1	45.6	1.3	7.7%	1.3	2.9	0.6	1.4	19.7	45.3	1.6	9.4%	1.3	2.9	1.3	1.8	
9	SCE/SoCalGas	24.5	47.7	13	1.5	2.9	22.3	45.1	2.6	11.7%	1.5	2.9	0.7	2.0	21.9	44.8	2.9	13.4%	1.4	2.9	1.8	3.7	
10	SCE/SoCalGas	24.2	46.3	10	1.6	3.0	21.7	43.1	3.2	14.3%	1.5	3.0	0.6	1.3	21.5	43.1	3.2	14.6%	1.4	3.0	2.0	3.8	
10	SDG&E	24.2	46.3	10	1.6	3.0	21.7	43.1	3.2	14.3%	1.5	3.0	0.8	1.3	21.5	43.1	3.2	14.6%	1.4	3.0	2.6	3.8	
11	PG&E	24.6	44.9	11	2.1	3.6	21.3	40.6	4.3	16.4%	1.9	3.4	0.8	1.2	20.7	39.9	5.1	19.2%	1.8	3.4	2.5	3.7	
12	PG&E	25.5	44.8	12	2.1	3.0	22.5	41.3	3.5	14.9%	1.9	2.9	1.2	1.8	22.5	41.4	3.4	14.4%	1.9	3.0	3.3	4.6	
13	PG&E	25.7	46.5	11	2.0	3.8	22.2	41.9	4.6	16.9%	1.8	3.6	0.8	1.3	21.2	40.7	5.8	21.4%	1.7	3.6	5.3	8.4	
14	SCE/SoCalGas	25.3	46.3	15	2.3	3.2	21.5	41.3	5.0	18.5%	2.1	3.0	1.6	2.5	20.8	40.4	5.8	21.7%	2.0	3.0	4.0	6.1	
14	SDG&E	25.3	46.3	15	2.3	3.2	21.5	41.3	5.0	18.5%	2.1	3.0	1.9	2.5	20.8	40.4	5.8	21.7%	2.0	3.0	4.9	6.1	
15	SCE/SoCalGas	22.4	49.1	11	1.7	5.4	19.7	44.3	4.8	14.8%	1.6	5.0	1.0	1.6	19.5	44.1	5.0	15.4%	1.5	5.0	>1	>1	
16	PG&E	30.4	48.9	22	3.3	2.7	25.0	43.5	5.4	20.6%	2.6	2.7	1.6	1.5	24.8	42.7	6.2	23.5%	2.7	2.6	2.2	2.2	

">1" = indicates cases where there is both first cost savings and annual utility bill savings.



Table 26: Single Family Mixed Fuel Efficiency & PV/Battery Package Cost-Effectiveness Results

CZ	Utility	BASECASE				Efficiency & PV/Battery						
		Total EDR	CALGreen Tier 1 EDR Target	lbs CO2 per sqft	PV kW	Total EDR	Total EDR Margin	% Comp Margin	lbs CO2 per sqft	PV kW	On-Bill B/C Ratio	TDV B/C Ratio
1	PG&E	32.5	23	3.0	3.3	21.9	10.6	31.8%	2.4	3.3	0.9	1.6
2	PG&E	25.0	12	2.2	2.8	14.9	10.1	27.3%	1.8	2.9	0.5	1.6
3	PG&E	23.9	10	1.9	2.7	13.9	10.0	27.7%	1.5	2.8	0.4	1.4
4	PG&E	23.1	8	1.9	2.7	13.0	10.1	24.9%	1.5	2.8	0.3	1.5
5	PG&E	22.2	10	1.8	2.6	12.8	9.4	29.7%	1.4	2.6	0.4	1.3
5	PG&E/SoCalGas	22.2	10	1.8	2.6	12.8	9.4	29.7%	1.4	2.6	0.3	1.3
6	SCE/SoCalGas	23.3	10	1.6	2.7	13.6	9.8	20.1%	1.2	2.8	0.8	1.3
7	SDG&E	20.3	5	1.3	2.6	11.1	9.2	9.0%	1.0	2.7	0.1	1.3
8	SCE/SoCalGas	21.3	10	1.4	2.9	12.9	8.4	23.7%	1.1	3.0	0.9	1.3
9	SCE/SoCalGas	24.5	13	1.5	2.9	15.7	8.8	24.7%	1.2	3.0	1.0	1.5
10	SCE/SoCalGas	24.2	10	1.6	3.0	14.6	9.6	27.3%	1.3	3.1	1.0	1.5
10	SDG&E	24.2	10	1.6	3.0	14.6	9.6	27.3%	1.3	3.1	0.6	1.5
11	PG&E	24.6	11	2.1	3.6	15.4	9.2	29.4%	1.8	3.5	0.4	1.5
12	PG&E	25.5	12	2.1	3.0	15.9	9.6	28.9%	1.8	3.0	0.4	1.7
13	PG&E	25.7	11	2.0	3.8	16.1	9.7	28.9%	1.7	3.7	0.4	1.6
14	SCE/SoCalGas	25.3	15	2.3	3.2	16.3	9.0	30.1%	1.8	3.1	1.3	1.7
14	SDG&E	25.3	15	2.3	3.2	16.3	9.0	30.1%	1.8	3.1	1.2	1.7
15	SCE/SoCalGas	22.4	11	1.7	5.4	15.3	7.1	25.1%	1.4	5.1	1.1	1.5
16	PG&E	30.4	22	3.3	2.7	19.9	10.5	32.6%	2.4	2.8	0.9	1.4

">1" = indicates cases where there is both first cost savings and annual utility bill savings.



Table 27: Single Family All-Electric Efficiency Package Cost-Effectiveness Results

		BASECASE					Non-Preempted								Equipment - Preempted							
CZ	Utility	Total EDR	Efficiency EDR	CALGreen Tier 1 EDR Target	lbs CO2 per sqft	PV kW	Total EDR	Efficiency EDR	Efficiency EDR Margin	% Comp Margin	lbs CO2 per sqft	PV kW	On-Bill B/C Ratio	TDV B/C Ratio	Total EDR	Efficiency EDR	Efficiency EDR Margin	% Comp Margin	lbs CO2 per sqft	PV kW	On-Bill B/C Ratio	TDV B/C Ratio
1	PG&E	46.8	68.2	36	1.5	3.3	31.8	53.0	15.2	40.2%	1.0	3.3	1.8	1.7	39.9	61.3	6.9	18.3%	1.3	3.3	2.9	2.7
2	PG&E	32.8	53.7	16	1.1	2.8	27.9	48.7	4.9	20.5%	0.9	2.8	1.2	1.1	27.7	48.5	5.1	21.2%	0.9	2.8	2.3	2.1
3	PG&E	33.1	55.6	14	1.0	2.7	28.5	50.9	4.7	20.6%	0.8	2.7	2.6	2.4	28.7	51.2	4.4	19.6%	0.9	2.7	1.8	1.6
4	PG&E	31.3	52.8	12	1.0	2.7	27.9	49.4	3.4	15.5%	0.9	2.7	1.9	1.8	27.4	48.9	3.9	17.6%	0.9	2.7	1.5	1.5
5	PG&E	32.5	54.2	16	1.0	2.6	28.1	49.9	4.4	19.7%	0.9	2.6	2.6	2.3	28.0	49.8	4.4	20.3%	0.9	2.6	1.9	1.7
5	PG&E/SoCalGas	32.5	54.2	16	1.0	2.6	28.1	49.9	4.4	19.7%	0.9	2.6	2.6	2.3	28.0	49.8	4.4	20.3%	0.9	2.6	1.9	1.7
6	SCE/SoCalGas	29.7	55.8	12	0.9	2.7	27.7	53.8	2.0	10.9%	0.8	2.7	1.3	1.4	26.8	53.0	2.9	16.0%	0.8	2.7	2.2	2.3
7	SDG&E	27.1	55.3	7	0.7	2.6	27.1	55.3	0.0	0.0%	0.7	2.6	-	-	24.8	53.0	2.2	16.9%	0.7	2.6	1.6	1.7
8	SCE/SoCalGas	26.1	51.5	10	0.8	2.9	24.5	49.9	1.6	8.9%	0.8	2.9	0.6	1.2	24.4	49.7	1.8	9.7%	0.8	2.9	2.8	3.0
9	SCE/SoCalGas	28.8	51.9	13	0.9	2.9	26.0	49.1	2.8	12.5%	0.8	2.9	0.8	2.0	25.5	48.6	3.3	14.7%	0.8	2.9	2.1	3.2
10	SCE/SoCalGas	28.8	50.7	11	0.9	3.0	25.7	47.6	3.1	14.0%	0.9	3.0	0.9	1.5	25.3	47.2	3.4	15.5%	0.8	3.0	2.3	3.2
10	SDG&E	28.8	50.7	11	0.9	3.0	25.7	47.6	3.1	14.0%	0.9	3.0	1.1	1.5	25.3	47.2	3.4	15.5%	0.8	3.0	2.6	3.2
11	PG&E	30.0	50.2	12	1.1	3.6	25.4	45.6	4.6	16.2%	1.0	3.6	1.2	1.5	24.1	44.3	5.9	20.8%	0.9	3.6	3.0	3.3
12	PG&E	30.9	50.1	13	1.0	3.0	27.1	46.3	3.8	15.3%	0.9	3.0	0.8	1.1	25.8	45.0	5.1	20.4%	0.9	3.0	2.0	2.5
13	PG&E	30.7	51.5	13	1.1	3.8	25.7	46.4	5.1	17.4%	0.9	3.8	1.1	1.4	24.7	45.4	6.0	20.9%	0.9	3.8	2.9	3.3
14	SCE/SoCalGas	31.3	52.2	16	1.4	3.2	25.7	46.6	5.6	18.9%	1.2	3.2	1.0	1.5	25.3	46.2	6.0	20.5%	1.2	3.2	2.3	3.1
14	SDG&E	31.3	52.2	16	1.4	3.2	25.7	46.6	5.6	18.9%	1.2	3.2	1.3	1.5	25.3	46.2	6.0	20.5%	1.2	3.2	2.9	3.1
15	SCE/SoCalGas	26.2	52.8	8	1.3	5.4	20.6	47.2	5.6	16.8%	1.1	5.4	1.1	1.6	18.9	45.5	7.3	21.8%	1.0	5.4	3.3	4.5
16	PG&E	46.5	64.6	39	1.7	2.7	36.8	54.9	9.7	25.2%	1.4	2.7	1.7	1.7	41.6	59.7	4.9	12.7%	1.6	2.7	2.4	2.3



Table 28: Single Family All-Electric Efficiency & PV-PV/Battery Package Cost-Effectiveness Results

CZ	Utility	BASECASE				Efficiency & PV							Efficiency & PV/Battery						
		Total EDR	CALGreen Tier 1 EDR Target	lbs CO2 per sqft	PV kW	Total EDR	Total EDR Margin	% Comp Margin	lbs CO2 per sqft	PV kW	On-Bill B/C Ratio	TDV B/C Ratio	Total EDR	Total EDR Margin	% Comp Margin	lbs CO2 per sqft	PV kW	On-Bill B/C Ratio	TDV B/C Ratio
1	PG&E	46.8	36	1.5	3.3	15.4	31.4	40.2%	0.5	6.0	1.8	1.5	5.6	41.2	51.9%	0.3	6.76	1.4	1.4
2	PG&E	32.8	16	1.1	2.8	13.4	19.4	20.5%	0.5	4.9	1.8	1.4	2.7	30.1	31.5%	0.3	5.51	1.4	1.4
3	PG&E	33.1	14	1.0	2.7	14.6	18.5	20.6%	0.5	4.5	2.2	1.7	3.7	29.3	31.6%	0.2	5.10	1.5	1.6
4	PG&E	31.3	12	1.0	2.7	14.1	17.2	15.5%	0.5	4.5	2.1	1.6	2.8	28.6	26.5%	0.2	5.15	1.5	1.6
5	PG&E	32.5	16	1.0	2.6	14.3	18.2	19.7%	0.5	4.3	2.3	1.8	3.8	28.7	32.7%	0.2	4.84	1.6	1.6
5	PG&E/SoCalGas	32.5	16	1.0	2.6	14.3	18.2	19.7%	0.5	4.3	2.3	1.8	3.8	28.7	32.7%	0.2	4.84	1.6	1.6
6	SCE/SoCalGas	29.7	12	0.9	2.7	15.5	14.3	10.9%	0.6	4.1	1.2	1.5	3.6	26.1	18.9%	0.3	4.68	1.2	1.4
7	SDG&E	27.1	7	0.7	2.6	15.8	11.3	0.7%	0.6	3.7	1.9	1.5	2.9	24.2	6.7%	0.3	4.21	1.3	1.5
8	SCE/SoCalGas	26.1	10	0.8	2.9	15.1	10.9	8.9%	0.6	4.0	1.0	1.5	4.5	21.6	24.9%	0.3	4.54	1.1	1.4
9	SCE/SoCalGas	28.8	13	0.9	2.9	17.3	11.5	12.5%	0.7	4.1	1.1	1.6	7.6	21.3	25.5%	0.4	4.66	1.1	1.5
10	SCE/SoCalGas	28.8	11	0.9	3.0	17.7	11.1	14.0%	0.7	4.2	1.1	1.5	7.6	21.2	27.0%	0.4	4.78	1.1	1.5
10	SDG&E	28.8	11	0.9	3.0	17.7	11.1	14.0%	0.7	4.2	1.7	1.5	7.6	21.2	27.0%	0.4	4.78	1.4	1.5
11	PG&E	30.0	12	1.1	3.6	15.8	14.2	16.2%	0.6	5.4	1.8	1.6	6.8	23.2	29.2%	0.4	6.11	1.5	1.6
12	PG&E	30.9	13	1.0	3.0	15.2	15.7	15.3%	0.5	5.0	1.7	1.4	5.6	25.4	29.3%	0.3	5.62	1.3	1.5
13	PG&E	30.7	13	1.1	3.8	17.3	13.4	17.4%	0.6	5.4	1.7	1.5	8.2	22.5	29.4%	0.4	6.14	1.4	1.5
14	SCE/SoCalGas	31.3	16	1.4	3.2	15.8	15.5	18.9%	0.9	4.8	1.2	1.6	7.4	23.9	30.9%	0.6	5.39	1.4	1.6
14	SDG&E	31.3	16	1.4	3.2	15.8	15.5	18.9%	0.9	4.8	1.8	1.6	7.4	23.9	30.9%	0.6	5.39	1.7	1.6
15	SCE/SoCalGas	26.2	8	1.3	5.4	20.0	6.2	16.8%	1.1	5.5	1.1	1.6	12.7	13.5	27.0%	0.8	6.25	1.2	1.5
16	PG&E	46.5	39	1.7	2.7	19.6	27.0	25.2%	0.9	5.5	2.1	1.6	11.1	35.4	34.3%	0.6	6.17	1.7	1.5

">1" = indicates cases where there is both first cost savings and annual utility bill savings.



Appendix D – Single Family Measure Summary

Table 29: Single Family Mixed Fuel Efficiency – Non-Preempted Package Measure Summary

CZ	Duct	Infiltratio	Wall	Attic	Roof	Glazing	Slab	DHW	HVAC	PV
1	VLLDCS	Code Min	Code Min	Code Min	Code Min	Code Min	R-10 slab insulation	Basic CHW credit (0.7)	0.35 W/cfm	1.0 PV scaling
2	VLLDCS	Code Min	Code Min	Code Min	Code Min	Code Min	R-10 slab insulation	Basic CHW credit (0.7)	0.35 W/cfm	1.0 PV scaling
3	VLLDCS	Code Min	Code Min	Code Min	Code Min	Code Min	R-10 slab insulation	Basic CHW credit (0.7)	0.35 W/cfm	1.0 PV scaling
4	VLLDCS	Code Min	Code Min	Code Min	Code Min	Code Min	R-10 slab insulation	Basic CHW credit (0.7)	0.35 W/cfm	1.0 PV scaling
5	VLLDCS	Code Min	Code Min	Code Min	Code Min	Code Min	R-10 slab insulation	Basic CHW credit (0.7)	0.35 W/cfm	1.0 PV scaling
6	VLLDCS	Code Min	Code Min	Code Min	Code Min	Code Min	Code Min	Basic CHW credit (0.7)	0.35 W/cfm	1.0 PV scaling
7	Code Min	Code Min	Code Min	Code Min	Code Min	Code Min	Code Min	Code Min	Code Min	1.0 PV scaling
8	< 12 ft ducts in attic	Code Min	Code Min	Code Min	Code Min	Code Min	Code Min	Basic CHW credit (0.7)	0.35 W/cfm	1.0 PV scaling
9	VLLDCS	Code Min	Code Min	Code Min	Code Min	Code Min	Code Min	Basic CHW credit (0.7)	0.35 W/cfm	1.0 PV scaling
10	VLLDCS	Code Min	Code Min	Code Min	0.25 solar reflectance	Code Min	R-10 slab insulation	Basic CHW credit (0.7)	0.35 W/cfm	1.0 PV scaling
11	VLLDCS	Code Min	Code Min	R-38 + R-30 attic	0.25 solar reflectance	Code Min	R-10 slab insulation	Basic CHW credit (0.7)	0.35 W/cfm	1.0 PV scaling
12	VLLDCS	Code Min	Code Min	Code Min	0.25 solar reflectance	Code Min	R-10 slab insulation	Basic CHW credit (0.7)	0.35 W/cfm	1.0 PV scaling
13	VLLDCS	Code Min	Code Min	R-38 + R-30 attic	0.25 solar reflectance	Code Min	R-10 slab insulation	Basic CHW credit (0.7)	0.35 W/cfm	1.0 PV scaling
14	VLLDCS	3 ACH50	Code Min	Code Min	0.25 solar reflectance	Code Min	R-10 slab insulation	Basic CHW credit (0.7)	0.35 W/cfm	1.0 PV scaling
15	VLLDCS	Code Min	Code Min	R-38 + R-30 attic	0.25 solar reflectance	Code Min	R-10 slab insulation	Basic CHW credit (0.7)	0.35 W/cfm	1.0 PV scaling
16	VLLDCS	Code Min	Code Min	Code Min	Code Min	0.24/0.50 windows	Code Min	Basic CHW credit (0.7)	0.35 W/cfm	1.0 PV scaling

VLLDCS – Verified Low Leakage Ducts in Conditioned Space



Table 30: Single Family Mixed Fuel Efficiency – Equipment, Preempted Package Measure Summary

CZ	Duct	Infiltratio	Wall	Attic	Roof	Glazing	Slab	DHW	HVAC	PV
1	VLLDCS	Code Min	Code Min	Code Min	Code Min	Code Min	Code Min	95 EF, basic compact dist.	96 AFUE, 0.35W/cfm	1.0 PV scaling
2	LLAHU + 2% leakage	Code Min	Code Min	Code Min	Code Min	Code Min	Code Min	95 EF, basic compact dist.	96 AFUE, 0.35W/cfm	1.0 PV scaling
3	VLLDCS	Code Min	Code Min	Code Min	Code Min	Code Min	Code Min	95 EF, basic compact dist.	96 AFUE, 0.35W/cfm	1.0 PV scaling
4	LLAHU + 2% leakage	Code Min	Code Min	Code Min	Code Min	Code Min	Code Min	95 EF, basic compact dist.	96 AFUE, 0.35W/cfm	1.0 PV scaling
5	LLAHU + 2% leakage	Code Min	Code Min	Code Min	Code Min	Code Min	Code Min	95 EF, basic compact dist.	96 AFUE, 0.35W/cfm	1.0 PV scaling
6	Code Min	Code Min	Code Min	Code Min	Code Min	Code Min	Code Min	95 EF, basic compact dist.	92 AFUE, 0.35W/cfm	1.0 PV scaling
7	Code Min	Code Min	Code Min	Code Min	Code Min	Code Min	Code Min	95 EF, basic compact dist.	92 AFUE, 0.35W/cfm	1.0 PV scaling
8	Code Min	Code Min	Code Min	Code Min	Code Min	Code Min	Code Min	95 EF, basic compact dist.	92 AFUE, 0.35W/cfm	1.0 PV scaling
9	Code Min	Code Min	Code Min	Code Min	Code Min	Code Min	Code Min	95 EF, basic compact dist.	16 SEER, 92 AFUE, 0.35W/cfm	1.0 PV scaling
10	LLAHU + 2% leakage	Code Min	Code Min	Code Min	Code Min	Code Min	Code Min	95 EF, basic compact dist.	16 SEER, 92 AFUE, 0.35W/cfm	1.0 PV scaling
11	LLAHU + 2% leakage	Code Min	Code Min	Code Min	Code Min	Code Min	Code Min	95 EF, basic compact dist.	18 SEER, 96 AFUE, 0.35W/cfm	1.0 PV scaling
12	LLAHU + 2% leakage	Code Min	Code Min	Code Min	Code Min	Code Min	Code Min	95 EF, basic compact dist.	16 SEER, 92 AFUE, 0.35W/cfm	1.0 PV scaling
13	VLLDCS	Code Min	Code Min	Code Min	Code Min	Code Min	Code Min	95 EF, basic compact dist.	16 SEER, 92 AFUE, 0.35W/cfm	1.0 PV scaling
14	VLLDCS	Code Min	Code Min	Code Min	Code Min	Code Min	Code Min	95 EF, basic compact dist.	16 SEER, 92 AFUE, 0.35W/cfm	1.0 PV scaling
15	LLAHU + 2% leakage	Code Min	Code Min	Code Min	Code Min	Code Min	Code Min	95 EF, basic compact dist.	16 SEER, 92 AFUE, 0.35W/cfm	1.0 PV scaling
16	VLLDCS	Code Min	Code Min	Code Min	Code Min	Code Min	Code Min	95 EF, basic compact dist.	18 SEER, 96 AFUE, 0.35W/cfm	1.0 PV scaling

LLAHU - Low Leakage Air Handling Unit

VLLDCS – Verified Low Leakage Ducts in Conditioned Space



Table 31: Single Family Mixed Fuel Efficiency & PV/Battery Package Measure Summary

CZ	Duct	Infiltration	Wall	Attic	Roof	Glazing	Slab	DHW	HVAC	PV
1	VLLDCS	Code Min	Code Min	Code Min	Code Min	Code Min	R-10 slab insulation	Basic CHW credit (0.7)	0.35 W/cfm	1.0 PV scaling + 5kWh batt
2	VLLDCS	Code Min	Code Min	Code Min	Code Min	Code Min	R-10 slab insulation	Basic CHW credit (0.7)	0.35 W/cfm	1.0 PV scaling + 5kWh batt
3	VLLDCS	Code Min	Code Min	Code Min	Code Min	Code Min	R-10 slab insulation	Basic CHW credit (0.7)	0.35 W/cfm	1.0 PV scaling + 5kWh batt
4	VLLDCS	Code Min	Code Min	Code Min	Code Min	Code Min	R-10 slab insulation	Basic CHW credit (0.7)	0.35 W/cfm	1.0 PV scaling + 5kWh batt
5	VLLDCS	Code Min	Code Min	Code Min	Code Min	Code Min	R-10 slab insulation	Basic CHW credit (0.7)	0.35 W/cfm	1.0 PV scaling + 5kWh batt
6	VLLDCS	Code Min	Code Min	Code Min	Code Min	Code Min	Code Min	Basic CHW credit (0.7)	0.35 W/cfm	1.0 PV scaling + 5kWh batt
7	Code Min	Code Min	Code Min	Code Min	Code Min	Code Min	Code Min	Basic CHW credit (0.7)	Code Min	1.0 PV scaling + 5kWh batt
8	< 12 ft ducts in attic	Code Min	Code Min	Code Min	Code Min	Code Min	Code Min	Basic CHW credit (0.7)	0.35 W/cfm	1.0 PV scaling + 5kWh batt
9	VLLDCS	Code Min	Code Min	Code Min	Code Min	Code Min	Code Min	Basic CHW credit (0.7)	0.35 W/cfm	1.0 PV scaling + 5kWh batt
10	VLLDCS	Code Min	Code Min	Code Min	0.25 solar reflectance	Code Min	R-10 slab insulation	Basic CHW credit (0.7)	0.35 W/cfm	1.0 PV scaling + 5kWh batt
11	VLLDCS	Code Min	Code Min	R-38 + R-30 attic	0.25 solar reflectance	Code Min	R-10 slab insulation	Basic CHW credit (0.7)	0.35 W/cfm	1.0 PV scaling + 5kWh batt
12	VLLDCS	Code Min	Code Min	Code Min	0.25 solar reflectance	Code Min	R-10 slab insulation	Basic CHW credit (0.7)	0.35 W/cfm	1.0 PV scaling + 5kWh batt
13	VLLDCS	Code Min	Code Min	R-38 + R-30 attic	0.25 solar reflectance	Code Min	R-10 slab insulation	Basic CHW credit (0.7)	0.35 W/cfm	1.0 PV scaling + 5kWh batt
14	VLLDCS	3 ACH50	Code Min	Code Min	0.25 solar reflectance	Code Min	R-10 slab insulation	Basic CHW credit (0.7)	0.35 W/cfm	1.0 PV scaling + 5kWh batt
15	VLLDCS	Code Min	Code Min	R-38 + R-30 attic	0.25 solar reflectance	Code Min	R-10 slab insulation	Basic CHW credit (0.7)	0.35 W/cfm	1.0 PV scaling + 5kWh batt
16	VLLDCS	Code Min	Code Min	Code Min	Code Min	0.24/0.50 windows	Code Min	Basic CHW credit (0.7)	0.35 W/cfm	1.0 PV scaling + 5kWh batt

VLLDCS – Verified Low Leakage Ducts in Conditioned Space



Table 32: Single Family All-Electric Efficiency – Non-Preempted Package Measure Summary

CZ	Duct	Infiltratio	Wall	Attic	Roof	Glazing	Slab	DHW	HVAC	PV
1	VLLDCS	Code Min	Code Min	R-38 + R-30 attic	Code Min	0.24/0.50 windows	R-10 slab insulation	Code Min	0.45 W/cfm	Std Design PV
2	VLLDCS	Code Min	Code Min	Code Min	Code Min	0.24/0.23 windows	R-10 slab insulation	Code Min	0.45 W/cfm	Std Design PV
3	VLLDCS	Code Min	Code Min	Code Min	Code Min	Code Min	R-10 slab insulation	Code Min	0.45 W/cfm	Std Design PV
4	VLLDCS	Code Min	Code Min	Code Min	Code Min	Code Min	R-10 slab insulation	Code Min	0.45 W/cfm	Std Design PV
5	VLLDCS	Code Min	Code Min	Code Min	Code Min	Code Min	R-10 slab insulation	Code Min	0.45 W/cfm	Std Design PV
6	VLLDCS	Code Min	Code Min	Code Min	Code Min	Code Min	Code Min	Code Min	0.45 W/cfm	Std Design PV
7	Code Min	Code Min	Code Min	Code Min	Code Min	Code Min	Code Min	Code Min	Code Min	Std Design PV
8	VLLDCS	Code Min	Code Min	Code Min	Code Min	Code Min	Code Min	Code Min	0.45 W/cfm	Std Design PV
9	VLLDCS	Code Min	Code Min	Code Min	0.25 solar reflectance	Code Min	Code Min	Code Min	0.45 W/cfm	Std Design PV
10	VLLDCS	Code Min	Code Min	Code Min	0.25 solar reflectance	Code Min	R-10 slab insulation	Code Min	0.45 W/cfm	Std Design PV
11	VLLDCS	Code Min	Code Min	R-38 + R-30 attic	0.25 solar reflectance	Code Min	R-10 slab insulation	Code Min	0.45 W/cfm	Std Design PV
12	VLLDCS	Code Min	Code Min	R-38 + R-30 attic	0.25 solar reflectance	Code Min	R-10 slab insulation	Code Min	0.45 W/cfm	Std Design PV
13	VLLDCS	3 ACH50	Code Min	R-38 + R-30 attic	0.25 solar reflectance	Code Min	R-10 slab insulation	Code Min	0.45 W/cfm	Std Design PV
14	VLLDCS	3 ACH50	Code Min	R-38 + R-30 attic	0.25 solar reflectance	Code Min	R-10 slab insulation	Code Min	0.45 W/cfm	Std Design PV
15	VLLDCS	Code Min	0.043 wall	R-38 + R-30 attic	0.25 solar reflectance	Code Min	R-10 slab insulation	Code Min	0.45 W/cfm	Std Design PV
16	VLLDCS	3 ACH50	Code Min	R-38 + R-30 attic	Code Min	0.24/0.50 windows	Code Min	Code Min	0.45 W/cfm	Std Design PV

VLLDCS – Verified Low Leakage Ducts in Conditioned Space



Table 33: Single Family All-Electric Efficiency – Equipment, Preempted Package Measure Summary

CZ	Duct	Infiltratio	Wall	Attic	Roof	Glazing	Slab	DHW	HVAC	PV
1	LLAHU + 2% leakage	Code Min	Code Min	Code Min	Code Min	Code Min	Code Min	NEEA Tier 3 HPWH	18 SEER, 10 HSPF, 0.45W/cfm	Std Design PV
2	LLAHU + 2% leakage	Code Min	Code Min	Code Min	Code Min	Code Min	Code Min	NEEA Tier 3 HPWH	18 SEER, 10 HSPF, 0.45W/cfm	Std Design PV
3	LLAHU + 2% leakage	Code Min	Code Min	Code Min	Code Min	Code Min	Code Min	NEEA Tier 3 HPWH	18 SEER, 10 HSPF, 0.45W/cfm	Std Design PV
4	LLAHU + 2% leakage	Code Min	Code Min	Code Min	Code Min	Code Min	Code Min	NEEA Tier 3 HPWH	18 SEER, 10 HSPF, 0.45W/cfm	Std Design PV
5	LLAHU + 2% leakage	Code Min	Code Min	Code Min	Code Min	Code Min	Code Min	NEEA Tier 3 HPWH	18 SEER, 10 HSPF, 0.45W/cfm	Std Design PV
6	Code Min	Code Min	Code Min	Code Min	Code Min	Code Min	Code Min	NEEA Tier 3 HPWH	16 SEER, 9 HSPF, 0.45W/cfm	Std Design PV
7	Code Min	Code Min	Code Min	Code Min	Code Min	Code Min	Code Min	NEEA Tier 3 HPWH	16 SEER, 9 HSPF, 0.45W/cfm	Std Design PV
8	Code Min	Code Min	Code Min	Code Min	Code Min	Code Min	Code Min	NEEA Tier 3 HPWH	0.45 W/cfm	Std Design PV
9	Code Min	Code Min	Code Min	Code Min	Code Min	Code Min	Code Min	NEEA Tier 3 HPWH	16 SEER, 9 HSPF, 0.45W/cfm	Std Design PV
10	LLAHU + 2% leakage	Code Min	Code Min	Code Min	Code Min	Code Min	Code Min	NEEA Tier 3 HPWH	16 SEER, 9 HSPF, 0.45W/cfm	Std Design PV
11	LLAHU + 2% leakage	Code Min	Code Min	Code Min	Code Min	Code Min	Code Min	NEEA Tier 3 HPWH	18 SEER, 10 HSPF, 0.45W/cfm	Std Design PV
12	LLAHU + 2% leakage	Code Min	Code Min	Code Min	Code Min	Code Min	Code Min	NEEA Tier 3 HPWH	18 SEER, 10 HSPF, 0.45W/cfm	Std Design PV
13	LLAHU + 2% leakage	Code Min	Code Min	Code Min	Code Min	Code Min	Code Min	NEEA Tier 3 HPWH	18 SEER, 10 HSPF, 0.45W/cfm	Std Design PV
14	LLAHU + 2% leakage	Code Min	Code Min	Code Min	Code Min	Code Min	Code Min	NEEA Tier 3 HPWH	18 SEER, 10 HSPF, 0.45W/cfm	Std Design PV
15	LLAHU + 2% leakage	Code Min	Code Min	Code Min	Code Min	Code Min	Code Min	NEEA Tier 3 HPWH	18 SEER, 10 HSPF, 0.45W/cfm	Std Design PV
16	LLAHU + 2% leakage	Code Min	Code Min	Code Min	Code Min	Code Min	Code Min	NEEA Tier 3 HPWH	18 SEER, 10 HSPF, 0.45W/cfm	Std Design PV

LLAHU - Low Leakage Air Handling Unit

VVLDCS – Verified Low Leakage Ducts in Conditioned Space



Table 34: Single Family All-Electric Efficiency & PV Package Measure Summary

CZ	Duct	Infiltratio	Wall	Attic	Roof	Glazing	Slab	DHW	HVAC	PV
1	VLLDCS	Code Min	Code Min	R-38 + R-30 attic	Code Min	0.24/0.50 windows	R-10 slab insulation	Code Min	0.45 W/cfm	0.9 PV scaling
2	VLLDCS	Code Min	Code Min	Code Min	Code Min	0.24/0.23 windows	R-10 slab insulation	Code Min	0.45 W/cfm	0.9 PV scaling
3	VLLDCS	Code Min	Code Min	Code Min	Code Min	Code Min	R-10 slab insulation	Code Min	0.45 W/cfm	0.9 PV scaling
4	VLLDCS	Code Min	Code Min	Code Min	Code Min	Code Min	R-10 slab insulation	Code Min	0.45 W/cfm	0.9 PV scaling
5	VLLDCS	Code Min	Code Min	Code Min	Code Min	Code Min	R-10 slab insulation	Code Min	0.45 W/cfm	0.9 PV scaling
6	VLLDCS	Code Min	Code Min	Code Min	Code Min	Code Min	Code Min	Code Min	0.45 W/cfm	0.9 PV scaling
7	Code Min	Code Min	Code Min	Code Min	Code Min	Code Min	Code Min	Code Min	0.45 W/cfm	0.9 PV scaling
8	VLLDCS	Code Min	Code Min	Code Min	Code Min	Code Min	Code Min	Code Min	0.45 W/cfm	0.9 PV scaling
9	VLLDCS	Code Min	Code Min	Code Min	0.25 solar reflectance	Code Min	Code Min	Code Min	0.45 W/cfm	0.9 PV scaling
10	VLLDCS	Code Min	Code Min	Code Min	0.25 solar reflectance	Code Min	R-10 slab insulation	Code Min	0.45 W/cfm	0.9 PV scaling
11	VLLDCS	Code Min	Code Min	R-38 + R-30 attic	0.25 solar reflectance	Code Min	R-10 slab insulation	Code Min	0.45 W/cfm	0.9 PV scaling
12	VLLDCS	Code Min	Code Min	R-38 + R-30 attic	0.25 solar reflectance	Code Min	R-10 slab insulation	Code Min	0.45 W/cfm	0.9 PV scaling
13	VLLDCS	3 ACH50	Code Min	R-38 + R-30 attic	0.25 solar reflectance	Code Min	R-10 slab insulation	Code Min	0.45 W/cfm	0.9 PV scaling
14	VLLDCS	3 ACH50	Code Min	R-38 + R-30 attic	0.25 solar reflectance	Code Min	R-10 slab insulation	Code Min	0.45 W/cfm	0.9 PV scaling
15	VLLDCS	Code Min	0.043 wall	R-38 + R-30 attic	0.25 solar reflectance	Code Min	R-10 slab insulation	Code Min	0.45 W/cfm	0.9 PV scaling
16	VLLDCS	3 ACH50	Code Min	R-38 + R-30 attic	Code Min	0.24/0.50 windows	Code Min	Code Min	0.45 W/cfm	0.9 PV scaling

VLLDCS – Verified Low Leakage Ducts in Conditioned Space



Table 35: Single Family All-Electric Efficiency & PV/Battery Package Measure Summary

CZ	Duct	Infiltration	Wall	Attic	Roof	Glazing	Slab	DHW	HVAC	PV
1	VLLDCS	Code Min	Code Min	R-38 + R-30 attic	Code Min	0.24/0.50 windows	R-10 slab insulation	Code Min	0.45 W/cfm	1.0 PV scaling + 5kWh batt
2	VLLDCS	Code Min	Code Min	Code Min	Code Min	0.24/0.23 windows	R-10 slab insulation	Code Min	0.45 W/cfm	1.0 PV scaling + 5kWh batt
3	VLLDCS	Code Min	Code Min	Code Min	Code Min	Code Min	R-10 slab insulation	Code Min	0.45 W/cfm	1.0 PV scaling + 5kWh batt
4	VLLDCS	Code Min	Code Min	Code Min	Code Min	Code Min	R-10 slab insulation	Code Min	0.45 W/cfm	1.0 PV scaling + 5kWh batt
5	VLLDCS	Code Min	Code Min	Code Min	Code Min	Code Min	R-10 slab insulation	Code Min	0.45 W/cfm	1.0 PV scaling + 5kWh batt
6	VLLDCS	Code Min	Code Min	Code Min	Code Min	Code Min	Code Min	Code Min	0.45 W/cfm	1.0 PV scaling + 5kWh batt
7	Code Min	Code Min	Code Min	Code Min	Code Min	Code Min	Code Min	Code Min	0.45 W/cfm	1.0 PV scaling + 5kWh batt
8	VLLDCS	Code Min	Code Min	Code Min	Code Min	Code Min	Code Min	Code Min	0.45 W/cfm	1.0 PV scaling + 5kWh batt
9	VLLDCS	Code Min	Code Min	Code Min	0.25 solar reflectance	Code Min	Code Min	Code Min	0.45 W/cfm	1.0 PV scaling + 5kWh batt
10	VLLDCS	Code Min	Code Min	Code Min	0.25 solar reflectance	Code Min	R-10 slab insulation	Code Min	0.45 W/cfm	1.0 PV scaling + 5kWh batt
11	VLLDCS	Code Min	Code Min	R-38 + R-30 attic	0.25 solar reflectance	Code Min	R-10 slab insulation	Code Min	0.45 W/cfm	1.0 PV scaling + 5kWh batt
12	VLLDCS	Code Min	Code Min	R-38 + R-30 attic	0.25 solar reflectance	Code Min	R-10 slab insulation	Code Min	0.45 W/cfm	1.0 PV scaling + 5kWh batt
13	VLLDCS	3 ACH50	Code Min	R-38 + R-30 attic	0.25 solar reflectance	Code Min	R-10 slab insulation	Code Min	0.45 W/cfm	1.0 PV scaling + 5kWh batt
14	VLLDCS	3 ACH50	Code Min	R-38 + R-30 attic	0.25 solar reflectance	Code Min	R-10 slab insulation	Code Min	0.45 W/cfm	1.0 PV scaling + 5kWh batt
15	VLLDCS	Code Min	0.043 wall (SF); 0.048 wall (MF)	R-38 + R-30 attic	0.25 solar reflectance	Code Min	R-10 slab insulation	Code Min	0.45 W/cfm	1.0 PV scaling + 5kWh batt
16	VLLDCS	3 ACH50	Code Min	R-38 + R-30 attic	Code Min	0.24/0.50 windows	Code Min	Code Min	0.45 W/cfm	1.0 PV scaling + 5kWh batt

VLLDCS – Verified Low Leakage Ducts in Conditioned Space



Appendix E – Multifamily Detailed Results

Table 36: Multifamily Mixed Fuel Efficiency Package Cost-Effectiveness Results

Climate Zone	Utility	BASECASE					Non-Preempted								Equipment - Preempted							
		Total EDR	Efficiency EDR	CALGreen Tier 1 EDR Target	lbs CO2 per sqft	PV kW per Building	Total EDR	Efficiency EDR	Efficiency EDR Margin	% Comp Margin	lbs CO2 per sqft	PV kW per Building	On-Bill B/C Ratio	TDV B/C Ratio	Total EDR	Efficiency EDR	Efficiency EDR Margin	% Comp Margin	lbs CO2 per sqft	PV kW per Building	On-Bill B/C Ratio	TDV B/C Ratio
01	PG&E	28.6	60.7	23	2.7	15.9	25.1	57.3	3.4	19.3%	2.3	16.0	1.1	1.2	26.4	58.4	2.3	12.2%	2.5	15.9	1.3	1.4
02	PG&E	25.7	56.5	12	2.4	13.9	24.2	54.7	1.8	9.9%	2.3	13.8	1.0	1.7	23.6	54.2	2.3	12.5%	2.2	13.9	1.1	1.5
03	PG&E	24.7	57.8	10	2.1	13.5	24.0	57.2	0.6	4.7%	2.1	13.5	1.0	1.1	23.1	56.2	1.6	11.2%	1.9	13.4	1.1	1.2
04	PG&E	25.5	56.8	8	2.2	13.6	24.3	55.5	1.3	7.7%	2.1	13.5	0.8	1.2	23.8	54.9	1.9	10.9%	2.0	13.5	1.1	1.7
05	PG&E	24.2	57.4	10	2.1	12.6	23.7	56.9	0.5	4.4%	2.0	12.6	1.0	1.0	22.7	55.9	1.5	10.9%	1.9	12.6	1.2	1.3
05	PG&E/SoCalGas	24.2	57.4	10	2.1	12.6	23.7	56.9	0.5	4.4%	2.0	12.6	0.8	1.0	22.7	55.9	1.5	10.9%	1.9	12.6	1.1	1.3
06	SCE/SoCalGas	26.8	63.2	10	2.2	13.9	25.8	61.9	1.3	7.0%	2.1	13.8	0.6	1.5	25.5	61.9	1.3	7.4%	2.0	13.9	1.4	1.7
07	SDG&E	26.8	64.5	5	2.1	13.2	26.1	63.6	0.9	5.3%	2.1	13.1	0.7	2.2	25.0	62.5	2.0	12.2%	2.0	13.2	1.1	1.4
08	SCE/SoCalGas	25.7	61.8	10	2.2	14.6	24.6	60.3	1.5	7.4%	2.1	14.5	0.7	1.4	24.6	60.7	1.1	5.7%	2.0	14.6	1.4	1.7
09	SCE/SoCalGas	26.4	59.7	13	2.2	14.7	25.0	57.9	1.8	8.2%	2.2	14.4	1.5	3.3	24.1	56.9	2.8	12.9%	2.1	14.4	1.7	2.9
10	SCE/SoCalGas	27.0	58.7	10	2.3	15.1	25.7	57.0	1.7	7.7%	2.2	14.9	0.8	1.7	24.7	55.8	2.9	13.0%	2.1	14.8	2.0	3.3
10	SDG&E	27.0	58.7	10	2.3	15.1	25.7	57.0	1.7	7.7%	2.2	14.9	1.1	1.7	24.7	55.8	2.9	13.0%	2.1	14.8	2.6	3.3
11	PG&E	24.5	54.5	11	2.4	16.6	22.3	51.6	2.9	11.9%	2.2	16.3	0.7	1.2	22.2	51.3	3.2	13.2%	2.2	16.1	1.8	3.3
12	PG&E	25.9	55.3	12	2.3	14.9	24.3	53.4	1.9	8.8%	2.2	14.8	1.1	2.2	23.5	52.5	2.8	12.8%	2.1	14.7	1.2	2.2
13	PG&E	26.1	55.9	11	2.3	17.5	23.7	52.8	3.1	12.1%	2.1	17.1	0.6	1.3	23.7	52.5	3.4	13.2%	2.1	16.9	2.0	3.8
14	SCE/SoCalGas	25.6	55.9	15	2.8	14.6	23.1	52.8	3.1	12.8%	2.5	14.3	0.7	1.2	23.2	52.6	3.3	13.3%	2.5	14.2	2.0	3.0
14	SDG&E	25.6	55.9	15	2.8	14.6	23.1	52.8	3.1	12.8%	2.5	14.3	0.9	1.2	23.2	52.6	3.3	13.3%	2.5	14.2	2.5	3.0
15	SCE/SoCalGas	25.0	59.2	11	2.5	21.6	22.7	55.0	4.2	12.9%	2.4	20.4	1.4	2.3	22.6	54.8	4.4	13.5%	2.3	20.4	>1	>1
16	PG&E	29.4	57.3	22	3.5	13.4	26.6	54.9	2.4	11.3%	3.0	13.7	1.1	1.2	26.9	54.4	2.9	13.1%	3.1	13.2	1.8	2.1

">1" = indicates cases where there is both first cost savings and annual utility bill savings.



Table 37: Multifamily Mixed Fuel Efficiency & PV/Battery Package Cost-Effectiveness Results

CZ	Utility	BASECASE				Efficiency & PV/Battery						
		Total EDR	CALGreen Tier 1 EDR Target	lbs CO2 per sqft	PV kW per Building	Total EDR	Total EDR Margin	% Comp Margin	lbs CO2 per sqft	PV kW per Building	On-Bill B/C Ratio	TDV B/C Ratio
01	PG&E	28.6	23	2.7	15.9	17.1	11.5	29.3%	2.1	16.5	0.4	1.2
02	PG&E	25.7	12	2.4	13.9	14.8	10.9	16.9%	2.1	14.2	0.2	1.6
03	PG&E	24.7	10	2.1	13.5	14.4	10.3	10.7%	1.9	13.9	0.1	1.4
04	PG&E	25.5	8	2.2	13.6	14.3	11.2	15.7%	1.9	13.9	0.2	1.6
05	PG&E	24.2	10	2.1	12.6	14.3	9.9	9.4%	1.8	13.1	0.2	1.4
05	PG&E/SoCalGas	24.2	10	2.1	12.6	14.3	9.9	9.4%	1.8	13.1	0.1	1.4
06	SCE/SoCalGas	26.8	10	2.2	13.9	16.1	10.7	10.0%	1.8	14.2	0.6	1.4
07	SDG&E	26.8	5	2.1	13.2	15.8	11.0	7.3%	1.7	13.6	0.0	1.4
08	SCE/SoCalGas	25.7	10	2.2	14.6	15.8	9.9	13.4%	1.8	14.9	0.7	1.3
09	SCE/SoCalGas	26.4	13	2.2	14.7	16.7	9.7	15.2%	1.8	14.9	0.9	1.5
10	SCE/SoCalGas	27.0	10	2.3	15.1	16.6	10.4	13.7%	1.9	15.3	1.0	1.6
10	SDG&E	27.0	10	2.3	15.1	16.6	10.4	13.7%	1.9	15.3	0.2	1.6
11	PG&E	24.5	11	2.4	16.6	14.0	10.5	19.9%	2.0	16.7	0.4	1.6
12	PG&E	25.9	12	2.3	14.9	15.6	10.3	17.8%	2.0	15.2	0.3	1.7
13	PG&E	26.1	11	2.3	17.5	15.4	10.7	20.1%	2.0	17.5	0.4	1.6
14	SCE/SoCalGas	25.6	15	2.8	14.6	16.0	9.6	20.8%	2.2	14.7	1.1	1.4
14	SDG&E	25.6	15	2.8	14.6	16.0	9.6	20.8%	2.2	14.7	0.5	1.4
15	SCE/SoCalGas	25.0	11	2.5	21.6	16.2	8.8	18.9%	2.1	20.9	1.3	1.7
16	PG&E	29.4	22	3.5	13.4	19.5	9.9	19.3%	2.7	14.1	0.5	1.3

"inf" = indicates cases where there is both first cost savings and annual utility bill savings.



Table 38: Multifamily All-Electric Efficiency Package Cost-Effectiveness Results

CZ	Utility	BASECASE					Non-Preempted								Equipment - Preempted							
		Total EDR	Efficiency EDR	CALGreen Tier 1 EDR Target	lbs CO2 per sqft	PV kW per Building	Total EDR	Efficiency EDR	Efficiency EDR Margin	% Comp Margin	lbs CO2 per sqft	PV kW per Building	On-Bill B/C Ratio	TDV B/C Ratio	Total EDR	Efficiency EDR	Efficiency EDR Margin	% Comp Margin	lbs CO2 per sqft	PV kW per Building	On-Bill B/C Ratio	TDV B/C Ratio
01	PG&E	41.1	70.6	36	1.6	15.9	37.5	67.0	3.6	14.6%	1.5	15.9	1.6	1.4	37.1	67.3	3.3	18.4%	1.4	15.9	2.4	2.3
02	PG&E	34.3	63.4	16	1.4	13.9	32.4	61.5	1.9	9.1%	1.3	13.9	1.7	2.1	31.1	60.2	3.2	15.1%	1.3	13.9	1.6	1.6
03	PG&E	33.5	64.2	14	1.3	13.5	33.5	64.2	0.0	0.0%	1.3	13.5	-	-	30.4	61.5	2.7	19.5%	1.1	13.5	1.7	1.6
04	PG&E	32.0	61.4	12	1.3	13.6	30.5	60.0	1.4	8.0%	1.2	13.6	1.4	1.5	29.7	59.2	2.2	12.2%	1.2	13.6	1.2	1.1
05	PG&E	34.7	65.4	16	1.3	12.6	34.1	64.8	0.6	3.4%	1.3	12.6	1.1	0.9	30.6	61.8	3.6	23.5%	1.2	12.6	2.1	2.0
05	PG&E/SoCalGas	34.7	65.4	16	1.3	12.6	34.1	64.8	0.6	3.4%	1.3	12.6	1.1	0.9	30.6	61.8	3.6	23.5%	1.2	12.6	2.1	2.0
06	SCE/SoCalGas	31.9	65.9	12	1.3	13.9	30.9	64.9	1.0	5.9%	1.3	13.9	0.7	1.3	29.8	63.7	2.2	13.0%	1.2	13.9	1.6	1.9
07	SDG&E	31.7	66.6	7	1.2	13.2	31.1	66.0	0.6	4.6%	1.2	13.2	0.6	1.0	29.7	64.7	1.9	13.6%	1.1	13.2	1.6	1.7
08	SCE/SoCalGas	29.8	63.6	10	1.3	14.6	28.6	62.4	1.2	6.5%	1.2	14.6	0.9	1.7	27.9	61.7	1.9	10.3%	1.2	14.6	1.6	1.8
09	SCE/SoCalGas	30.4	61.9	13	1.3	14.7	28.7	60.3	1.6	8.1%	1.3	14.7	1.3	2.7	28.8	60.4	1.5	7.4%	1.2	14.7	1.6	1.6
10	SCE/SoCalGas	31.2	61.3	11	1.4	15.1	29.3	59.5	1.8	8.7%	1.3	15.1	1.2	2.0	29.3	59.5	1.8	8.6%	1.3	15.1	1.7	2.0
10	SDG&E	31.2	61.3	11	1.4	15.1	29.3	59.5	1.8	8.7%	1.3	15.1	1.5	2.0	29.3	59.5	1.8	8.6%	1.3	15.1	2.0	2.0
11	PG&E	31.9	60.6	12	1.4	16.6	28.5	57.1	3.5	13.1%	1.3	16.6	1.4	1.6	28.1	56.7	3.9	14.4%	1.3	16.6	2.0	2.3
12	PG&E	32.0	59.9	13	1.3	14.9	29.4	57.3	2.6	11.4%	1.2	14.9	0.9	1.1	29.0	57.0	2.9	13.0%	1.2	14.9	1.6	1.6
13	PG&E	32.1	60.5	13	1.4	17.5	28.8	57.2	3.3	12.6%	1.2	17.5	1.3	1.6	28.3	56.7	3.8	14.3%	1.2	17.5	2.0	2.3
14	SCE/SoCalGas	32.5	61.6	16	1.7	14.6	28.9	57.9	3.7	13.8%	1.6	14.6	1.2	1.6	28.7	57.8	3.8	14.3%	1.6	14.6	1.6	2.2
14	SDG&E	32.5	61.6	16	1.7	14.6	28.9	57.9	3.7	13.8%	1.6	14.6	1.5	1.6	28.7	57.8	3.8	14.3%	1.6	14.6	2.0	2.2
15	SCE/SoCalGas	28.2	61.0	8	1.8	21.6	23.9	56.6	4.4	14.2%	1.6	21.6	1.5	2.3	21.9	54.6	6.4	20.6%	1.5	21.6	1.2	1.7
16	PG&E	40.2	66.6	39	1.9	13.4	36.2	62.5	4.1	15.0%	1.7	13.4	2.1	2.1	37.1	63.4	3.2	11.4%	1.7	13.4	1.6	1.7

">1" = indicates cases where there is both first cost savings and annual utility bill savings.



Table 39: Multifamily All-Electric Efficiency & PV-PV/Battery Package Cost-Effectiveness Results

Climate Zone	Utility	BASECASE				Efficiency & PV							Efficiency & PV/Battery						
		Total EDR	CALGreen Tier 1 EDR Target	lbs CO2 per sqft	PV kW per Building	Total EDR	Total EDR Margin	% Comp Margin	lbs CO2 per sqft	PV kW per Building	On-Bill B/C Ratio	TDV B/C Ratio	Total EDR	Total EDR Margin	% Comp Margin	lbs CO2 per sqft	PV kW per Building	On-Bill B/C Ratio	TDV B/C Ratio
01	PG&E	41.1	36	1.6	15.9	18.6	22.5	14.6%	0.8	26.9	2.0	1.5	6.6	34.5	24.6%	0.4	30.3	1.3	1.4
02	PG&E	34.3	16	1.4	13.9	16.8	17.5	9.1%	0.7	21.9	2.4	1.8	3.4	30.9	16.1%	0.3	24.8	1.4	1.7
03	PG&E	33.5	14	1.3	13.5	17.4	16.1	2.6%	0.7	20.8	2.4	1.7	4.0	29.5	8.6%	0.3	23.6	1.3	1.6
04	PG&E	32.0	12	1.3	13.6	17.0	15.0	8.0%	0.7	20.2	2.4	1.8	3.1	28.9	16.0%	0.3	22.9	1.30	1.77
05	PG&E	34.7	16	1.3	12.6	17.6	17.1	3.4%	0.7	19.9	2.5	1.8	4.4	30.3	8.4%	0.3	22.5	1.4	1.7
05	PG&E/SoCalGas	34.7	16	1.3	12.6	17.6	17.1	3.4%	0.7	19.9	2.5	1.8	4.4	30.3	8.4%	0.3	22.5	1.4	1.7
06	SCE/SoCalGas	31.9	12	1.3	13.9	18.1	13.8	5.9%	1.0	19.5	1.2	1.7	4.4	27.5	8.9%	0.5	22.1	1.2	1.6
07	SDG&E	31.7	7	1.2	13.2	18.9	12.8	4.6%	0.9	18.1	2.1	1.8	4.6	27.1	6.6%	0.5	20.5	1.2	1.6
08	SCE/SoCalGas	29.8	10	1.3	14.6	18.2	11.6	6.5%	1.0	19.4	1.3	1.8	5.6	24.2	12.5%	0.5	22.0	1.2	1.6
09	SCE/SoCalGas	30.4	13	1.3	14.7	19.1	11.3	8.1%	1.0	19.4	1.3	1.9	7.1	23.3	15.1%	0.6	22.0	1.3	1.7
10	SCE/SoCalGas	31.2	11	1.4	15.1	20.4	10.8	8.7%	1.1	19.9	1.3	1.8	7.9	23.3	14.7%	0.6	22.5	1.3	1.7
10	SDG&E	31.2	11	1.4	15.1	20.4	10.8	8.7%	1.1	19.9	2.1	1.8	7.9	23.3	14.7%	0.6	22.5	1.4	1.7
11	PG&E	31.9	12	1.4	16.6	18.5	13.4	13.1%	0.8	22.8	2.2	1.8	6.6	25.3	21.1%	0.4	25.8	1.4	1.8
12	PG&E	32.0	13	1.3	14.9	17.6	14.4	11.4%	0.7	21.7	2.1	1.6	5.4	26.6	20.4%	0.4	24.5	1.3	1.7
13	PG&E	32.1	13	1.4	17.5	19.9	12.2	12.6%	0.8	23.3	2.1	1.7	8.2	23.9	20.6%	0.4	26.4	1.4	1.7
14	SCE/SoCalGas	32.5	16	1.7	14.6	18.5	14.0	13.8%	1.3	20.2	1.4	1.9	7.7	24.8	21.8%	0.8	22.8	1.4	1.8
14	SDG&E	32.5	16	1.7	14.6	18.5	14.0	13.8%	1.3	20.2	2.2	1.9	7.7	24.8	21.8%	0.8	22.8	1.7	1.8
15	SCE/SoCalGas	28.2	8	1.8	21.6	21.1	7.1	14.2%	1.5	23.6	1.4	2.1	11.3	16.9	20.2%	1.1	26.6	1.3	1.8
16	PG&E	40.2	39	1.9	13.4	20.6	19.6	15.0%	1.2	22.0	2.6	1.9	10.3	29.9	23.0%	0.8	24.8	1.6	1.7

">1" = indicates cases where there is both first cost savings and annual utility bill savings.



Appendix F – Multifamily Measure Summary

Table 40: Multifamily Mixed Fuel Efficiency – Non-Preempted Package Measure Summary

CZ	Duct	Infiltration	Wall	Attic	Roof	Glazing	Slab	DHW	HVAC	PV
1	VLLDCS	Code Min	Code Min	Code Min	Code Min	0.24/0.50 windows	R-10 slab insulation	Basic CHW credit (0.7)	0.35 W/cfm	1.0 PV scaling
2	VLLDCS	Code Min	Code Min	Code Min	0.25 solar reflectance	Code Min	R-10 slab insulation	Basic CHW credit (0.7)	0.35 W/cfm	1.0 PV scaling
3	Code Min	Code Min	Code Min	Code Min	Code Min	Code Min	R-10 slab insulation	Basic CHW credit (0.7)	0.35 W/cfm	1.0 PV scaling
4	VLLDCS	Code Min	Code Min	Code Min	0.25 solar reflectance	Code Min	R-10 slab insulation	Basic CHW credit (0.7)	0.35 W/cfm	1.0 PV scaling
5	Code Min	Code Min	Code Min	Code Min	Code Min	Code Min	R-10 slab insulation	Basic CHW credit (0.7)	0.35 W/cfm	1.0 PV scaling
6	VLLDCS	Code Min	Code Min	Code Min	0.25 solar reflectance	Code Min	Code Min	Basic CHW credit (0.7)	0.35 W/cfm	1.0 PV scaling
7	Code Min	Code Min	Code Min	Code Min	0.25 solar reflectance	Code Min	Code Min	Basic CHW credit (0.7)	0.35 W/cfm	1.0 PV scaling
8	VLLDCS	Code Min	Code Min	Code Min	0.25 solar reflectance	Code Min	Code Min	Enh CHW credit (0.6)	0.35 W/cfm	1.0 PV scaling
9	VLLDCS	Code Min	Code Min	Code Min	0.25 solar reflectance	Code Min	Code Min	Basic CHW credit (0.7)	0.35 W/cfm	1.0 PV scaling
10	VLLDCS	Code Min	Code Min	Code Min	0.25 solar reflectance	Code Min	R-10 slab insulation	Basic CHW credit (0.7)	0.35 W/cfm	1.0 PV scaling
11	VLLDCS	Code Min	Code Min	Code Min	0.25 solar reflectance	0.24/0.23 windows	R-10 slab insulation	Basic CHW credit (0.7)	0.35 W/cfm	1.0 PV scaling
12	VLLDCS	Code Min	Code Min	Code Min	0.25 solar reflectance	Code Min	R-10 slab insulation	Basic CHW credit (0.7)	0.35 W/cfm	1.0 PV scaling
13	VLLDCS	Code Min	Code Min	Code Min	0.25 solar reflectance	0.24/0.23 windows	R-10 slab insulation	Basic CHW credit (0.7)	0.35 W/cfm	1.0 PV scaling
14	VLLDCS	Code Min	Code Min	Code Min	0.25 solar reflectance	0.24/0.23 windows	R-10 slab insulation	Basic CHW credit (0.7)	0.35 W/cfm	1.0 PV scaling
15	VLLDCS	Code Min	Code Min	Code Min	0.25 solar reflectance	0.24/0.23 windows	R-10 slab insulation	Basic CHW credit (0.7)	0.35 W/cfm	1.0 PV scaling
16	VLLDCS	Code Min	Code Min	Code Min	Code Min	0.24/0.50 windows	R-10 slab insulation	Basic CHW credit (0.7)	0.35 W/cfm	1.0 PV scaling

VLLDCS – Verified Low-Leakage Ducts in Conditioned Space



Table 41: Multifamily Mixed Fuel Efficiency – Equipment, Preempted Package Measure Summary

CZ	Duct	Infiltratio	Wall	Attic	Roof	Glazing	Slab	DHW	HVAC	PV
1	Code Min	Code Min	Code Min	Code Min	Code Min	Code Min	Code Min	95 EF, basic compact dist.	16 SEER, 92 AFUE, 0.35W/cfm	1.0 PV scaling
2	Code Min	Code Min	Code Min	Code Min	Code Min	Code Min	Code Min	95 EF, basic compact dist.	16 SEER, 92 AFUE, 0.35W/cfm	1.0 PV scaling
3	Code Min	Code Min	Code Min	Code Min	Code Min	Code Min	Code Min	95 EF, basic compact dist.	92 AFUE, 0.35W/cfm	1.0 PV scaling
4	Code Min	Code Min	Code Min	Code Min	Code Min	Code Min	Code Min	95 EF, basic compact dist.	16 SEER, 0.35 W/cfm	1.0 PV scaling
5	Code Min	Code Min	Code Min	Code Min	Code Min	Code Min	Code Min	95 EF, basic compact dist.	92 AFUE, 0.45W/cfm	1.0 PV scaling
6	Code Min	Code Min	Code Min	Code Min	Code Min	Code Min	Code Min	95 EF, basic compact dist.	Code Min	1.0 PV scaling
7	Code Min	Code Min	Code Min	Code Min	Code Min	Code Min	Code Min	95 EF, basic compact dist.	16 SEER, 0.35 W/cfm	1.0 PV scaling
8	Code Min	Code Min	Code Min	Code Min	Code Min	Code Min	Code Min	95 EF, basic compact dist.	Code Min	1.0 PV scaling
9	Code Min	Code Min	Code Min	Code Min	Code Min	Code Min	Code Min	95 EF, basic compact dist.	16 SEER, 0.35 W/cfm	1.0 PV scaling
10	Code Min	Code Min	Code Min	Code Min	Code Min	Code Min	Code Min	95 EF, basic compact dist.	16 SEER, 0.35 W/cfm	1.0 PV scaling
11	Code Min	Code Min	Code Min	Code Min	Code Min	Code Min	Code Min	95 EF, basic compact dist.	16 SEER, 92 AFUE, 0.35W/cfm	1.0 PV scaling
12	Code Min	Code Min	Code Min	Code Min	Code Min	Code Min	Code Min	95 EF, basic compact dist.	16 SEER, 92 AFUE, 0.35W/cfm	1.0 PV scaling
13	Code Min	Code Min	Code Min	Code Min	Code Min	Code Min	Code Min	95 EF, basic compact dist.	16 SEER, 92 AFUE, 0.35W/cfm	1.0 PV scaling
14	Code Min	Code Min	Code Min	Code Min	Code Min	Code Min	Code Min	95 EF, basic compact dist.	16 SEER, 92 AFUE, 0.35W/cfm	1.0 PV scaling
15	Code Min	Code Min	Code Min	Code Min	Code Min	Code Min	Code Min	95 EF, basic compact dist.	16 SEER, 0.35 W/cfm	1.0 PV scaling
16	Code Min	Code Min	Code Min	Code Min	Code Min	Code Min	Code Min	95 EF, basic compact dist.	16 SEER, 92 AFUE, 0.35W/cfm	1.0 PV scaling

VLLDCS – Verified Low-Leakage Ducts in Conditioned Space



Table 42: Multifamily Mixed Fuel Efficiency & PV/Battery Package Measure Summary

CZ	Duct	Infiltration	Wall	Attic	Roof	Glazing	Slab	DHW	HVAC	PV
1	VLLDCS	Code Min	Code Min	Code Min	Code Min	0.24/0.50 windows	R-10 slab insulation	Basic CHW credit (0.7)	0.35 W/cfm	1.0 PV scaling + 22kWh batt
2	VLLDCS	Code Min	Code Min	Code Min	0.25 solar reflectance	Code Min	R-10 slab insulation	Basic CHW credit (0.7)	0.35 W/cfm	1.0 PV scaling + 22kWh batt
3	Code Min	Code Min	Code Min	Code Min	Code Min	Code Min	R-10 slab insulation	Basic CHW credit (0.7)	0.35 W/cfm	1.0 PV scaling + 22kWh batt
4	VLLDCS	Code Min	Code Min	Code Min	0.25 solar reflectance	Code Min	R-10 slab insulation	Basic CHW credit (0.7)	0.35 W/cfm	1.0 PV scaling + 22kWh batt
5	Code Min	Code Min	Code Min	Code Min	Code Min	Code Min	R-10 slab insulation	Basic CHW credit (0.7)	0.35 W/cfm	1.0 PV scaling + 22kWh batt
6	VLLDCS	Code Min	Code Min	Code Min	0.25 solar reflectance	Code Min	Code Min	Basic CHW credit (0.7)	0.35 W/cfm	1.0 PV scaling + 22kWh batt
7	Code Min	Code Min	Code Min	Code Min	0.25 solar reflectance	Code Min	Code Min	Basic CHW credit (0.7)	0.35 W/cfm	1.0 PV scaling + 22kWh batt
8	VLLDCS	Code Min	Code Min	Code Min	0.25 solar reflectance	Code Min	Code Min	Enh CHW credit (0.6)	0.35 W/cfm	1.0 PV scaling + 22kWh batt
9	VLLDCS	Code Min	Code Min	Code Min	0.25 solar reflectance	Code Min	Code Min	Basic CHW credit (0.7)	0.35 W/cfm	1.0 PV scaling + 22kWh batt
10	VLLDCS	Code Min	Code Min	Code Min	0.25 solar reflectance	Code Min	R-10 slab insulation	Basic CHW credit (0.7)	0.35 W/cfm	1.0 PV scaling + 22kWh batt
11	VLLDCS	Code Min	Code Min	Code Min	0.25 solar reflectance	0.24/0.23 windows	R-10 slab insulation	Basic CHW credit (0.7)	0.35 W/cfm	1.0 PV scaling + 22kWh batt
12	VLLDCS	Code Min	Code Min	Code Min	0.25 solar reflectance	Code Min	R-10 slab insulation	Basic CHW credit (0.7)	0.35 W/cfm	1.0 PV scaling + 22kWh batt
13	VLLDCS	Code Min	Code Min	Code Min	0.25 solar reflectance	0.24/0.23 windows	R-10 slab insulation	Basic CHW credit (0.7)	0.35 W/cfm	1.0 PV scaling + 22kWh batt
14	VLLDCS	Code Min	Code Min	Code Min	0.25 solar reflectance	0.24/0.23 windows	R-10 slab insulation	Basic CHW credit (0.7)	0.35 W/cfm	1.0 PV scaling + 22kWh batt
15	VLLDCS	Code Min	Code Min	Code Min	0.25 solar reflectance	0.24/0.23 windows	R-10 slab insulation	Basic CHW credit (0.7)	0.35 W/cfm	1.0 PV scaling + 22kWh batt
16	VLLDCS	Code Min	Code Min	Code Min	Code Min	0.24/0.50 windows	R-10 slab insulation	Basic CHW credit (0.7)	0.35 W/cfm	1.0 PV scaling + 22kWh batt

VLLDCS – Verified Low-Leakage Ducts in Conditioned Space



Table 43: Multifamily All-Electric Efficiency – Non-Preempted Package Measure Summary

<u>CZ</u>	<u>Duct</u>	<u>Infiltration</u>	<u>Wall</u>	<u>Attic</u>	<u>Roof</u>	<u>Glazing</u>	<u>Slab</u>	<u>DHW</u>	<u>HVAC</u>	<u>PV</u>
1	VLLDCS	Code Min	Code Min	Code Min	Code Min	0.24/0.50 windows	R-10 slab insulation	Code Min	0.45 W/cfm	Std Design PV
2	VLLDCS	Code Min	Code Min	Code Min	0.25 solar reflectance	Code Min	R-10 slab insulation	Code Min	0.45 W/cfm	Std Design PV
3	Code Min	Code Min	Code Min	Code Min	Code Min	Code Min	Code Min	Code Min	Code Min	Std Design PV
4	VLLDCS	Code Min	Code Min	Code Min	0.25 solar reflectance	Code Min	R-10 slab insulation	Code Min	0.45 W/cfm	Std Design PV
5	VLLDCS	Code Min	Code Min	Code Min	Code Min	Code Min	R-10 slab insulation	Code Min	Code Min	Std Design PV
6	VLLDCS	Code Min	Code Min	Code Min	0.25 solar reflectance	Code Min	Code Min	Code Min	0.45 W/cfm	Std Design PV
7	Code Min	Code Min	Code Min	Code Min	0.25 solar reflectance	Code Min	Code Min	Code Min	0.45 W/cfm	Std Design PV
8	VLLDCS	Code Min	Code Min	Code Min	0.25 solar reflectance	Code Min	Code Min	Code Min	0.45 W/cfm	Std Design PV
9	VLLDCS	Code Min	Code Min	Code Min	0.25 solar reflectance	Code Min	Code Min	Code Min	0.45 W/cfm	Std Design PV
10	VLLDCS	Code Min	Code Min	Code Min	0.25 solar reflectance	Code Min	R-10 slab insulation	Code Min	0.45 W/cfm	Std Design PV
11	VLLDCS	Code Min	Code Min	Code Min	0.25 solar reflectance	0.24/0.23 windows	R-10 slab insulation	Code Min	0.45 W/cfm	Std Design PV
12	VLLDCS	Code Min	Code Min	Code Min	0.25 solar reflectance	0.24/0.23 windows	R-10 slab insulation	Code Min	0.45 W/cfm	Std Design PV
13	VLLDCS	Code Min	Code Min	Code Min	0.25 solar reflectance	0.24/0.23 windows	R-10 slab insulation	Code Min	0.45 W/cfm	Std Design PV
14	VLLDCS	Code Min	Code Min	Code Min	0.25 solar reflectance	0.24/0.23 windows	R-10 slab insulation	Code Min	0.45 W/cfm	Std Design PV
15	VLLDCS	Code Min	Code Min	Code Min	0.25 solar reflectance	0.24/0.23 windows	R-10 slab insulation	Code Min	0.45 W/cfm	Std Design PV
16	VLLDCS	Code Min	Code Min	Code Min	Code Min	0.24/0.50 windows	R-10 slab insulation	Code Min	0.45 W/cfm	Std Design PV

VLLDCS – Verified Low-Leakage Ducts in Conditioned Space



Table 44: Multifamily All-Electric Efficiency – Equipment, Preempted Package Measure Summary

CZ	Duct	Infiltratio	Wall	Attic	Roof	Glazing	Slab	DHW	HVAC	PV
1	Code Min	Code Min	Code Min	Code Min	Code Min	Code Min	Code Min	NEEA Tier 3 HPWH	16 SEER, 9 HSPF, 0.45W/cfm	Std Design PV
2	Code Min	Code Min	Code Min	Code Min	Code Min	Code Min	Code Min	NEEA Tier 3 HPWH	16 SEER, 9 HSPF, 0.45W/cfm	Std Design PV
3	Code Min	Code Min	Code Min	Code Min	Code Min	Code Min	Code Min	NEEA Tier 3 HPWH	16 SEER, 9 HSPF, 0.45W/cfm	Std Design PV
4	Code Min	Code Min	Code Min	Code Min	Code Min	Code Min	Code Min	NEEA Tier 3 HPWH	16 SEER, 9 HSPF, 0.45W/cfm	Std Design PV
5	Code Min	Code Min	Code Min	Code Min	Code Min	Code Min	Code Min	NEEA Tier 3 HPWH	16 SEER, 9 HSPF, 0.45W/cfm	Std Design PV
6	Code Min	Code Min	Code Min	Code Min	Code Min	Code Min	Code Min	NEEA Tier 3 HPWH	0.45 W/cfm	Std Design PV
7	Code Min	Code Min	Code Min	Code Min	Code Min	Code Min	Code Min	NEEA Tier 3 HPWH	0.45 W/cfm	Std Design PV
8	Code Min	Code Min	Code Min	Code Min	Code Min	Code Min	Code Min	NEEA Tier 3 HPWH	0.45 W/cfm	Std Design PV
9	Code Min	Code Min	Code Min	Code Min	Code Min	Code Min	Code Min	NEEA Tier 3 HPWH	0.45 W/cfm	Std Design PV
10	Code Min	Code Min	Code Min	Code Min	Code Min	Code Min	Code Min	NEEA Tier 3 HPWH	0.45 W/cfm	Std Design PV
11	Code Min	Code Min	Code Min	Code Min	Code Min	Code Min	Code Min	NEEA Tier 3 HPWH	16 SEER, 9 HSPF, 0.45W/cfm	Std Design PV
12	Code Min	Code Min	Code Min	Code Min	Code Min	Code Min	Code Min	NEEA Tier 3 HPWH	16 SEER, 9 HSPF, 0.45W/cfm	Std Design PV
13	Code Min	Code Min	Code Min	Code Min	Code Min	Code Min	Code Min	NEEA Tier 3 HPWH	16 SEER, 9 HSPF, 0.45W/cfm	Std Design PV
14	Code Min	Code Min	Code Min	Code Min	Code Min	Code Min	Code Min	NEEA Tier 3 HPWH	16 SEER, 9 HSPF, 0.45W/cfm	Std Design PV
15	Code Min	Code Min	Code Min	Code Min	Code Min	Code Min	Code Min	NEEA Tier 3 HPWH	18 SEER, 10 HSPF, 0.45W/cfm	Std Design PV
16	Code Min	Code Min	Code Min	Code Min	Code Min	Code Min	Code Min	NEEA Tier 3 HPWH	16 SEER, 9 HSPF, 0.45W/cfm	Std Design PV

VLLDCS – Verified Low-Leakage Ducts in Conditioned Space



Table 45: Multifamily All-Electric Efficiency & PV Package Measure Summary

CZ	Duct	Infiltration	Wall	Attic	Roof	Glazing	Slab	DHW	HVAC	PV
1	VLLDCS	Code Min	Code Min	Code Min	Code Min	0.24/0.50 windows	R-10 slab insulation	Code Min	0.45 W/cfm	0.9 PV scaling
2	VLLDCS	Code Min	Code Min	Code Min	0.25 solar reflectance	Code Min	R-10 slab insulation	Code Min	0.45 W/cfm	0.9 PV scaling
3	Code Min	Code Min	Code Min	Code Min	Code Min	Code Min	R-10 slab insulation	Code Min	0.45 W/cfm	0.9 PV scaling
4	VLLDCS	Code Min	Code Min	Code Min	0.25 solar reflectance	Code Min	R-10 slab insulation	Code Min	0.45 W/cfm	0.9 PV scaling
5	VLLDCS	Code Min	Code Min	Code Min	Code Min	Code Min	R-10 slab insulation	Code Min	Code Min	0.9 PV scaling
6	VLLDCS	Code Min	Code Min	Code Min	0.25 solar reflectance	Code Min	Code Min	Code Min	0.45 W/cfm	0.9 PV scaling
7	Code Min	Code Min	Code Min	Code Min	0.25 solar reflectance	Code Min	Code Min	Code Min	0.45 W/cfm	0.9 PV scaling
8	VLLDCS	Code Min	Code Min	Code Min	0.25 solar reflectance	Code Min	Code Min	Code Min	0.45 W/cfm	0.9 PV scaling
9	VLLDCS	Code Min	Code Min	Code Min	0.25 solar reflectance	Code Min	Code Min	Code Min	0.45 W/cfm	0.9 PV scaling
10	VLLDCS	Code Min	Code Min	Code Min	0.25 solar reflectance	Code Min	R-10 slab insulation	Code Min	0.45 W/cfm	0.9 PV scaling
11	VLLDCS	Code Min	Code Min	Code Min	0.25 solar reflectance	0.24/0.23 windows	R-10 slab insulation	Code Min	0.45 W/cfm	0.9 PV scaling
12	VLLDCS	Code Min	Code Min	Code Min	0.25 solar reflectance	0.24/0.23 windows	R-10 slab insulation	Code Min	0.45 W/cfm	0.9 PV scaling
13	VLLDCS	Code Min	Code Min	Code Min	0.25 solar reflectance	0.24/0.23 windows	R-10 slab insulation	Code Min	0.45 W/cfm	0.9 PV scaling
14	VLLDCS	Code Min	Code Min	Code Min	0.25 solar reflectance	0.24/0.23 windows	R-10 slab insulation	Code Min	0.45 W/cfm	0.9 PV scaling
15	VLLDCS	Code Min	Code Min	Code Min	0.25 solar reflectance	0.24/0.23 windows	R-10 slab insulation	Code Min	0.45 W/cfm	0.9 PV scaling
16	VLLDCS	Code Min	Code Min	Code Min	Code Min	0.24/0.50 windows	R-10 slab insulation	Code Min	0.45 W/cfm	0.9 PV scaling

VLLDCS – Verified Low-Leakage Ducts in Conditioned Space



Table 46: Multifamily All-Electric Efficiency & PV/Battery Package Measure Summary

CZ	Duct	Infiltration	Wall	Attic	Roof	Glazing	Slab	DHW	HVAC	PV
1	VLLDCS	Code Min	Code Min	Code Min	Code Min	0.24/0.50 windows	R-10 slab insulation	Code Min	0.45 W/cfm	1.0 PV scaling + 22kWh batt
2	VLLDCS	Code Min	Code Min	Code Min	0.25 solar reflectance	Code Min	R-10 slab insulation	Code Min	0.45 W/cfm	1.0 PV scaling + 22kWh batt
3	Code Min	Code Min	Code Min	Code Min	Code Min	Code Min	R-10 slab insulation	Code Min	0.45 W/cfm	1.0 PV scaling + 22kWh batt
4	VLLDCS	Code Min	Code Min	Code Min	0.25 solar reflectance	Code Min	R-10 slab insulation	Code Min	0.45 W/cfm	1.0 PV scaling + 22kWh batt
5	VLLDCS	Code Min	Code Min	Code Min	Code Min	Code Min	R-10 slab insulation	Code Min	Code Min	1.0 PV scaling + 22kWh batt
6	VLLDCS	Code Min	Code Min	Code Min	0.25 solar reflectance	Code Min	Code Min	Code Min	0.45 W/cfm	1.0 PV scaling + 22kWh batt
7	Code Min	Code Min	Code Min	Code Min	0.25 solar reflectance	Code Min	Code Min	Code Min	0.45 W/cfm	1.0 PV scaling + 22kWh batt
8	VLLDCS	Code Min	Code Min	Code Min	0.25 solar reflectance	Code Min	Code Min	Code Min	0.45 W/cfm	1.0 PV scaling + 22kWh batt
9	VLLDCS	Code Min	Code Min	Code Min	0.25 solar reflectance	Code Min	Code Min	Code Min	0.45 W/cfm	1.0 PV scaling + 22kWh batt
10	VLLDCS	Code Min	Code Min	Code Min	0.25 solar reflectance	Code Min	R-10 slab insulation	Code Min	0.45 W/cfm	1.0 PV scaling + 22kWh batt
11	VLLDCS	Code Min	Code Min	Code Min	0.25 solar reflectance	0.24/0.23 windows	R-10 slab insulation	Code Min	0.45 W/cfm	1.0 PV scaling + 22kWh batt
12	VLLDCS	Code Min	Code Min	Code Min	0.25 solar reflectance	0.24/0.23 windows	R-10 slab insulation	Code Min	0.45 W/cfm	1.0 PV scaling + 22kWh batt
13	VLLDCS	Code Min	Code Min	Code Min	0.25 solar reflectance	0.24/0.23 windows	R-10 slab insulation	Code Min	0.45 W/cfm	1.0 PV scaling + 22kWh batt
14	VLLDCS	Code Min	Code Min	Code Min	0.25 solar reflectance	0.24/0.23 windows	R-10 slab insulation	Code Min	0.45 W/cfm	1.0 PV scaling + 22kWh batt
15	VLLDCS	Code Min	Code Min	Code Min	0.25 solar reflectance	0.24/0.23 windows	R-10 slab insulation	Code Min	0.45 W/cfm	1.0 PV scaling + 22kWh batt
16	VLLDCS	Code Min	Code Min	Code Min	Code Min	0.24/0.50 windows	R-10 slab insulation	Code Min	0.45 W/cfm	1.0 PV scaling + 22kWh batt

VLLDCS – Verified Low-Leakage Ducts in Conditioned Space



Appendix G – Results by Climate Zone

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Climate Zone 12	106
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Climate Zone 14 SCE/SoCalGas	110
Climate Zone 14 SDGE	112
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Climate Zone 1**Table 47: Single Family Climate Zone 1 Results Summary**

Climate Zone 1 PG&E Single Family		Annual Net kWh	Annual therms	EDR Margin ⁴	PV Size Change (kW) ⁵	CO2-Equivalent Emissions (lbs/sf)		NPV of Lifetime Incremental Cost (\$)	Benefit to Cost Ratio (B/C)	
						Total	Reduction		On-Bill	TDV
Mixed Fuel ¹	Code Compliant	(0)	581	n/a	n/a	3.00	n/a	n/a	n/a	n/a
	Efficiency-Non-Preempted	(0)	480	5.0	(0.08)	2.51	0.49	\$1,355	3.38	2.82
	Efficiency-Equipment	0	440	6.5	(0.07)	2.32	0.68	\$1,280	4.92	4.10
	Efficiency & PV/Battery	(28)	480	10.5	0.04	2.40	0.60	\$5,311	0.87	1.61
All-Electric ²	Code Compliant	7,079	0	n/a	n/a	1.51	n/a	n/a	n/a	n/a
	Efficiency-Non-Preempted	4,461	0	15.0	0.00	1.01	0.50	\$7,642	1.79	1.66
	Efficiency-Equipment	5,933	0	6.5	0.00	1.29	0.22	\$2,108	2.94	2.74
	Efficiency & PV	889	0	31.0	2.67	0.52	1.00	\$18,192	1.81	1.45
	Efficiency & PV/Battery	(14)	0	41.0	3.45	0.28	1.23	\$24,770	1.45	1.40
Mixed Fuel to All-Electric ³	Code Compliant	7,079	0	0.0	0.00	1.51	1.49	(\$5,349)	0.37	0.91
	Efficiency & PV	889	0	31.0	2.67	0.52	2.48	\$12,844	1.43	2.11
	Neutral Cost	5,270	0	8.0	1.35	1.26	1.74	\$0	0.00	1.09
	Min Cost Effectiveness	3,106	0	18.0	2.97	0.95	2.04	(\$6,372)	1.08	>1

¹All reductions and incremental costs relative to the **mixed fuel** code compliant home.

²All reductions and incremental costs relative to the **all-electric** code compliant home.

³All reductions and incremental costs relative to the **mixed fuel** code compliant home except the EDR Margins are relative to the Standard Design for each case which is the **all-electric** code compliant home. Incremental costs for these packages reflect the costs used in the On-Bill cost effectiveness methodology. Costs differ for the TDV methodology due to differences in the site gas infrastructure costs (see Section 2.6).

⁴This represents the Efficiency EDR Margin for the Efficiency-Non-Preempted and Efficiency-Equipment packages and Total EDR Margin for the Efficiency & PV, Efficiency & PV/Battery, Neutral Cost, and Min Cost Effectiveness packages.

⁵Positive values indicate an increase in PV capacity relative to the Standard Design.



Table 48: Multifamily Climate Zone 1 Results Summary (Per Dwelling Unit)

Climate Zone 1 PG&E Multifamily		Annual Net kWh	Annual therms	EDR Margin ⁴	PV Size Change (kW) ⁵	CO2-Equivalent Emissions (lbs/sf)		NPV of Lifetime Incremental Cost (\$)	Benefit to Cost Ratio (B/C)	
						Total	Reduction		On-Bill	TDV
Mixed Fuel ¹	Code Compliant	(0)	180	n/a	n/a	2.75	n/a	n/a	n/a	n/a
	Efficiency-Non-Preempted	(0)	147	3.0	0.00	2.31	0.44	\$960	1.10	1.18
	Efficiency-Equipment	(0)	159	2.0	(0.01)	2.48	0.27	\$507	1.29	1.41
	Efficiency & PV/Battery	(14)	147	11.5	0.07	2.13	0.61	\$3,094	0.35	1.21
All-Electric ²	Code Compliant	2,624	0	n/a	n/a	1.62	n/a	n/a	n/a	n/a
	Efficiency-Non-Preempted	2,328	0	3.5	0.00	1.46	0.15	\$949	1.55	1.40
	Efficiency-Equipment	2,278	0	3.0	0.00	1.41	0.20	\$795	2.39	2.26
	Efficiency & PV	499	0	22.5	1.37	0.75	0.86	\$5,538	2.04	1.50
	Efficiency & PV/Battery	(7)	0	34.5	1.80	0.38	1.24	\$8,919	1.33	1.43
Mixed Fuel to All-Electric ³	Code Compliant	2,624	0	0.0	0.00	1.62	1.13	(\$2,337)	0.38	1.01
	Efficiency & PV	62	0	22.5	1.37	0.75	2.00	\$3,202	1.63	>1
	Neutral Cost	1,693	0	9.5	0.70	1.25	1.50	\$0	0.00	1.57
	Min Cost Effectiveness	1,273	0	14.0	1.01	1.09	1.66	(\$1,052)	1.14	3.76

¹All reductions and incremental costs relative to the **mixed fuel** code compliant home.

²All reductions and incremental costs relative to the **all-electric** code compliant home.

³All reductions and incremental costs relative to the **mixed fuel** code compliant home except the EDR Margins are relative to the Standard Design for each case which is the **all-electric** code compliant home. Incremental costs for these packages reflect the costs used in the On-Bill cost effectiveness methodology. Costs differ for the TDV methodology due to differences in the site gas infrastructure costs (see Section 2.6).

⁴This represents the Efficiency EDR Margin for the Efficiency-Non-Preempted and Efficiency-Equipment packages and Total EDR Margin for the Efficiency & PV, Efficiency & PV/Battery, Neutral Cost, and Min Cost Effectiveness packages.

⁵Positive values indicate an increase in PV capacity relative to the Standard Design.



Climate Zone 2**Table 49: Single Family Climate Zone 2 Results Summary**

Climate Zone 2 PG&E Single Family		Annual Net kWh	Annual therms	EDR Margin ⁴	PV Size Change (kW) ⁵	CO2-Equivalent Emissions (lbs/sf)		NPV of Lifetime Incremental Cost (\$)	Benefit to Cost Ratio (B/C)	
						Total	Reduction		On-Bill	TDV
Mixed Fuel ¹	Code Compliant	(0)	421	n/a	n/a	2.23	n/a	n/a	n/a	n/a
	Efficiency-Non-Preempted	0	360	3.0	(0.04)	1.94	0.30	\$1,504	1.63	1.66
	Efficiency-Equipment	(0)	352	3.0	(0.03)	1.90	0.33	\$724	3.77	3.63
	Efficiency & PV/Battery	(22)	360	10.0	0.06	1.82	0.41	\$5,393	0.47	1.56
All-Electric ²	Code Compliant	5,014	0	n/a	n/a	1.11	n/a	n/a	n/a	n/a
	Efficiency-Non-Preempted	4,079	0	4.5	0.00	0.94	0.18	\$3,943	1.21	1.07
	Efficiency-Equipment	4,122	0	5.0	0.00	0.94	0.17	\$2,108	2.25	2.10
	Efficiency & PV	847	0	19.0	2.07	0.49	0.63	\$12,106	1.83	1.38
	Efficiency & PV/Battery	(15)	0	30.0	2.71	0.26	0.86	\$18,132	1.37	1.43
Mixed Fuel to All-Electric ³	Code Compliant	5,014	0	0.0	0.00	1.11	1.12	(\$5,349)	0.52	1.59
	Efficiency & PV	847	0	19.0	2.07	0.49	1.75	\$6,758	1.76	39.70
	Neutral Cost	2,891	0	9.5	1.36	0.82	1.41	\$0	>1	>1

¹All reductions and incremental costs relative to the **mixed fuel** code compliant home.²All reductions and incremental costs relative to the **all-electric** code compliant home.³All reductions and incremental costs relative to the **mixed fuel** code compliant home except the EDR Margins are relative to the Standard Design for each case which is the **all-electric** code compliant home. Incremental costs for these packages reflect the costs used in the On-Bill cost effectiveness methodology. Costs differ for the TDV methodology due to differences in the site gas infrastructure costs (see Section 2.6).⁴This represents the Efficiency EDR Margin for the Efficiency-Non-Preempted and Efficiency-Equipment packages and Total EDR Margin for the Efficiency & PV, Efficiency & PV/Battery, and Neutral Cost packages.⁵Positive values indicate an increase in PV capacity relative to the Standard Design.

Table 50: Multifamily Climate Zone 2 Results Summary (Per Dwelling Unit)

Climate Zone 2 PG&E Multifamily		Annual Net kWh	Annual therms	EDR Margin ⁴	PV Size Change (kW) ⁵	CO2-Equivalent Emissions (lbs/sf)		NPV of Lifetime Incremental Cost (\$)	Benefit to Cost Ratio (B/C)	
						Total	Reduction		On-Bill	TDV
Mixed Fuel ¹	Code Compliant	(0)	150	n/a	n/a	2.37	n/a	n/a	n/a	n/a
	Efficiency-Non-Preempted	0	142	1.5	(0.02)	2.25	0.12	\$309	0.97	1.75
	Efficiency-Equipment	(0)	134	2.0	(0.01)	2.15	0.22	\$497	1.08	1.49
	Efficiency & PV/Battery	(11)	142	10.5	0.04	2.07	0.30	\$2,413	0.17	1.60
All-Electric ²	Code Compliant	2,151	0	n/a	n/a	1.38	n/a	n/a	n/a	n/a
	Efficiency-Non-Preempted	2,038	0	1.5	0.00	1.32	0.06	\$361	1.73	2.05
	Efficiency-Equipment	1,928	0	3.0	0.00	1.25	0.13	\$795	1.56	1.56
	Efficiency & PV	476	0	17.5	1.00	0.72	0.67	\$3,711	2.42	1.82
	Efficiency & PV/Battery	(7)	0	30.5	1.36	0.35	1.04	\$6,833	1.38	1.74
Mixed Fuel to All-Electric ³	Code Compliant	2,151	0	0.0	0.00	1.38	0.99	(\$2,337)	0.53	1.42
	Efficiency & PV	60	0	17.5	1.00	0.72	1.65	\$1,375	3.31	>1
	Neutral Cost	1,063	0	10.5	0.70	0.96	1.41	\$0	>1	>1

¹All reductions and incremental costs relative to the **mixed fuel** code compliant home.

²All reductions and incremental costs relative to the **all-electric** code compliant home.

³All reductions and incremental costs relative to the **mixed fuel** code compliant home except the EDR Margins are relative to the Standard Design for each case which is the **all-electric** code compliant home. Incremental costs for these packages reflect the costs used in the On-Bill cost effectiveness methodology. Costs differ for the TDV methodology due to differences in the site gas infrastructure costs (see Section 2.6).

⁴This represents the Efficiency EDR Margin for the Efficiency-Non-Preempted and Efficiency-Equipment packages and Total EDR Margin for the Efficiency & PV, Efficiency & PV/Battery, and Neutral Cost packages.

⁵Positive values indicate an increase in PV capacity relative to the Standard Design.



Climate Zone 3**Table 51: Single Family Climate Zone 3 Results Summary**

Climate Zone 3 PG&E Single Family		Annual Net kWh	Annual therms	EDR Margin ⁴	PV Size Change (kW) ⁵	CO2-Equivalent Emissions (lbs/sf)		NPV of Lifetime Incremental Cost (\$)	Benefit to Cost Ratio (B/C)	
						Total	Reduction		On-Bill	TDV
Mixed Fuel ¹	Code Compliant	(0)	348	n/a	n/a	1.88	n/a	n/a	n/a	n/a
	Efficiency-Non-Preempted	(0)	296	2.5	(0.03)	1.63	0.26	\$1,552	1.28	1.31
	Efficiency-Equipment	(0)	273	4.0	(0.03)	1.52	0.37	\$1,448	1.91	1.97
	Efficiency & PV/Battery	(20)	296	10.0	0.07	1.50	0.38	\$5,438	0.38	1.38
All-Electric ²	Code Compliant	4,355	0	n/a	n/a	1.00	n/a	n/a	n/a	n/a
	Efficiency-Non-Preempted	3,584	0	4.5	0.00	0.85	0.15	\$1,519	2.60	2.36
	Efficiency-Equipment	3,670	0	4.0	0.00	0.86	0.14	\$2,108	1.76	1.62
	Efficiency & PV	790	0	18.0	1.77	0.46	0.54	\$8,517	2.22	1.68
	Efficiency & PV/Battery	(12)	0	29.0	2.37	0.23	0.76	\$14,380	1.50	1.58
Mixed Fuel to All-Electric ³	Code Compliant	4,355	0	0.0	0.00	1.00	0.89	(\$5,349)	0.55	1.53
	Efficiency & PV	790	0	18.0	1.77	0.46	1.43	\$3,169	2.88	>1
	Neutral Cost	2,217	0	10.5	1.35	0.70	1.18	\$0	>1	>1

¹All reductions and incremental costs relative to the **mixed fuel** code compliant home.

²All reductions and incremental costs relative to the **all-electric** code compliant home.

³All reductions and incremental costs relative to the **mixed fuel** code compliant home except the EDR Margins are relative to the Standard Design for each case which is the **all-electric** code compliant home. Incremental costs for these packages reflect the costs used in the On-Bill cost effectiveness methodology. Costs differ for the TDV methodology due to differences in the site gas infrastructure costs (see Section 2.6).

⁴This represents the Efficiency EDR Margin for the Efficiency-Non-Preempted and Efficiency-Equipment packages and Total EDR Margin for the Efficiency & PV, Efficiency & PV/Battery, and Neutral Cost packages.

⁵Positive values indicate an increase in PV capacity relative to the Standard Design.



Table 52: Multifamily Climate Zone 3 Results Summary (Per Dwelling Unit)

Climate Zone 3 PG&E Multifamily		Annual Net kWh	Annual therms	EDR Margin ⁴	PV Size Change (kW) ⁵	CO2-Equivalent Emissions (lbs/sf)		NPV of Lifetime Incremental Cost (\$)	Benefit to Cost Ratio (B/C)	
						Total	Reduction		On-Bill	TDV
Mixed Fuel ¹	Code Compliant	(0)	133	n/a	n/a	2.13	n/a	n/a	n/a	n/a
	Efficiency-Non-Preempted	(0)	127	0.5	(0.00)	2.06	0.07	\$175	1.00	1.11
	Efficiency-Equipment	(0)	119	1.5	(0.00)	1.94	0.19	\$403	1.11	1.23
	Efficiency & PV/Battery	(10)	127	10.0	0.05	1.86	0.27	\$2,279	0.11	1.41
All-Electric ²	Code Compliant	1,944	0	n/a	n/a	1.27	n/a	n/a	n/a	n/a
	Efficiency-Non-Preempted	1,944	0	0.0	0.00	1.27	0.00	\$0	-	-
	Efficiency-Equipment	1,698	0	2.5	0.00	1.13	0.14	\$795	1.73	1.58
	Efficiency & PV	457	0	16.0	0.92	0.69	0.58	\$3,272	2.43	1.73
	Efficiency & PV/Battery	(7)	0	29.5	1.26	0.33	0.94	\$6,344	1.32	1.64
Mixed Fuel to All-Electric ³	Code Compliant	1,944	0	0.0	0.00	1.27	0.86	(\$2,337)	0.58	1.46
	Efficiency & PV	57	0	16.0	0.92	0.69	1.43	\$936	4.18	>1
	Neutral Cost	845	0	11.5	0.70	0.85	1.28	\$0	>1	>1

¹All reductions and incremental costs relative to the **mixed fuel** code compliant home.

²All reductions and incremental costs relative to the **all-electric** code compliant home.

³All reductions and incremental costs relative to the **mixed fuel** code compliant home except the EDR Margins are relative to the Standard Design for each case which is the **all-electric** code compliant home. Incremental costs for these packages reflect the costs used in the On-Bill cost effectiveness methodology. Costs differ for the TDV methodology due to differences in the site gas infrastructure costs (see Section 2.6).

⁴This represents the Efficiency EDR Margin for the Efficiency-Non-Preempted and Efficiency-Equipment packages and Total EDR Margin for the Efficiency & PV, Efficiency & PV/Battery, and Neutral Cost packages.

⁵Positive values indicate an increase in PV capacity relative to the Standard Design.



Climate Zone 4**Table 53: Single Family Climate Zone 4 Results Summary**

Climate Zone 4 PG&E Single Family		Annual Net kWh	Annual therms	EDR Margin ⁴	PV Size Change (kW) ⁵	CO2-Equivalent Emissions (lbs/sf)		NPV of Lifetime Incremental Cost (\$)	Benefit to Cost Ratio (B/C)	
						Total	Reduction		On-Bill	TDV
Mixed Fuel ¹	Code Compliant	0	347	n/a	n/a	1.88	n/a	n/a	n/a	n/a
	Efficiency-Non-Preempted	0	306	2.5	(0.03)	1.68	0.20	\$1,556	0.93	1.15
	Efficiency-Equipment	(0)	294	2.5	(0.02)	1.62	0.26	\$758	2.39	2.67
	Efficiency & PV/Battery	(18)	306	10.0	0.07	1.55	0.33	\$5,434	0.30	1.48
All-Electric ²	Code Compliant	4,342	0	n/a	n/a	1.00	n/a	n/a	n/a	n/a
	Efficiency-Non-Preempted	3,775	0	3.0	0.00	0.89	0.11	\$1,519	1.92	1.84
	Efficiency-Equipment	3,747	0	3.5	0.00	0.88	0.12	\$2,108	1.52	1.52
	Efficiency & PV	814	0	17.0	1.84	0.48	0.52	\$8,786	2.13	1.62
	Efficiency & PV/Battery	(11)	0	28.5	2.44	0.25	0.75	\$14,664	1.46	1.61
Mixed Fuel to All-Electric ³	Code Compliant	4,342	0	0.0	0.00	1.00	0.88	(\$5,349)	0.55	1.59
	Efficiency & PV	814	0	17.0	1.84	0.48	1.40	\$3,438	2.64	>1
	Neutral Cost	2,166	0	10.0	1.35	0.70	1.18	\$0	>1	>1

¹All reductions and incremental costs relative to the **mixed fuel** code compliant home.

²All reductions and incremental costs relative to the **all-electric** code compliant home.

³All reductions and incremental costs relative to the **mixed fuel** code compliant home except the EDR Margins are relative to the Standard Design for each case which is the **all-electric** code compliant home. Incremental costs for these packages reflect the costs used in the On-Bill cost effectiveness methodology. Costs differ for the TDV methodology due to differences in the site gas infrastructure costs (see Section 2.6).

⁴This represents the Efficiency EDR Margin for the Efficiency-Non-Preempted and Efficiency-Equipment packages and Total EDR Margin for the Efficiency & PV, Efficiency & PV/Battery, and Neutral Cost packages.

⁵Positive values indicate an increase in PV capacity relative to the Standard Design.



Table 54: Multifamily Climate Zone 4 Results Summary (Per Dwelling Unit)

Climate Zone 4 PG&E Multifamily		Annual Net kWh	Annual therms	EDR Margin ⁴	PV Size Change (kW) ⁵	CO2-Equivalent Emissions (lbs/sf)		NPV of Lifetime Incremental Cost (\$)	Benefit to Cost Ratio (B/C)	
						Total	Reduction		On-Bill	TDV
Mixed Fuel ¹	Code Compliant	(0)	134	n/a	n/a	2.16	n/a	n/a	n/a	n/a
	Efficiency-Non-Preempted	(0)	127	1.0	(0.01)	2.06	0.10	\$329	0.75	1.24
	Efficiency-Equipment	(0)	123	1.5	(0.01)	2.01	0.15	\$351	1.06	1.74
	Efficiency & PV/Battery	(9)	127	11.0	0.04	1.87	0.29	\$2,429	0.17	1.60
All-Electric ²	Code Compliant	1,887	0	n/a	n/a	1.25	n/a	n/a	n/a	n/a
	Efficiency-Non-Preempted	1,794	0	1.0	0.00	1.21	0.05	\$361	1.38	1.54
	Efficiency-Equipment	1,712	0	2.0	0.00	1.15	0.10	\$795	1.23	1.09
	Efficiency & PV	453	0	15.0	0.83	0.69	0.57	\$3,158	2.43	1.81
	Efficiency & PV/Battery	(7)	0	28.5	1.17	0.32	0.93	\$6,201	1.30	1.77
Mixed Fuel to All-Electric ³	Code Compliant	1,887	0	0.0	0.00	1.25	0.90	(\$2,337)	0.65	1.77
	Efficiency & PV	57	0	15.0	0.83	0.69	1.47	\$822	4.96	>1
	Neutral Cost	767	0	11.0	0.70	0.82	1.33	\$0	>1	>1

¹All reductions and incremental costs relative to the **mixed fuel** code compliant home.

²All reductions and incremental costs relative to the **all-electric** code compliant home.

³All reductions and incremental costs relative to the **mixed fuel** code compliant home except the EDR Margins are relative to the Standard Design for each case which is the **all-electric** code compliant home. Incremental costs for these packages reflect the costs used in the On-Bill cost effectiveness methodology. Costs differ for the TDV methodology due to differences in the site gas infrastructure costs (see Section 2.6).

⁴This represents the Efficiency EDR Margin for the Efficiency-Non-Preempted and Efficiency-Equipment packages and Total EDR Margin for the Efficiency & PV, Efficiency & PV/Battery, and Neutral Cost packages.

⁵Positive values indicate an increase in PV capacity relative to the Standard Design..



Climate Zone 5 PG&E**Table 55: Single Family Climate Zone 5 PG&E Results Summary**

Climate Zone 5 PG&E Single Family		Annual Net kWh	Annual therms	EDR Margin ⁴	PV Size Change (kW) ⁵	CO2-Equivalent Emissions (lbs/sf)		NPV of Lifetime Incremental Cost (\$)	Benefit to Cost Ratio (B/C)	
						Total	Reduction		On-Bill	TDV
Mixed Fuel ¹	Code Compliant	0	331	n/a	n/a	1.79	n/a	n/a	n/a	n/a
	Efficiency-Non-Preempted	(0)	281	2.5	(0.03)	1.55	0.24	\$1,571	1.10	1.22
	Efficiency-Equipment	(0)	279	2.5	(0.02)	1.54	0.25	\$772	2.29	2.48
	Efficiency & PV/Battery	(14)	281	9.0	0.07	1.43	0.36	\$5,433	0.37	1.32
All-Electric ²	Code Compliant	4,452	0	n/a	n/a	1.01	n/a	n/a	n/a	n/a
	Efficiency-Non-Preempted	3,687	0	4.0	0.00	0.86	0.15	\$1,519	2.58	2.31
	Efficiency-Equipment	3,737	0	4.0	0.00	0.87	0.14	\$2,108	1.85	1.70
	Efficiency & PV	798	0	18.0	1.72	0.46	0.55	\$8,307	2.31	1.76
	Efficiency & PV/Battery	(8)	0	28.5	2.29	0.24	0.78	\$14,047	1.59	1.63
Mixed Fuel to All-Electric ³	Code Compliant	4,452	0	0.0	0.00	1.01	0.78	(\$5,349)	0.48	1.32
	Efficiency & PV	798	0	18.0	1.72	0.46	1.33	\$2,959	2.72	>1
	Neutral Cost	2,172	0	11.0	1.35	0.70	1.10	\$0	>1	40.07

¹All reductions and incremental costs relative to the **mixed fuel** code compliant home.²All reductions and incremental costs relative to the **all-electric** code compliant home.³All reductions and incremental costs relative to the **mixed fuel** code compliant home except the EDR Margins are relative to the Standard Design for each case which is the **all-electric** code compliant home. Incremental costs for these packages reflect the costs used in the On-Bill cost effectiveness methodology. Costs differ for the TDV methodology due to differences in the site gas infrastructure costs (see Section 2.6).⁴This represents the Efficiency EDR Margin for the Efficiency-Non-Preempted and Efficiency-Equipment packages and Total EDR Margin for the Efficiency & PV, Efficiency & PV/Battery, and Neutral Cost packages.⁵Positive values indicate an increase in PV capacity relative to the Standard Design.

Table 56: Multifamily Climate Zone 5 PG&E Results Summary (Per Dwelling Unit)

Climate Zone 5 PG&E Multifamily		Annual Net kWh	Annual therms	EDR Margin ⁴	PV Size Change (kW) ⁵	CO2-Equivalent Emissions (lbs/sf)		NPV of Lifetime Incremental Cost (\$)	Benefit to Cost Ratio (B/C)	
						Total	Reduction		On-Bill	TDV
Mixed Fuel ¹	Code Compliant	0	131	n/a	n/a	2.10	n/a	n/a	n/a	n/a
	Efficiency-Non-Preempted	(0)	126	0.5	(0.00)	2.03	0.07	\$180	0.99	1.03
	Efficiency-Equipment	(0)	117	1.5	(0.00)	1.92	0.19	\$358	1.24	1.34
	Efficiency & PV/Battery	(7)	126	9.5	0.05	1.84	0.26	\$2,273	0.15	1.38
All-Electric ²	Code Compliant	2,044	0	n/a	n/a	1.32	n/a	n/a	n/a	n/a
	Efficiency-Non-Preempted	1,990	0	0.5	0.00	1.30	0.03	\$247	1.09	0.86
	Efficiency-Equipment	1,738	0	3.5	0.00	1.15	0.17	\$795	2.15	2.03
	Efficiency & PV	465	0	17.0	0.91	0.70	0.62	\$3,293	2.53	1.82
	Efficiency & PV/Battery	(6)	0	30.0	1.24	0.34	0.98	\$6,314	1.44	1.69
Mixed Fuel to All-Electric ³	Code Compliant	2,044	0	0.0	0.00	1.32	0.78	(\$2,337)	0.50	1.28
	Efficiency & PV	58	0	17.0	0.91	0.70	1.40	\$956	3.80	>1
	Neutral Cost	874	0	12.5	0.70	0.87	1.23	\$0	>1	23.44

¹All reductions and incremental costs relative to the **mixed fuel** code compliant home.

²All reductions and incremental costs relative to the **all-electric** code compliant home.

³All reductions and incremental costs relative to the **mixed fuel** code compliant home except the EDR Margins are relative to the Standard Design for each case which is the **all-electric** code compliant home. Incremental costs for these packages reflect the costs used in the On-Bill cost effectiveness methodology. Costs differ for the TDV methodology due to differences in the site gas infrastructure costs (see Section 2.6).

⁴This represents the Efficiency EDR Margin for the Efficiency-Non-Preempted and Efficiency-Equipment packages and Total EDR Margin for the Efficiency & PV, Efficiency & PV/Battery, and Neutral Cost packages.

⁵Positive values indicate an increase in PV capacity relative to the Standard Design.



Climate Zone 5 PG&E/SoCalGas**Table 57: Single Family Climate Zone 5 PG&E/SoCalGas Results Summary**

Climate Zone 5 PG&E/SoCalGas Single Family		Annual Net kWh	Annual therms	EDR Margin ⁴	PV Size Change (kW) ⁵	CO2-Equivalent Emissions (lbs/sf)		NPV of Lifetime Incremental Cost (\$)	Benefit to Cost Ratio (B/C)	
						Total	Reduction		On- Bill	TDV
Mixed Fuel ¹	Code Compliant	0	331	n/a	n/a	1.79	n/a	n/a	n/a	n/a
	Efficiency-Non-Preempted	(0)	281	2.5	(0.03)	1.55	0.24	\$1,571	0.92	1.22
	Efficiency-Equipment	(0)	279	2.5	(0.02)	1.54	0.25	\$772	1.98	2.48
	Efficiency & PV/Battery	(14)	281	9.0	0.07	1.43	0.36	\$5,433	0.31	1.32
All-Electric ²	Code Compliant	4,452	0	n/a	n/a	1.01	n/a	n/a	n/a	n/a
	Efficiency-Non-Preempted	3,687	0	4.0	0.00	0.86	0.15	\$1,519	2.58	2.31
	Efficiency-Equipment	3,737	0	4.0	0.00	0.87	0.14	\$2,108	1.85	1.70
	Efficiency & PV	798	0	18.0	1.72	0.46	0.55	\$8,307	2.31	1.76
	Efficiency & PV/Battery	(8)	0	28.5	2.29	0.24	0.78	\$14,047	1.59	1.63
Mixed Fuel to All-Electric ³	Code Compliant	4,452	0	0.0	0.00	1.01	0.78	(\$5,349)	0.48	1.32
	Efficiency & PV	798	0	18.0	1.72	0.46	1.33	\$2,959	2.75	>1
	Neutral Cost	2,172	0	11.0	1.35	0.70	1.10	\$0	>1	40.07

¹All reductions and incremental costs relative to the **mixed fuel** code compliant home.

²All reductions and incremental costs relative to the **all-electric** code compliant home.

³All reductions and incremental costs relative to the **mixed fuel** code compliant home except the EDR Margins are relative to the Standard Design for each case which is the **all-electric** code compliant home. Incremental costs for these packages reflect the costs used in the On-Bill cost effectiveness methodology. Costs differ for the TDV methodology due to differences in the site gas infrastructure costs (see Section 2.6).

⁴This represents the Efficiency EDR Margin for the Efficiency-Non-Preempted and Efficiency-Equipment packages and Total EDR Margin for the Efficiency & PV, Efficiency & PV/Battery, and Neutral Cost packages.

⁵Positive values indicate an increase in PV capacity relative to the Standard Design.



Table 58: Multifamily Climate Zone 5 PG&E/SoCalGas Results Summary (Per Dwelling Unit)

Climate Zone 5 PG&E/SoCalGas Multifamily		Annual Net kWh	Annual therms	EDR Margin ⁴	PV Size Change (kW) ⁵	CO2-Equivalent Emissions (lbs/sf)		NPV of Lifetime Incremental Cost (\$)	Benefit to Cost Ratio (B/C)	
						Total	Reduction		On-Bill	TDV
Mixed Fuel ¹	Code Compliant	0	131	n/a	n/a	2.10	n/a	n/a	n/a	n/a
	Efficiency-Non-Preempted	(0)	126	0.5	(0.00)	2.03	0.07	\$180	0.85	1.03
	Efficiency-Equipment	(0)	117	1.5	(0.00)	1.92	0.19	\$358	1.09	1.34
	Efficiency & PV/Battery	(7)	126	9.5	0.05	1.84	0.26	\$2,273	0.14	1.38
All-Electric ²	Code Compliant	2,044	0	n/a	n/a	1.32	n/a	n/a	n/a	n/a
	Efficiency-Non-Preempted	1,990	0	0.5	0.00	1.30	0.03	\$247	1.09	0.86
	Efficiency-Equipment	1,738	0	3.5	0.00	1.15	0.17	\$795	2.15	2.03
	Efficiency & PV	465	0	17.0	0.91	0.70	0.62	\$3,293	2.53	1.82
	Efficiency & PV/Battery	(6)	0	30.0	1.24	0.34	0.98	\$6,314	1.44	1.69
Mixed Fuel to All-Electric ³	Code Compliant	2,044	0	0.0	0.00	1.32	0.78	(\$2,337)	0.65	1.28
	Efficiency & PV	58	0	17.0	0.91	0.70	1.40	\$956	4.98	>1
	Neutral Cost	874	0	12.5	0.70	0.87	1.23	\$0	>1	23.44

¹All reductions and incremental costs relative to the **mixed fuel** code compliant home.

²All reductions and incremental costs relative to the **all-electric** code compliant home.

³All reductions and incremental costs relative to the **mixed fuel** code compliant home except the EDR Margins are relative to the Standard Design for each case which is the **all-electric** code compliant home. Incremental costs for these packages reflect the costs used in the On-Bill cost effectiveness methodology. Costs differ for the TDV methodology due to differences in the site gas infrastructure costs (see Section 2.6).

⁴This represents the Efficiency EDR Margin for the Efficiency-Non-Preempted and Efficiency-Equipment packages and Total EDR Margin for the Efficiency & PV, Efficiency & PV/Battery, and Neutral Cost packages.

⁵Positive values indicate an increase in PV capacity relative to the Standard Design.



Climate Zone 6**Table 59: Single Family Climate Zone 6 Results Summary**

Climate Zone 6 SCE/SoCalGas Single Family		Annual Net kWh	Annual therms	EDR Margin ⁴	PV Size Change (kW) ⁵	CO2-Equivalent Emissions (lbs/sf)		NPV of Lifetime Incremental Cost (\$)	Benefit to Cost Ratio (B/C)	
						Total	Reduction		On-Bill	TDV
Mixed Fuel ¹	Code Compliant	(0)	249	n/a	n/a	1.57	n/a	n/a	n/a	n/a
	Efficiency-Non-Preempted	0	229	2.0	(0.02)	1.47	0.10	\$1,003	0.66	1.15
	Efficiency-Equipment	(0)	218	1.5	(0.01)	1.41	0.15	\$581	1.58	2.04
	Efficiency & PV/Battery	(13)	229	9.5	0.08	1.22	0.34	\$4,889	0.84	1.27
All-Electric ²	Code Compliant	3,099	0	n/a	n/a	0.87	n/a	n/a	n/a	n/a
	Efficiency-Non-Preempted	2,885	0	2.0	0.00	0.83	0.05	\$926	1.31	1.41
	Efficiency-Equipment	2,746	0	2.5	0.00	0.80	0.08	\$846	2.20	2.29
	Efficiency & PV	722	0	14.0	1.37	0.63	0.24	\$6,341	1.19	1.48
	Efficiency & PV/Battery	(6)	0	26.0	1.93	0.33	0.55	\$12,036	1.15	1.43
Mixed Fuel to All-Electric ³	Code Compliant	3,099	0	0.0	0.00	0.87	0.69	(\$5,349)	1.19	2.46
	Efficiency & PV	722	0	14.0	1.37	0.63	0.93	\$992	3.07	>1
	Neutral Cost	959	0	12.0	1.36	0.67	0.89	\$0	>1	>1

¹All reductions and incremental costs relative to the **mixed fuel** code compliant home.²All reductions and incremental costs relative to the **all-electric** code compliant home.³All reductions and incremental costs relative to the **mixed fuel** code compliant home except the EDR Margins are relative to the Standard Design for each case which is the **all-electric** code compliant home. Incremental costs for these packages reflect the costs used in the On-Bill cost effectiveness methodology. Costs differ for the TDV methodology due to differences in the site gas infrastructure costs (see Section 2.6).⁴This represents the Efficiency EDR Margin for the Efficiency-Non-Preempted and Efficiency-Equipment packages and Total EDR Margin for the Efficiency & PV, Efficiency & PV/Battery, and Neutral Cost packages.⁵Positive values indicate an increase in PV capacity relative to the Standard Design.

Table 60: Multifamily Climate Zone 6 Results Summary (Per Dwelling Unit)

Climate Zone 6 SCE/SoCalGas Multifamily		Annual Net kWh	Annual therms	EDR Margin ⁴	PV Size Change (kW) ⁵	CO2-Equivalent Emissions (lbs/sf)		NPV of Lifetime Incremental Cost (\$)	Benefit to Cost Ratio (B/C)	
						Total	Reduction		On-Bill	TDV
Mixed Fuel ¹	Code Compliant	(0)	114	n/a	n/a	2.17	n/a	n/a	n/a	n/a
	Efficiency-Non-Preempted	(0)	112	1.0	(0.01)	2.14	0.03	\$190	0.65	1.49
	Efficiency-Equipment	(0)	103	1.0	(0.00)	2.03	0.15	\$213	1.43	1.74
	Efficiency & PV/Battery	(6)	112	10.5	0.04	1.76	0.41	\$2,294	0.56	1.35
All-Electric ²	Code Compliant	1,558	0	n/a	n/a	1.28	n/a	n/a	n/a	n/a
	Efficiency-Non-Preempted	1,531	0	1.0	0.00	1.26	0.02	\$231	0.65	1.34
	Efficiency-Equipment	1,430	0	2.0	0.00	1.20	0.08	\$361	1.62	1.91
	Efficiency & PV	427	0	13.5	0.70	0.97	0.31	\$2,580	1.24	1.71
	Efficiency & PV/Battery	(5)	0	27.5	1.02	0.49	0.79	\$5,590	1.22	1.58
Mixed Fuel to All-Electric ³	Code Compliant	1,558	0	0.0	0.00	1.28	0.90	(\$2,337)	2.59	2.38
	Efficiency & PV	53	0	13.5	0.70	0.97	1.20	\$243	9.50	>1
	Neutral Cost	459	0	12.5	0.70	0.99	1.18	\$0	>1	>1

¹All reductions and incremental costs relative to the **mixed fuel** code compliant home.

²All reductions and incremental costs relative to the **all-electric** code compliant home.

³All reductions and incremental costs relative to the **mixed fuel** code compliant home except the EDR Margins are relative to the Standard Design for each case which is the **all-electric** code compliant home. Incremental costs for these packages reflect the costs used in the On-Bill cost effectiveness methodology. Costs differ for the TDV methodology due to differences in the site gas infrastructure costs (see Section 2.6).

⁴This represents the Efficiency EDR Margin for the Efficiency-Non-Preempted and Efficiency-Equipment packages and Total EDR Margin for the Efficiency & PV, Efficiency & PV/Battery, and Neutral Cost packages.

⁵Positive values indicate an increase in PV capacity relative to the Standard Design.



Climate Zone 7**Table 61: Single Family Climate Zone 7 Results Summary**

Climate Zone 7 SDG&E Single Family		Annual Net kWh	Annual therms	EDR Margin ⁴	PV Size Change (kW) ⁵	CO2-Equivalent Emissions (lbs/sf)		NPV of Lifetime Incremental Cost (\$)	Benefit to Cost Ratio (B/C)	
						Total	Reduction		On-Bill	TDV
Mixed Fuel ¹	Code Compliant	(0)	196	n/a	n/a	1.30	n/a	n/a	n/a	n/a
	Efficiency-Non-Preempted	(0)	196	0.0	0.00	1.30	0.00	\$0	-	-
	Efficiency-Equipment	0	171	1.5	(0.00)	1.18	0.12	\$606	1.50	1.40
	Efficiency & PV/Battery	(12)	189	9.0	0.10	1.04	0.26	\$4,028	0.06	1.32
All-Electric ²	Code Compliant	2,479	0	n/a	n/a	0.75	n/a	n/a	n/a	n/a
	Efficiency-Non-Preempted	2,479	0	0.0	0.00	0.75	0.00	\$0	-	-
	Efficiency-Equipment	2,222	0	2.0	0.00	0.69	0.06	\$846	1.60	1.65
	Efficiency & PV	674	0	11.0	1.10	0.58	0.17	\$4,436	1.87	1.55
	Efficiency & PV/Battery	(6)	0	24.0	1.61	0.29	0.46	\$9,936	1.25	1.47
Mixed Fuel to All-Electric ³	Code Compliant	2,479	0	0.0	0.00	0.75	0.55	(\$5,349)	1.04	2.54
	Efficiency & PV	674	0	11.0	1.10	0.58	0.72	(\$912)	>1	>1
	Neutral Cost	267	0	13.5	1.35	0.55	0.75	\$0	>1	>1

¹All reductions and incremental costs relative to the **mixed fuel** code compliant home.²All reductions and incremental costs relative to the **all-electric** code compliant home.³All reductions and incremental costs relative to the **mixed fuel** code compliant home except the EDR Margins are relative to the Standard Design for each case which is the **all-electric** code compliant home. Incremental costs for these packages reflect the costs used in the On-Bill cost effectiveness methodology. Costs differ for the TDV methodology due to differences in the site gas infrastructure costs (see Section 2.6).⁴This represents the Efficiency EDR Margin for the Efficiency-Non-Preempted and Efficiency-Equipment packages and Total EDR Margin for the Efficiency & PV, Efficiency & PV/Battery, and Neutral Cost packages.⁵Positive values indicate an increase in PV capacity relative to the Standard Design.

Table 62: Multifamily Climate Zone 7 Results Summary (Per Dwelling Unit)

Climate Zone 7 SDG&E Multifamily		Annual Net kWh	Annual therms	EDR Margin ⁴	PV Size Change (kW) ⁵	CO2-Equivalent Emissions (lbs/sf)		NPV of Lifetime Incremental Cost (\$)	Benefit to Cost Ratio (B/C)	
						Total	Reduction		On-Bill	TDV
Mixed Fuel ¹	Code Compliant	(0)	110	n/a	n/a	2.11	n/a	n/a	n/a	n/a
	Efficiency-Non-Preempted	(0)	108	0.5	(0.01)	2.08	0.03	\$90	0.73	2.24
	Efficiency-Equipment	(0)	99	2.0	(0.00)	1.96	0.15	\$366	1.07	1.41
	Efficiency & PV/Battery	(6)	108	11.0	0.05	1.71	0.40	\$2,188	0.03	1.40
All-Electric ²	Code Compliant	1,434	0	n/a	n/a	1.21	n/a	n/a	n/a	n/a
	Efficiency-Non-Preempted	1,416	0	0.5	0.00	1.20	0.01	\$202	0.60	1.02
	Efficiency-Equipment	1,319	0	1.5	0.00	1.14	0.07	\$361	1.59	1.71
	Efficiency & PV	412	0	12.5	0.61	0.94	0.27	\$2,261	2.08	1.76
	Efficiency & PV/Battery	(5)	0	27.0	0.92	0.47	0.74	\$5,203	1.19	1.62
Mixed Fuel to All-Electric ³	Code Compliant	1,434	0	0.0	0.00	1.21	0.90	(\$2,337)	1.12	2.47
	Efficiency & PV	51	0	12.5	0.61	0.94	1.17	(\$75)	>1	>1
	Neutral Cost	294	0	13.5	0.70	0.91	1.20	\$0	>1	>1

¹All reductions and incremental costs relative to the **mixed fuel** code compliant home.

²All reductions and incremental costs relative to the **all-electric** code compliant home.

³All reductions and incremental costs relative to the **mixed fuel** code compliant home except the EDR Margins are relative to the Standard Design for each case which is the **all-electric** code compliant home. Incremental costs for these packages reflect the costs used in the On-Bill cost effectiveness methodology. Costs differ for the TDV methodology due to differences in the site gas infrastructure costs (see Section 2.6).

⁴This represents the Efficiency EDR Margin for the Efficiency-Non-Preempted and Efficiency-Equipment packages and Total EDR Margin for the Efficiency & PV, Efficiency & PV/Battery, and Neutral Cost packages.

⁵Positive values indicate an increase in PV capacity relative to the Standard Design.



Climate Zone 8**Table 63: Single Family Climate Zone 8 Results Summary**

Climate Zone 8 SCE/SoCalGas Single Family		Annual Net kWh	Annual therms	EDR Margin ⁴	PV Size Change (kW) ⁵	CO2-Equivalent Emissions (lbs/sf)		NPV of Lifetime Incremental Cost (\$)	Benefit to Cost Ratio (B/C)	
						Total	Reduction		On-Bill	TDV
Mixed Fuel ¹	Code Compliant	(0)	206	n/a	n/a	1.38	n/a	n/a	n/a	n/a
	Efficiency-Non-Preempted	(0)	198	1.0	(0.02)	1.34	0.05	\$581	0.57	1.41
	Efficiency-Equipment	0	181	1.5	(0.01)	1.27	0.12	\$586	1.30	1.82
	Efficiency & PV/Battery	(13)	198	8.0	0.08	1.11	0.27	\$4,466	0.90	1.31
All-Electric ²	Code Compliant	2,576	0	n/a	n/a	0.80	n/a	n/a	n/a	n/a
	Efficiency-Non-Preempted	2,483	0	1.5	0.00	0.78	0.02	\$926	0.57	1.22
	Efficiency-Equipment	2,352	0	1.5	0.00	0.75	0.05	\$412	2.82	3.03
	Efficiency & PV	703	0	10.5	1.13	0.62	0.18	\$5,373	1.00	1.48
	Efficiency & PV/Battery	(7)	0	21.5	1.67	0.32	0.48	\$11,016	1.09	1.42
Mixed Fuel to All-Electric ³	Code Compliant	2,576	0	0.0	0.00	0.80	0.58	(\$5,349)	1.83	2.99
	Efficiency & PV	703	0	10.5	1.13	0.62	0.77	\$25	107.93	>1
	Neutral Cost	439	0	11.0	1.36	0.60	0.78	\$0	>1	>1

¹All reductions and incremental costs relative to the **mixed fuel** code compliant home.²All reductions and incremental costs relative to the **all-electric** code compliant home.³All reductions and incremental costs relative to the **mixed fuel** code compliant home except the EDR Margins are relative to the Standard Design for each case which is the **all-electric** code compliant home. Incremental costs for these packages reflect the costs used in the On-Bill cost effectiveness methodology. Costs differ for the TDV methodology due to differences in the site gas infrastructure costs (see Section 2.6).⁴This represents the Efficiency EDR Margin for the Efficiency-Non-Preempted and Efficiency-Equipment packages and Total EDR Margin for the Efficiency & PV, Efficiency & PV/Battery, and Neutral Cost packages.⁵Positive values indicate an increase in PV capacity relative to the Standard Design.

Table 64: Multifamily Climate Zone 8 Results Summary (Per Dwelling Unit)

Climate Zone 8 SCE/SoCalGas Multifamily		Annual Net kWh	Annual therms	EDR Margin ⁴	PV Size Change (kW) ⁵	CO2-Equivalent Emissions (lbs/sf)		NPV of Lifetime Incremental Cost (\$)	Benefit to Cost Ratio (B/C)	
						Total	Reduction		On-Bill	TDV
Mixed Fuel ¹	Code Compliant	(0)	109	n/a	n/a	2.18	n/a	n/a	n/a	n/a
	Efficiency-Non-Preempted	(0)	106	1.5	(0.02)	2.13	0.05	\$250	0.70	1.36
	Efficiency-Equipment	(0)	99	1.0	(0.00)	2.04	0.14	\$213	1.37	1.67
	Efficiency & PV/Battery	(6)	106	9.5	0.03	1.77	0.41	\$2,353	0.74	1.32
All-Electric ²	Code Compliant	1,409	0	n/a	n/a	1.26	n/a	n/a	n/a	n/a
	Efficiency-Non-Preempted	1,373	0	1.0	0.00	1.24	0.02	\$231	0.87	1.72
	Efficiency-Equipment	1,276	0	1.5	0.00	1.18	0.08	\$361	1.63	1.75
	Efficiency & PV	426	0	11.5	0.60	0.99	0.27	\$2,240	1.26	1.78
	Efficiency & PV/Battery	(5)	0	24.0	0.92	0.53	0.73	\$5,249	1.24	1.59
Mixed Fuel to All-Electric ³	Code Compliant	1,409	0	0.0	0.00	1.26	0.91	(\$2,337)	6.69	2.67
	Efficiency & PV	53	0	11.5	0.60	0.99	1.18	(\$96)	>1	>1
	Neutral Cost	309	0	12.0	0.70	0.98	1.20	\$0	>1	>1

¹All reductions and incremental costs relative to the **mixed fuel** code compliant home.

²All reductions and incremental costs relative to the **all-electric** code compliant home.

³All reductions and incremental costs relative to the **mixed fuel** code compliant home except the EDR Margins are relative to the Standard Design for each case which is the **all-electric** code compliant home. Incremental costs for these packages reflect the costs used in the On-Bill cost effectiveness methodology. Costs differ for the TDV methodology due to differences in the site gas infrastructure costs (see Section 2.6).

⁴This represents the Efficiency EDR Margin for the Efficiency-Non-Preempted and Efficiency-Equipment packages and Total EDR Margin for the Efficiency & PV, Efficiency & PV/Battery, and Neutral Cost packages.

⁵Positive values indicate an increase in PV capacity relative to the Standard Design.



Climate Zone 9**Table 65: Single Family Climate Zone 9 Results Summary**

Climate Zone 9 SCE/SoCalGas Single Family		Annual Net kWh	Annual therms	EDR Margin ⁴	PV Size Change (kW) ⁵	CO2-Equivalent Emissions (lbs/sf)		NPV of Lifetime Incremental Cost (\$)	Benefit to Cost Ratio (B/C)	
						Total	Reduction		On-Bill	TDV
Mixed Fuel ¹	Code Compliant	0	229	n/a	n/a	1.53	n/a	n/a	n/a	n/a
	Efficiency-Non-Preempted	(0)	216	2.5	(0.04)	1.46	0.07	\$912	0.69	1.97
	Efficiency-Equipment	0	201	2.5	(0.04)	1.38	0.15	\$574	1.80	3.66
	Efficiency & PV/Battery	(14)	216	8.5	0.05	1.23	0.30	\$4,785	0.99	1.48
All-Electric ²	Code Compliant	2,801	0	n/a	n/a	0.87	n/a	n/a	n/a	n/a
	Efficiency-Non-Preempted	2,645	0	2.5	0.00	0.84	0.04	\$1,180	0.78	1.96
	Efficiency-Equipment	2,460	0	3.0	0.00	0.80	0.07	\$846	2.11	3.22
	Efficiency & PV	745	0	11.5	1.16	0.66	0.21	\$5,778	1.08	1.64
	Efficiency & PV/Battery	(9)	0	21.0	1.72	0.37	0.50	\$11,454	1.11	1.53
Mixed Fuel to All-Electric ³	Code Compliant	2,801	0	0.0	0.00	0.87	0.66	(\$5,349)	1.67	2.90
	Efficiency & PV	745	0	11.5	1.16	0.66	0.87	\$429	7.15	>1
	Neutral Cost	594	0	10.0	1.36	0.67	0.86	\$0	>1	>1

¹All reductions and incremental costs relative to the **mixed fuel** code compliant home.²All reductions and incremental costs relative to the **all-electric** code compliant home.³All reductions and incremental costs relative to the **mixed fuel** code compliant home except the EDR Margins are relative to the Standard Design for each case which is the **all-electric** code compliant home. Incremental costs for these packages reflect the costs used in the On-Bill cost effectiveness methodology. Costs differ for the TDV methodology due to differences in the site gas infrastructure costs (see Section 2.6).⁴This represents the Efficiency EDR Margin for the Efficiency-Non-Preempted and Efficiency-Equipment packages and Total EDR Margin for the Efficiency & PV, Efficiency & PV/Battery, and Neutral Cost packages.⁵Positive values indicate an increase in PV capacity relative to the Standard Design.

Table 66: Multifamily Climate Zone 9 Results Summary (Per Dwelling Unit)

Climate Zone 9 SCE/SoCalGas Multifamily		Annual Net kWh	Annual therms	EDR Margin ⁴	PV Size Change (kW) ⁵	CO2-Equivalent Emissions (lbs/sf)		NPV of Lifetime Incremental Cost (\$)	Benefit to Cost Ratio (B/C)	
						Total	Reduction		On-Bill	TDV
Mixed Fuel ¹	Code Compliant	0	111	n/a	n/a	2.24	n/a	n/a	n/a	n/a
	Efficiency-Non-Preempted	(0)	109	1.5	(0.03)	2.19	0.05	\$136	1.46	3.35
	Efficiency-Equipment	(0)	101	2.5	(0.03)	2.08	0.16	\$274	1.66	2.87
	Efficiency & PV/Battery	(7)	109	9.5	0.03	1.84	0.40	\$2,234	0.90	1.49
All-Electric ²	Code Compliant	1,468	0	n/a	n/a	1.33	n/a	n/a	n/a	n/a
	Efficiency-Non-Preempted	1,414	0	1.5	0.00	1.30	0.03	\$231	1.29	2.70
	Efficiency-Equipment	1,334	0	1.5	0.00	1.25	0.08	\$361	1.63	1.58
	Efficiency & PV	441	0	11.0	0.60	1.04	0.29	\$2,232	1.34	1.91
	Efficiency & PV/Battery	(7)	0	23.0	0.92	0.58	0.75	\$5,236	1.28	1.67
Mixed Fuel to All-Electric ³	Code Compliant	1,468	0	0.0	0.00	1.33	0.91	(\$2,337)	4.38	2.55
	Efficiency & PV	55	0	11.0	0.60	1.04	1.20	(\$104)	>1	>1
	Neutral Cost	331	0	11.0	0.70	1.03	1.21	\$0	>1	>1

¹All reductions and incremental costs relative to the **mixed fuel** code compliant home.

²All reductions and incremental costs relative to the **all-electric** code compliant home.

³All reductions and incremental costs relative to the **mixed fuel** code compliant home except the EDR Margins are relative to the Standard Design for each case which is the **all-electric** code compliant home. Incremental costs for these packages reflect the costs used in the On-Bill cost effectiveness methodology. Costs differ for the TDV methodology due to differences in the site gas infrastructure costs (see Section 2.6).

⁴This represents the Efficiency EDR Margin for the Efficiency-Non-Preempted and Efficiency-Equipment packages and Total EDR Margin for the Efficiency & PV, Efficiency & PV/Battery, and Neutral Cost packages.

⁵Positive values indicate an increase in PV capacity relative to the Standard Design.



Climate Zone 10 SCE/SoCalGas**Table 67: Single Family Climate Zone 10 SCE/SoCalGas Results Summary**

Climate Zone 10 SCE/SoCalGas Single Family		Annual Net kWh	Annual therms	EDR Margin ⁴	PV Size Change (kW) ⁵	CO2-Equivalent Emissions (lbs/sf)		NPV of Lifetime Incremental Cost (\$)	Benefit to Cost Ratio (B/C)	
						Total	Reduction		On-Bill	TDV
Mixed Fuel ¹	Code Compliant	(0)	239	n/a	n/a	1.61	n/a	n/a	n/a	n/a
	Efficiency-Non-Preempted	(0)	217	3.0	(0.07)	1.48	0.13	\$1,648	0.63	1.33
	Efficiency-Equipment	(0)	209	3.0	(0.06)	1.45	0.16	\$593	2.05	3.84
	Efficiency & PV/Battery	(12)	217	9.5	0.03	1.25	0.36	\$5,522	1.00	1.48
All-Electric ²	Code Compliant	2,981	0	n/a	n/a	0.94	n/a	n/a	n/a	n/a
	Efficiency-Non-Preempted	2,673	0	3.0	0.00	0.88	0.07	\$1,773	0.92	1.52
	Efficiency-Equipment	2,563	0	3.0	0.00	0.85	0.10	\$949	2.27	3.19
	Efficiency & PV	762	0	11.0	1.17	0.70	0.24	\$6,405	1.08	1.50
	Efficiency & PV/Battery	(6)	0	21.0	1.74	0.41	0.53	\$12,129	1.11	1.51
Mixed Fuel to All-Electric ³	Code Compliant	2,981	0	0.0	0.00	0.94	0.67	(\$5,349)	1.45	2.66
	Efficiency & PV	762	0	11.0	1.17	0.70	0.91	\$1,057	3.04	>1
	Neutral Cost	770	0	9.0	1.36	0.74	0.87	\$0	>1	>1

¹All reductions and incremental costs relative to the **mixed fuel** code compliant home.²All reductions and incremental costs relative to the **all-electric** code compliant home.³All reductions and incremental costs relative to the **mixed fuel** code compliant home except the EDR Margins are relative to the Standard Design for each case which is the **all-electric** code compliant home. Incremental costs for these packages reflect the costs used in the On-Bill cost effectiveness methodology. Costs differ for the TDV methodology due to differences in the site gas infrastructure costs (see Section 2.6).⁴This represents the Efficiency EDR Margin for the Efficiency-Non-Preempted and Efficiency-Equipment packages and Total EDR Margin for the Efficiency & PV, Efficiency & PV/Battery, and Neutral Cost packages.⁵Positive values indicate an increase in PV capacity relative to the Standard Design.

Table 68: Multifamily Climate Zone 10 SCE/SoCalGas Results Summary (Per Dwelling Unit)

Climate Zone 10 SCE/SoCalGas Multifamily		Annual Net kWh	Annual therms	EDR Margin ⁴	PV Size Change (kW) ⁵	CO2-Equivalent Emissions (lbs/sf)		NPV of Lifetime Incremental Cost (\$)	Benefit to Cost Ratio (B/C)	
						Total	Reduction		On-Bill	TDV
Mixed Fuel ¹	Code Compliant	(0)	112	n/a	n/a	2.29	n/a	n/a	n/a	n/a
	Efficiency-Non-Preempted	(0)	108	1.5	(0.02)	2.23	0.06	\$278	0.81	1.69
	Efficiency-Equipment	(0)	102	2.5	(0.04)	2.13	0.16	\$250	1.96	3.27
	Efficiency & PV/Battery	(6)	108	10.0	0.03	1.88	0.41	\$2,376	0.98	1.57
All-Electric ²	Code Compliant	1,507	0	n/a	n/a	1.39	n/a	n/a	n/a	n/a
	Efficiency-Non-Preempted	1,425	0	1.5	0.00	1.34	0.05	\$361	1.16	2.00
	Efficiency-Equipment	1,369	0	1.5	0.00	1.31	0.08	\$361	1.71	1.98
	Efficiency & PV	450	0	10.5	0.60	1.09	0.30	\$2,371	1.31	1.79
	Efficiency & PV/Battery	(4)	0	23.0	0.93	0.63	0.76	\$5,395	1.27	1.69
Mixed Fuel to All-Electric ³	Code Compliant	1,507	0	0.0	0.00	1.39	0.90	(\$2,337)	3.35	2.36
	Efficiency & PV	56	0	10.5	0.60	1.09	1.20	\$34	70.89	>1
	Neutral Cost	372	0	10.5	0.70	1.10	1.19	\$0	>1	>1

¹All reductions and incremental costs relative to the **mixed fuel** code compliant home.

²All reductions and incremental costs relative to the **all-electric** code compliant home.

³All reductions and incremental costs relative to the **mixed fuel** code compliant home except the EDR Margins are relative to the Standard Design for each case which is the **all-electric** code compliant home. Incremental costs for these packages reflect the costs used in the On-Bill cost effectiveness methodology. Costs differ for the TDV methodology due to differences in the site gas infrastructure costs (see Section 2.6).

⁴This represents the Efficiency EDR Margin for the Efficiency-Non-Preempted and Efficiency-Equipment packages and Total EDR Margin for the Efficiency & PV, Efficiency & PV/Battery, and Neutral Cost packages.

⁵Positive values indicate an increase in PV capacity relative to the Standard Design.



Climate Zone 10 SDGE**Table 69: Single Family Climate Zone 10 SDGE Results Summary**

Climate Zone 10 SDG&E Single Family		Annual Net kWh	Annual therms	EDR Margin ⁴	PV Size Change (kW) ⁵	CO2-Equivalent Emissions (lbs/sf)		NPV of Lifetime Incremental Cost (\$)	Benefit to Cost Ratio (B/C)	
						Total	Reduction		On-Bill	TDV
Mixed Fuel ¹	Code Compliant	(0)	239	n/a	n/a	1.61	n/a	n/a	n/a	n/a
	Efficiency-Non-Preempted	(0)	217	3.0	(0.07)	1.48	0.13	\$1,648	0.80	1.33
	Efficiency-Equipment	(0)	209	3.0	(0.06)	1.45	0.16	\$593	2.64	3.84
	Efficiency & PV/Battery	(12)	217	9.5	0.03	1.25	0.36	\$5,522	0.58	1.48
All-Electric ²	Code Compliant	2,981	0	n/a	n/a	0.94	n/a	n/a	n/a	n/a
	Efficiency-Non-Preempted	2,673	0	3.0	0.00	0.88	0.07	\$1,773	1.08	1.52
	Efficiency-Equipment	2,563	0	3.0	0.00	0.85	0.10	\$949	2.62	3.19
	Efficiency & PV	762	0	11.0	1.17	0.70	0.24	\$6,405	1.68	1.50
	Efficiency & PV/Battery	(6)	0	21.0	1.74	0.41	0.53	\$12,129	1.42	1.51
Mixed Fuel to All-Electric ³	Code Compliant	2,981	0	0.0	0.00	0.94	0.67	(\$5,349)	0.90	2.66
	Efficiency & PV	762	0	11.0	1.17	0.70	0.91	\$1,057	4.55	>1
	Neutral Cost	770	0	9.0	1.36	0.74	0.87	\$0	>1	>1

¹All reductions and incremental costs relative to the **mixed fuel** code compliant home.²All reductions and incremental costs relative to the **all-electric** code compliant home.³All reductions and incremental costs relative to the **mixed fuel** code compliant home except the EDR Margins are relative to the Standard Design for each case which is the **all-electric** code compliant home. Incremental costs for these packages reflect the costs used in the On-Bill cost effectiveness methodology. Costs differ for the TDV methodology due to differences in the site gas infrastructure costs (see Section 2.6).⁴This represents the Efficiency EDR Margin for the Efficiency-Non-Preempted and Efficiency-Equipment packages and Total EDR Margin for the Efficiency & PV, Efficiency & PV/Battery, and Neutral Cost packages.⁵Positive values indicate an increase in PV capacity relative to the Standard Design.

Table 70: Multifamily Climate Zone 10 SDGE Results Summary (Per Dwelling Unit)

Climate Zone 10 SDG&E Multifamily		Annual Net kWh	Annual therms	EDR Margin ⁴	PV Size Change (kW) ⁵	CO2-Equivalent Emissions (lbs/sf)		NPV of Lifetime Incremental Cost (\$)	Benefit to Cost Ratio (B/C)	
						Total	Reduction		On-Bill	TDV
Mixed Fuel ¹	Code Compliant	(0)	112	n/a	n/a	2.29	n/a	n/a	n/a	n/a
	Efficiency-Non-Preempted	(0)	108	1.5	(0.02)	2.23	0.06	\$278	1.09	1.69
	Efficiency-Equipment	(0)	102	2.5	(0.04)	2.13	0.16	\$250	2.60	3.27
	Efficiency & PV/Battery	(6)	108	10.0	0.03	1.88	0.41	\$2,376	0.23	1.57
All-Electric ²	Code Compliant	1,507	0	n/a	n/a	1.39	n/a	n/a	n/a	n/a
	Efficiency-Non-Preempted	1,425	0	1.5	0.00	1.34	0.05	\$361	1.53	2.00
	Efficiency-Equipment	1,369	0	1.5	0.00	1.31	0.08	\$361	2.05	1.98
	Efficiency & PV	450	0	10.5	0.60	1.09	0.30	\$2,371	2.12	1.79
	Efficiency & PV/Battery	(4)	0	23.0	0.93	0.63	0.76	\$5,395	1.44	1.69
Mixed Fuel to All-Electric ³	Code Compliant	1,507	0	0.0	0.00	1.39	0.90	(\$2,337)	0.73	2.36
	Efficiency & PV	56	0	10.5	0.60	1.09	1.20	\$34	54.15	>1
	Neutral Cost	372	0	10.5	0.70	1.10	1.19	\$0	>1	>1

¹All reductions and incremental costs relative to the **mixed fuel** code compliant home.

²All reductions and incremental costs relative to the **all-electric** code compliant home.

³All reductions and incremental costs relative to the **mixed fuel** code compliant home except the EDR Margins are relative to the Standard Design for each case which is the **all-electric** code compliant home. Incremental costs for these packages reflect the costs used in the On-Bill cost effectiveness methodology. Costs differ for the TDV methodology due to differences in the site gas infrastructure costs (see Section 2.6).

⁴This represents the Efficiency EDR Margin for the Efficiency-Non-Preempted and Efficiency-Equipment packages and Total EDR Margin for the Efficiency & PV, Efficiency & PV/Battery, and Neutral Cost packages.

⁵Positive values indicate an increase in PV capacity relative to the Standard Design.



Climate Zone 11**Table 71: Single Family Climate Zone 11 Results Summary**

Climate Zone 11 PG&E Single Family		Annual Net kWh	Annual therms	EDR Margin ⁴	PV Size Change (kW) ⁵	CO2-Equivalent Emissions (lbs/sf)		NPV of Lifetime Incremental Cost (\$)	Benefit to Cost Ratio (B/C)	
						Total	Reduction		On-Bill	TDV
Mixed Fuel ¹	Code Compliant	(0)	378	n/a	n/a	2.14	n/a	n/a	n/a	n/a
	Efficiency-Non-Preempted	(0)	333	4.0	(0.19)	1.90	0.24	\$3,143	0.78	1.20
	Efficiency-Equipment	0	320	5.0	(0.21)	1.83	0.31	\$1,222	2.50	3.68
	Efficiency & PV/Battery	(18)	333	9.0	(0.09)	1.78	0.36	\$7,026	0.36	1.51
All-Electric ²	Code Compliant	4,585	0	n/a	n/a	1.15	n/a	n/a	n/a	n/a
	Efficiency-Non-Preempted	3,815	0	4.5	0.00	0.99	0.16	\$3,735	1.24	1.47
	Efficiency-Equipment	3,533	0	5.5	0.00	0.93	0.22	\$2,108	2.97	3.33
	Efficiency & PV	957	0	14.0	1.79	0.60	0.55	\$10,827	1.84	1.55
	Efficiency & PV/Battery	(13)	0	23.0	2.49	0.36	0.79	\$17,077	1.49	1.61
Mixed Fuel to All-Electric ³	Code Compliant	4,585	0	0.0	0.00	1.15	0.99	(\$5,349)	0.49	1.69
	Efficiency & PV	957	0	14.0	1.79	0.60	1.54	\$5,478	1.64	>1
	Neutral Cost	2,429	0	7.0	1.36	0.85	1.29	\$0	>1	>1

¹All reductions and incremental costs relative to the **mixed fuel** code compliant home.²All reductions and incremental costs relative to the **all-electric** code compliant home.³All reductions and incremental costs relative to the **mixed fuel** code compliant home except the EDR Margins are relative to the Standard Design for each case which is the **all-electric** code compliant home. Incremental costs for these packages reflect the costs used in the On-Bill cost effectiveness methodology. Costs differ for the TDV methodology due to differences in the site gas infrastructure costs (see Section 2.6).⁴This represents the Efficiency EDR Margin for the Efficiency-Non-Preempted and Efficiency-Equipment packages and Total EDR Margin for the Efficiency & PV, Efficiency & PV/Battery, and Neutral Cost packages.⁵Positive values indicate an increase in PV capacity relative to the Standard Design.

Table 72: Multifamily Climate Zone 11 Results Summary (Per Dwelling Unit)

Climate Zone 11 PG&E Multifamily		Annual Net kWh	Annual therms	EDR Margin ⁴	PV Size Change (kW) ⁵	CO2-Equivalent Emissions (lbs/sf)		NPV of Lifetime Incremental Cost (\$)	Benefit to Cost Ratio (B/C)	
						Total	Reduction		On-Bill	TDV
Mixed Fuel ¹	Code Compliant	(0)	141	n/a	n/a	2.38	n/a	n/a	n/a	n/a
	Efficiency-Non-Preempted	0	127	2.5	(0.05)	2.18	0.20	\$850	0.65	1.17
	Efficiency-Equipment	(0)	126	3.0	(0.06)	2.16	0.22	\$317	1.84	3.29
	Efficiency & PV/Battery	(9)	127	10.5	0.01	2.00	0.38	\$2,950	0.39	1.60
All-Electric ²	Code Compliant	1,974	0	n/a	n/a	1.42	n/a	n/a	n/a	n/a
	Efficiency-Non-Preempted	1,732	0	3.5	0.00	1.29	0.13	\$1,011	1.40	1.64
	Efficiency-Equipment	1,707	0	3.5	0.00	1.26	0.16	\$795	2.02	2.33
	Efficiency & PV	504	0	13.0	0.77	0.81	0.61	\$3,601	2.22	1.81
	Efficiency & PV/Battery	(6)	0	25.0	1.14	0.45	0.98	\$6,759	1.42	1.81
Mixed Fuel to All-Electric ³	Code Compliant	1,974	0	0.0	0.00	1.42	0.96	(\$2,337)	0.56	1.33
	Efficiency & PV	63	0	13.0	0.77	0.81	1.56	\$1,264	3.03	>1
	Neutral Cost	866	0	9.0	0.70	0.99	1.38	\$0	>1	73.96

¹All reductions and incremental costs relative to the **mixed fuel** code compliant home.

²All reductions and incremental costs relative to the **all-electric** code compliant home.

³All reductions and incremental costs relative to the **mixed fuel** code compliant home except the EDR Margins are relative to the Standard Design for each case which is the **all-electric** code compliant home. Incremental costs for these packages reflect the costs used in the On-Bill cost effectiveness methodology. Costs differ for the TDV methodology due to differences in the site gas infrastructure costs (see Section 2.6).

⁴This represents the Efficiency EDR Margin for the Efficiency-Non-Preempted and Efficiency-Equipment packages and Total EDR Margin for the Efficiency & PV, Efficiency & PV/Battery, and Neutral Cost packages.

⁵Positive values indicate an increase in PV capacity relative to the Standard Design.



Climate Zone 12**Table 73: Single Family Climate Zone 12 Results Summary**

Climate Zone 12 PG&E Single Family		Annual Net kWh	Annual therms	EDR Margin ⁴	PV Size Change (kW) ⁵	CO2-Equivalent Emissions (lbs/sf)		NPV of Lifetime Incremental Cost (\$)	Benefit to Cost Ratio (B/C)	
						Total	Reduction		On-Bill	TDV
Mixed Fuel ¹	Code Compliant	(0)	390	n/a	n/a	2.11	n/a	n/a	n/a	n/a
	Efficiency-Non-Preempted	(0)	344	3.5	(0.06)	1.88	0.23	\$1,679	1.18	1.83
	Efficiency-Equipment	0	338	3.0	(0.05)	1.85	0.26	\$654	3.31	4.65
	Efficiency & PV/Battery	(23)	344	9.5	0.04	1.76	0.35	\$5,568	0.43	1.72
All-Electric ²	Code Compliant	4,492	0	n/a	n/a	1.05	n/a	n/a	n/a	n/a
	Efficiency-Non-Preempted	3,958	0	3.5	0.00	0.94	0.10	\$3,735	0.78	1.06
	Efficiency-Equipment	3,721	0	5.0	0.00	0.90	0.15	\$2,108	2.00	2.51
	Efficiency & PV	867	0	15.5	1.97	0.51	0.53	\$11,520	1.69	1.41
	Efficiency & PV/Battery	(15)	0	25.0	2.62	0.29	0.76	\$17,586	1.29	1.48
Mixed Fuel to All-Electric ³	Code Compliant	4,492	0	0.0	0.00	1.05	1.07	(\$5,349)	0.63	1.89
	Efficiency & PV	867	0	15.5	1.97	0.51	1.60	\$6,172	1.77	>1
	Neutral Cost	2,374	0	8.0	1.35	0.76	1.36	\$0	>1	>1

¹All reductions and incremental costs relative to the **mixed fuel** code compliant home.²All reductions and incremental costs relative to the **all-electric** code compliant home.³All reductions and incremental costs relative to the **mixed fuel** code compliant home except the EDR Margins are relative to the Standard Design for each case which is the **all-electric** code compliant home. Incremental costs for these packages reflect the costs used in the On-Bill cost effectiveness methodology. Costs differ for the TDV methodology due to differences in the site gas infrastructure costs (see Section 2.6).⁴This represents the Efficiency EDR Margin for the Efficiency-Non-Preempted and Efficiency-Equipment packages and Total EDR Margin for the Efficiency & PV, Efficiency & PV/Battery, and Neutral Cost packages.⁵Positive values indicate an increase in PV capacity relative to the Standard Design.

Table 74: Multifamily Climate Zone 12 Results Summary (Per Dwelling Unit)

Climate Zone 12 PG&E Multifamily		Annual Net kWh	Annual therms	EDR Margin ⁴	PV Size Change (kW) ⁵	CO2-Equivalent Emissions (lbs/sf)		NPV of Lifetime Incremental Cost (\$)	Benefit to Cost Ratio (B/C)	
						Total	Reduction		On-Bill	TDV
Mixed Fuel ¹	Code Compliant	(0)	143	n/a	n/a	2.33	n/a	n/a	n/a	n/a
	Efficiency-Non-Preempted	(0)	135	1.5	(0.02)	2.21	0.12	\$291	1.10	2.22
	Efficiency-Equipment	0	128	2.5	(0.03)	2.12	0.21	\$434	1.25	2.22
	Efficiency & PV/Battery	(11)	135	10.0	0.03	2.03	0.30	\$2,394	0.30	1.75
All-Electric ²	Code Compliant	1,963	0	n/a	n/a	1.34	n/a	n/a	n/a	n/a
	Efficiency-Non-Preempted	1,792	0	2.5	0.00	1.24	0.09	\$1,011	0.91	1.12
	Efficiency-Equipment	1,744	0	2.5	0.00	1.21	0.13	\$795	1.56	1.63
	Efficiency & PV	472	0	14.0	0.84	0.73	0.60	\$3,835	2.08	1.65
	Efficiency & PV/Battery	(8)	0	26.5	1.20	0.38	0.96	\$6,943	1.26	1.68
Mixed Fuel to All-Electric ³	Code Compliant	1,963	0	0.0	0.00	1.34	1.00	(\$2,337)	0.64	1.66
	Efficiency & PV	59	0	14.0	0.84	0.73	1.60	\$1,498	2.88	>1
	Neutral Cost	872	0	9.5	0.70	0.92	1.42	\$0	>1	>1

¹All reductions and incremental costs relative to the **mixed fuel** code compliant home.

²All reductions and incremental costs relative to the **all-electric** code compliant home.

³All reductions and incremental costs relative to the **mixed fuel** code compliant home except the EDR Margins are relative to the Standard Design for each case which is the **all-electric** code compliant home. Incremental costs for these packages reflect the costs used in the On-Bill cost effectiveness methodology. Costs differ for the TDV methodology due to differences in the site gas infrastructure costs (see Section 2.6).

⁴This represents the Efficiency EDR Margin for the Efficiency-Non-Preempted and Efficiency-Equipment packages and Total EDR Margin for the Efficiency & PV, Efficiency & PV/Battery, and Neutral Cost packages.

⁵Positive values indicate an increase in PV capacity relative to the Standard Design.



Climate Zone 13**Table 75: Single Family Climate Zone 13 Results Summary**

Climate Zone 13 PG&E Single Family		Annual Net kWh	Annual therms	EDR Margin ⁴	PV Size Change (kW) ⁵	CO2-Equivalent Emissions (lbs/sf)		NPV of Lifetime Incremental Cost (\$)	Benefit to Cost Ratio (B/C)	
						Total	Reduction		On-Bill	TDV
Mixed Fuel ¹	Code Compliant	(0)	352	n/a	n/a	2.02	n/a	n/a	n/a	n/a
	Efficiency-Non-Preempted	(0)	311	4.5	(0.21)	1.80	0.22	\$3,060	0.76	1.28
	Efficiency-Equipment	(0)	292	5.5	(0.24)	1.70	0.32	\$611	5.26	8.40
	Efficiency & PV/Battery	(19)	311	9.5	(0.11)	1.69	0.33	\$6,954	0.36	1.56
All-Electric ²	Code Compliant	4,180	0	n/a	n/a	1.08	n/a	n/a	n/a	n/a
	Efficiency-Non-Preempted	3,428	0	5.0	0.00	0.92	0.15	\$4,154	1.12	1.40
	Efficiency-Equipment	3,177	0	6.0	0.00	0.87	0.21	\$2,108	2.88	3.30
	Efficiency & PV	934	0	13.0	1.61	0.57	0.50	\$10,532	1.70	1.47
	Efficiency & PV/Battery	(11)	0	22.0	2.32	0.35	0.73	\$16,806	1.40	1.54
Mixed Fuel to All-Electric ³	Code Compliant	4,180	0	0.0	0.00	1.08	0.94	(\$5,349)	0.54	1.83
	Efficiency & PV	934	0	13.0	1.61	0.57	1.44	\$5,184	1.56	>1
	Neutral Cost	2,092	0	7.0	1.36	0.79	1.23	\$0	>1	>1

¹All reductions and incremental costs relative to the **mixed fuel** code compliant home.²All reductions and incremental costs relative to the **all-electric** code compliant home.³All reductions and incremental costs relative to the **mixed fuel** code compliant home except the EDR Margins are relative to the Standard Design for each case which is the **all-electric** code compliant home. Incremental costs for these packages reflect the costs used in the On-Bill cost effectiveness methodology. Costs differ for the TDV methodology due to differences in the site gas infrastructure costs (see Section 2.6).⁴This represents the Efficiency EDR Margin for the Efficiency-Non-Preempted and Efficiency-Equipment packages and Total EDR Margin for the Efficiency & PV, Efficiency & PV/Battery, and Neutral Cost packages.⁵Positive values indicate an increase in PV capacity relative to the Standard Design.

Table 76: Multifamily Climate Zone 13 Results Summary (Per Dwelling Unit)

Climate Zone 13 PG&E Multifamily		Annual Net kWh	Annual therms	EDR Margin ⁴	PV Size Change (kW) ⁵	CO2-Equivalent Emissions (lbs/sf)		NPV of Lifetime Incremental Cost (\$)	Benefit to Cost Ratio (B/C)	
						Total	Reduction		On-Bill	TDV
Mixed Fuel ¹	Code Compliant	(0)	135	n/a	n/a	2.30	n/a	n/a	n/a	n/a
	Efficiency-Non-Preempted	(0)	123	3.0	(0.05)	2.12	0.18	\$831	0.63	1.27
	Efficiency-Equipment	(0)	121	3.0	(0.07)	2.10	0.21	\$290	1.95	3.75
	Efficiency & PV/Battery	(9)	123	10.5	0.00	1.95	0.35	\$2,936	0.38	1.64
All-Electric ²	Code Compliant	1,849	0	n/a	n/a	1.36	n/a	n/a	n/a	n/a
	Efficiency-Non-Preempted	1,629	0	3.0	0.00	1.24	0.12	\$1,011	1.31	1.56
	Efficiency-Equipment	1,590	0	3.5	0.00	1.21	0.16	\$795	1.98	2.28
	Efficiency & PV	501	0	12.0	0.73	0.80	0.56	\$3,462	2.12	1.71
	Efficiency & PV/Battery	(5)	0	23.5	1.11	0.44	0.92	\$6,650	1.35	1.74
Mixed Fuel to All-Electric ³	Code Compliant	1,849	0	0.0	0.00	1.36	0.94	(\$2,337)	0.63	1.54
	Efficiency & PV	63	0	12.0	0.73	0.80	1.50	\$1,125	3.22	>1
	Neutral Cost	773	0	8.5	0.70	0.94	1.36	\$0	>1	>1

¹All reductions and incremental costs relative to the **mixed fuel** code compliant home.

²All reductions and incremental costs relative to the **all-electric** code compliant home.

³All reductions and incremental costs relative to the **mixed fuel** code compliant home except the EDR Margins are relative to the Standard Design for each case which is the **all-electric** code compliant home. Incremental costs for these packages reflect the costs used in the On-Bill cost effectiveness methodology. Costs differ for the TDV methodology due to differences in the site gas infrastructure costs (see Section 2.6).

⁴This represents the Efficiency EDR Margin for the Efficiency-Non-Preempted and Efficiency-Equipment packages and Total EDR Margin for the Efficiency & PV, Efficiency & PV/Battery, and Neutral Cost packages.

⁵Positive values indicate an increase in PV capacity relative to the Standard Design.



Climate Zone 14 SCE/SoCalGas**Table 77: Single Family Climate Zone 14 SCE/SoCalGas Results Summary**

Climate Zone 14 SCE/SoCalGas Single Family		Annual Net kWh	Annual therms	EDR Margin ⁴	PV Size Change (kW) ⁵	CO2-Equivalent Emissions (lbs/sf)		NPV of Lifetime Incremental Cost (\$)	Benefit to Cost Ratio (B/C)	
						Total	Reduction		On-Bill	TDV
Mixed Fuel ¹	Code Compliant	(0)	371	n/a	n/a	2.35	n/a	n/a	n/a	n/a
	Efficiency-Non-Preempted	(0)	319	4.5	(0.17)	2.06	0.29	\$1,662	1.57	2.46
	Efficiency-Equipment	(0)	305	5.5	(0.19)	1.98	0.36	\$799	3.95	6.14
	Efficiency & PV/Battery	(5)	319	9.0	(0.08)	1.83	0.52	\$5,526	1.31	1.74
All-Electric ²	Code Compliant	4,725	0	n/a	n/a	1.38	n/a	n/a	n/a	n/a
	Efficiency-Non-Preempted	3,819	0	5.5	0.00	1.19	0.19	\$4,154	0.95	1.46
	Efficiency-Equipment	3,676	0	6.0	0.00	1.16	0.22	\$2,108	2.29	3.13
	Efficiency & PV	953	0	15.5	1.60	0.93	0.45	\$10,459	1.21	1.62
	Efficiency & PV/Battery	(2)	0	23.5	2.21	0.63	0.75	\$16,394	1.35	1.59
Mixed Fuel to All-Electric ³	Code Compliant	4,725	0	0.0	0.00	1.38	0.97	(\$5,349)	0.72	1.67
	Efficiency & PV	953	0	15.5	1.60	0.93	1.42	\$5,111	1.01	>1
	Neutral Cost	2,299	0	8.5	1.35	1.15	1.19	\$0	0.00	>1
	Min Cost Effectiveness	1,853	0	10.0	1.61	1.12	1.23	(\$1,000)	1.24	>1

¹All reductions and incremental costs relative to the **mixed fuel** code compliant home.

²All reductions and incremental costs relative to the **all-electric** code compliant home.

³All reductions and incremental costs relative to the **mixed fuel** code compliant home except the EDR Margins are relative to the Standard Design for each case which is the **all-electric** code compliant home. Incremental costs for these packages reflect the costs used in the On-Bill cost effectiveness methodology. Costs differ for the TDV methodology due to differences in the site gas infrastructure costs (see Section 2.6).

⁴This represents the Efficiency EDR Margin for the Efficiency-Non-Preempted and Efficiency-Equipment packages and Total EDR Margin for the Efficiency & PV, Efficiency & PV/Battery, Neutral Cost, and Min Cost Effectiveness packages.

⁵Positive values indicate an increase in PV capacity relative to the Standard Design.



Table 78: Multifamily Climate Zone 14 SCE/SoCalGas Results Summary (Per Dwelling Unit)

Climate Zone 14 SCE/SoCalGas Multifamily		Annual Net kWh	Annual therms	EDR Margin ⁴	PV Size Change (kW) ⁵	CO2-Equivalent Emissions (lbs/sf)		NPV of Lifetime Incremental Cost (\$)	Benefit to Cost Ratio (B/C)	
						Total	Reduction		On-Bill	TDV
Mixed Fuel ¹	Code Compliant	(0)	141	n/a	n/a	2.76	n/a	n/a	n/a	n/a
	Efficiency-Non-Preempted	(0)	126	3.0	(0.04)	2.53	0.23	\$874	0.73	1.21
	Efficiency-Equipment	(0)	126	3.0	(0.05)	2.52	0.23	\$347	1.96	2.99
	Efficiency & PV/Battery	(3)	126	9.5	0.01	2.18	0.58	\$2,957	1.09	1.39
All-Electric ²	Code Compliant	2,022	0	n/a	n/a	1.73	n/a	n/a	n/a	n/a
	Efficiency-Non-Preempted	1,759	0	3.5	0.00	1.58	0.15	\$1,011	1.24	1.65
	Efficiency-Equipment	1,748	0	3.5	0.00	1.56	0.16	\$795	1.59	2.20
	Efficiency & PV	504	0	14.0	0.70	1.26	0.47	\$3,356	1.39	1.91
	Efficiency & PV/Battery	(2)	0	24.5	1.03	0.79	0.94	\$6,380	1.36	1.77
Mixed Fuel to All-Electric ³	Code Compliant	2,022	0	0.0	0.00	1.73	1.03	(\$2,337)	1.13	1.48
	Efficiency & PV	63	0	14.0	0.70	1.26	1.50	\$1,019	2.57	>1
	Neutral Cost	772	0	10.0	0.70	1.41	1.35	\$0	>1	>1

¹All reductions and incremental costs relative to the **mixed fuel** code compliant home.

²All reductions and incremental costs relative to the **all-electric** code compliant home.

³All reductions and incremental costs relative to the **mixed fuel** code compliant home except the EDR Margins are relative to the Standard Design for each case which is the **all-electric** code compliant home. Incremental costs for these packages reflect the costs used in the On-Bill cost effectiveness methodology. Costs differ for the TDV methodology due to differences in the site gas infrastructure costs (see Section 2.6).

⁴This represents the Efficiency EDR Margin for the Efficiency-Non-Preempted and Efficiency-Equipment packages and Total EDR Margin for the Efficiency & PV, Efficiency & PV/Battery, and Neutral Cost packages.

⁵Positive values indicate an increase in PV capacity relative to the Standard Design.



Climate Zone 14 SDGE**Table 79: Single Family Climate Zone 14 SDGE Results Summary**

Climate Zone 14 SDG&E Single Family		Annual Net kWh	Annual therms	EDR Margin ⁴	PV Size Change (kW) ⁵	CO2-Equivalent Emissions (lbs/sf)		NPV of Lifetime Incremental Cost (\$)	Benefit to Cost Ratio (B/C)	
						Total	Reduction		On-Bill	TDV
Mixed Fuel ¹	Code Compliant	(0)	371	n/a	n/a	2.35	n/a	n/a	n/a	n/a
	Efficiency-Non-Preempted	(0)	319	4.5	(0.17)	2.06	0.29	\$1,662	1.92	2.46
	Efficiency-Equipment	(0)	305	5.5	(0.19)	1.98	0.36	\$799	4.88	6.14
	Efficiency & PV/Battery	(5)	319	9.0	(0.08)	1.83	0.52	\$5,526	1.23	1.74
All-Electric ²	Code Compliant	4,725	0	n/a	n/a	1.38	n/a	n/a	n/a	n/a
	Efficiency-Non-Preempted	3,819	0	5.5	0.00	1.19	0.19	\$4,154	1.30	1.46
	Efficiency-Equipment	3,676	0	6.0	0.00	1.16	0.22	\$2,108	2.92	3.13
	Efficiency & PV	953	0	15.5	1.60	0.93	0.45	\$10,459	1.80	1.62
	Efficiency & PV/Battery	(2)	0	23.5	2.21	0.63	0.75	\$16,394	1.67	1.59
Mixed Fuel to All-Electric ³	Code Compliant	4,725	0	0.0	0.00	1.38	0.97	(\$5,349)	0.60	1.67
	Efficiency & PV	953	0	15.5	1.60	0.93	1.42	\$5,111	1.94	>1
	Neutral Cost	2,299	0	8.5	1.35	1.15	1.19	\$0	>1	>1

¹All reductions and incremental costs relative to the **mixed fuel** code compliant home.²All reductions and incremental costs relative to the **all-electric** code compliant home.³All reductions and incremental costs relative to the **mixed fuel** code compliant home except the EDR Margins are relative to the Standard Design for each case which is the **all-electric** code compliant home. Incremental costs for these packages reflect the costs used in the On-Bill cost effectiveness methodology. Costs differ for the TDV methodology due to differences in the site gas infrastructure costs (see Section 2.6).⁴This represents the Efficiency EDR Margin for the Efficiency-Non-Preempted and Efficiency-Equipment packages and Total EDR Margin for the Efficiency & PV, Efficiency & PV/Battery, and Neutral Cost packages.⁵Positive values indicate an increase in PV capacity relative to the Standard Design.

Table 80: Multifamily Climate Zone 14 SDGE Results Summary (Per Dwelling Unit)

Climate Zone 14 SDG&E Multifamily		Annual Net kWh	Annual therms	EDR Margin ⁴	PV Size Change (kW) ⁵	CO2-Equivalent Emissions (lbs/sf)		NPV of Lifetime Incremental Cost (\$)	Benefit to Cost Ratio (B/C)	
						Total	Reduction		On-Bill	TDV
Mixed Fuel ¹	Code Compliant	(0)	141	n/a	n/a	2.76	n/a	n/a	n/a	n/a
	Efficiency-Non-Preempted	(0)	126	3.0	(0.04)	2.53	0.23	\$874	0.93	1.21
	Efficiency-Equipment	(0)	126	3.0	(0.05)	2.52	0.23	\$347	2.48	2.99
	Efficiency & PV/Battery	(3)	126	9.5	0.01	2.18	0.58	\$2,957	0.51	1.39
All-Electric ²	Code Compliant	2,022	0	n/a	n/a	1.73	n/a	n/a	n/a	n/a
	Efficiency-Non-Preempted	1,759	0	3.5	0.00	1.58	0.15	\$1,011	1.47	1.65
	Efficiency-Equipment	1,748	0	3.5	0.00	1.56	0.16	\$795	2.00	2.20
	Efficiency & PV	504	0	14.0	0.70	1.26	0.47	\$3,356	2.16	1.91
	Efficiency & PV/Battery	(2)	0	24.5	1.03	0.79	0.94	\$6,380	1.69	1.77
Mixed Fuel to All-Electric ³	Code Compliant	2,022	0	0.0	0.00	1.73	1.03	(\$2,337)	0.51	1.48
	Efficiency & PV	63	0	14.0	0.70	1.26	1.50	\$1,019	2.60	>1
	Neutral Cost	772	0	10.0	0.70	1.41	1.35	\$0	>1	>1

¹All reductions and incremental costs relative to the **mixed fuel** code compliant home.

²All reductions and incremental costs relative to the **all-electric** code compliant home.

³All reductions and incremental costs relative to the **mixed fuel** code compliant home except the EDR Margins are relative to the Standard Design for each case which is the **all-electric** code compliant home. Incremental costs for these packages reflect the costs used in the On-Bill cost effectiveness methodology. Costs differ for the TDV methodology due to differences in the site gas infrastructure costs (see Section 2.6).

⁴This represents the Efficiency EDR Margin for the Efficiency-Non-Preempted and Efficiency-Equipment packages and Total EDR Margin for the Efficiency & PV, Efficiency & PV/Battery, and Neutral Cost packages.

⁵Positive values indicate an increase in PV capacity relative to the Standard Design.



Climate Zone 15**Table 81: Single Family Climate Zone 15 Results Summary**

Climate Zone 15 SCE/SoCalGas Single Family		Annual Net kWh	Annual therms	EDR Margin ⁴	PV Size Change (kW) ⁵	CO2-Equivalent Emissions (lbs/sf)		NPV of Lifetime Incremental Cost (\$)	Benefit to Cost Ratio (B/C)	
						Total	Reduction		On-Bill	TDV
Mixed Fuel ¹	Code Compliant	0	149	n/a	n/a	1.69	n/a	n/a	n/a	n/a
	Efficiency-Non-Preempted	0	141	4.5	(0.43)	1.56	0.13	\$2,179	1.00	1.58
	Efficiency-Equipment	(0)	132	4.5	(0.45)	1.51	0.18	(\$936)	>1	>1
	Efficiency & PV/Battery	(3)	141	7.0	(0.34)	1.38	0.32	\$6,043	1.15	1.51
All-Electric ²	Code Compliant	2,149	0	n/a	n/a	1.32	n/a	n/a	n/a	n/a
	Efficiency-Non-Preempted	1,230	0	5.5	0.00	1.12	0.20	\$4,612	1.12	1.58
	Efficiency-Equipment	866	0	7.0	0.00	1.04	0.28	\$2,108	3.30	4.47
	Efficiency & PV	1,030	0	6.0	0.12	1.10	0.22	\$5,085	1.12	1.57
	Efficiency & PV/Battery	(2)	0	13.0	0.83	0.84	0.48	\$11,382	1.16	1.54
Mixed Fuel to All-Electric ³	Code Compliant	2,149	0	0.0	0.00	1.32	0.37	(\$5,349)	1.73	2.21
	Efficiency & PV	1,030	0	6.0	0.12	1.10	0.59	(\$264)	>1	>1
	Neutral Cost	23	0	6.0	1.36	1.13	0.57	\$0	>1	>1

¹All reductions and incremental costs relative to the **mixed fuel** code compliant home.²All reductions and incremental costs relative to the **all-electric** code compliant home.³All reductions and incremental costs relative to the **mixed fuel** code compliant home except the EDR Margins are relative to the Standard Design for each case which is the **all-electric** code compliant home. Incremental costs for these packages reflect the costs used in the On-Bill cost effectiveness methodology. Costs differ for the TDV methodology due to differences in the site gas infrastructure costs (see Section 2.6).⁴This represents the Efficiency EDR Margin for the Efficiency-Non-Preempted and Efficiency-Equipment packages and Total EDR Margin for the Efficiency & PV, Efficiency & PV/Battery, and Neutral Cost packages.⁵Positive values indicate an increase in PV capacity relative to the Standard Design.

Table 82: Multifamily Climate Zone 15 Results Summary (Per Dwelling Unit)

Climate Zone 15 SCE/SoCalGas Multifamily		Annual Net kWh	Annual therms	EDR Margin ⁴	PV Size Change (kW) ⁵	CO2-Equivalent Emissions (lbs/sf)		NPV of Lifetime Incremental Cost (\$)	Benefit to Cost Ratio (B/C)	
						Total	Reduction		On-Bill	TDV
Mixed Fuel ¹	Code Compliant	0	93	n/a	n/a	2.53	n/a	n/a	n/a	n/a
	Efficiency-Non-Preempted	0	92	4.0	(0.15)	2.42	0.11	\$510	1.35	2.28
	Efficiency-Equipment	0	86	4.0	(0.16)	2.33	0.20	(\$157)	>1	>1
	Efficiency & PV/Battery	(3)	92	8.5	(0.10)	2.13	0.40	\$2,604	1.29	1.70
All-Electric ²	Code Compliant	1,243	0	n/a	n/a	1.78	n/a	n/a	n/a	n/a
	Efficiency-Non-Preempted	954	0	4.0	0.00	1.61	0.17	\$1,011	1.50	2.28
	Efficiency-Equipment	764	0	6.0	0.00	1.50	0.29	\$1,954	1.24	1.72
	Efficiency & PV	548	0	7.0	0.24	1.50	0.28	\$1,826	1.43	2.07
	Efficiency & PV/Battery	(3)	0	16.5	0.62	1.08	0.70	\$5,020	1.34	1.80
Mixed Fuel to All-Electric ³	Code Compliant	1,243	0	0.0	0.00	1.78	0.75	(\$2,337)	6.36	2.35
	Efficiency & PV	68	0	7.0	0.24	1.50	1.03	(\$511)	>1	>1
	Neutral Cost	78	0	7.5	0.70	1.48	1.05	\$0	>1	>1

¹All reductions and incremental costs relative to the **mixed fuel** code compliant home.

²All reductions and incremental costs relative to the **all-electric** code compliant home.

³All reductions and incremental costs relative to the **mixed fuel** code compliant home except the EDR Margins are relative to the Standard Design for each case which is the **all-electric** code compliant home. Incremental costs for these packages reflect the costs used in the On-Bill cost effectiveness methodology. Costs differ for the TDV methodology due to differences in the site gas infrastructure costs (see Section 2.6).

⁴This represents the Efficiency EDR Margin for the Efficiency-Non-Preempted and Efficiency-Equipment packages and Total EDR Margin for the Efficiency & PV, Efficiency & PV/Battery, and Neutral Cost packages.

⁵Positive values indicate an increase in PV capacity relative to the Standard Design.



Climate Zone 16**Table 83: Single Family Climate Zone 16 Results Summary**

Climate Zone 16 PG&E Single Family		Annual Net kWh	Annual therms	EDR Margin⁴	PV Size Change (kW)⁵	CO2-Equivalent Emissions (lbs/sf)		NPV of Lifetime Incremental Cost (\$)	Benefit to Cost Ratio (B/C)	
						Total	Reduction		On-Bill	TDV
Mixed Fuel¹	Code Compliant	(0)	605	n/a	n/a	3.31	n/a	n/a	n/a	n/a
	Efficiency-Non-Preempted	0	454	5.0	0.01	2.59	0.72	\$3,542	1.62	1.46
	Efficiency-Equipment	0	474	6.0	(0.08)	2.66	0.65	\$2,441	2.19	2.20
	Efficiency & PV/Battery	(18)	454	10.5	0.10	2.36	0.95	\$7,399	0.87	1.37
All-Electric²	Code Compliant	7,694	0	n/a	n/a	1.73	n/a	n/a	n/a	n/a
	Efficiency-Non-Preempted	5,696	0	9.5	0.00	1.38	0.35	\$5,731	1.72	1.69
	Efficiency-Equipment	6,760	0	4.5	0.00	1.55	0.18	\$2,108	2.36	2.32
	Efficiency & PV	1,032	0	26.5	2.75	0.94	0.79	\$16,582	2.09	1.62
	Efficiency & PV/Battery	(11)	0	35.0	3.45	0.64	1.09	\$22,838	1.71	1.55
Mixed Fuel to All-Electric³	Code Compliant	7,694	0	0.0	0.00	1.73	1.58	(\$5,349)	0.31	0.68
	Efficiency & PV	1,032	0	26.5	2.75	0.94	2.37	\$11,234	1.55	2.02
	Neutral Cost	5,398	0	8.5	1.35	1.51	1.80	\$0	0.00	0.74
	Min Cost Effectiveness	3,358	0	16.0	2.56	1.32	1.99	(\$4,753)	1.24	1.40

¹All reductions and incremental costs relative to the **mixed fuel** code compliant home.²All reductions and incremental costs relative to the **all-electric** code compliant home.³All reductions and incremental costs relative to the **mixed fuel** code compliant home except the EDR Margins are relative to the Standard Design for each case which is the **all-electric** code compliant home. Incremental costs for these packages reflect the costs used in the On-Bill cost effectiveness methodology. Costs differ for the TDV methodology due to differences in the site gas infrastructure costs (see Section 2.6).⁴This represents the Efficiency EDR Margin for the Efficiency-Non-Preempted and Efficiency-Equipment packages and Total EDR Margin for the Efficiency & PV, Efficiency & PV/Battery, Neutral Cost, and Min Cost Effectiveness packages.⁵Positive values indicate an increase in PV capacity relative to the Standard Design.

Table 84: Multifamily Climate Zone 16 Results Summary (Per Dwelling Unit)

Climate Zone 16 PG&E Multifamily		Annual Net kWh	Annual therms	EDR Margin ⁴	PV Size Change (kW) ⁵	CO2-Equivalent Emissions (lbs/sf)		NPV of Lifetime Incremental Cost (\$)	Benefit to Cost Ratio (B/C)	
						Total	Reduction		On-Bill	TDV
Mixed Fuel ¹	Code Compliant	0	206	n/a	n/a	3.45	n/a	n/a	n/a	n/a
	Efficiency-Non-Preempted	(0)	172	2.0	0.03	3.02	0.44	\$937	1.11	1.19
	Efficiency-Equipment	(0)	183	2.5	(0.02)	3.12	0.33	\$453	1.76	2.15
	Efficiency & PV/Battery	(9)	172	9.5	0.08	2.65	0.80	\$3,028	0.47	1.28
All-Electric ²	Code Compliant	2,699	0	n/a	n/a	1.86	n/a	n/a	n/a	n/a
	Efficiency-Non-Preempted	2,329	0	4.0	0.00	1.70	0.16	\$843	2.08	2.05
	Efficiency-Equipment	2,470	0	3.0	0.00	1.74	0.13	\$795	1.59	1.70
	Efficiency & PV	518	0	19.5	1.07	1.23	0.63	\$4,423	2.58	1.89
	Efficiency & PV/Battery	(6)	0	29.5	1.42	0.75	1.11	\$7,533	1.65	1.69
Mixed Fuel to All-Electric ³	Code Compliant	2,699	0	0.0	0.00	1.86	1.59	(\$2,337)	0.43	1.03
	Efficiency & PV	65	0	19.5	1.07	1.23	2.22	\$2,087	2.87	>1
	Neutral Cost	1,518	0	10.0	0.70	1.56	1.90	\$0	>1	2.58

¹All reductions and incremental costs relative to the **mixed fuel** code compliant home.

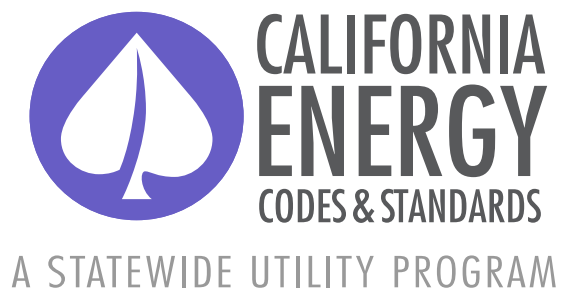
²All reductions and incremental costs relative to the **all-electric** code compliant home.

³All reductions and incremental costs relative to the **mixed fuel** code compliant home except the EDR Margins are relative to the Standard Design for each case which is the **all-electric** code compliant home. Incremental costs for these packages reflect the costs used in the On-Bill cost effectiveness methodology. Costs differ for the TDV methodology due to differences in the site gas infrastructure costs (see Section 2.6).

⁴This represents the Efficiency EDR Margin for the Efficiency-Non-Preempted and Efficiency-Equipment packages and Total EDR Margin for the Efficiency & PV, Efficiency & PV/Battery, and Neutral Cost packages.

⁵Positive values indicate an increase in PV capacity relative to the Standard Design.





Title 24, Parts 6 and 11
Local Energy Efficiency Ordinances

2019 Nonresidential New Construction Reach Code Cost Effectiveness Study

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1 Introduction

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

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

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

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

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

Figure 1. Measure Category and Package Overview

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

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

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

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

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

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



higher minimum efficiencies than the federal standards require, the focus of this study is to identify and evaluate cost-effective packages that do not include high efficiency equipment. However, because high efficiency appliances are often the easiest and most affordable measures to increase energy performance, this study provides an analysis of high efficiency appliances for informational purposes. While federal preemption would limit a reach code, in practice, builders may install any package of compliant measures to achieve the performance requirements, including higher efficiency appliances that are federally regulated.

2 Methodology and Assumptions

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

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

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

2.1 Building Prototypes

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

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

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

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

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

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

Figure 2. Prototype Characteristics Summary

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

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

2.2 Cost Effectiveness

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

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

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

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

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

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

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

Figure 3. Utility Tariffs used based on Climate Zone

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

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

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

- ◆ **Net Present Value (NPV):** The Reach Code Team uses net savings (NPV benefits *minus* NPV costs) as the cost effectiveness metric. If the net savings of a measure or package is positive, it is considered cost effective. Negative savings represent net costs. A measure that has negative energy cost benefits (energy cost increase) can still be cost effective if the costs to implement the measure are more negative (i.e., material and maintenance cost savings).
- ◆ **Benefit-to-Cost Ratio (B/C):** Ratio of the present value of all benefits to the present value of all costs over 15 years (NPV benefits *divided by* NPV costs). The criteria for cost effectiveness is a B/C greater than 1.0. A value of one indicates the savings over the life of the measure are equivalent to the incremental cost of that measure.

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

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

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

3 Measure Description and Cost

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

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

3.1 Energy Efficiency Measures

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

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

3.1.1 Envelope

◆ **Modify Solar Heat Gain Coefficient (SHGC) fenestration**

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

In all cases, the fenestration visible transmittance and U-factor remain at prescriptive values.

- ◆ **Fenestration as a function of orientation:** Limit the amount of fenestration area as a function of orientation. East-facing and west-facing windows are each limited to one-half of the average amount of north-facing and south-facing windows.

3.1.2 HVAC and SWH

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

3.1.3 Lighting

- ◆ **Interior lighting reduced lighting power density (LPD):** Reduce LPD by 15 percent for Medium Office, 10 percent for Medium Retail and by 10 percent for the nonresidential areas of the Small Hotel.
- ◆ **Institutional tuning:** Limit the maximum output or maximum power draw of lighting to 85 percent of full light output or full power draw.
- ◆ **Daylight dimming plus off:** Turn daylight-controlled lights completely off when the daylight available in the daylight zone is greater than 150 percent of the illuminance received from the general lighting system at full power. There is no associated cost with this measure, as the 2019 T24 Standards already require multilevel lighting and daylight sensors in primary and secondary daylight spaces. This measure is simply a revised control strategy and does not increase the number of sensors required or labor to install and program a sensor.
- ◆ **Occupant sensing in open plan offices:** In an open plan office area greater than 250 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 *Appendices 6.2*. The appendix also includes the resulting LPD that is modeled as the proposed by building type and by space function.

Figure 4. Energy Efficiency Measures - Specification and Cost

Measure	Baseline T24 Requirement	Measure Applicability				Incremental Cost	Sources & Notes
		● Included in Packages 1A, 1B, 3A, 3C — Not applicable					
		Med Office	Med Retail	Small Hotel			
				Guest rooms	Comm Spaces		
Envelope							
Modify SHGC Fenestration	SHGC of 0.25	●	●	●	●	\$1.60 /ft² window for SHGC decreases, \$0/ft² for SHGC increases	Costs from one manufacturer.
Fenestration as a Function of Orientation	Limit on total window area and west-facing window area as a function of wall area.	●	—	—	—	\$0	No additional cost associated with the measure which is a design consideration not an equipment cost.
HVAC and SHW							
Drain Water Heat Recovery	No heat recovery required	—	—	●	—	\$841 /unit	Assume 1 heat recovery unit for every 3 guestrooms. Costs from three manufacturers.
VAV Box Minimum Flow	20 percent of maximum (design) airflow	●	—	—	●	\$0	No additional cost associated with the measure which is a design consideration not an equipment cost.
Economizers on Small Capacity Systems	Economizers required for units > 54,000 Btu/hr	—	●	—	—	\$2,857 /unit	Costs from one manufacturer's representative and one mechanical contractor.

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

⁸ <http://www.csthermalstats.org/download.html>

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



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

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

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



3.2 Solar Photovoltaics and Battery Measures

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

3.2.1 Solar Photovoltaics

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

- ◆ 15 W/ft² covering 50 percent of the roof area, or
- ◆ Enough to nearly offset the annual energy consumption.

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

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

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

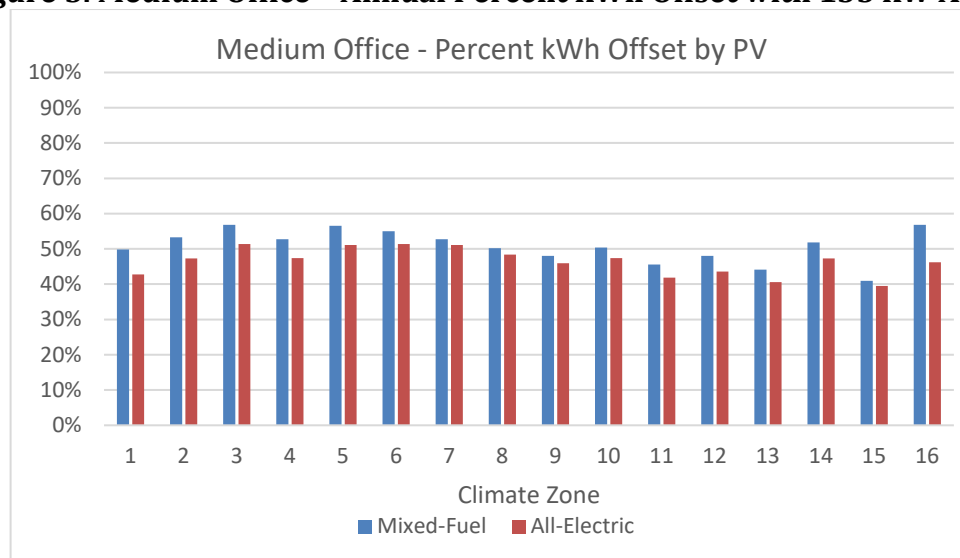
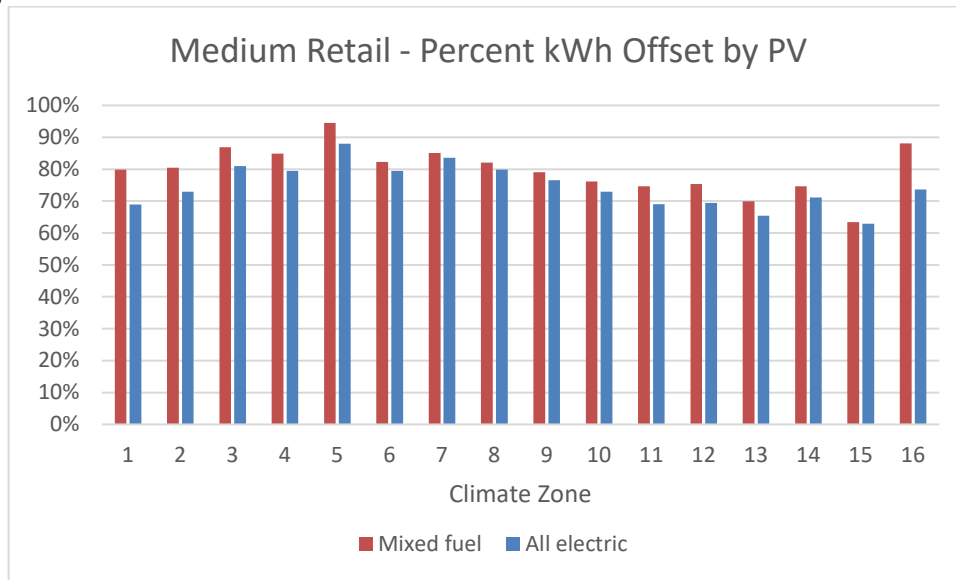
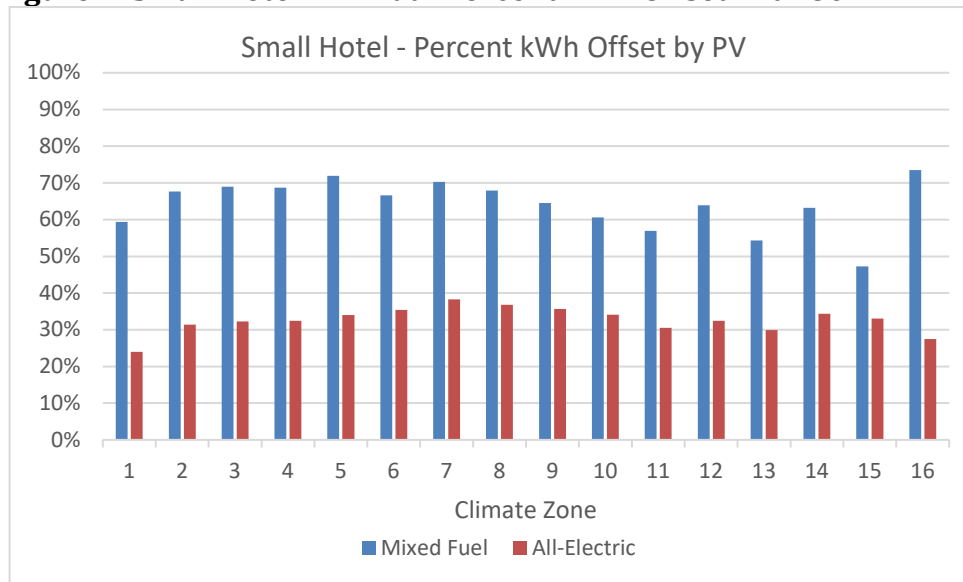


Figure 6. Medium Retail – Annual Percent kWh Offset with 110 kW Array**Figure 7. Small Hotel – Annual Percent kWh Offset with 80 kW Array**

The costs for PV include first cost to purchase and install the system, inverter replacement costs, and annual maintenance costs. A summary of the medium office costs and sources is given in Figure 8. Upfront solar PV system costs are reduced by the federal income tax credit (ITC), approximately 19 percent due to a phased reduction in the credit through the year 2022.¹²

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

Figure 8. Medium Office Upfront PV Costs

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

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

3.2.2 Battery Storage

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

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

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

The Reach Code Team used costs of \$558 kWh based on a 2018 IOU Codes and Standards Program report, assuming a replacement is necessary in year 15.¹⁸ Batteries are also eligible for the ITC if they are installed at the same time as the renewable generation source and at least 75 percent of the energy used to charge

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

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

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

¹⁶ Battery controls are discussed in Sections 2.1.5.4 and Appendix D of the Residential Alternative Calculation Method Reference Manual, available here: <https://ww2.energy.ca.gov/2019publications/CEC-400-2018-021/CEC-400-2019-005-CMF.pdf>

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

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



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

3.2.3 PV-only and PV+Battery Packages

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

- ◆ **Small PV Size:** 3 kW, assumed to be the minimal PV system considered for installation in a nonresidential building.
- ◆ **Large PV Size:** PV capacity equal to 15 W/ft² over 50 percent of the roof area, or sized to nearly offset annual electricity consumption, as described in Section 3.2.1.
- ◆ **Small Battery Size:** 5 kWh, assumed to be the minimal battery system considered for installation in a nonresidential building, and representative of smaller products currently available on the market.
- ◆ **Large Battery Size:** 50 kWh, assumed to be a substantially large size for a nonresidential setting. Generally, the reach code team found diminishing on-bill and TDV benefits as the battery size increased.

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

3.3 All Electric Measures

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

3.3.1 HVAC and Water Heating

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

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

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

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

3.3.1.1 Medium Office

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

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

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

¹⁹ Raftery, P., A. Geronazzo, H. Cheng, and G. Paliaga. 2018. Quantifying energy losses in hot water reheat systems. Energy and Buildings, 179: 183-199. November. <https://doi.org/10.1016/j.enbuild.2018.09.020>. Retrieved from <https://escholarship.org/uc/item/3as8f8gx>



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

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

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

Figure 10. Medium Office HVAC System Costs

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

3.3.1.2 Medium Retail

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

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

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

Figure 11. Medium Retail HVAC System Costs

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

3.3.1.3 Small Hotel

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

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

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

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

Figure 12. Small Hotel HVAC and Water Heating System Costs

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

3.3.2 Infrastructure Impacts

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

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

3.3.2.1 *Electrical Panel Sizing and Wiring*

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

VAV terminal units with hot water reheat coils that are replaced with electric resistance reheat coils require additional electrical infrastructure. In the case of electric resistance coils, the Reach Code Team assumed that on average, a VAV terminal unit serves around 900 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 13 include the cost to add electrical panels as well as the cost to add electrical lines to each VAV terminal unit electric resistance coil in the medium office prototype. Additionally, the Reach Code Team subtracted the electrical infrastructure costs associated with hot water pumps required in the mixed fuel baseline, which are not required in the all-electric measures.

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

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

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

3.3.2.2 Natural Gas

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

The Reach Code Team determined that for a new construction building with natural gas piping, there is a service line (branch connection) from the natural gas main to the building meter. In the medium office prototype, natural gas piping is routed to the boiler. The Reach Code Team assumed that the boiler is on the first floor, and that 30 feet of piping is required from the connection to the main to the boiler. The Reach Code Team assumed 1" corrugated stainless steel tubing (CSST) material is used for the plumbing distribution. The Reach Code Team included costs for a natural gas plan review, service extension, and a gas meter, as shown in Figure 14 below. The natural gas plan review cost is based on information received from the City of Palo Alto Utilities. The meter costs are from PG&E and include both material and labor. The service extension costs are based on guidance from PG&E, who noted that the cost range is highly varied and that there is no "typical" cost, with costs being highly dependent on length of extension, terrain, whether the building is in a developed or undeveloped area, and number of buildings to be served. While an actual service extension cost is highly uncertain, the team believes the costs assumed in this analysis are within a reasonable range based on a sample range of costs provided by PG&E. These costs assume development in a previously developed area.

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

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

3.4 Preempted High Efficiency Appliances

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

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

Figure 15. High Efficiency Appliance Assumptions

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

3.5 Greenhouse Gas Emissions

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

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

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



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

4 Results

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

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

Figure 16. Package Summary

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

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



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

The TDV and on-bill based cost effectiveness results are presented in terms of B/C ratio and NPV in this section. What constitutes a ‘benefit’ or a ‘cost’ varies with the scenarios because both energy savings and incremental construction costs may be negative depending on the package. Typically, utility bill savings are categorized as a ‘benefit’ while incremental construction costs are treated as ‘costs.’ In cases where both construction costs are negative and utility bill savings are negative, the construction cost savings are treated as the ‘benefit’ while the utility bill negative savings are as the ‘cost.’

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

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

4.1 Cost Effectiveness Results – Medium Office

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

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

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

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

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



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

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



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

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



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

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

* The Incremental Package Cost is equal to the sum of the incremental HVAC and water heating equipment costs from

Figure 10, the electrical infrastructure incremental cost of \$27,802 (see section 3.3.2.1), and the natural gas infrastructure incremental costs of \$(18,949) (see section 3.3.2.2).

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

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



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

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

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

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

4.2 Cost Effectiveness Results – Medium Retail

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

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

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

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



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

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



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

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



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

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

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



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

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



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

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



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

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



4.3 Cost Effectiveness Results – Small Hotel

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

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

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

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

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

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

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



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

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



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

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

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

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



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

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

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

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

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



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

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



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

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

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

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

Jurisdictions interested in adopting PV-only reach codes should reference the mixed-fuel cost effectiveness results because a mixed-fuel building is the baseline for the nonresidential prototypes analyzed in this study. PV or PV+Battery packages are added to all-electric federal code minimum reference which (in many scenarios) do not have a positive compliance margin compared to the mixed-fuel baseline model, and are solely provided for informational purposes. Jurisdictions interested in reach codes requiring all-electric+PV or all-electric+PV+battery should reference package 3B results in Sections 4.1 – 4.3.²⁵

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

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

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

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

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

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

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



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

		Mixed Fuel						All-Electric					
		3kW			135kW			3kW			135kW		
		On-Bill	TDV	5kWh	On-Bill	TDV	50kWh	On-Bill	TDV	5kWh	On-Bill	TDV	50kWh
CZ	PV	0	0	0	0	0	0	0	0	0	0	0	0
	Battery	On-Bill	TDV	On-Bill	TDV	On-Bill	TDV	On-Bill	TDV	On-Bill	TDV	On-Bill	TDV
	Utility	On-Bill	TDV	On-Bill	TDV	On-Bill	TDV	On-Bill	TDV	On-Bill	TDV	On-Bill	TDV
	PG&E	2.8	1.5	1.7	0.9	1.7	1.3	0.9	1.6	0.9	1.6	2.5	2.0
	PG&E	3.7	1.9	2.1	1.1	2.2	1.6	0.8	2.2	0.9	2.6	3.2	2.4
	PG&E	3.7	1.8	2.2	1.0	2.1	1.5	1.9	1.4	2.0	4.0	3.4	2.5
	PG&E	3.6	2.0	2.1	1.2	2.3	1.6	2.1	1.5	1.1	2.7	3.3	2.5
	CPAU	2.1	2.0	1.3	1.2	1.8	1.6	1.6	1.5	9.8	2.7	2.9	2.5
	PG&E	4.2	1.9	2.4	1.1	2.5	1.6	1.8	2.3	1.9	2.7	4.0	2.7
	SCG	4.2	1.9	2.4	1.1	2.5	1.6	2.3	1.5	>1	>1	>1	3.0
	SCE	2.0	2.0	1.2	1.1	1.3	1.6	1.2	1.5	>1	8.2	2.4	2.7
	LA	1.2	2.0	0.7	1.1	0.8	1.6	0.7	1.5	>1	8.2	1.5	2.7
	SDG&E	3.2	2.0	1.9	1.2	2.1	1.6	1.9	1.5	>1	>1	3.7	2.7
	SCE	1.9	2.0	1.1	1.2	1.3	1.7	1.2	1.5	>1	>1	2.2	2.7
	LA	1.2	2.0	0.7	1.2	0.7	1.7	0.7	1.5	>1	>1	1.3	2.7
	SCE	1.9	2.0	1.1	1.2	1.3	1.7	1.2	1.5	>1	>1	2.2	2.7
	SDG&E	3.8	1.9	2.2	1.1	2.1	1.6	1.9	1.5	>1	6.3	3.3	2.3
	SCE	2.1	1.9	1.2	1.1	1.3	1.6	1.2	1.5	>1	6.3	2.0	2.3
	PG&E	3.6	1.9	2.1	1.1	2.2	1.6	2.0	1.5	1.1	3.6	3.2	2.4
	PG&E	3.5	1.9	2.1	1.1	2.2	1.6	2.0	1.5	0.9	3.2	3.1	2.4
	SMUD	1.4	1.9	0.8	1.1	1.1	1.6	1.04	1.5	>1	3.2	1.9	2.4
	PG&E	3.5	1.8	2.0	1.1	2.2	1.5	2.0	1.4	1.1	3.6	3.1	2.3
	SDG&E	3.4	2.3	2.0	1.3	2.2	1.9	2.0	1.7	>1	3.1	3.6	2.8
	SCE	1.9	2.3	1.1	1.3	1.3	1.9	1.2	1.7	>1	3.1	2.2	2.8
	SCE	1.8	2.1	1.1	1.2	1.2	1.7	1.1	1.6	>1	>1	1.8	2.4
	PG&E	3.9	2.0	2.3	1.1	2.3	1.6	2.1	1.5	0.3	0.6	2.5	1.8
	LA	1.2	2.0	0.7	1.1	0.7	1.6	0.7	1.5	>1	0.6	1.3	1.8



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

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



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

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

5 Summary, Conclusions, and Further Considerations

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

5.1 Summary

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

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

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

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

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

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

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

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

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

5.2 Conclusions and Further Considerations

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

Findings indicate the following overall conclusions:

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

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

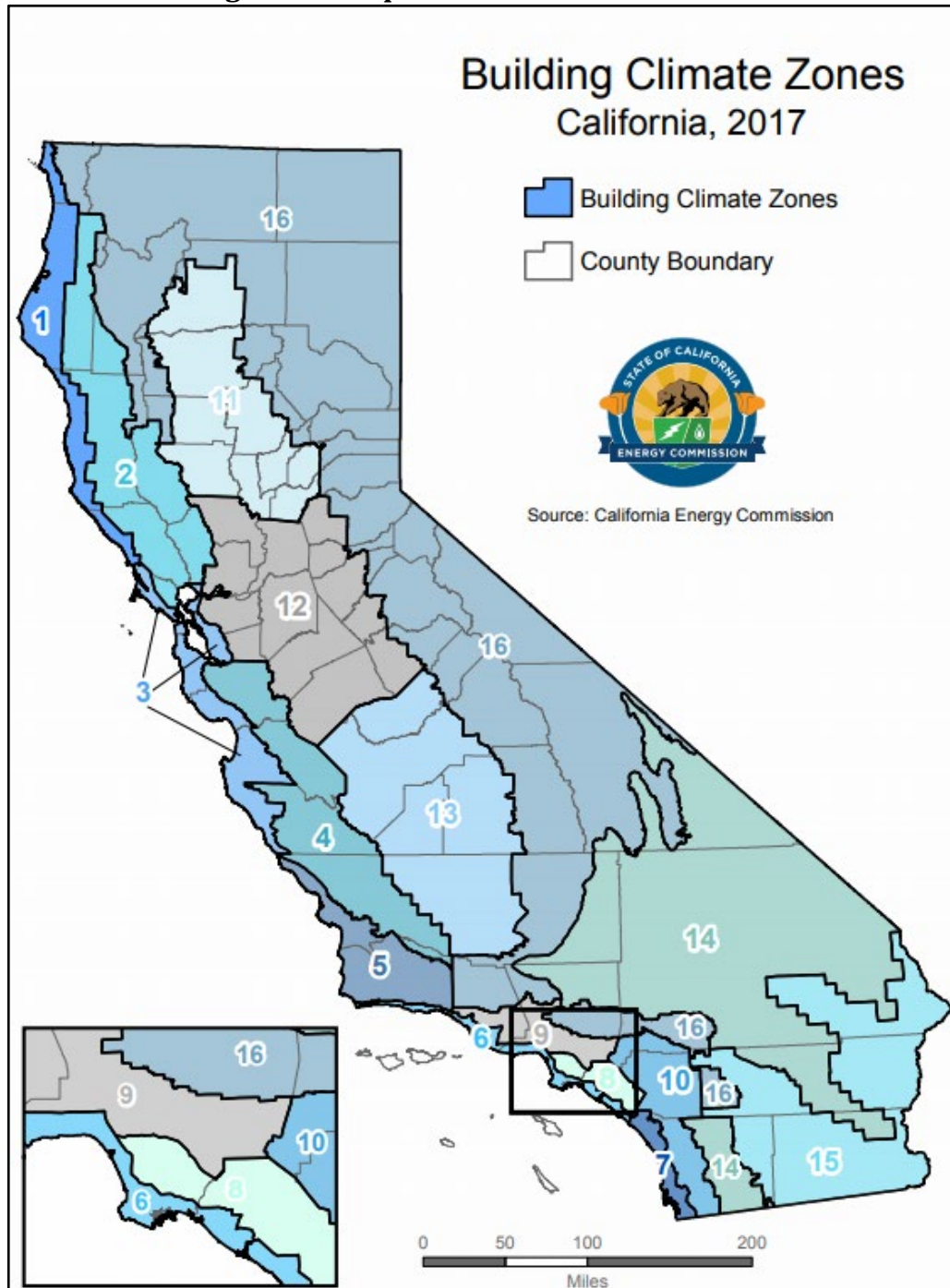
6 Appendices

6.1 Map of California Climate Zones

Climate zone geographical boundaries are depicted in Figure 44. The map in Figure 44 along with a zip-code search directory is available at:

https://ww2.energy.ca.gov/maps/renewable/building_climate_zones.html

Figure 44. Map of California Climate Zones



6.2 Lighting Efficiency Measures

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

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

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

6.3 Drain Water Heat Recovery Measure Analysis

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

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

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

6.4 Utility Rate Schedules

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

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

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

6.5 Mixed Fuel Baseline Energy Figures

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

Figure 47. Medium Office – Mixed Fuel Baseline

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

Figure 48. Medium Retail – Mixed Fuel Baseline

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

Figure 49. Small Hotel – Mixed Fuel Baseline

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

6.6 Hotel TDV Cost Effectiveness with Propane Baseline

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

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

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

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

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



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

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

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

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

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

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



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

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

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

6.7.1 Cost Effectiveness Results – Medium Office

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

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

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



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

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



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

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



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

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



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

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



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

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



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

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



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

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



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

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



6.7.2 Cost Effectiveness Results – Medium Retail

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

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

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

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



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

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



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

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



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

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



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

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



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

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



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

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



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

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



6.7.3 Cost Effectiveness Results – Small Hotel

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

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

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

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



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

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



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

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



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

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



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

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



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

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



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

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



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

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



6.8 List of Relevant Efficiency Measures Explored

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

Figure 78. List of Relevant Efficiency Measures Explored

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

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



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



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



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



6.9 Additional Rates Analysis - Healdsburg

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

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



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

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



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

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



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

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



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City of Carlsbad Energy Conservation Ordinance Cost Effectiveness Analysis

February 20, 2019

Submitted To:

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Executive Summary

The City of Carlsbad requires a cost effectiveness study be completed to implement an energy conservation ordinance. TRC investigated measures originating from Carlsbad's Climate Action Plan and further developed by Center for Sustainable Energy (CSE).¹ The energy ordinance would require that residential and nonresidential new construction and alterations implement efficiency and renewable energy measures that exceed the requirements of 2016 and 2019 Title 24 Building Energy Efficiency Standards (T24). Cost effectiveness analysis is required by the California Energy Commission (CEC) before adopting local energy ordinances, and may support or justify local ordinances by demonstrating that the building industry and building occupants are not unduly burdened because of the ordinance.

TRC determined cost-effectiveness in two ways: 1) using time dependent valuation (TDV) of energy as per the CEC Life Cycle Cost Methodology and 2) using San Diego Gas & Electric (SDG&E) utility rates to determine bill impacts. TRC uses a benefit to cost (B/C) ratio as the cost effectiveness metric. If the benefits of a measure are positive and greater than the costs of the measure, then the B/C ratio will be greater than 1.0 and the measure or package is considered cost effective. Cost-effective measures are highlighted in green in the following tables.

TRC analyzed the following measures for residential and nonresidential new construction individually and as a package, as shown in Figure 1 and Figure 2:

- ◆ solar photovoltaic (PV),
- ◆ heat pump water heating with
 - a federally-required minimum energy factor (EF) of 2.0, and
 - a uniform energy factor (UEF) of 3.1 representing a Northwest Energy Efficiency Alliance (NEEA) Rated Tier 3 product

Because nonresidential buildings typically have very low hot water demands, and water heaters with storage tanks may waste energy while on standby, TRC also investigated the cost effectiveness of small tank electric resistance water heaters in the nonresidential prototypes.

Figure 1 shows that both single family and low-rise multifamily residential new construction are cost effective using the Bill B/C ratio when installing HPWHs paired with PV as compared to the 2019 Title 24 baseline. However, these measures are not cost effective using the TDV B/C ratio.

New Construction	Single-family		Low-rise Multifamily	
Measure (2019 Title 24 Baseline)	B/C ratio (TDV)	B/C ratio (Bill)	B/C ratio (TDV)	B/C ratio (Bill)
Federal Min HPWH + 0.3 kW Solar PV	0.0	1.1	0.0	3.0
Tier 3 HPWH + 0.3 kW Solar PV	0.5	2.1	0.5	3.2

Figure 1: New Construction Residential Summary

TRC analyzed solar PV and water heating measures individually and packaged for nonresidential new construction compared to the 2016 Title 24 baseline. As per Carlsbad measure descriptions, PV was sized at:

¹ City of Carlsbad Climate Action Plan (Sept 2015). Dyett & Bhatia Urban and Regional Planners. Available at: <http://www.carlsbadca.gov/civicax/filebank/blobdownload.aspx?BlobID=29361>

- ◆ 15 kW per 10,000 ft² of gross floor area on buildings of 10,000 ft² or more, and
- ◆ 5 kW for buildings under 10,000 ft².

Figure 2 shows that electric water heating alone is not cost effective using either TDV or Bill B/C ratios. Solar PV alone, and solar PV in conjunction with electric water heating, are cost effective using both the TDV and Bill B/C ratio for each nonresidential new construction prototype with the exception of the retail strip mall, which has a very low hot water demand.

New Construction	Small Office		Medium Office		Warehouse		Retail Strip Mall	
Measure (2016 Title 24 Baseline)	B/C ratio (TDV)	B/C ratio (Bill)	B/C ratio (TDV)	B/C ratio (Bill)	B/C ratio (TDV)	B/C ratio (Bill)	B/C ratio (TDV)	B/C ratio (Bill)
Solar PV	1.7	2.6	1.6	2.0	1.4	1.7	1.7	2.1
Federal Min Efficiency HPWH	-1.0	-3.3	-10.6	-22.7	-2.1	-5.6	-4.0	-4.7
Federal Min Efficiency HPWH + PV	1.3	1.9	1.5	1.8	1.4	1.7	0.9	1.2
Tier 3 HPWH	0.6	-1.1	-5.3	-12.7	-0.6	-2.8	-1.2	-0.3
Tier 3 HPWH + PV	1.6	2.2	1.5	1.9	1.4	1.7	1.3	1.7
Electric Resistance WH	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
Electric Resistance WH + PV	1.6	2.2	1.4	1.7	1.4	1.7	0.7	0.7

Figure 2: New Construction Nonresidential Summary, Tier 3 HPWH.

TRC analyzed solar PV measures for nonresidential alterations compared to the 2016 Title 24 baseline. The solar PV sizing requirement for alterations is identical to that of new construction and is triggered by roof additions $\geq 2,000$ ft² or permit valuations $\geq \$1,000,000$ that affect ≥ 75 percent the building. Figure 3 shows Bill Net Savings and TDV Net Savings for solar on nonresidential alterations.

Major Alterations	Small Office		Medium Office		Warehouse		Retail Strip Mall	
Measure	B/C ratio (TDV)	B/C ratio (Bill)	B/C ratio (TDV)	B/C ratio (Bill)	B/C ratio (TDV)	B/C ratio (Bill)	B/C ratio (TDV)	B/C ratio (Bill)
Solar PV	1.5	2.5	1.5	2.4	1.4	1.7	1.5	3.0

Figure 3: Nonresidential Alterations Summary

Based on our analysis described in this report, TRC provides the following recommendations for reach code requirements relative to the 2016 and 2019 Title 24 requirements for the City of Carlsbad consideration:

2016 Title 24

- ◆ An ordinance to implement CAP Actions B-1 and B-2 that requires solar PV on nonresidential new construction and certain alterations. Carlsbad may allow smaller PV sizes or other exceptions for buildings that demonstrate that they will over generate with a 5 kW PV size.
- ◆ An ordinance to implement CAP Action J-2 that requires heat pump water heating in nonresidential new construction when paired with PV installation. Carlsbad may require other efficiency measures (e.g., solar thermal, compact hot water distribution, and/or drain water heat recovery) whenever a natural gas water heater is installed and require the performance path when electric resistance water heater is installed.

2019 Title 24

- ◆ An ordinance to implement CAP Action J-2 that requires heat pump water heating in all low-rise residential new construction when paired with additional 0.3 kW of solar PV. These measures were shown to be cost effective using the Bill B/C ratio, but not the TDV B/C ratio.
- ◆ Carlsbad may require other efficiency measures (e.g., solar thermal, compact hot water distribution, and/or drain water heat recovery) whenever a natural gas water heater is installed and require the performance path when electric resistance water heater is installed.

I Introduction

The City of Carlsbad engaged TRC to research and analyze the cost effectiveness of proposed energy ordinances exceeding 2016 and 2019 Title 24 Part 6 Building Energy Efficiency Standards (T24). The T24 Standards are the minimum energy efficiency requirements for building construction in California.

The proposed ordinances are shaped by investigating measures that allow a building to perform better than minimum T24 requirements while being cost effective over the lifetime of the measures, as per the requirements in Section 10-106 of the California Code of Regulations. Cost effectiveness analysis may support or justify local ordinances by demonstrating that the building industry and building occupants are not unduly burdened because of the ordinance.

I.1 Scope

TRC has assessed the cost effectiveness of several measures, relevant to both new construction and alterations scenarios, in both residential and nonresidential buildings. TRC determined cost effectiveness by investigating and comparing the costs and energy savings benefits associated with several building energy efficiency measures, described in more detail in *Section 2: Methodology*.

The measures researched in this cost-effectiveness study are solar PV and heat pump water heating. Water heating is among the higher energy-consuming building functions that typically use natural gas for fuel.

I.2 Limitations

This study has the following limitations:

- ◆ **Location.** All analysis performed is intended to be relevant to Carlsbad climate, San Diego Gas and Electric (SDG&E) utility rates, and labor/material costs.
- ◆ **Prototypes.** The prototypes studied are low-rise residential, offices, warehouse, and retail strip mall. Findings may not pertain to accessory dwelling units, high-rise residential, or other commercial spaces, such as restaurants and fitness centers, which have much higher water heating loads.
- ◆ **Existing Conditions.** A wide range of existing conditions are possible in alterations scenarios, such as existing heating, ventilation and air conditioning (HVAC) system, domestic hot water (DHW) system, and electrical infrastructure capacity, and each has a potential to impact measure cost effectiveness. Based on industry engagement and previous research, TRC performed the analysis using one set of assumptions for existing conditions. In some cases, software capabilities dictated existing conditions.
- ◆ **Federal Preemption.** The U.S. Department of Energy (DOE) regulates the minimum efficiencies required for all appliances, such as space conditioning or water heating equipment. State or city codes that mandate appliance efficiencies higher than the DOE's may risk litigation by industry organizations. Consequently, TRC analyzed a federal minimum efficiency heat pump water heater with a Uniform Energy Factor equal to 2.0. 2019 Title 24 allows a HPWH with federal minimum efficiency to prescriptively comply when including a 0.3 kW PV system. In this study, TRC also examined a high efficiency HPWH to reflect the performance of market standard equipment, not to suggest that Carlsbad should mandate high efficiency heat pumps in a local ordinance.
- ◆ **Sensitivity.** The study assumes one set of market conditions at one specific point in time, including utility rates and equipment costs. This study does not analyze potential cost-effectiveness outcomes under a variety of market conditions. For example, TRC assumed that a solar photovoltaic (PV) array would be

purchased by a building owner because it conservatively assumes a large upfront cost, and it simplifies having to develop a long-term leasing mechanism which can vary depending on the lessor or economic conditions.

2 Methodology

TRC analyzed the cost effectiveness of potential ordinance measures by applying them to building prototypes using the CEC's life cycle cost (LCC) methodology, which used to establish the state's cost effective building energy standards (Title 24, Part 6).²

2.1 Cost Effectiveness

TRC determined cost effectiveness by assessing the incremental costs of each measure and comparing them to the energy cost savings over the measure life. Incremental costs represent the equipment, installation, replacements, and maintenance costs of the proposed measure relative to the 2016 or 2019 Title 24 Standards minimum requirements. We estimated savings using both time dependent valuation (TDV) of energy and utility bill rates:

- ◆ **TDV** is a normalized monetary format developed and used by the CEC 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. The 2016 or 2019 TDV values are based on long term discounted costs—30 years for all residential measures and 15 years for all nonresidential measures except envelope measures.
- ◆ **Utility bill impacts** are estimated for each calendar month for electricity and natural gas consumption for each prototype using Title 24 compliance simulation software outputs and spreadsheets. TRC used the below SDG&E rates to estimate bill impacts, which include net energy metering:³
 - ◆ Residential: DR-SES for electricity and GR for gas.
 - ◆ Commercial: TOU-A or AL-TOU for electricity and GN-3 for gas

The EECC commodity rate plan is implemented in conjunction with the TOU-A and AL-TOU rate schedules for buildings with less than 20 kW and greater than 20 kW of monthly peak demands, respectively.

TRC obtained measure costs through interviews with California contractors and distributors and reviewed online sources, such as Home Depot and RS Means. We added taxes and contractor markups as appropriate. Please find detailed costs in *Appendix B: Cost Data*. Measure costs are the same when comparing to either TDV or utility bill savings.

TRC performed a net present value (NPV) calculation over 30 years for residential and 15 years for nonresidential prototypes, assuming a 3% discount rate and a 2% energy escalation rate. These values are selected to be consistent with the CEC LCC methodology and studies commissioned by the CEC. TRC uses a benefit to cost (B/C) ratio as the cost effectiveness metric. If the benefits of a measure are positive and greater than the costs of the measure, then the B/C ratio will be greater than 1.0 and the measure or package is considered cost effective.

2.2 Prototypes

TRC estimated the energy impacts of most measures using CEC-approved modeling software. TRC used CBECC-Res 2019.0.9 to simulate the residential prototypes and CBECC-Com 2016.3.0 for the nonresidential prototypes

² 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

³ Available at: <https://www.sdge.com/rates-and-regulations/current-and-effective-tariffs>.

in California climate zone 7 (CZ7).⁴ TRC used seven prototypes as the basis for determining cost effectiveness, coordinated with the City of Carlsbad:

- ◆ 2,100 ft² single-family single-story home
- ◆ 2,700 ft² single-family two-story home
- ◆ 6,960 ft² low-rise multifamily residential building, with two stories and eight dwelling units
- ◆ 5,502 ft² one-story small office building
- ◆ 53,628 ft² three-story medium office building
- ◆ 49,495 ft² one-story warehouse building
- ◆ 9,375 ft² retail strip mall

Prototypes are based on CEC prototypes in the Residential and Nonresidential Alternate Calculation Method Manuals, with equal geometry oriented facing north, east, south, and west.⁵ The prototype geometries were developed with both new construction and alterations characteristics. The residential new construction prototypes meet 2019 Title 24 prescriptive requirements. The commercial new construction prototypes meet 2016 T24 prescriptive requirements and the alterations prototypes use estimated characteristics for buildings constructed prior to an energy code. See *Section 3 Measure Descriptions* for further detail on why the T24 code baselines differed for residential and nonresidential buildings, and for the City of Carlsbad's list of measure action items. A summary of baseline prototype characteristics is available in *Appendix A: Prototype Details*.

Solar PV

The residential baseline prototypes include PV arrays that are automatically sized by the compliance software based on the electrical consumption of a prescriptive mixed-fuel home. Electrifying one or more appliances does not automatically increase the PV size in the model in the baseline model. TRC includes the costs and energy savings associated with increasing the PV array size from the baseline model's automatically sized PV array.

CBECC-Com is not currently capable of simulating solar PV. For this study, TRC instead determined the PV output of a solar array in CZ7 using CBECC-Res and then applied the outputs to CBECC-Com hourly results. During periods of over-generation (i.e., when electricity from the PV system is being fed into the grid), the TDV of the PV output needs to be reduced to fairly portray the value of solar export relative to TDV associated with reducing energy consumption. TRC reduced the TDV associated with solar output by removing the retail rate adder component of the calculation.

⁴ More information on CBECC-Res available at: <http://www.bwilcox.com/BEES/BEES.html>. More information on CBECC-Com available at: <http://bees.archenergy.com/software.html>

⁵ Available at: <https://www.energy.ca.gov/title24/2016standards/>

3 Measure Descriptions

TRC investigated HPWH and solar PV measures intended to reduce greenhouse gas emissions associated with fossil fuels that were provided by the Center for Sustainable Energy and the City of Carlsbad. TRC recommended that Carlsbad investigate HPWH and PV measures in different code cycles (2016 and 2019 T24) for residential and nonresidential measures because:

- ◆ 2019 T24 includes prescriptive compliance pathways for HPWH and includes solar PV requirements for residential buildings only (see Section 3.1 for more detail). Measures based on 2019 T24 requirements will simplify compliance for the local building industry when the new T24 code is implemented on January 1, 2020.
- ◆ 2016 T24 does not include prescriptive compliance pathways for HPWH or solar PV for nonresidential buildings. Measures that require HPWH and solar PV would require building industry outreach and education efforts under either 2016 or 2019 T24. Thus, a nonresidential ordinance could be enacted earlier to begin reducing emissions earlier.

TRC investigated the following measures:

1. **Individual Water Heating Measures** – Per Carlsbad’s CAP Thermal Ordinance Measure J-2, TRC investigated requiring HPWH or electric resistance water heating in nonresidential new construction under 2016 T24.
2. **Individual Solar PV Measures** – TRC investigated the following nonresidential measures under 2016 T24.
 - a. New Construction – PV Ordinance Measure B-1
 - i. Require a minimum of 5 kW PV for all nonresidential new construction under 10,000 ft²
 - ii. Require 15 kW PV per 10,000 ft² for nonresidential new construction ≥ 10,000 ft²
 - b. Alterations – PV Ordinance Measure B-2. For existing nonresidential buildings that have roof additions ≥ 2,000 ft² and/or with a permit valuation of ≥ \$1,000,000 that affect ≥ 75 percent of the building
 - i. Require a minimum of 5 kW PV on buildings < 10,000 ft²
 - ii. Require 15 kW PV per 10,000 ft² on buildings ≥ 10,000 ft²
3. **Packaged Measures** – TRC packaged electric water heating and solar PV measures together.
 - a. Nonresidential New Construction (2016 Title 24) – PV Ordinance Measure B-1 & Thermal Ordinance Measure J-2
 - i. Require the installation of a HPWH or electric resistance water heating.
 - ii. Require a minimum of 5 kW PV for all nonresidential new construction < 10,000 ft².
 - iii. Require 15 kW PV per 10,000 ft² for all nonresidential new construction ≥ 10,000 ft².
 - b. Residential New Construction (2019 Title 24) – Thermal Ordinance Measure J2
 - i. Require the installation of a HPWH for domestic hot water needs.
 - ii. Require 0.3 kW PV in addition to 2019 Title 24 PV requirements per HPWH.

TRC investigated electric resistance water heating in nonresidential buildings because nonresidential buildings typically have very low service hot water demand, and consequently have small tank (~15 gallons) or tankless hot water systems installed. Tankless heat pump water heaters are not yet readily available on the market, thus TRC investigated electric resistance water heaters as an alternative.

TRC developed specific measure characteristics, such as appropriate manufacturers and efficiency levels, by requiring that the measure must be readily available in the Carlsbad region and that the measure may not

trigger federal preemption. Please see *Appendix B: Cost Data* for disaggregated costs. TRC estimated the cost effectiveness of individual measures and as part of packages for relevant building types, described in *Section 4 Cost Effectiveness Results*.

3.1 Electric Water Heating

In general, heat pumps use a refrigeration cycle to absorb heat from one medium and reject heat to another medium. HPWHs have tanks and require an air supply for heat rejection, which can be either ambient or ducted. They can be installed in conditioned or unconditioned spaces, though locating a HPWH in conditioned space will impact space conditioning loads.⁶⁶ The size and shape of the HPWH is comparable to a natural gas storage water heater, and condensate draining is required. HPWHs can produce similar temperatures to natural gas water heaters under typical weather conditions but may occasionally need to switch to an electric resistance mode in cold weather.

2019 T24 offers several prescriptive paths for residential DHW compliance, including pathways for HPWHs. The prescriptive pathways in 2019 Title 24 Section 150.1(c)8, and which would yield zero TDV savings benefits by definition, are summarized below for CZ7:

1. Gas instantaneous water heater
2. Gas storage water heater < 55 gallons + low U-factor fenestration + one of:
 - a. compact HW distribution or
 - b. drain water heat recovery
3. Gas storage water heater > 55 gallons
4. HPWH + one of:
 - a. compact HW distribution and drain water heat recovery, or
 - b. 0.3 kW PV system
5. HPWH meeting Northeast Energy Efficiency Alliance (NEEA) Advanced Water Heater Specification Tier 3

Federal preemption prevents the City of Carlsbad from mandating a higher than minimum efficiency level.⁷ Nonetheless, TRC simulated both federal minimum heat pump water heating and NEEA Tier 3 heat pump water heating efficiency levels to explore a variety of cost effectiveness scenarios. Tier 3 HPWH are more prevalent on the market than HPWH meeting federal minimum efficiency, and there does not appear to be a correlation between HPWH efficiency and cost. Since the federal minimum efficiency for a smaller 50-gallon water heater is electric resistance rather than heat pump equipment, both Tier 3 and federal minimum water heaters were simulated with a 66-gallon tank size to fully avoid any potential preemption concerns.

- ◆ **Relevance:** Residential and nonresidential new construction.
- ◆ **Baseline assumptions:** TRC assumed one water heater in the single story single-family prototype, nonresidential prototype, and each multifamily dwelling unit.⁸

⁶⁶ TRC modeled HPWHs located in conditioned space.

⁷ Federal minimum efficiencies for water heaters are available at: https://www.ecfr.gov/cgi-bin/text-idx?SID=80dfa785ea350ebee184bb0ae03e7f0&mc=true&node=se10.3.430_132&rgn=div8

⁸ When a HPWH is selected, the CBECC-Res standard model assumes that a HPWH is in conditioned space. This impacts space conditioning loads, which are also reflected in the standard model.

- ◆ Residential: Gas tankless water heater, EF=0.82, 20-year EUL based on DEER. 125V, 20A circuit as per prescriptive T24 requirements. Floor drain required. Flushing required every five years by a service professional.
- ◆ Nonresidential:
 - ◆ Gas water heater, 15 gallons, EF=0.68, 15-year EUL based on DEER. 120V, 20A circuit. Floor drain required.
- ◆ **Proposed measure:**
 - ◆ Residential: HPWH, UEF=3.1 (NEEA Tier 3) or federal minimum efficiency (EF=2.0). 66 gallons. 15-year EUL based on DEER. 240V, 30A circuit. Located in conditioned space, non-ducted, including condensate drained to a floor drain. No additional maintenance that requires a service professional.
 - ◆ Nonresidential:
 - ◆ HPWH, UEF=3.1 (Tier 3) or federal minimum efficiency (EF=2.0), 66 gallons. Same specifications as residential HPWH above.
 - ◆ Electric storage water heater, 15 gallons, EF=0.95, 15-year EUL based on DEER. 240V, 30A circuit. Floor drain required.

Cost sources: Home Depot, Lowes, EComfort, DEER, contractor interviews.

3.2 Solar Photovoltaics

2019 Title 24 prescriptively requires installation of solar PV on residential new construction, but neither 2016 nor 2019 does so for nonresidential new construction. TRC assumed that all renewable energy would be generated on-site through a solar PV installation. This represents the highest potential upfront cost and assumes that off-site procurement would be more economical.

TRC applies savings from the federal income tax credit (ITC). Because it is scheduled to be phased out between 2020 and 2022, an average ITC of 16% is used for residential systems and 19% for commercial systems. While the long-term availability of the ITC is unknown, TRC assumes that the ITC will be available during the majority of Carlsbad's local ordinance implementation.

- ◆ **Relevance:** Nonresidential new construction and alterations, residential new construction
- ◆ **Baseline assumptions:** No solar PV installed for nonresidential, prescriptive PV for residential
- ◆ **Proposed measure:**
 - ◆ Residential new construction: 0.3 kW solar PV per HPWH
 - ◆ Nonresidential new construction, and for existing nonresidential buildings that have roof additions $\geq 2,000$ ft² and/or with a permit valuation of $\geq \$1,000,000$ that affect 75 percent or more of the building:
 - ◆ 15 kW solar PV per 10,000 ft² on buildings with gross floor area of $\geq 10,000$ ft²
 - ◆ 5 kW solar PV on buildings with $< 10,000$ ft²

◆ **Cost sources:** NREL, LBNL^{9,10}

Note that TDV savings for solar PV during time of export are calculated by assuming all TDV components except the retail adjustment.¹¹ The solar PV sizing definitions result the in the following PV sizes for each prototype, as show in Figure 4 below.

	Small Office	Medium Office	Warehouse	Retail Strip Mall
Gross Floor Area (ft ²)	5,502	53,628	49,495	9,375
Solar PV Rule	5 kW	15 kW/ 10,000 ft ²	15 kW/ 10,000 ft ²	5 kW
Solar PV Size	5 kW	80 kW	74 kW	5 kW

Figure 4: Nonresidential PV Sizing

⁹ F. Ran et al. (September 2016) U.S. Solar Photovoltaic System Cost Benchmark: Q1 2016. National Renewable Energy Laboratory. Available at: <https://www.nrel.gov/docs/fy16osti/66532.pdf>

¹⁰ Barbose, G. and Darghouth, N. (September 2017) Tracking the Sun 10. Lawrence Berkeley National Laboratory. Available at: http://eta-publications.lbl.gov/sites/default/files/tracking_the_sun_10_report.pdf

¹¹ Correspondence with Environment, Energy and Economics (E3). August 5th, 2018.

4 Cost Effectiveness Results

Cost effectiveness results are presented in this section for residential and nonresidential measures, separately for new construction and alteration measures. Each measure or package cost effectiveness is provided within an individual row. Because of the impact of PV generation, net metering credits, and monthly minimum charges, an individual measure's energy impacts (both TDV and Bill) may not sum to the package. Similarly, the kWh and therms savings, multiplied by the utility rates, will not equate to the NPV bill impacts.

Cost effectiveness is determined over a 15-year or 30-year lifespan (as described in *Methodology*), including first costs, equipment replacements, maintenance, and energy savings. TRC uses a benefit to cost (B/C) ratio as the cost effectiveness metric. If the benefits of a measure are positive and greater than the costs of the measure, then the B/C ratio will be greater than 1.0 and the measure or package is considered cost effective. Within each prototype results, therms savings vary by type of water heater because water heaters are located in conditioned space and affect space heating loads slightly differently.

Results are sensitive to the assumptions outlined in *Section 3 Measure Descriptions*. Measures that are not cost effective by a few hundred dollars over a 30-year timespan may be easily switched to being cost effective (and vice versa) through minor changes in assumptions and/or changes in the policies underlying those assumptions. Cells highlighted in green emphasize that measures or packages are cost effective.

4.1 Residential New Construction

Single-family and low-rise multifamily new construction results are presented below in Figure 5 and Figure 6. Single family results represent averages of the 2,100 ft² and 2,700 ft² prototypes.

TRC analyzed new construction residential buildings for heat pump water heating with 0.3 kW PV per water heater in addition to 2019 Title 24 prescriptive PV requirements. A federal minimum efficiency HPWH paired with 0.3 kW PV is a 2019 T24 prescriptive pathway (see *Section 3.1 Electric Water Heating* item 4.b), so this package produces \$0 of TDV savings. Similarly, a Tier 3 HPWH is also a 2019 T24 prescriptive compliance pathway and produces \$0 of TDV savings by itself, so the TDV Savings of the Tier 3 HPWH + 0.3 kW PV are due solely to the PV system. Results in Figure 5 and Figure 6 show that the HPWH with PV measure is cost effective by using Bill B/C ratio though not by TDV B/C ratio.

Average Single Family New Construction	kWh savings	therms savings	Life cycle Costs	\$TDV savings	\$Bill savings	B/C ratio (TDV)	B/C ratio (Bill)
Federal Min. Efficiency HPWH + 0.3 kW PV	-919	104	\$1,533	\$0	\$1,704	0.0	1.1
Tier 3 HPWH + 0.3 kW PV	-297	103	\$1,533	\$841	\$3,146	0.5	2.1

Figure 5: Average Single-family New Construction Cost Effectiveness Summary

In the multifamily building, HPWHs with PV are cost effective using the Bill B/ C Ratio (Figure 6). Multifamily TDV Savings are approximately eight times that of single family since there are eight units in the multifamily residential prototype. Multifamily Bill Savings, however, are more than eight times greater than that of single family because the energy usage of the eight HPWHs in the multifamily building is only about five times as great as one HPWH, thus having eight times as much solar PV system has a greater net effect. The lack of a one-to-one relationship between HPWHs and energy usage can be explained in part by the smaller dwelling unit size in the multifamily prototype.

Multifamily New Construction	kWh savings	therms savings	Life cycle Costs	\$TDV savings	\$Bill savings	B/C ratio (TDV)	B/C ratio (Bill)
Federal Min. Efficiency HPWH + 0.3 kW PV	-3,244	582	\$12,262	\$0	\$36,233	0.0	3.0
Tier 3 HPWH + 0.3 kW PV	-135	547	\$12,262	\$6,674	\$39,385	0.5	3.2

Figure 6: Multifamily New Construction Cost Effectiveness Summary

4.2 Nonresidential

Small office, medium office, warehouse, and retail strip mall new construction and alterations results are presented below in Figure 7 through Figure 11.

4.2.1 New Construction

TRC analyzed new construction buildings for heat pump water heating and solar PV. As shown in Figure 7 through Figure 10, electric water heating alone is not cost effective by TDV or Bill B/C ratio in any nonresidential new construction case. Solar PV and solar PV + HPWH show both TDV and Bill B/C ratios greater than 1 in every case, except that of the retail strip mall with a federal minimum efficiency HPWH or electric resistance water heating.

Small Office New construction	kWh savings	therms savings	Life-cycle Costs	\$TDV savings	\$Bill savings	B/C ratio (TDV)	B/C ratio (Bill)
5 kW PV	8,190	0	\$10,494	\$17,595	\$27,682	1.7	2.6
Federal Min Efficiency HPWH	-2,272	252	\$1,619	-\$1,624	-\$5,281	-1.0	-3.3
Federal Min Efficiency HPWH + 5 kW PV	5,919	252	\$11,857	\$15,971	\$22,402	1.3	1.9
Tier 3 HPWH	-1,241	249	\$1,619	\$900	-\$1,761	0.6	-1.1
Tier 3 HPWH + 5 kW PV	6,949	249	\$11,857	\$18,495	\$25,922	1.6	2.2
Electric Resistance WH	-2,629	248	-\$939	-\$2,564	-\$6,550	< 1	< 1
Electric Resistance WH + 5 kW PV	5,561	248	\$9,556	\$15,032	\$21,133	1.6	2.2

Figure 7: Small Office New Construction Cost Effectiveness Summary

Medium Office New Construction	kWh savings	therms savings	Life-cycle Costs	\$TDV savings	\$Bill savings	B/C ratio (TDV)	B/C ratio (Bill)
80 kW PV	131,764	0	\$168,835	\$268,099	\$346,008	1.6	2.0
Federal Minimum Efficiency HPWH	-9,802	449	\$1,619	-\$17,121	-\$36,717	-10.6	-22.7
Federal Minimum Efficiency HPWH + 80 kW PV	121,962	449	\$170,198	\$251,536	\$309,808	1.5	1.8
Tier 3 HPWH	-6,311	433	\$1,619	-\$8,614	-\$20,535	-5.3	-12.7
Tier 3 HPWH + 80 kW PV	125,454	433	\$170,198	\$259,864	\$326,188	1.5	1.9
Electric Resistance WH	-14,087	495	-\$939	-\$27,269	-\$60,700	< 1	< 1
Electric Resistance WH + 80 kW PV	117,677	495	\$167,896	\$241,478	\$284,372	1.4	1.7

Figure 8: Medium Office New Construction Cost Effectiveness Summary

Warehouse New Construction	kWh savings	therms savings	Life-cycle Costs	\$TDV savings	\$Bill savings	B/C ratio (TDV)	B/C ratio (Bill)
74 kW PV	121,609	0	\$155,823	\$223,221	\$272,625	1.4	1.7
Federal Minimum Efficiency HPWH	-2,673	182	\$1,619	-\$3,425	-\$8,990	-2.1	-5.6
Federal Minimum Efficiency HPWH + 74 kW PV	118,936	182	\$157,186	\$220,765	\$264,219	1.4	1.7
Tier 3 HPWH	-1,553	172	\$1,619	-\$927	-\$4,493	-0.6	-2.8
Tier 3 HPWH + 74 kW PV	120,056	172	\$157,186	\$222,872	\$268,272	1.4	1.7
Electric Resistance	-2,757	171	-\$939	-\$3,797	-\$11,340	< 1	< 1
Electric Resistance + 74 kW PV	118,852	171	\$154,885	\$220,609	\$262,224	1.4	1.7

Figure 9: Warehouse New Construction Cost Effectiveness Summary

Retail Strip Mall New Construction	kWh savings	therms savings	Life-cycle Costs	\$TDV savings	\$Bill savings	B/C ratio (TDV)	B/C ratio (Bill)
5 kW PV	8,190	0	\$10,494	\$17,583	\$22,026	1.7	2.1
Federal Minimum Efficiency HPWH	-3,205	141	\$1,619	-\$6,445	-\$7,630	-4.0	-4.7
Federal Minimum Efficiency HPWH + 5 kW PV	4,985	141	\$11,857	\$11,145	\$14,035	0.9	1.2
Tier 3 HPWH	-1,352	127	\$1,619	-\$1,871	-\$435	-1.2	-0.3
Tier 3 HPWH + 5 kW PV	6,838	127	\$11,857	\$15,716	\$20,740	1.3	1.7
Electric Resistance	-4,857	138	-\$939	-\$11,012	-\$15,791	< 1	< 1
Electric Resistance + 5 kW PV	3,333	138	\$9,556	\$6,577	\$6,462	0.7	0.7

Figure 10: Retail Strip Mall New Construction Cost Effectiveness Summary

4.2.2 Alterations

TRC analyzed alterations buildings for solar PV. The cost of installing PV in a retrofit is approximately \$0.25/W higher than new construction costs. As shown in Figure 11, solar PV remains cost effective using both TDV and Bill B/C ratios.

Alterations Prototype	kWh savings	therms savings	Life-cycle Costs	\$TDV savings	\$Bill savings	B/C ratio (TDV)	B/C ratio (Bill)
Small Office, 5 kW PV	8,190	0	\$11,503	\$17,596	\$28,563	1.5	2.5
Medium Office, 80 kW PV	131,764	0	\$185,057	\$272,452	\$453,105	1.5	2.4
Warehouse, 74 kW PV	121,609	0	\$166,083	\$234,348	\$278,098	1.4	1.7
Retail Strip mall, 5 kW PV	8,190	0	\$11,503	\$17,593	\$34,962	1.5	3.0

Figure 11: Nonresidential Alterations Cost Effectiveness Summary

5 Conclusions and Recommendations

TRC provides these conclusions and recommendations based on the cost-effectiveness findings.

5.1 2019 Residential New Construction

5.1.1 Heat Pump Water Heating and Solar PV – Thermal Ordinance Measure J-2

Both federal minimum efficiency and Tier 3 heat pump water heating systems, when paired with 0.3 kW of additional PV per water heater, are cost effective using a Bill B/C ratio, but not a TDV B/C ratio. This suggests that TDV rate assumptions do not align with current SDG&E utility rates.

While Tier 3 HPWH analysis was performed to provide a market-ready alternative to a federally minimum compliant HPWH, Carlsbad cannot mandate an equipment efficiency higher than the federal minimum without triggering federal preemption.¹² As described in *Section 3 Measure Descriptions*, HPWHs are prescriptively allowed in the 2019 Title 24 through the following pathways:

- ◆ Heat pump water heater + 0.3 kW PV system
- ◆ Heat pump water heater + compact HW distribution and drain water heat recovery
- ◆ Tier 3 heat pump water heater

These cost effectiveness findings support reach code requirements for only the first implementation pathway (HPWH + PV), but the alternate pathways may also comply with the reach code:

- ◆ Some property developers may wish to install natural gas water heaters. To accommodate these developers, Carlsbad may allow natural gas water heaters to be installed when accompanied by higher efficiency measures, such as solar thermal collectors, compact hot water distribution, and/or drain water heat recovery.
- ◆ 2019 Title 24 does not describe a prescriptive path for electric resistance water heaters. Property developers can choose to install an electric resistance water heater but would have to compensate in other areas of the home through the performance path. Carlsbad may require the performance path when installing an electric resistance water heater.

TRC recommends that Carlsbad coordinate with the CEC on how to appropriately require HPWH + PV systems as a reach measure, while providing adequate options for the building community.

5.2 2016 Nonresidential New Construction

5.2.1 Solar PV – PV Ordinance Measure B-1

Solar PV on nonresidential new construction is cost effective using both the TDV and Bill B/C ratios. TRC recommends a prescriptive compliance pathway based on gross floor area which would require:

- ◆ Nonresidential new construction buildings of 10,000 ft² or more to install a minimum of 15 kW of solar PV per 10,000 ft² of gross floor area.
- ◆ Nonresidential new construction buildings less than 10,000 ft² to install 5 kW of solar PV.

¹² Federal minimum efficiencies for water heaters are available here: https://www.ecfr.gov/cgi-bin/text-id.x?SID=80dfa785ea350eb0ee184bb0ae03e7f0&mc=true&node=se10.3.430_132&rgn=div8

These PV sizing requirements generally fall well short of the utility limits on PV array sizes that are intended to mitigate widespread overgeneration. The only exception may be that a 5 kW PV array may generate more electricity than consumed over the course of a year in a small building (e.g., < 3,000 ft²). Carlsbad may wish to allow smaller PV sizes or other exceptions for buildings that demonstrate that they will over generate with a 5 kW PV size.

5.2.2 Electric Water Heating – Thermal Ordinance Measure J-2

Electric water heating alone was not cost effective using either TDV or Bill B/C ratios in any nonresidential prototype. TRC does not recommend requiring electric water heating individually.

5.2.3 Solar PV and Electric Water Heating – PV Ordinance Measure B-1 & Thermal Ordinance J-2

Solar PV paired with electric water heating is cost effective using both TDV and Bill B/C ratios in every nonresidential prototype, except in the retail strip mall. The retail strip mall is cost effective with a HPWH and solar PV using the Bill B/C ratio, but not the TDV B/C ratio, because it has a very small hot water heating load.

TRC recommends that Carlsbad provide property developers with options of different types of water heating technologies while making heat pump water heaters the default choice. Carlsbad may choose to require other efficiency measures (e.g., solar thermal) whenever a natural gas water heater is installed and require the performance path when electric resistance water heater is installed.

There City of Carlsbad may seek to develop policy for two building types that that were not investigated directly in this study:

1. **High rise multifamily buildings:** Because CBECC-Res and CBECC-Com hot water simulation algorithms are identical for low-rise or high-rise multifamily dwelling units, TRC suggests that low-rise multifamily family building results may also be applicable to high-rise multifamily buildings that have individual water heaters at each dwelling unit. TRC found that in low-rise multifamily buildings with individual heat pump water heaters at each dwelling unit, plus PV, was cost effective.
2. **Service water heating in restaurants:** While a restaurant prototype was not studied in-depth, cost effectiveness trends in Figure 5 through Figure 10 indicate that heat pump water heaters plus PV are cost effective with higher hot water demands (i.e., therms savings). For example, the Retail Strip Mall had the lowest hot water consumption and was less cost effective than the other scenarios. The 2,500 ft² small restaurant prototype service hot water system has a hot water demand (~600 therms/year) slightly higher than the prototypes analyzed in this study (e.g., medium office with ~450 therms/year). Thus, it is probable that service water heating in restaurants would also be cost effective with HPWH + PV.

5.3 2016 Nonresidential Alterations

5.3.1 Solar PV – PV Ordinance Measure B-2

Solar PV on nonresidential alterations is cost effective using both a TDV and Bill B/C ratio. TRC recommends a prescriptive compliance pathway based on gross floor area which would require nonresidential buildings that have roof additions $\geq 2,000$ ft² and/or with a permit valuation of $\geq \$1,000,000$ that affect ≥ 75 percent of the building to install a minimum of:

- ◆ 5 KW PV on buildings < 10,000 ft²
- ◆ 15 kW of solar PV per 10,000 ft² of gross floor area on buildings on buildings $\geq 10,000$ ft²

Appendix A: Prototype Details

New construction prototypes baseline characteristics are summarized in Figure 12 and Figure 13, and they are based on prescriptive 2019 T24 requirements.

Building Type	One-Story	Two-Story	Low-Rise Multifamily
Dwelling Units	1	2	8
Area (ft ²)	2,100	2,700	6,960
Roof Area (ft ²)	2,540	1,690	3480
# of floors	1	2	2
Window-to-Floor Area Ratio	20%	20%	15%
HVAC System	Central Ducted Split Air Conditioner with Gas Furnace		
HVAC Distribution System	Ducts in Attic	Ducts in Attic	Ducts in Conditioned Space
Thermal Zones	1	1	2
Domestic Water Heating	Natural Gas Tankless Water Heater, 0 Gallon Tank, EF=0.82		8x Natural Gas Tankless Water Heater, 0 Gallon Tank, EF=0.82

Figure 12: Residential Baseline Prototypes Summary

Building Type	Medium Office	Small Office	Warehouse	Retail Strip Mall
Floor Area (ft ²)	53,628	5,502	49,495	9,375
# of Floors	3	1	1	1
Window-to-Floor Area Ratio	13%	11%	0.4%	6%
HVAC Distribution System	3x Packaged Variable Air Volume with VAV Hot Water Reheat	5x Packaged Single Zone Air Conditioners	3x Packaged Single Zones	4x Packaged Single Zone Air Conditioners
Cooling System	Direct Expansion, 9.8 EER, Economizer	Direct Expansion, 13 SEER, No Economizer	Direct Expansion, 11.0 EER, Economizer	Direct Expansion, 11.0 EER, Economizer
Heating System	Boiler, 80% Thermal Efficiency	Furnace, 78% AFUE	Furnace, 78% AFUE	Furnace, 78% AFUE
Conditioned Thermal Zones	18	5	3	4
Domestic Water Heating	Natural Gas Small Storage, EF = 0.64	Natural Gas Small Storage, EF = 0.71	Natural Gas Small Storage, EF = 0.67	Natural Gas Small Storage, EF = 0.65

Figure 13: Nonresidential Baseline Prototypes Summary

Figure 14 and Figure 15 compare the building characteristics for new construction and alteration scenarios. TRC simulated alteration prototypes with “pre-code” conditions according to the Residential Compliance Manual Appendix B to estimate the energy impact of measures in alteration scenarios.¹³ Generally, we assumed building characteristic that pre-date code without substantial upgrades. While lighting or fenestration upgrades are likely over time, we used pre-code characteristics to represent the highest potential energy usage in the building stock, while the new construction code represent the lowest potential energy usage.

The differences between pre-code and new construction nonresidential prototypes applies to envelope characteristics and lighting power density (see Figure 15); while for residential prototypes, the differences apply to HVAC characteristics as well.

¹³ Available at: <http://www.energy.ca.gov/2015publications/CEC-400-2015-024/CEC-400-2015-024-CMF-REV3.pdf>

	Component	Pre-Code	New Construction (2019 T24)
Envelope	Attic Insulation (R-value)	13	38
	Radiant Barrier	No	Yes
	Below Roof Deck Insulation (R-value)	0	19
	Window U-Factor	1.28	0.30
	Window SHGC	0.80	0.23
	Infiltration ACH50	10	5
Lighting	Power Adjustment Multiplier	0.63	0.63
	Fraction Portable	0.22	0.22
HVAC	Duct Location	Attic	Attic
	Duct Leakage	10%	5%
	HERS Verified Duct Sealing	No	No
	Duct Insulation (R-value)	2.1	8.0
	IAQ Fan W/cfm	None	0.25
	Whole House Fan	No	No

Figure 14: Residential Pre-code and New Construction Assumptions

Component	Pre-Code	New Construction (2016 T24)
Roof Insulation (R-Value)	8	19.63
Roof Solar Reflectance	0.10	0.63
Wall Insulation (R-Value)	0	14
Window U-Factor	1.23	0.36
Window SHGC	0.71	0.25
Window VT	0.60	0.42
Lighting Power Density (W/ft ²)	1.2	0.75

Figure 15: Nonresidential Pre-code and New Construction Assumptions

Appendix B: Cost Data

Heat Pump Water Heating

Residential: New Construction				
HP Water Heater	<i>Single-Family</i>		<i>Multifamily</i>	
Cost Type	Baseline	Proposed	Baseline	Proposed
First Cost	\$2,494	\$3,158	\$19,951	\$25,264
<i>Water Heater</i>	\$789	\$1,713	\$6,312	\$13,704
<i>Installation</i>	\$1,017	\$945	\$8,136	\$7,560
<i>Flue</i>	\$313	\$0	\$2,504	\$0
<i>Electrical</i>	\$375	\$500	\$3,000	\$4,000
Replacement	\$1,806	\$2,658	\$14,451	\$21,264
Maintenance (per year)	\$59	\$0	\$474	\$0
EUL (years)	20	15	20	15

Figure 16. Residential New Construction Heat Pump Water Heating Costs

Nonresidential: New Construction		
HP Water Heater	<i>All Prototypes</i>	
Cost Type	Baseline	Proposed
First Cost	\$1,919	\$2,658
<i>Water Heater</i>	\$941	\$1,713
<i>Installation</i>	\$666	\$945
<i>Flue</i>	\$313	\$0
Replacement	\$1,606	\$2,658
Maintenance	\$0	\$0
EUL (years)	15	15

Figure 17. Nonresidential New Construction HPWH Costs

Electric Resistance Water Heating

Nonresidential: New Construction		
Electric Resistance Water Heater		All Prototypes
Cost Type	Baseline	Proposed
First Cost	\$1,794	\$1,100
Water Heater	\$600	\$600
Natural Gas Piping	\$550	\$0
Flue	\$313	\$0
Electrical	\$331	\$500
Replacement	\$600	\$600
EUL (years)	15	15

Figure 18. Nonresidential New Construction Electric Resistance Water Heater Costs

Solar PV Measures

Residential: New Construction				
PV	Single-Family		Multifamily	
Cost Type	Baseline	Proposed	Baseline	Proposed
PV Size	0 kW	0.3 kW	0 kW	2.4 kW
First Cost	\$0	\$738	\$0	\$5,907
Cost	\$0	\$879	\$0	\$7,032
ITC	\$0	\$(141)	\$0	\$(1,125)
1 st Inverter Replacement	\$0	\$45	\$0	\$360
2 nd Inverter Replacement	\$0	\$36	\$0	\$288
Maintenance (per year)	\$0	\$6	\$0	\$48
Inverter EUL (years)	n/a	11	n/a	11

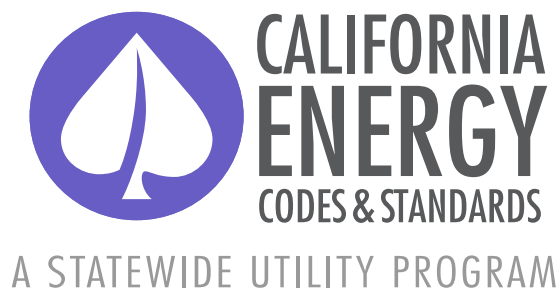
Figure 19. Residential New Construction Solar PV Costs

Nonresidential: New Construction						
PV	<i>Small Office/ Retail Strip Mall</i>		<i>Medium Office</i>		<i>Warehouse</i>	
Cost Type	Baseline	Proposed	Baseline	Proposed	Baseline	Proposed
PV Size	0 kW	5 kW	0 kW	80 kW	0 kW	74 kW
First Cost	\$0	\$8,591	\$0	\$138,215	\$0	\$127,653
Cost	\$0	\$10,650	\$0	\$171,341	\$0	\$158,137
ITC	\$0	\$(2,059)	\$0	\$(33,126)	\$0	\$(30,573)
1 st Inverter Replacement	\$0	\$750	\$0	\$12,066	\$0	\$11,136
2 nd Inverter Replacement	\$0	\$600	\$0	\$9,653	\$0	\$8,909
Maintenance	\$0	\$100	\$0	\$1,609	\$0	\$1,485
Inverter EUL (years)	n/a	11	n/a	11	n/a	11

Figure 20. Nonresidential New Construction Solar PV Costs

Nonresidential: Alterations								
PV	<i>Small Office</i>		<i>Medium Office</i>		<i>Warehouse</i>		<i>Retail Strip Mall</i>	
Cost Type	Baseline	Proposed	Baseline	Proposed	Baseline	Proposed	Baseline	Proposed
PV Size	0 kW	5 kW	0 kW	80 kW	0 kW	74 kW	0 kW	5 kW
First Cost	\$0	\$9,599	\$0	\$154,438	\$0	\$137,824	\$0	\$9,599
Cost	\$0	\$11,900	\$0	\$191,452	\$0	\$176,697	\$0	\$(2,301)
ITC	\$0	\$(2,301)	\$0	\$(37,014)	\$0	\$(38,873)	\$0	\$(2,301)
1 st Inverter Replacement	\$0	\$750	\$0	\$12,066	\$0	\$11,136	\$0	\$750
2 nd Inverter Replacement	\$0	\$600	\$0	\$9,653	\$0	\$8,909	\$0	\$600
Maintenance	\$0	\$100	\$0	\$1,609	\$0	\$1,458	\$0	\$100
Inverter EUL (years)	n/a	11	n/a	11	n/a	11	n/a	11

Figure 21. Nonresidential Alterations Solar PV Costs



Title 24, Parts 6 and 11
Local Energy Efficiency Ordinances

2019 Cost-Effectiveness Study: Existing Low-rise Residential Building Efficiency Upgrade

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Acronyms

ACH50	Air Changes per Hour at 50 pascals pressure differential
ACM	Alternative Calculation Method
AFUE	Annual Fuel Utilization Efficiency
B/C	Lifecycle Benefit-to-Cost Ratio
BEopt	Building Energy Optimization Tool
BSC	Building Standards Commission
CBECC-Res	Computer program developed by the California Energy Commission for use in demonstrating compliance with the California Residential Building Energy Efficiency Standards
CFI	California Flexible Installation
CZ	California Climate Zone
EDR	Energy Design Rating
EER	Energy Efficiency Ratio
HERS Rater	Home Energy Rating System Rater
HVAC	Heating, Ventilation, and Air Conditioning
IOU	Investor Owned Utility
kWh	Kilowatt Hour
MF	Multifamily
NPV	Net Present Value
PG&E	Pacific Gas and Electric Company
SCE	Southern California Edison
SDG&E	San Diego Gas and Electric
SEER	Seasonal Energy Efficiency Ratio
SF	Single Family
CASE	Codes and Standards Enhancement
TDV	Time Dependent Valuation
Title 24	Title 24, Part 6
TOU	Time-Of-Use

1 Overview

The California Codes and Standards Reach Codes team has completed a preliminary cost-effectiveness study for existing building upgrades. This analysis evaluated the feasibility and cost-effectiveness of retrofit measures in California existing homes built before 2006. A customer-based lifecycle cost approach to evaluating cost-effectiveness was applied quantifying the utility cost savings associated with energy efficiency measures compared to the costs associated with the measures. This preliminary study updated a cost-effectiveness study completed in June 2018 (Statewide Reach Codes Team, 2018). The focus of this study was to revisit the recommended retrofit efficiency measure and package cost-effectiveness based on current utility rates and updated measure costs. Additional efforts have been identified that will be evaluated and released in an updated Existing Building Efficiency Upgrade Cost-Effectiveness Study in 2020. These include:

- Revisit base case assumptions for different vintages
- Additional HVAC upgrade options including:
 - High efficiency equipment replacement as alternative to non-preempted upgrade
 - Air sealing and attic insulation at time of HVAC replacement
 - Improved duct insulation, tighter ducts, buried ducts
- Additional building envelope improvements
 - Higher ceiling insulation requirements
 - Address low-slope roof replacements
- Lighting luminaire replacements in addition to lamp replacements
- Evaluation of electrification measures at equipment change-out and electrification-ready
- Additions: Installation of PV system when building an addition, and
- PV System Installation: Additional efficiency upgrade requirements when installing PV

2 Introduction

The California Building Energy Efficiency Standards Title 24, Part 6 (Title 24) (Energy Commission, 2018b) is maintained and updated every three years by two state agencies, the California Energy Commission (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, the 2019 Building Energy Efficiency Standards, effective January 1, 2020, for existing single family and low-rise (one- to three-habitable story) multifamily buildings when a remodel is submitted for permit. This analysis does not apply to high-rise multifamily buildings (four habitable stories or greater), nor to common areas categorized as nonresidential spaces within low-rise multifamily buildings. Each jurisdiction must establish the appropriate threshold for triggering the requirements, often based on the value of the project or percent of floor area impacted. Alternatively, a jurisdiction could require the upgrades described in this analysis at the time of sale or listing of a home. The analysis includes scenarios of individual measures, as well as package upgrades, and identifies cost-effective options based on the existing conditions of the building in all sixteen California Climate Zones (CZ) (see Appendix A – California Climate Zone Map for a graphical depiction of Climate Zone locations).



This analysis does not evaluate the impact of retrofit measures on Title 24 compliance margins, as the proposed measures are required in addition to achieving compliance with all codes. The analysis uses a customer-based lifecycle cost approach for evaluating cost-effectiveness of the proposed upgrades, which requires estimating and quantifying incremental costs and the energy and utility cost savings for each energy efficiency measure. The applied approach establishes recommendations based on existing conditions and cost-effectiveness of each measure or package.

3 Methodology and Assumptions

The general approach applied in this analysis is to evaluate performance and determine cost-effectiveness of various energy retrofit measures, individually and as packages. Both single family and low-rise multifamily cases are considered, for three unique building vintages: pre-1978, 1978-1991, and 1992-2005. The vintages were defined based on review of historic Title 24 code requirements and selecting year ranges with distinguishing features.

The California Building Energy Code Compliance – Residential (CBECC-Res) 2016.3.0 (SP2 977) compliance simulation tool was used to evaluate energy savings for most measures, with the exception of those outside the code compliance scope. In these cases, the National Renewable Energy Laboratory’s Building Energy Optimization (BEopt) v2.8 software and the EnergyPlus v8.8 simulation engine were used.

This analysis builds on the work completed for the 2016 Title 24 code (Statewide Reach Codes Team, 2018) and has been updated to reflect changes in measure costs over time as well as current utility tariffs. Energy simulations were not re-evaluated in CBECC-Res 2019 because there have been minimal updates to the software that impact the energy use results. This was validated by evaluating the pre-1978 basecase model in climate zone 12 with the version of the CBECC-Res software for the 2019 code, and comparing annual energy use with that from the 2016 version of software. Both total electricity and natural gas use differed between the two version by less than one percent. Therefore, this analysis can support ordinances adopted under either the 2016 or 2019 Title 24 code.

3.1 Building Prototypes

The Energy Commission defines building prototypes which it uses to evaluate the cost-effectiveness of proposed changes to Title 24 requirements. For the multifamily analysis, the Energy Commission eight-unit, two-story, multifamily new construction prototype was determined to be representative of low-rise multifamily buildings across the state within the vintages evaluated under this analysis. A single two-bedroom unit was extracted from the multifamily building model because CBECC-Res cannot evaluate building envelope air sealing for multifamily buildings. The two-bedroom unit was modified to be orientation neutral and represent the average properties of a lower floor and upper floor unit. Only individual, in-unit water heating and space conditioning systems were evaluated. Additional details on the multifamily prototype can be found in the Alternative Calculation Method (ACM) Approval Manual (Energy Commission, 2018a).

Average home size has steadily increased over time,¹ and the Energy Commission single family new construction prototypes are larger than many existing single family homes across California. For this analysis an existing home

¹ <https://www.census.gov/const/C25Ann/sfttotalmedavgsgft.pdf>



model developed by the Energy Commission for residential ACM testing² was used with the following revisions. The original model includes an existing 1,440 square foot space and a 225 square foot addition. For this analysis, the entire 1,665 square feet was evaluated as existing space and features (i.e., insulation levels, glazing) were applied consistently across the entire building consistent with the existing home specifications in Table 2. Additions are not addressed in this analysis as they are already addressed by the Title 24, Part 6 code.

Table 1 describes the basic characteristics of each prototype.

Table 1: Prototype Characteristics

	<u>Single Family</u>	<u>Multifamily</u>
Existing Conditioned Floor Area	1,665 ft ²	960 ft ² unit
Num. of Stories	1	1
Num. of Bedrooms	3	2
Window-to-Floor Area Ratio	13%	15%

Three building vintages were evaluated to determine sensitivity of existing building performance on cost-effectiveness of upgrades. For example, it is widely recognized that adding attic insulation in an older home with no insulation is cost-effective, however, newer homes will likely have at least some existing insulation in the attic reducing the potential savings from the measure. The building characteristics for each vintage were determined based on either prescriptive requirements from the Title 24 code that was in effect or standard construction practice during that time period. Based on the vintages selected, this analysis covers homes built before 2006. Homes built between 2006 and 2012 are expected to be similar in envelope characteristics to the 1992-2005 era homes, but include higher performing HVAC.

Table 2 summarizes the assumptions for each of the three vintages. Additionally, the analysis assumed the following features when modeling the prototype buildings:

- Individual space conditioning and water heating systems, one per apartment or single family building. Multifamily buildings with central HVAC or water heating systems were not considered in this evaluation.
- Split-system air conditioner with gas furnace. Efficiency defined by year of the most recent equipment replacement (based on standard equipment lifetime).
- Small storage gas water heater. Efficiency defined by year of most recent equipment replacement (based on standard equipment lifetime).
- Gas cooktop, oven, and clothes dryer.

² Residential ACM test U12 can be accessed at the following website:
<http://www.bwilcox.com/BEES/cbecc2016.html>



Table 2: Efficiency Characteristics for Three Vintage Cases

<u>Building Component Efficiency Feature</u>	<u>Vintage Case</u>		
	<u>Pre-1978</u>	<u>1978-1991</u>	<u>1992-2005</u>
<i>Envelope</i>			
Exterior Walls	2x4 16"oc wood frame, R-0	2x4 16"oc wood frame, R-11	2x4 16"oc wood frame, R-13
Foundation Type & Insulation	Raised floor, R-0	Uninsulated slab (CZ 2-15) Raised floor, R-0 (CZ 1 & 16)	Uninsulated slab (CZ 1-15) Raised floor, R-19 (CZ 16)
Ceiling Insulation & Attic Type	Vented attic, R-11 @ ceiling level Vented attic, R-5 @ ceiling level (CZ 6 & 7)	Vented attic, R-19 @ ceiling level	Vented attic, R-19 @ ceiling level
Roofing Material & Color	Asphalt shingles, dark	Asphalt shingles, dark	Asphalt shingles, dark
Radiant Barrier	No	No	No
Window Type: U-factor / SHGC ¹	Metal, single pane: 1.16 / 0.76	Metal, dual pane: 0.79 / 0.70	Vinyl, dual pane Low-E: 0.55 / 0.40
House Infiltration	10 ACH50	10 ACH50	7 ACH50
<i>HVAC Equipment²</i>			
Heating Efficiency	78 AFUE (assumes 1 replacement)	78 AFUE (assumes 1 replacement)	78 AFUE
Cooling Efficiency	9.7 SEER (assumes 1 replacement)	9.7 SEER (assumes 1 replacement)	9.7 SEER
Duct Location & Details	Attic, R-2.1, 30% leakage	Attic, R-2.1, 25% leakage	Attic, R-4.2, 25% leakage
Whole Building Mechanical Ventilation	None	None	None
<i>Water Heating Equipment²</i>			
Water Heater Efficiency	0.575 Energy Factor (assumes 2 replacements)	0.575 Energy Factor (assumes 1 replacement)	0.575 Energy Factor
Water Heater Tank	40gal uninsulated tank	40gal uninsulated tank	40gal uninsulated tank
Pipe Insulation	None	None	None
Hot Water Fixtures	Standard, non-low flow	Standard, non-low flow	Standard, non-low flow

¹ Window type selections were made based on conversations with window industry expert, Ken Nittler. If a technology was entering the market during the time period (e.g. Low-E during 1992-2005 or dual pane during 1978-1991) that technology was included in the analysis. This provides a conservative assumption for overall building performance and additional measures may be cost effective for buildings with lower performing windows, for example buildings with metal single pane windows in the 1978-1991 vintage.

²Multifamily analysis assumes one HVAC and water heating system per apartment.



3.2 Efficiency Measures

The methodology used in the analyses for each of the prototypical building types begins with a design that matches the specifications as described in Table 2 for each of the three vintages. Prospective energy efficiency measures were modeled in each of the prototypes to determine the projected electricity and natural gas energy savings relative to the baseline vintage. In some cases, where logical, measures were packaged together. Unless specified otherwise, all measures were evaluated using CBECC-Res.

All measures are evaluated based on work required above and beyond any work triggered by Title 24 code requirements. Measures apply regardless of the scope of the remodel and are evaluated assuming they are not otherwise required by Title 24. For example, duct sealing is required by code whenever heating and cooling equipment is altered. For this analysis duct sealing was evaluated for those projects where it is not already triggered by code (i.e., no changes to the heating or cooling equipment). Where appropriate, measure requirements align with those defined in Title 24. The one exception is the cool roof measure which applies when a building is already installing a new roof as part of the remodel. The minimum solar reflectance value is more stringent than that required in Title 24, Part 6.

Following are descriptions of each of the efficiency upgrade measures applied in this analysis.

Attic Insulation: Add attic insulation in buildings with vented attic spaces to meet R-38.

Air Sealing & Weather-stripping: Apply air sealing practices throughout all accessible areas of the building. For this study, it was assumed that older vintage buildings would be leakier than newer buildings and that approximately 30% improvement in air leakage was achievable through air sealing of all accessible areas. For modeling purposes, it was assumed that air sealing can reduce infiltration levels from 10 to 7 air changes per hour at 50 Pascals pressure difference (ACH50) in the two older vintages (pre-1992) and from 7 to 5 ACH50 in the newer vintage.

Cool Roof: For steep slope roofs, install a roofing product rated by the Cool Roof Rating Council (CRRC) with an aged solar reflectance of 0.25 or higher and thermal emittance of 0.75 or higher. This measure only applies to buildings that are installing a new roof as part of the scope of the remodel; the cost and energy savings associated with this upgrade reflects the incremental step between a standard roofing product with one that is CRRC rated with an aged solar reflectance of 0.25. This is similar to cool roof requirements in 2019 Title 24 Section 150.2(b)1Ii but assumes a higher solar reflectance.

Window Replacement: Replace existing single pane windows with a dual pane product, which has a U-factor equal to 0.32 or lower and a Solar Heat Gain Coefficient (SHGC) equal to 0.25 or lower. This measure was only evaluated for the pre-1978 vintage, which is assumed to have single-pane, metal-frame windows.

Duct Sealing: Air seal all ductwork to meet the requirements of the 2019 Title 24 Section 150.2(b)1E. For this analysis, a final duct leakage value of 15 percent was applied, which corresponds to Option i in the Title 24 code section referenced.

Water Heater Blanket: Add R-6 insulation to the exterior of existing residential tank storage water heaters. For the analysis, the water heater was modeled within conditioned space, which is a typical configuration for older homes. This assumption is conservative since a water heater located in unconditioned space will tend to have higher tank losses and installing a water heater blanket in those situations will result in additional savings. The energy savings for this measure reflect only water heating energy savings only, and do not include any impacts to the space conditioning load, which reduces space cooling loads and increases space heating loads. The impact on space conditioning energy used would be minimal. In most climates, with the exception of heating dominated ones, the combination of these two impacts results in net energy savings. This measure was



evaluated using EnergyPlus. This measure was evaluated for individual water heaters only and would not apply to central water heating systems.

Hot Water Pipe Insulation: Insulate all accessible hot water pipes with R-3 pipe insulation. In certain buildings which have slab on grade construction, and the majority of pipes located either underground or within the walls, most of the pipes will be inaccessible. For the purposes of this analysis a conservative assumption that only ten percent of the pipes could be insulated was applied. In buildings where pipes are located in the attic, crawlspace, or are otherwise more accessible, energy savings will be higher than those presented in this analysis. This measure was evaluated using BEopt and EnergyPlus.

Low Flow Fixtures: Upgrade sink and shower fittings to meet current CALGreen requirements, which require maximum flow rates of 1.8 gallons per minute (gpm) for showerheads and kitchen faucets, and 1.2 gpm for bathroom faucets. Baseline whole house hot water use was based on BEopt assumptions and this measure assumed the upgraded fixtures reduce flow rates by ten percent for showerheads and 20 percent for all faucets based on a 2010 water use study (ConSol, 2010). This measure was evaluated using BEopt and EnergyPlus.

LED Lighting: Replace screw-in incandescent lamps and compact fluorescent lamps (CFLs) with screw-in light emitting diode (LED) lamps. This analysis was conducted external to the energy model and evaluated replacement of both a single 45 W incandescent lamp and a 13W CFL lamp with an 11 W LED lamp operating 620 hours annually. Annual hour estimates were based on whole building average hours of operation from a 2010 lighting study by KEMA (KEMA, 2010). Lifetime assumptions were 1,000 hours for incandescent lamps, 10,000 hours for CFLs and 25,000 hours for LED lamps.

Lighting Vacancy Sensors: Install manual on - automatic off vacancy sensors that meet the requirements of Title 24 Section 110.9(b)4. This analysis was conducted external to the energy model, assuming ten percent savings in operating hours for a single vacancy sensor installed on a switch controlling three lamps. Energy savings were calculated assuming both 45 W incandescent lamps and 11 W LED lamps, operating 620 hours annually. Annual hour estimates were based on whole building average hours of operation from a 2010 lighting study by KEMA (KEMA, 2010).

3.3 Efficiency Packages

A few of the measures described above were also evaluated as part of a package. Three packages were developed as described below.

Envelope & Duct Package – R-38 Attic Insulation & Air Sealing & Duct Sealing: Air sealing and attic insulation are very often applied as a package in building retrofits. The boundary between the living space and vented attics is where a significant amount of building air leakage can occur and sealing these areas as well as ducts prior to covering the attic floor with insulation is both practical and effective. Air sealing, duct sealing and insulation also directly address occupant comfort, as they reduce heat transfer, and result in more even temperatures within the building.

Water Heating Package – Water Heater Blanket, Hot Water Pipe Insulation, & Low-Flow Fixtures: These three water heating measures are all relatively low cost and work together to reduce building hot water energy use.

3.4 Measure Cost

Table 3 summarizes the cost assumptions for each of the measures evaluated. Costs were obtained from various sources, including local contractors, internet searches, past projects, and technical reports.



Table 3: Measure Descriptions & Cost Assumptions¹

Measure	Performance Level	Incremental Cost – Single Family Building			Incremental Cost - Multifamily Residential Unit			Source	Notes (SF = single family; MF = multifamily)
		Pre 1978	1978 – 1991	1992 - 2005	Pre 1978	1978 – 1991	1992 - 2005		
Attic Insulation	R-38	\$1,915	\$1,548	\$1,548	\$500	\$405	\$405	Retrofit contractor ²	\$1.37/sqft ceiling area to add insulation to existing R-11 insulation \$1.21/sqft to add insulation to existing R-19 insulation
Air sealing	7 ACH50	\$959	\$959	n/a	\$341	\$341	n/a	Retrofit contractor ²	\$173 materials & 19.5 hours labor (\$40.30/hr common labor rate) ⁵ for SF. \$67 materials and 6.8 hours labor for MF.
	5 ACH50	n/a	n/a	\$959	n/a	n/a	\$341		
Cool roof	Aged Reflectance ≥ 0.25	\$577	\$577	\$577	\$167	\$167	\$167	Research report ³	Based on \$0.32/sqft roof area incremental cost for cool asphalt shingle product, plus a 10% contractor markup. Higher reflectance values for lower cost are achievable for tile roof products
Window U-factor/ SHGC	0.32/0.25	\$9,810	n/a	n/a	\$5,873	n/a	n/a	Retrofit contractor ⁴	Based on \$45/sqft window area installed cost
Duct sealing	15% of nominal airflow	\$240	\$240	\$240	\$120	\$120	\$120	HVAC contractor	Assumes 4 hours of labor for SF and 2 hours per MF apartment with ducts in the attic (\$54/hr HVAC labor rate) ⁵ + \$24 material for SF and \$12 material for MF (per unit).
Water heater blanket	R-6	\$40	\$40	\$40	\$40	\$40	\$40	Internet search	\$20 blanket + ½-hr labor (\$40.30/hr laborer rate) ⁵
Hot water pipe insulation	3/4" (R-3)	\$42	\$42	\$42	\$42	\$42	\$42	Internet search	\$0.20/ft of ¾" pipe insulation. 10ft total + 1-hr labor (\$40.30/hr common labor rate) ⁵
Low flow fixtures	CALGreen	\$126	\$126	\$126	\$86	\$86	\$86	Retrofit contractor ⁴	Showerheads at \$34.74 each + sink aerators at \$5.37 each + 1-hr labor (\$40.30/hr common labor rate) ⁵ . 2 showerheads & 3 aerators assumed for SF and 1 showerhead and 2 aerators for MF.
LED lamp	11W screw-in bulb	\$4	\$4	\$4	\$4	\$4	\$4	Internet search	\$4 for LED dimmable A19 lamp 60W equivalent. \$0.97 for an equivalent incandescent product which was used to estimate total replacement costs. Cost based on a single lamp replacement
Vacancy Sensor	Manual on, auto off	\$30	\$30	\$30	\$30	\$30	\$30	Internet search	\$20 per sensor + 1/4-hr labor (\$40.30/hr common labor rate) ⁵ .

¹ Costs include contractor overhead and profit² Source: Retrofit contractor pricing, including labor, obtained by Davis Energy Group through the 2012 LA County Retrofit Program (DEG, 2017).³ Codes and Standards Enhancement Initiative: Residential Roof Envelope Measures. 2013 Title 24.http://www.energy.ca.gov/title24/2013standards/prerulemaking/documents/current/Reports/Residential/Envelope/2013_CASE_R_Roof_Measures_Oct_2011.pdf⁴ Source: Retrofit contractor pricing obtained by Davis Energy Group through the Stockton Energy Challenge neighborhood retrofit program (DEG, 2017).⁵ Labor rates are estimated from RSMeans (RSMeans, 2014).

3.4.1 Cost-Effectiveness

A customer-based approach to evaluating cost-effectiveness was used based on experience with reach code adoption by local governments. Residential utility rates at the time of the analysis were applied to calculate utility costs for all cases and determine cost-effectiveness for the proposed measures and packages. First year utility costs were calculated using hourly electricity and gas output from CBECC-Res and applying the utility tariffs summarized in Table 4. The applicable residential time-of-use (TOU) rate was applied to all cases.

Climate zones have been applied according to the predominant investor owned utility (IOU) serving the population of each zone. Climate Zones 10 and 14 are evaluated with both SCE/SoCalGas and SDG&E tariffs since each utility has customers within these climate zones. Climate Zone 5 is evaluated under both PG&E and SoCalGas natural gas rates.

Table 4: IOU Utility Tariffs Applied Based on Climate Zone

Climate Zones	Electric/Gas Utility	Electricity (Standard)	Natural Gas
1-5, 11-13, 16	PG&E	E-TOU, Option B	G1
5	PG&E / SoCalGas	E-TOU, Option B	GR
6, 8-10, 14, 15	SCE/SoCalGas	TOU-D-4-9	GR
7, 10, 14	SDG&E	D TOU-DR1	GR

Source: Utility websites, see Appendix B – Utility Rate Tariffs for details on the tariffs applied.

Utility rates are assumed to escalate over time, using assumptions from research conducted by Energy and Environmental Economics (E3) in the 2019 study Residential Building Electrification in California study (Energy & Environmental Economics, 2019). Escalation of natural gas rates between 2019 and 2022 is based on the currently filed General Rate Cases (GRCs) for PG&E, SoCalGas and SDG&E. From 2023 through 2025, gas rates are assumed to escalate at 4% per year above inflation, which reflects historical rate increases between 2013 and 2018. Escalation of electricity rates from 2019 through 2025 is assumed to be 2% per year above inflation, based on electric utility estimates. After 2025, escalation rates for both natural gas and electric rates are assumed to drop to a more conservative 1% escalation per year above inflation for long-term rate trajectories beginning in 2026 through 2050. See Appendix B – Utility Rate Tariffs for additional details.

Cost-effectiveness was evaluated for all 16 climate zones and results are presented as a lifecycle benefit-to-cost (B/C) ratio, a net present value (NPV) metric which represents the cost-effectiveness of a measure over a 30-year lifetime taking into account discounting of future savings and costs and financing of incremental first costs. A value of one indicates the NPV of the savings over the life of the measure is equivalent to the NPV of the lifetime incremental cost of that measure. A value greater than one represents a positive return on investment. The B/C ratio is calculated according to Equation 1.

Equation 1

$$\text{Benefit – to – Cost Ratio} = \frac{\text{NPV of lifetime benefit}}{\text{NPV of lifetime cost}}$$

The benefit is represented by annual utility savings and the cost by incremental first cost and replacement costs. The lifetime costs or benefits are calculated according to Equation 2.



Equation 2

$$NPV \text{ of lifetime cost or benefit} = \sum_{t=0}^n \frac{(Annual \text{ cost or benefit})_t}{(1+r)^t}$$

Where:

- n = analysis term
- r = discount rate

The following summarizes the assumptions applied in this analysis to both methodologies.

- Analysis term of 30-years
- Real discount rate of 3 percent
- First incremental costs are financed into a mortgage or loan

Table 5 summarizes the financing assumptions and terms that were applied in this analysis. The analysis term is 30 years in all cases. The LED lighting and vacancy sensor upgrades are the only measures that are not assumed to be financed.

Table 5: Final Financing Assumptions

	Loan Term	Loan Rate
Single Family	30	5%
Multifamily	10	4%

Simple payback is also presented and is calculated using the equation below.

$$\text{Simple payback} = \text{First incremental cost} / \text{First year utility cost savings} \quad \text{Equation 3}$$

Maintenance costs were not included for any measures because there are no incremental maintenance costs expected for any of the measures evaluated. Any maintenance requirements that would apply are similar to both the upgrade and the base case. LED lamp upgrade is the only measure with assumed replacement costs based on lifetime assumptions of LED and incandescent technologies and estimated operating hours. See the measures description in Section 2.2 for additional details.

4 Results

Cost-effectiveness analysis was completed for the three vintages and both single family and multifamily unit prototypes. Evaluations looked to identify cost-effective energy upgrades for existing buildings at the time of a remodel. Results are summarized below as well as in Table 6 for single family and Table 7 for multifamily.

Results of cost-effectiveness analysis along with energy savings are presented in Appendix D – Measure Cost-effectiveness Tables in Table 13 through Table 50 for single family and multifamily buildings, by climate zone. Site energy savings, cost savings, measure cost, and cost-effectiveness including simple payback and lifecycle B/C ratio are provided. Results are presented for each of the three vintages. Shaded rows in the tables indicate that the measure is not cost-effective. The lifecycle B/C ratio threshold of one for the financed measures is roughly equivalent to a simple payback of 20 years for single family and 24 years for multifamily. For Climate Zones 10 and 14, cost-effectiveness results are separated out for buildings in both SCE and SDG&E territories, which differ based on applicable utility rates.



Some measure results do not differ between the vintages such as LED lamp replacement and water heating upgrades. The water heating and LED lighting measures are cost-effective for both single family and multifamily in all cases. Cost-effectiveness for the envelope and sealing measures is dependent on climate zone and building vintage. A summary of these results is provided below.

Envelope & Duct Package – R-38 Attic Insulation & Air Sealing & Duct Sealing: All three of these measures are cost-effective for all vintages in inland, cooling climates, as well as cold climates (Climate Zone 1, and 9-16 for single family and Climate Zone 1, 2, 4, and 8-16 for multifamily).

Duct sealing is cost-effective in all cases except for single family homes in Climate Zone 6 built after 1991 and Climate Zone 7 built after 1977; and multifamily in Climate Zone 5 PG&E territory and Climate Zone 7 built after 1991.

Air sealing and attic insulation are less cost-effective in newer vintages in transitional and coastal climates. This package of measures is cost-effective in the following cases:

- Buildings built between 1992 and 2005: Single family Climate Zones 1 and 9-16; and multifamily Climate Zones 1, 2, 4, and 8-16.
- Buildings built between 1978 and 1991: Single family Climate Zones 1, 4 and 8-16; and multifamily Climate Zones 1, 2, 4 and 8-16.
- Buildings built before 1978: Single family and multifamily in Climate Zones 1-16.

Cost-effectiveness of the envelope and duct measures was better in SDG&E territory than SCE territory for both Climate Zone 10 and 14.

Cool Roof: Cool roof is cost-effective for all vintages of single family homes in Climate Zones 8 through 15 and multifamily homes in Climate Zones 2, 4, and 6 through 16. It is also cost-effective for homes built before 1978 for single family in Climate Zone 2, 4, 6, and 7 and for multifamily buildings in Climate Zone 5.

Window Replacement: Window replacements are only cost-effective in buildings built before 1978 in single family homes in Climate Zones 10 in SDG&E territory only and 13 through 15; and in multifamily homes in Climate Zones 5 in PG&E territory only, 10 in SDG&E territory only, and 11-16.

Water Heating Package – Water Heater Blanket, Hot Water Pipe Insulation, & Low-Flow Fixtures: The package including these three water heating measures is cost-effective in all climate zones.

Lighting – LED Lamps: Replacing either an existing CFL or incandescent lamp with an LED lamp is cost-effective in all climate zones. The lighting results in Appendix D report cost-effectiveness for replacement of CLFs with LED lamps. Replacement of incandescent with LED lamps result in simple paybacks of less than one year. While vacancy sensors are cost-effective when incandescent lamps are assumed, once lamps are replaced with LED luminaires, most of the savings disappear and vacancy sensors are not cost-effective. In 2020, industry standard practice will be 45 lumens per Watt or greater for all lamps, which make the vacancy sensor measure not cost-effective.



Table 6: Summary of Single Family Results

CASE		CZ1-PGE	CZ2-PGE	CZ3-PGE	CZ4-PGE	CZ5-PGE	CZ5-SCG	CZ6-SCE	CZ7-SDGE	CZ8-SCE	CZ9-SCE	CZ10-SCE	CZ10-SDGE	CZ11-PGE	CZ12-PGE	CZ13-PGE	CZ14-SCE	CZ14-SDGE	CZ15-SCE	CZ16-PGE
Envelope & Duct Package	Pre-1978	Ducts ¹ / R-38 ² / Air Seal ³	Ducts/ R-38/ Air Seal	Ducts/ R-38/ Air Seal	Ducts/ R-38/ Air Seal	Ducts/ R-38/ Air Seal	Ducts	Ducts	Ducts	Ducts/ R-38/ Air Seal	Ducts/ R-38/ Air Seal	Ducts/ R-38/ Air Seal	Ducts/ R-38/ Air Seal	Ducts/ R-38/ Air Seal	Ducts/ R-38/ Air Seal	Ducts/ R-38/ Air Seal	Ducts/ R-38/ Air Seal	Ducts/ R-38/ Air Seal	Ducts/ R-38/ Air Seal	Ducts/ R-38/ Air Seal
	1978-1991	Ducts/ R-38/ Air Seal	Ducts	Ducts	Ducts	Ducts	Ducts	N/A	N/A	Ducts	Ducts/ R-38/ Air Seal	Ducts/ R-38/ Air Seal	Ducts/ R-38/ Air Seal	Ducts/ R-38/ Air Seal	Ducts/ R-38/ Air Seal	Ducts/ R-38/ Air Seal	Ducts/ R-38/ Air Seal	Ducts/ R-38/ Air Seal	Ducts/ R-38/ Air Seal	Ducts/ R-38/ Air Seal
	1992-2005	Ducts	Ducts	Ducts	Ducts	Ducts	Ducts	N/A	N/A	Ducts	Ducts	Ducts/ R-38/ Air Seal	Ducts/ R-38/ Air Seal	Ducts/ R-38/ Air Seal	Ducts/ R-38/ Air Seal	Ducts/ R-38/ Air Seal	Ducts/ R-38/ Air Seal	Ducts/ R-38/ Air Seal	Ducts/ R-38/ Air Seal	Ducts/ R-38/ Air Seal
Cool Roof	Pre-1978	N/A	Yes	N/A	Yes	N/A	N/A	N/A	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	N/A
	1978-1991	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	N/A
	1992-2005	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	N/A
Windows	Pre-1978	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	Yes	Yes	N/A	Yes	N/A	Yes	Yes	N/A
Water Heating Package	All Vintages	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
LED Lamps	All Vintages	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

¹ Ducts refers to the Duct Sealing upgrade, which calls for the air seal of all ductwork to meet the requirements of the 2019 Title 24 Section 150.2(b)1E.

² R-38 refers to the Attic Insulation upgrade, which calls for the addition of attic insulation to a minimum level of R-38 in vented attics.

³ Air Seal refers to the Air Sealing upgrade, which calls for the sealing of all accessible cracks, holes and gaps in the building envelope at walls, floors, and ceilings.



Table 7: Summary of Multifamily Results

CASE		CZ1-PGE	CZ2-PGE	CZ3-PGE	CZ4-PGE	CZ5-PGE	CZ5-SCG	CZ6-SCE	CZ7-SDGE	CZ8-SCE	CZ9-SCE	CZ10-SCE	CZ10-SDGE	CZ11-PGE	CZ12-PGE	CZ13-PGE	CZ14-SCE	CZ14-SDGE	CZ15-SCE	CZ16-PGE
Envelope & Duct Package	Pre-1978	Ducts/R-38/Air Seal	Ducts/R-38/Air Seal	Ducts/R-38/Air Seal	Ducts/R-38/Air Seal	Ducts/R-38/Air Seal	Ducts/R-38/Air Seal	Ducts	Ducts/R-38/	Ducts/R-38/Air Seal	Ducts/R-38/Air Seal	Ducts/R-38/Air Seal	Ducts/R-38/Air Seal	Ducts/R-38/Air Seal	Ducts/R-38/Air Seal	Ducts/R-38/Air Seal	Ducts/R-38/Air Seal	Ducts/R-38/Air Seal	Ducts/R-38/Air Seal	Ducts/R-38/Air Seal
	1978-1991	Ducts/R-38/Air Seal	Ducts/R-38/Air Seal	Ducts	Ducts/R-38/Air Seal	Ducts	Ducts	Ducts	Ducts	Ducts/R-38/Air Seal	Ducts/R-38/Air Seal	Ducts/R-38/Air Seal	Ducts/R-38/Air Seal	Ducts/R-38/Air Seal	Ducts/R-38/Air Seal	Ducts/R-38/Air Seal	Ducts/R-38/Air Seal	Ducts/R-38/Air Seal	Ducts/R-38/Air Seal	Ducts/R-38/Air Seal
	1992-2005	Ducts/R-38/Air Seal	Ducts/R-38/Air Seal	Ducts	Ducts	N/A	N/A	N/A	N/A	Ducts	Ducts/R-38/Air Seal	Ducts/R-38/Air Seal	Ducts/R-38/Air Seal	Ducts/R-38/Air Seal	Ducts/R-38/Air Seal	Ducts/R-38/Air Seal	Ducts/R-38/Air Seal	Ducts/R-38/Air Seal	Ducts/R-38/Air Seal	Ducts/R-38/Air Seal
Cool Roof	Pre-1978	N/A	Yes	N/A	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
	1978-1991	N/A	Yes	N/A	Yes	N/A	N/A	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
	1992-2005	N/A	Yes	N/A	Yes	N/A	N/A	N/A	N/A	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Windows	Pre-1978	N/A	N/A	N/A	N/A	Yes	N/A	N/A	N/A	N/A	N/A	N/A	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Water Heating Package	All Vintages	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
LED Lamps	All Vintages	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

¹ Ducts refers to the Duct Sealing upgrade, which calls for the air seal of all ductwork to meet the requirements of the 2019 Title 24 Section 150.2(b)1E.

² R-38 refers to the Attic Insulation upgrade, which calls for the addition of attic insulation to a minimum level of R-38 in vented attics.

³ Air Seal refers to the Air Sealing upgrade, which calls for the sealing of all accessible cracks, holes and gaps in the building envelope at walls, floors, and ceilings.



5 Recommendations & Discussion

This analysis evaluated the feasibility and cost-effectiveness of retrofit measures in California existing homes built before 2006. A customer-based lifecycle cost approach to evaluating cost-effectiveness was applied quantifying the utility cost savings associated with energy efficiency measures compared to the costs associated with the measures.

5.1 Recommended Efficiency Measures

Based on the analysis, the following cost-effective measures or packages of measures are recommended. The multifamily measures apply only to residential spaces in low-rise buildings (3 stories or fewer) and not to any common or non-residential spaces. Descriptions of each measure or package are provided below. In most cases, exceptions are defined which would exempt a particular project from a measure if certain conditions exist. These exceptions are based on existing on-site conditions and cost-effectiveness.

Attic Insulation: Add attic insulation to a minimum level of R-38 in vented attics. This measure applies to homes according to vintage, building type and climate zone as defined in Table 6 and Table 7.

Exception 1: Buildings without vented attic spaces and buildings with existing attic insulation levels greater than R-19 in Climate Zones 1-5 and 8-16 and greater than R-5 in Climate Zones 6 and 7.

Air Sealing: Seal all accessible cracks, holes and gaps in the building envelope at walls, floors, and ceilings. Pay special attention to penetrations including plumbing, electrical, and mechanical vents, recessed can light fixtures, and windows. Weather-strip doors if not already present. Verification shall be conducted following a prescriptive checklist (to be developed) which outlines what building aspects need to be addressed by the permit applicant and verified by an inspector. Compliance can also be demonstrated with blower door testing showing at least a 30% reduction from pre-retrofit conditions. This measure applies to homes according to vintage, building type and climate zone as defined in Table 6 and Table 7.

Exception 1: Buildings that can demonstrate blower door test results showing 5 ACH50 or lower or can otherwise demonstrate that air sealing meeting the requirements of this ordinance was conducted within the last 12 months.

Duct Sealing: Air seal all ductwork to meet the requirements of the 2019 Title 24 Section 150.2(b)1E, with the exception that duct testing is not required to be verified by a HERS Rater. The duct system must be tested to confirm that the requirements have been met. The building department may allow the contractor to self-certify, may request to be present at the time of leakage testing, or may engage another third-party consultant to verify the duct sealing. See Appendix C – Standards Sections for additional details on the requirements per Title 24. This measure applies to homes according to vintage, building type and climate zone as defined in Table 6 and Table 7.

Exception 1: All exceptions as stated in the 2019 Title 24 Section 150.2(b)1E are allowed.

Exception 2: Projects that require duct sealing as part of an HVAC alteration or replacement must meet all of the requirements of Title 24, Part 6, including HERS Rater verification.

Envelope & Duct Package: This is the combination of the Attic Insulation, Air Sealing, and Duct Sealing upgrades listed above.

Cool Roof: When replacing a roof, install a roofing product rated by the Cool Roof Rating Council to have an aged solar reflectance equal to or greater than 0.25, and a thermal emittance equal to or greater than 0.75, regardless of the compliance approach (prescriptive or performance). This measure only applies to steep slope roofs (ratio of rise to run greater than 2:12) and to buildings that are installing a new roof as part of the scope of



the remodel and where more than 50 percent of the roof is being replaced. This applies only to certain homes according to vintage, building type and climate zone as defined in Table 6 and Table 7. Low slope roofs (ratio of rise to run of 2:12 or less) shall meet the requirements of Section 150.2(b)1iii of 2019 Title 24 Standards. See Appendix C – Standards Sections for additional details on the requirements per Title 24.

Exception 1: Projects that are not installing a new roof as part of the scope. Only areas of roof that are to be re-roofed are subject to the cool roof upgrade.

Exception 2: All exceptions as stated in the 2019 Title 24 Section 150.2(b)1ii for steep slope roofs and 150.2(b)1iii for low slope roofs are allowed.

Windows: In a few climate zones, window upgrades were found to be cost-effective for the pre-1978 vintage buildings with existing single pane windows but is not included as a recommended measure. The cost requirement for window replacement is significant and the margin for cost-effectiveness is lower than many other measures.

Water Heating Package: Add exterior insulation meeting a minimum of R-6 to storage water heaters. Insulate all accessible hot water pipes with pipe insulation a minimum of ¾" inch thick. This includes insulating the supply pipe leaving the water heater, piping to faucets underneath sinks, and accessible pipes in attic spaces or crawlspaces. Upgrade fittings in sinks and showers to meet current CALGreen requirements.

Exception 1: Water heater blanket is not required on water heaters less than 20 gallons.

Exception 2: Water heater blanket not required if application of a water heater blanket voids the warranty on the water heater.

Exception 3: Fixtures with rated or measured flow rates no more than ten percent greater than current CALGreen requirements.

Exception 4: Water heater blanket is not required for multifamily buildings with central water heating systems.

Lighting – LED Lamps: Replace all interior and exterior screw-in (A-base) incandescent, halogen, and compact fluorescent lamps with screw-in LED lamps.



5.2 Other Considerations

HERS Field Verification: HERS field verification is not required to meet any of the requirements for the recommended measures unless the measure is used to meet Title 24 compliance. Measure installation shall be verified by a city building inspector or another third-party inspector deemed appropriate by the building department. While a HERS Rater is not required, one could be used as an alternative to inspections by the building department.

Combustion Appliance Safety and Indoor Air Quality: Implementation of some of the recommended measures will affect the pressure balance of the home which can subsequently impact the safe operation of existing combustion appliances as well as indoor air quality. Buildings with older gas appliances can present serious health and safety problems which may not be addressed in a remodel if the appliances are not being replaced. It is recommended that the building department require inspection and testing of all combustion appliances after completion of the retrofit work. It's also recommended that jurisdictions require combustion safety testing by a certified professional whenever air sealing and insulation measures are applied, and existing combustion appliances are located within the pressure boundary of the building.

Jurisdictions may also want to consider requiring mechanical ventilation in homes where air sealing has been conducted. In older buildings, outdoor air is typically introduced through leaks in the building envelope. After air sealing a building, it may be necessary to forcefully bring in fresh outdoor air using supply and/or exhaust fans to minimize issues associated with indoor air quality.

Required Measures Included in Title 24 Performance Simulation: If any of the measures above are included in a performance Title 24 compliance report, it's suggested that trade-offs be allowed as long as all minimum code requirements are met. For example, if a project is installing new windows and a new roof and insulating the attic and is demonstrating compliance with Title 24 with a performance simulation run, it would be acceptable if the installed roof did not meet the requirements listed above as long as this was traded off with either an increase in attic insulation or better performing windows. This would also allow trade-offs for projects that are installing high impact measures, such as solar water heating or whole house fans. This would require two simulation runs; however, it's not expected this approach would be utilized often. Run #1 would evaluate the proposed building upgrades. This would also be the report submitted to the building department for the permit application demonstrating compliance with Title 24. Run #2 would also be completed with the minimum ordinance requirements modeled for each of the affected building components. In order to show compliance with the ordinance the applicant would need to demonstrate that the proposed upgrades (#1) would result in annual time dependent valuation (TDV) energy use equal to or less than the annual TDV energy use of the case based on the ordinance requirements (#2).

5.3 Next Steps

The focus of this study was to update the existing building upgrade cost-effectiveness study completed in June 2018 (Statewide Reach Codes Team, 2018), based on current utility rates and updated upgrade costs. Additional efforts have been identified that will be evaluated and released in an updated Existing Building Efficiency Upgrade Cost-Effectiveness Study in 2020. These include:

- Revisit base case assumptions for different vintages
- Additional HVAC upgrade options including:
 - High efficiency equipment replacement as alternative to non-preempted upgrade
 - Air sealing and attic insulation at time of HVAC replacement
 - Improved duct insulation, tighter ducts, buried ducts
- Additional building envelope improvements



- Higher ceiling insulation requirements
- Address low-slope roof replacements
- Lighting luminaire replacements in addition to lamp replacements
- Evaluation of electrification measures at equipment change-out and electrification-ready
- PV requirements at time of addition, and
- Additional efficiency upgrade requirements when installing PV

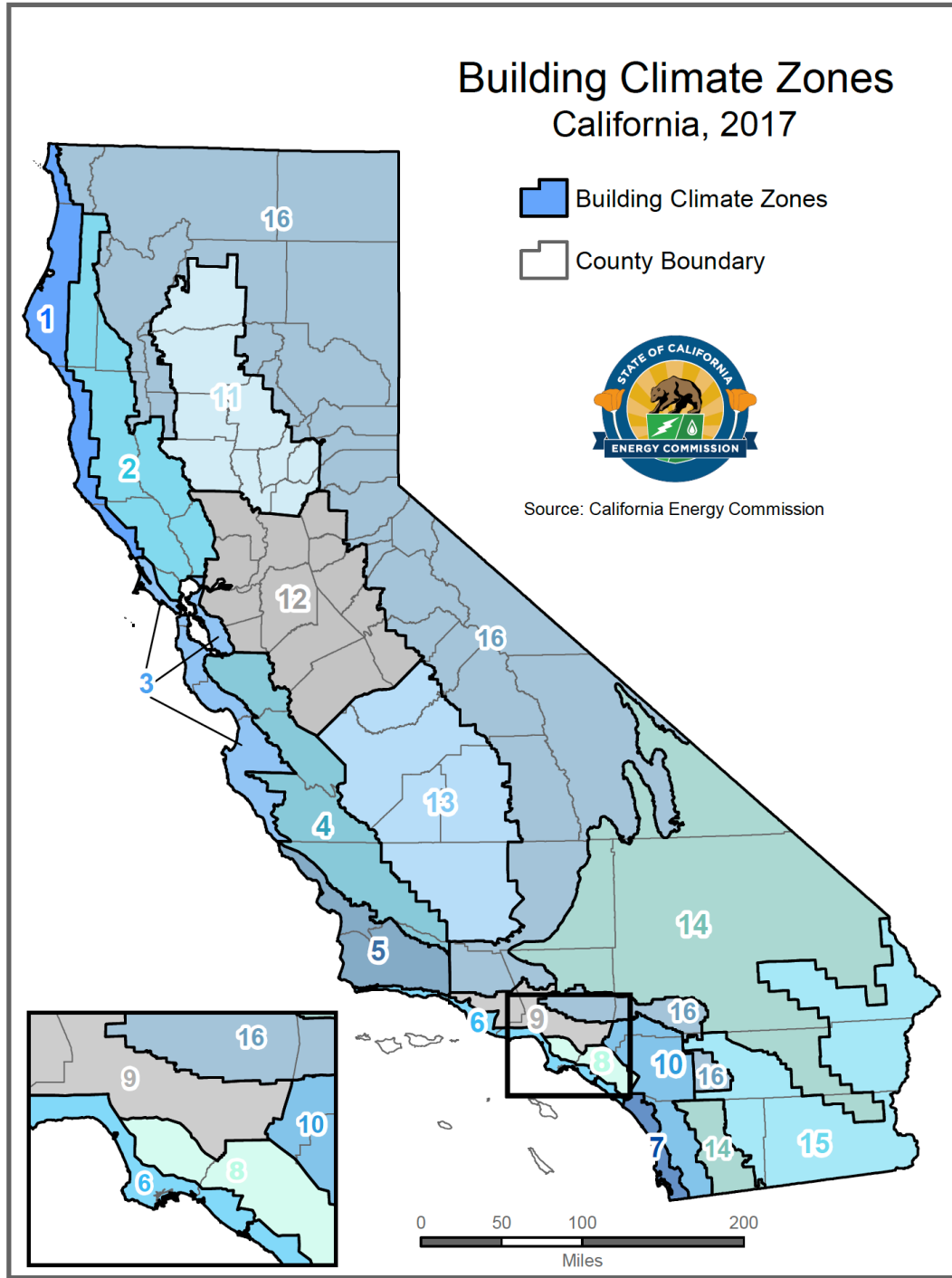


6 References

- California Energy Commission. 2018a. 2019 Alternative Calculation Method Approval Manual. CEC-400-2018-023-CMF. December 2018. California Energy Commission. <https://www.energy.ca.gov/2018publications/CEC-400-2018-023/CEC-400-2018-023-CMF.pdf>
- California Energy Commission. 2018b. 2019 Building Energy Efficiency Standards for Residential and Nonresidential Buildings. CEC-400-2018-020-CMF. December 2018. California Energy Commission. <https://www.energy.ca.gov/2018publications/CEC-400-2018-020/CEC-400-2018-020-CMF.pdf>
- ConSol. 2010. Water Use in the California Residential Home. January 2010. http://www.cbia.org/uploads/5/1/2/6/51268865/2010_-_chf_water_use_study.pdf
- DEG. 2017. Large Scale Residential Retrofit Program. Prepared for the California Energy Commission by Davis Energy Group. January 2017. <http://www.energy.ca.gov/2017publications/CEC-500-2017-009/CEC-500-2017-009.pdf>
- KEMA. 2010. Final Evaluation Report: Upstream Lighting Program, Vol 1. KEMA, Inc. February 2010. http://www.energydataweb.com/cpucfiles/18/finalupstreamlightingevaluationreport_2.pdf
- RSMeans. 2014. RSMeans Residential Cost Data 2014.
- Statewide Reach Codes Team. 2018. Existing Building Efficiency Upgrade Cost-Effectiveness Study. June 8, 2018. https://localenergycodes.com/download/378/file_path/fieldList/Residential%20Retrofit%20Cost-Eff%20Report



Appendix A – California Climate Zone Map



Appendix B – Utility Rate Tariffs

PG&E 23

SCE 25

SoCalGas 28

SDG&E..... 28

Escalation Assumptions..... 31



PG&E

The following pages provide details on the PG&E electricity and natural gas tariffs applied in this study. Table 8 describes the baseline territories that were assumed for each climate zone.

Table 8: PG&E Baseline Territory by Climate Zone

	Baseline Territory
CZ01	V
CZ02	X
CZ03	T
CZ04	X
CZ05	T
CZ11	R
CZ12	S
CZ13	R
CZ16	Y

The PG&E monthly gas rate in \$/therm was applied on a monthly basis for the 12-month period ending January 2019 according to the rates shown below.

Pacific Gas and Electric Company							
Residential Non-CARE and CARE Gas Tariff Rates							
January 1, 2018, to Present							
(\$/therm) ^{1/}							
Effective Date	Advice Letter Number	Minimum Transportation Charge ^{2/} (per day)	Procurement Charge	Transportation Charge ^{2/}		TOTAL Residential Non-CARE Schedules Charge ^{3/}	
				Baseline	Excess	Baseline	Excess
01/01/18	3918-G	\$0.09863	\$0.37310	\$0.91828	\$1.46925	\$1.29138	\$1.84235
02/01/18	3931-G	\$0.09863	\$0.40635	\$0.91828	\$1.46925	\$1.32463	\$1.87560
03/01/18	3941-G	\$0.09863	\$0.32103	\$0.91828	\$1.46925	\$1.23931	\$1.79028
04/01/18	3959-G	\$0.09863	\$0.34783	\$0.91828	\$1.46925	\$1.26611	\$1.81708
05/01/18	3969-G	\$0.09863	\$0.26995	\$0.91828	\$1.46925	\$1.18823	\$1.73920
06/01/18	3980-G	\$0.09863	\$0.21571	\$0.91828	\$1.46925	\$1.13399	\$1.68496
07/01/18	3984-G	\$0.09863	\$0.22488	\$0.93438	\$1.49502	\$1.15926	\$1.71990
08/01/18	3995-G	\$0.09863	\$0.28814	\$0.93438	\$1.49502	\$1.22252	\$1.78316
09/01/18	4008-G	\$0.09863	\$0.25597	\$0.93438	\$1.49502	\$1.19035	\$1.75099
10/01/18	4018-G	\$0.09863	\$0.27383	\$0.93438	\$1.49502	\$1.20821	\$1.76885
11/01/18	4034-G	\$0.09863	\$0.35368	\$0.93438	\$1.49502	\$1.28806	\$1.84870
12/01/18	4046-G	\$0.09863	\$0.42932	\$0.93438	\$1.49502	\$1.36370	\$1.92434
01/01/19	4052-G	\$0.09863	\$0.43394 ^{7/}	\$0.99414	\$1.59063	\$1.42808	\$2.02457

^{1/} Unless otherwise noted

^{2/} Effective July 1, 2005, the Transportation Charge will be no less than the Minimum Transportation Charge of \$0.09863 (per day). Applicable to Rate Schedule G-1 only and does not apply to submetered tenants of master-metered customers served under gas Rate Schedule GS and GT.

^{3/} Schedule G-PPPS (Public Purpose Program Surcharge) needs to be added to the TOTAL Non-CARE Charge and TOTAL CARE Charge for bill calculation. See Schedule G-PPPS for details and exempt customers.

^{4/} CARE Schedules include California Solar Initiative (CSI) Exemption in accordance with Advice Letter 3257-G-A.

^{5/} Per dwelling unit per day (Multifamily Service)

^{6/} Per installed space per day (Mobilehome Park Service)

^{7/} This procurement rate includes a charge of \$0.03686 per therm to reflect account balance amortizations in accordance with Advice Letter 3157-G.

^{8/} Residential bill credit of (\$29.85) per household, annual bill credit occurring in the October 2018 bill cycle, thereafter in the April bill cycle.

Seasons: Winter = Nov-Mar Summer = April-Oct





**Pacific Gas and
Electric Company**

U 39

San Francisco, California

Cancelling

Revised
Revised

Cal. P.U.C. Sheet No.
Cal. P.U.C. Sheet No.

43533-E
42728-E

**ELECTRIC SCHEDULE E-TOU
RESIDENTIAL TIME-OF-USE SERVICE**

Sheet 4

RATES:
(Cont'd.)

OPTION B TOTAL RATES

Total Energy Rates (\$ per kWh)	PEAK	OFF-PEAK
Summer (all usage)	\$0.37188 (R)	\$0.26882 (R)
Winter (all usage)	\$0.23441 (R)	\$0.21561 (R)

Delivery Minimum Bill Amount (\$ per meter per day) \$0.32854

California Climate Credit (per household, per semi-annual payment occurring in the April and October bill cycles) (\$39.42)

Total bundled service charges shown on customer's bills are unbundled according to the component rates shown below. Where the delivery minimum bill amount applies, the customer's bill will equal the sum of (1) the delivery minimum bill amount plus (2) for bundled service, the generation rate times the number of kWh used. For revenue accounting purposes, the revenues from the delivery minimum bill amount will be assigned to the Transmission, Transmission Rate Adjustments, Reliability Services, Public Purpose Programs, Nuclear Decommissioning, Competition Transition Charges, Energy Cost Recovery Amount, DWR Bond, and New System Generation Charges based on kWh usage times the corresponding unbundled rate component per kWh, with any residual revenue assigned to Distribution.***

UNBUNDLING OF OPTION B TOTAL RATES

Generation	PEAK	OFF-PEAK
Summer (all usage)	\$0.21238	\$0.10932
Winter (all usage)	\$0.10554	\$0.08674
Distribution**		
Summer (all usage)	\$0.10716 (R)	\$0.10716 (R)
Winter (all usage)	\$0.07653 (R)	\$0.07653 (R)
Transmission* (all usage)	\$0.02469 (R)	
Transmission Rate Adjustments* (all usage)	\$0.00214	
Reliability Services* (all usage)	\$0.00260	
Public Purpose Programs (all usage)	\$0.01413	
Nuclear Decommissioning (all usage)	\$0.00020	
Competition Transition Charges (all usage)	\$0.00132	
Energy Cost Recovery Amount (all usage)	(\$0.00005)	
DWR Bond (all usage)	\$0.00503 (R)	
New System Generation Charge (all usage)**	\$0.00228	

* Transmission, Transmission Rate Adjustments and Reliability Service charges are combined for presentation on customer bills.

** Distribution and New System Generation Charges are combined for presentation on customer bills.

*** This same assignment of revenues applies to direct access and community choice aggregation customers.

(Continued)

Advice	5444-E	Issued by	Submitted	December 18, 2018
Decision	18-08-013	Robert S. Kenney	Effective	January 1, 2019
		Vice President, Regulatory Affairs	Resolution	





**Pacific Gas and
Electric Company®**

U 39

San Francisco, California

Cancelling Revised Cal. P.U.C. Sheet No. 34735-G
Revised Cal. P.U.C. Sheet No. 34691-G

**GAS SCHEDULE G-1
RESIDENTIAL SERVICE**

Sheet 1

APPLICABILITY: This rate schedule¹ applies to natural gas service to Core End-Use Customers on PG&E's Transmission and/or Distribution Systems. To qualify, service must be to individually-metered single family premises for residential use, including those in a multifamily complex, and to separately-metered common areas in a multifamily complex where Schedules GM, GS, or GT are not applicable. Common area accounts that are separately metered by PG&E have an option of switching to a core commercial rate schedule. Common area accounts are those accounts that provide gas service to common use areas as defined in Rule 1.

Per D.15-10-032 and D.18-03-017, transportation rates include GHG Compliance Cost for non-covered entities. Customers who are directly billed by the Air Resources Board (ARB), i.e., covered entities, are exempt from paying AB 32 GHG Compliance Costs through PG&E's rates.² A "Cap-and-Trade Cost Exemption" credit for these costs will be shown as a line item on exempt customers' bills.^{3,4}

TERRITORY: Schedule G-1 applies everywhere within PG&E's natural gas Service Territory.

RATES: Customers on this schedule pay a Procurement Charge and a Transportation Charge, per meter, as shown below. The Transportation Charge will be no less than the Minimum Transportation Charge, as follows:

	<u>Minimum Transportation Charge:</u> ⁵		<u>Per Day</u>	
			\$0.09863	
			<u>Per Therm</u>	
	<u>Baseline</u>		<u>Excess</u>	
<u>Procurement:</u>	\$0.43394	(l)	\$0.43394	(l)
<u>Transportation Charge:</u>	\$0.99414	(l)	\$1.59063	(l)
Total:	\$1.42808	(l)	\$2.02457	(l)
California Natural Gas Climate Credit (per Household, annual payment occurring in October 2018 bill cycle, and thereafter in the April bill cycle)	(\$25.45)	(l)		

Public Purpose Program Surcharge:

Customers served under this schedule are subject to a gas Public Purpose Program (PPP) Surcharge under Schedule G-PPPS.

See Preliminary Statement, Part B for the Default Tariff Rate Components.

The Procurement Charge on this schedule is equivalent to the rate shown on informational Schedule G-CP—Gas Procurement Service to Core End-Use Customers.

¹ PG&E's gas tariffs are available online at www.pge.com.

² Covered entities are not exempt from paying costs associated with LUAF Gas and Gas used by Company Facilities.

³ The exemption credit will be equal to the effective non-exempt AB 32 GHG Compliance Cost Rate (\$ per therm) included in Preliminary Statement – Part B, multiplied by the customer's billed volumes (therms) for each billing period.

⁴ PG&E will update its billing system annually to reflect newly exempt or newly excluded customers to conform with lists of Directly Billed Customers provided annually by the ARB.

⁵ The Minimum Transportation charge does not apply to submetered tenants of master-metered customers served under gas rate Schedules GS and GT.

(Continued)

<i>Advice</i>	4052-G	<i>Issued by</i>	<i>Submitted</i>	December 21, 2018
<i>Decision</i>	97-10-065 & 98-07-025	Robert S. Kenney	<i>Effective</i>	January 1, 2019
		<i>Vice President, Regulatory Affairs</i>	<i>Resolution</i>	

SCE



The following pages provide details on are the SCE electricity tariffs applied in this study. Table 9 describes the baseline territories that were assumed for each climate zone.

Table 9: SCE Baseline Territory by Climate Zone

	Baseline Territory			
CZ06	6			
CZ08	8			
CZ09	9			
CZ10	10			
CZ14	14			
CZ15	15			

	Delivery	Generation	Total Rate
TOU-Default-Rate-1 (On-Peak 4:00 pm - 9:00 pm)			
Energy Charge - \$/kWh			
Summer Season - On-Peak	0.19880	0.20072	0.39952
Mid-Peak	0.19880	0.05948	0.25828
Off-Peak	0.15574	0.06023	0.21597
Winter Season - Mid-Peak	0.19880	0.08308	0.28188
Off-Peak	0.15574	0.11309	0.26883
Super-Off-Peak	0.15062	0.01344	0.16406
Basic Charge - \$/day			
Single-Family Residence	0.031	0.000	0.031
Multi-Family Residence	0.024	0.000	0.024
Minimum Charge - \$/day			
Single Family Residence	0.338	0.000	0.338
Multi-Family Residence	0.338	0.000	0.338
Baseline Credit - \$/kWh	(0.06512)	0.00000	(0.06512)



	Delivery	Generation	Total Rate
TOU-D-Rate PRIME			
Energy Charge - \$/kWh			
Summer Season - On-Peak	0.15926	0.19811	0.35737
Mid-Peak	0.15926	0.10092	0.26018
Off-Peak	0.08308	0.04687	0.12995
Winter Season - Mid-Peak	0.16268	0.16761	0.33029
Off-Peak	0.08081	0.04331	0.12412
Super-Off-Peak	0.08081	0.04331	0.12412
Customer Charge - \$/day	0.395	0.000	0.395

TOU Period	Weekdays		Weekends and Holidays	
	Summer	Winter	Summer	Winter
On-Peak	4 p.m. - 9 p.m.			
Mid-Peak		4 p.m. - 9 p.m.	4 p.m. - 9 p.m.	4 p.m. - 9 p.m.
Off-Peak	All other hours	9 p.m. - 8 a.m.	All other hours	9 p.m. - 8 a.m.
Super-Off-Peak		8 a.m. - 4 p.m.		8 a.m. - 4 p.m.

PROPOSED
(7 Year Average 2010-2016)

Summer kWh per Day			Winter kWh per Day		
Baseline Region	Basic	All Electric	Baseline Region	Basic	All Electric
05	17.2	17.9	05	18.7	29.1
06	11.4	8.8	06	11.3	13.0
08	12.6	9.8	08	10.6	12.7
09	16.5	12.4	09	12.3	14.3
10	18.9	15.8	10	12.5	17.0
13	22.0	24.6	13	12.6	24.3
14	18.7	18.3	14	12.0	21.3
15	46.4	24.1	15	9.9	18.2
16	14.4	13.5	16	12.6	23.1



SoCalGas

Following are the SoCalGas natural gas tariffs applied in this study. Table 10 describes the baseline territories that were assumed for each climate zone.

Table 10: SoCalGas Baseline Territory by Climate Zone

	Baseline Territory
CZ05	2
CZ06	1
CZ08	1
CZ09	1
CZ10	1
CZ14	2
CZ15	1

SOUTHERN CALIFORNIA GAS COMPANY Revised CAL P.U.C. SHEET NO. 55854-G
LOS ANGELES, CALIFORNIA CANCELING Revised CAL P.U.C. SHEET NO. 55828-G

Schedule No. GR <u>RESIDENTIAL SERVICE</u> (Includes GR, GR-C and GT-R Rates)				Sheet 1
APPLICABILITY				
The GR rate is applicable to natural gas procurement service to individually metered residential customers.				
The GR-C, cross-over rate, is a core procurement option for individually metered residential core transportation customers with annual consumption over 50,000 therms, as set forth in Special Condition 10.				
The GT-R rate is applicable to Core Aggregation Transportation (CAT) service to individually metered residential customers, as set forth in Special Condition 11.				
The California Alternate Rates for Energy (CARE) discount of 20%, reflected as a separate line item on the bill, is applicable to income-qualified households that meet the requirements for the CARE program as set forth in Schedule No. G-CARE.				
TERRITORY				
Applicable throughout the service territory.				
RATES				
Customer Charge, per meter per day:	GR 16.438¢	GR-C 16.438¢	GT-R 16.438¢	
For "Space Heating Only" customers, a daily Customer Charge applies during the winter period from November 1 through April 30 ^{1/} :				
	33.149¢	33.149¢	33.149¢	
Baseline Rate, per therm (baseline usage defined in Special Conditions 3 and 4):				
Procurement Charge: ^{2/}	41.589¢	42.676¢	N/A	R
Transmission Charge:	63.566¢	63.566¢	63.566¢	
Total Baseline Charge:	105.155¢	106.242¢	63.566¢	R
Non-Baseline Rate, per therm (usage in excess of baseline usage):				
Procurement Charge: ^{2/}	41.589¢	42.676¢	N/A	R
Transmission Charge:	96.806¢	96.806¢	96.806¢	
Total Non-Baseline Charge:	138.395¢	139.482¢	96.806¢	R
^{1/} For the summer period beginning May 1 through October 31, with some exceptions, usage will be accumulated to at least 20 Ccf (100 cubic feet) before billing.				
(Footnotes continue next page.)				
(Continued)				
(TO BE INSERTED BY UTILITY) ADVICE LETTER NO. 5410 DECISION NO. 106		ISSUED BY Dan Skopec Vice President Regulatory Affairs		
		(TO BE INSERTED BY CAL PUC) SUBMITTED <u>Jan 7, 2019</u> EFFECTIVE <u>Jan 10, 2019</u> RESOLUTION NO. <u>G-3351</u>		



SDG&E

Following are the SDG&E electricity and natural gas tariffs applied in this study. Table 11 describes the baseline territories that were assumed for each climate zone.

Table 11: SDG&E Baseline Territory by Climate Zone

	Baseline Territory
CZ07	Coastal
CZ10	Inland
CZ14	Mountain



San Diego Gas & Electric Company
San Diego, California

Revised Cal. P.U.C. Sheet No. 31320-E

Canceled Revised Cal. P.U.C. Sheet No. 31103-E

Sheet 2

SCHEDULE TOU-DR1
RESIDENTIAL TIME-OF-USE

RATES

Total Rates:

Description – TOU DR1	UDC Total Rate	DWR-BC Rate	EECC Rate + DWR Credit	Total Rate
Summer:				
On-Peak	0.29562	R 0.00503	R 0.35013	R 0.65078
Off-Peak	0.29562	R 0.00503	R 0.11235	R 0.41300
Super Off-Peak	0.29562	R 0.00503	R 0.05739	R 0.35804
Winter:				
On-Peak	0.32037	R 0.00503	R 0.07618	R 0.40158
Off-Peak	0.32037	R 0.00503	R 0.06762	R 0.39302
Super Off-Peak	0.32037	R 0.00503	R 0.05812	R 0.38352
Summer Baseline Adjustment Credit up to 130% of Baseline	(0.19921)	I		(0.19921) I
Winter Baseline Adjustment Credit up to 130% of Baseline	(0.16853)	I		(0.16853) I
Minimum Bill (\$/day)	0.329			0.329

Description – TOU DR1	UDC Total Rate	DWR-BC Rate	EECC Rate + DWR Credit	Total Rate	Total Effective Care Rate
Summer – CARE Rates:					
On-Peak	0.29494	R 0.00000	0.35013 R	0.64507 R	0.41628 R
Off-Peak	0.29494	R 0.00000	0.11235 R	0.40729 R	0.26077 R
Super Off-Peak	0.29494	R 0.00000	0.05739 R	0.35233 R	0.22483 R
Winter – CARE Rates:					
On-Peak	0.31969	R 0.00000	0.07618 R	0.39587 R	0.25330 R
Off-Peak	0.31969	R 0.00000	0.06762 R	0.38731 R	0.24770 R
Super Off-Peak	0.31969	R 0.00000	0.05812 R	0.37781 R	0.24149 R
Summer Baseline Adjustment Credit up to 130% of Baseline	(0.19921)	I		(0.19921) I	(0.13028) I
Winter Baseline Adjustment Credit up to 130% of Baseline	(0.16853)	I		(0.16853) I	(0.11022) I
Minimum Bill (\$/day)	0.164			0.164	0.164

Note:

- (1) Total Rates consist of UDC, Schedule DWR-BC (Department of Water Resources Bond Charge), and Schedule EECC (Electric Energy Commodity Cost) rates, with the EECC rates reflecting a DWR Credit.
- (2) Total Rates presented are for customers that receive commodity supply and delivery service from Utility.
- (3) DWR-BC charges do not apply to CARE customers.
- (4) As identified in the rates tables, customer bills will also include line-item summer and winter credits for usage up to 130% of baseline to provide the rate capping benefits adopted by Assembly Bill 1X and Senate Bill 695.

(Continued)

2011

Advice Ltr. No. 3326-E

Decision No. _____

Issued by
Dan Skopec
Vice President
Regulatory Affairs

Submitted Dec 28, 2018

Effective Jan 1, 2019

Resolution No. _____





San Diego Gas & Electric Company
San Diego, California

Revised Cal. P.U.C. Sheet No. 23614-G
Canceling Revised Cal. P.U.C. Sheet No. 23601-G

SCHEDULE GR

Sheet 1

RESIDENTIAL NATURAL GAS SERVICE (Includes Rates for GR, GR-C, GTC/GTCA)

APPLICABILITY

The GR rate is applicable to natural gas procurement service for individually metered residential customers.

The GR-C, cross-over rate, is a core procurement option for individually metered residential core transportation customers with annual consumption over 50,000 therms, as set forth in Special Condition 10.

The GTC/GTCA rate is applicable to intrastate gas transportation-only services to individually metered residential customers, as set forth in Special Condition 11.

Customers taking service under this schedule may be eligible for a 20% California Alternate Rate for Energy (CARE) program discount, reflected as a separate line item on the bill, if they qualify to receive service under the terms and conditions of Schedule G-CARE.

TERRITORY

Within the entire territory served natural gas by the utility.

RATES

	GR	GR-C	GTC/GTCA ^{1/}
Baseline Rate, per therm (baseline usage defined in Special Conditions 3 and 4):			
Procurement Charge: ^{2/}	\$0.41614	\$0.41614 R	N/A
Transmission Charge:	\$1.01230	\$1.01230	\$1.01230
Total Baseline Charge:	\$1.42844	\$1.42844 R	\$1.01230
Non-Baseline Rate, per therm (usage in excess of baseline usage):			
Procurement Charge: ^{2/}	\$0.41614	\$0.41614 R	N/A
Transmission Charge:	\$1.19980	\$1.19980	\$1.19980
Total Non-Baseline Charge:	\$1.61594	\$1.61594 R	\$1.19980
Minimum Bill, per day:^{3/}			
Non-CARE customers:	\$0.09863	\$0.09863	\$0.09863
CARE customers:	\$0.07890	\$0.07890	\$0.07890

^{1/} The rates for core transportation-only customers, with the exception of customers taking service under Schedule GT-NGV, include any FERC Settlement Proceeds Memorandum Account (FSPMA) credit adjustments.

^{2/} This charge is applicable to Utility Procurement Customers and includes the GPC and GPC-A Procurement Charges shown in Schedule GPC which are subject to change monthly as set forth in Special Condition 7.

^{3/} Effective starting May 1, 2017, the minimum bill is calculated as the minimum bill charge of \$0.09863 per day times the number of days in the billing cycle (approximately \$3 per month) with a 20% discount applied for CARE customer resulting in a minimum bill charge of \$0.07890 per day (approximately \$2.40 per month).

(Continued)

1C5
Advice Ltr. No. 2735-G
Decision No. _____

Issued by
Dan Skopec
Vice President
Regulatory Affairs

Submitted Jan 7, 2019
Effective Jan 10, 2019
Resolution No. _____



Escalation Assumptions

The average annual escalation rates in the following table were used in this study and are from E3's 2019 study Residential Building Electrification in California (Energy & Environmental Economics, 2019). These rates are applied to the 2019 rate schedules over a thirty-year period beginning in 2020. SDG&E was not covered in the E3 study. The Reach Code Team reviewed SDG&E's GRC filing and applied the same approach that E3 applied for PG&E and SoCalGas to arrive at average escalation rates between 2020 and 2022.

Table 12: Real Utility Rate Escalation Rate Assumptions

	Statewide Electric Residential Average Rate (%/year, real)	Natural Gas Residential Core Rate (%/yr escalation, real)		
		PG&E	SoCalGas	SDG&E
2020	2.0%	1.48%	6.37%	5.00%
2021	2.0%	5.69%	4.12%	3.14%
2022	2.0%	1.11%	4.12%	2.94%
2023	2.0%	4.0%	4.0%	4.0%
2024	2.0%	4.0%	4.0%	4.0%
2025	2.0%	4.0%	4.0%	4.0%
2026	1.0%	1.0%	1.0%	1.0%
2027	1.0%	1.0%	1.0%	1.0%
2028	1.0%	1.0%	1.0%	1.0%
2029	1.0%	1.0%	1.0%	1.0%
2030	1.0%	1.0%	1.0%	1.0%
2031	1.0%	1.0%	1.0%	1.0%
2032	1.0%	1.0%	1.0%	1.0%
2033	1.0%	1.0%	1.0%	1.0%
2034	1.0%	1.0%	1.0%	1.0%
2035	1.0%	1.0%	1.0%	1.0%
2036	1.0%	1.0%	1.0%	1.0%
2037	1.0%	1.0%	1.0%	1.0%
2038	1.0%	1.0%	1.0%	1.0%
2039	1.0%	1.0%	1.0%	1.0%
2040	1.0%	1.0%	1.0%	1.0%
2041	1.0%	1.0%	1.0%	1.0%
2042	1.0%	1.0%	1.0%	1.0%
2043	1.0%	1.0%	1.0%	1.0%
2044	1.0%	1.0%	1.0%	1.0%
2045	1.0%	1.0%	1.0%	1.0%
2046	1.0%	1.0%	1.0%	1.0%
2047	1.0%	1.0%	1.0%	1.0%
2048	1.0%	1.0%	1.0%	1.0%
2049	1.0%	1.0%	1.0%	1.0%



Appendix C – Standards Sections

6.1.1 2019 Building Energy Efficiency Standards Section 150.2(b)1I

Roofs. Replacements of the exterior surface of existing roofs, including adding a new surface layer on top of the existing exterior surface, shall meet the requirements of Section 110.8 and the applicable requirements of Subsections i and ii where more than 50 percent of the roof is being replaced

- i. Low-rise residential buildings with steep-sloped roofs, in Climate Zones 10 through 15 shall have a minimum aged solar reflectance of 0.20 and a minimum thermal emittance of 0.75, or a minimum SRI of 16.

EXCEPTION TO 150.2(b)1Ii: The following shall be considered equivalent to Subsection i:

- a. Air-space of 1.0 inch (25 mm) is provided between the top of the roof deck to the bottom of the roofing product; or
- b. The installed roofing product has a profile ratio of rise to width of 1 to 5 for 50 percent or greater of the width of the roofing product; or
- c. Existing ducts in the attic are insulated and sealed according to Section 150.1(c)9; or
- d. Buildings with at least R-38 ceiling insulation; or
- e. Buildings with a radiant barrier in the attic meeting the requirements of Section 150.1(c)2; or
- f. Buildings that have no ducts in the attic; or
- g. In Climate Zones 10-15, R-2or greater insulation above the roof deck.
- ii. Low-sloped roofs in Climate Zones 13 and 15 shall have a 3-year aged solar reflectance equal or greater than 0.63 and a thermal emittance equal or greater than 0.75, or a minimum SRI of 75.

EXCEPTION 1 to Section 150.2(b)1Iii: Buildings with no ducts in the attic.

EXCEPTION 2 to Section 150.2(b)1Iii: The aged solar reflectance can be met by using insulation at the roof deck specified in TABLE 150.2-B.

6.1.2 2019 Building Energy Efficiency Standards Section 150.2(b)1E

Altered Space-Conditioning System - Duct Sealing: In all Climate Zones, when a space-conditioning system serving a single family or multifamily dwelling is altered by the installation or replacement of space-conditioning system equipment, including replacement of the air handler, outdoor condensing unit of a split system air conditioner or heat pump, or cooling or heating coil; the duct system that is connected to the altered space-conditioning system equipment shall be sealed, as confirmed through field verification and diagnostic testing in accordance with the applicable procedures for duct sealing of altered existing duct systems as specified in Reference Residential Appendix RA3.1 and the leakage compliance criteria specified in subsection i, ii, or iii below. Additionally, when altered ducts, air-handling units, cooling or heating coils, or plenums are located in garage spaces, the system shall comply with Section 150.2(b)1Diic regardless of the length of any new or replacement space-conditioning ducts installed in the garage space.

- i. The measured duct leakage shall be equal to or less than 15 percent of system air handler airflow as determined utilizing the procedures in Reference Residential Appendix Section RA3.1.4.3.1; or
- ii. The measured duct leakage to outside shall be equal to or less than 10 percent of system air handler airflow as determined utilizing the procedures in Reference Residential Appendix Section RA3.1.4.3.4; or
- iii. If it is not possible to meet the duct sealing requirements of either Section 150.2(b)1Ei or Section 150.2(b)1Eii, then, all accessible leaks shall be sealed and verified through a visual inspection and a smoke test by a certified HERS Rater utilizing the methods specified in Reference Residential Appendix RA3.1.4.3.5.

EXCEPTION 1 to Section 150.2(b)1E: Duct Sealing. Duct systems that are documented to have been previously sealed as confirmed through field verification and diagnostic testing in accordance with procedures in the Reference Residential Appendix RA3.1.

EXCEPTION 2 to Section 150.2(b)1E: Duct Sealing. Duct systems with less than 40 linear feet as determined by visual inspection.



EXCEPTION 3 to Section 150.2(b)1E: Duct Sealing. Existing duct systems constructed, insulated or sealed with asbestos.

6.1.3 2019 Building Energy Efficiency Standards Section 110.9(b)4

Occupant Sensing Controls. Occupant sensing controls include occupant sensors, motion sensors, and vacancy sensors, including those with a Partial-ON or Partial-OFF function. Occupant sensing controls shall:

- A. Be capable of automatically turning the controlled lights in the area either off or down no more than 20 minutes after the area has been vacated;
- B. For manual-on controls, have a grace period of no less than 15 seconds and no more than 30 seconds to turn on lighting automatically after the sensor has timed out; and
- C. Provide a visible status signal that indicates that the device is operating properly, or that it has failed or malfunctioned. The visible status signal may have an override that turns off the signal.

EXCEPTION to Section 110.9(b)4: Occupant Sensing Control systems may consist of a combination of single or multi-level Occupant, Motion, or Vacancy Sensor Controls, provided that components installed to comply with manual-on requirements shall not be capable of conversion by occupants from manual-on to automatic-on functionality



Appendix D – Measure Cost-effectiveness Tables

Climate Zone 1: The envelope and duct package is cost-effective for single family built before 1992 and multifamily homes built before 2006. For single family homes built between 1992 and 2005 duct sealing alone is cost-effective. Cool roof upgrades and window replacements are not cost-effective.

Note: Grey rows indicate option is not cost effective.

Table 13: CZ 1 - Single Family Efficiency Upgrade Cost-effectiveness Results

Measure	Vintage	Electricity Savings (kWh)	Gas Savings (therms)	Measure Cost	Utility Cost Savings	Simple Payback	Lifecycle Benefit-Cost Ratio
Envelope & Duct Package	Pre-1978	154	179	\$3,472	\$366	9.49	2.10
	1978-1991	80	93	\$3,212	\$190	16.95	1.18
	1992-2005	65	76	\$3,212	\$155	20.73	0.96
R-38 Attic Insulation	Pre-1978	50	57	\$2,273	\$119	19.17	1.04
	1978-1991	23	27	\$2,013	\$55	36.46	0.55
	1992-2005	23	26	\$2,013	\$54	37.14	0.54
Duct Sealing	Pre-1978	84	97	\$240	\$198	1.21	16.51
	1978-1991	37	43	\$240	\$88	2.72	7.34
	1992-2005	31	36	\$240	\$73	3.28	6.09
Cool Roof	Pre-1978	-28	-34	\$635	-\$68	-9.41	-2.12
	1978-1991	-21	-25	\$635	-\$49	-12.88	-1.55
	1992-2005	-22	-26	\$635	-\$52	-12.19	-1.64
Windows	Pre-1978	111	130	\$9,810	\$265	37.08	0.54
Water Heating Package	All Vintages	0	19	\$208	\$33	6.35	3.16
LED Lamp vs. CFL	All Vintages	1.2	0	\$3.99	\$0.29	13.96	4.45

Table 14: CZ 1 - Multifamily Efficiency Upgrade Cost-effectiveness Results (Per Unit)

Measure	Vintage	Electricity Savings (kWh)	Gas Savings (therms)	Measure Cost	Utility Cost Savings	Simple Payback	Lifecycle Benefit-Cost Ratio
Envelope & Duct Package	Pre-1978	58	67	\$1,054	\$137	7.72	3.15
	1978-1991	28	33	\$987	\$56	17.59	1.38
	1992-2005	21	25	\$987	\$41	24.21	1.00
R-38 Attic Insulation	Pre-1978	15	16	\$594	\$34	17.48	1.39
	1978-1991	7	8	\$526	\$15	34.59	0.70
	1992-2005	7	8	\$526	\$13	39.30	0.62
Duct Sealing	Pre-1978	32	37	\$120	\$76	1.57	15.47
	1978-1991	12	13	\$120	\$24	4.99	4.88
	1992-2005	8	10	\$120	\$16	7.55	3.22
Cool Roof	Pre-1978	-7	-9	\$184	-\$17	-10.60	-2.30
	1978-1991	-4	-6	\$184	-\$10	-19.10	-1.27
	1992-2005	-4	-6	\$184	-\$9	-20.78	-1.17
Windows	Pre-1978	78	92	\$5,873	\$185	31.71	0.77
Water Heating Package	All Vintages	0	16	\$168	\$28	6.02	4.07
LED Lamp vs. CFL	All Vintages	1.2	0	\$3.99	\$0.29	13.96	4.45



Climate Zone 2: The envelope and duct package is cost-effective for single family homes built before 1978 and multifamily homes built before 2006. For single family homes built between 1978 and 2005 duct sealing alone is cost-effective. Cool roof upgrades are cost-effective for single family homes built before 1978 and multifamily homes built before 2006. Window replacements are not cost-effective.

Note: Grey rows indicate option is not cost effective.

Table 15: CZ 2 - Single Family Efficiency Upgrade Cost-effectiveness Results

Measure	Vintage	Electricity Savings (kWh)	Gas Savings (therms)	Measure Cost	Utility Cost Savings	Simple Payback	Lifecycle Benefit-Cost Ratio
Envelope & Duct Package	Pre-1978	578	109	\$3,472	\$387	8.97	2.17
	1978-1991	194	51	\$3,212	\$154	20.80	0.94
	1992-2005	125	45	\$3,212	\$117	27.47	0.72
R-38 Attic Insulation	Pre-1978	385	38	\$2,273	\$195	11.67	1.65
	1978-1991	137	18	\$2,013	\$79	25.47	0.76
	1992-2005	91	17	\$2,013	\$60	33.30	0.58
Duct Sealing	Pre-1978	203	56	\$240	\$169	1.42	13.77
	1978-1991	52	21	\$240	\$55	4.39	4.50
	1992-2005	31	20	\$240	\$44	5.50	3.60
Cool Roof	Pre-1978	219	-20	\$635	\$37	17.12	1.02
	1978-1991	95	-15	\$635	\$8	76.43	0.19
	1992-2005	47	-15	\$635	-\$9	-69.12	-0.33
Windows	Pre-1978	529	39	\$9,810	\$246	39.93	0.48
Water Heating Package	All Vintages	0	19	\$208	\$33	6.31	3.19
LED Lamp vs. CFL	All Vintages	1.2	0	\$3.99	\$0.32	12.62	4.92

Table 16: CZ 2 - Multifamily Efficiency Upgrade Cost-effectiveness Results (Per Unit)

Measure	Vintage	Electricity Savings (kWh)	Gas Savings (therms)	Measure Cost	Utility Cost Savings	Simple Payback	Lifecycle Benefit-Cost Ratio
Envelope & Duct Package	Pre-1978	224	40	\$1,054	\$136	7.76	3.05
	1978-1991	89	18	\$987	\$52	18.83	1.25
	1992-2005	69	15	\$987	\$42	23.26	1.02
R-38 Attic Insulation	Pre-1978	116	11	\$594	\$55	10.89	2.15
	1978-1991	51	5	\$526	\$23	22.40	1.04
	1992-2005	44	5	\$526	\$21	24.65	0.95
Duct Sealing	Pre-1978	112	22	\$120	\$72	1.67	14.16
	1978-1991	44	6	\$120	\$23	5.22	4.50
	1992-2005	26	5	\$120	\$16	7.49	3.15
Cool Roof	Pre-1978	94	-5	\$184	\$22	8.31	2.67
	1978-1991	65	-3	\$184	\$17	10.98	2.04
	1992-2005	45	-3	\$184	\$11	16.88	1.31
Windows	Pre-1978	409	29	\$5,873	\$179	32.85	0.71
Water Heating Package	All Vintages	0	16	\$168	\$27	6.16	3.98
LED Lamp vs. CFL	All Vintages	1.2	0	\$3.99	\$0.32	12.62	4.92



Climate Zone 3: The envelope and duct package is cost-effective for single family and multifamily homes built before 1978. For single family and multifamily homes built between 1978 and 2005 duct sealing alone is cost-effective. Cool roof upgrades and window replacements are not cost-effective.

Note: Grey rows indicate option is not cost effective.

Table 17: CZ 3 - Single Family Efficiency Upgrade Cost-effectiveness Results

Measure	Vintage	Electricity Savings (kWh)	Gas Savings (therms)	Measure Cost	Utility Cost Savings	Simple Payback	Lifecycle Benefit-Cost Ratio
Envelope & Duct Package	Pre-1978	132	99	\$3,472	\$222	15.61	1.28
	1978-1991	41	46	\$3,212	\$91	35.39	0.56
	1992-2005	36	40	\$3,212	\$78	40.97	0.49
R-38 Attic Insulation	Pre-1978	74	37	\$2,273	\$91	24.87	0.80
	1978-1991	17	17	\$2,013	\$36	56.57	0.35
	1992-2005	16	17	\$2,013	\$33	60.55	0.33
Duct Sealing	Pre-1978	53	51	\$240	\$110	2.19	9.11
	1978-1991	15	17	\$240	\$35	6.88	2.91
	1992-2005	14	16	\$240	\$31	7.65	2.61
Cool Roof	Pre-1978	17	-18	\$635	-\$25	-25.51	-0.80
	1978-1991	-9	-13	\$635	-\$24	-26.20	-0.76
	1992-2005	-10	-13	\$635	-\$24	-26.17	-0.76
Windows	Pre-1978	92	72	\$9,810	\$159	61.51	0.32
Water Heating Package	All Vintages	0	19	\$208	\$33	6.39	3.15
LED Lamp vs. CFL	All Vintages	1.2	0	\$3.99	\$0.29	13.75	4.52

Table 18: CZ 3 - Multifamily Efficiency Upgrade Cost-effectiveness Results (Per Unit)

Measure	Vintage	Electricity Savings (kWh)	Gas Savings (therms)	Measure Cost	Utility Cost Savings	Simple Payback	Lifecycle Benefit-Cost Ratio
Envelope & Duct Package	Pre-1978	54	35	\$1,054	\$72	14.60	1.66
	1978-1991	19	15	\$987	\$26	38.21	0.63
	1992-2005	14	12	\$987	\$20	48.42	0.50
R-38 Attic Insulation	Pre-1978	26	10	\$594	\$25	24.16	0.99
	1978-1991	10	5	\$526	\$10	53.48	0.45
	1992-2005	8	5	\$526	\$9	57.71	0.42
Duct Sealing	Pre-1978	25	18	\$120	\$37	3.27	7.41
	1978-1991	7	5	\$120	\$8	14.65	1.65
	1992-2005	4	4	\$120	\$6	19.37	1.25
Cool Roof	Pre-1978	12	-4	\$184	-\$2	-78.18	-0.35
	1978-1991	7	-3	\$184	-\$1	-167.26	-0.17
	1992-2005	3	-3	\$184	-\$2	-76.88	-0.33
Windows	Pre-1978	67	49	\$5,873	\$98	60.05	0.40
Water Heating Package	All Vintages	0	16	\$168	\$26	6.41	3.82
LED Lamp vs. CFL	All Vintages	1.2	0	\$3.99	\$0.29	13.75	4.52



Climate Zone 4: The envelope and duct package is cost-effective for single family homes built before 1978 and multifamily homes built before 1992. For single family homes built between 1978 and 2005 and multifamily homes built between 1992 and 2005 duct sealing alone is cost-effective. Cool roof upgrades are cost-effective for single family homes built before 1978 and multifamily homes built before 2006. Window replacements are not cost-effective.

Note: Grey rows indicate option is not cost effective.

Table 19: CZ 4 - Single Family Efficiency Upgrade Cost-effectiveness Results

Measure	Vintage	Electricity Savings (kWh)	Gas Savings (therms)	Measure Cost	Utility Cost Savings	Simple Payback	Lifecycle Benefit-Cost Ratio
Envelope & Duct Package	Pre-1978	560	93	\$3,472	\$349	9.95	1.95
	1978-1991	228	44	\$3,212	\$146	21.94	0.89
	1992-2005	158	38	\$3,212	\$116	27.80	0.70
R-38 Attic Insulation	Pre-1978	383	35	\$2,273	\$186	12.23	1.57
	1978-1991	172	17	\$2,013	\$84	24.10	0.80
	1992-2005	124	16	\$2,013	\$68	29.55	0.65
Duct Sealing	Pre-1978	185	46	\$240	\$144	1.67	11.73
	1978-1991	60	17	\$240	\$48	5.04	3.88
	1992-2005	34	15	\$240	\$37	6.53	3.02
Cool Roof	Pre-1978	240	-16	\$635	\$49	13.00	1.38
	1978-1991	147	-12	\$635	\$29	21.69	0.82
	1992-2005	87	-12	\$635	\$10	64.71	0.25
Windows	Pre-1978	567	28	\$9,810	\$234	41.95	0.45
Water Heating Package	All Vintages	0	19	\$208	\$33	6.33	3.18
LED Lamp vs. CFL	All Vintages	1.2	0	\$3.99	\$0.32	12.63	4.92

Table 20: CZ 4 - Multifamily Efficiency Upgrade Cost-effectiveness Results (Per Unit)

Measure	Vintage	Electricity Savings (kWh)	Gas Savings (therms)	Measure Cost	Utility Cost Savings	Simple Payback	Lifecycle Benefit-Cost Ratio
Envelope & Duct Package	Pre-1978	214	33	\$1,054	\$118	8.93	2.64
	1978-1991	93	15	\$987	\$49	20.05	1.17
	1992-2005	75	12	\$987	\$40	24.65	0.95
R-38 Attic Insulation	Pre-1978	114	10	\$594	\$51	11.61	2.01
	1978-1991	53	5	\$526	\$23	22.89	1.02
	1992-2005	47	5	\$526	\$21	24.91	0.94
Duct Sealing	Pre-1978	107	17	\$120	\$61	1.96	12.06
	1978-1991	49	5	\$120	\$22	5.47	4.27
	1992-2005	33	4	\$120	\$16	7.61	3.08
Cool Roof	Pre-1978	101	-4	\$184	\$26	7.19	3.12
	1978-1991	75	-3	\$184	\$21	8.94	2.52
	1992-2005	57	-3	\$184	\$15	12.49	1.80
Windows	Pre-1978	438	21	\$5,873	\$173	34.01	0.68
Water Heating Package	All Vintages	0	16	\$168	\$26	6.43	3.81
LED Lamp vs. CFL	All Vintages	1.2	0	\$3.99	\$0.32	12.63	4.92



Climate Zone 5 PG&E/PG&E: The envelope and duct package is cost-effective for single family and multifamily homes built before 1978. For single family homes built between 1978 and 2005 and multifamily homes built between 1978 and 1991 duct sealing alone is cost-effective. Cool roof upgrades are cost-effective for multifamily homes built before 1978 but are not cost-effective for single family homes. Window replacements are cost-effective for multifamily homes built before 1978 but are not cost-effective for single family homes.

Note: Grey rows indicate option is not cost effective.

Table 21: CZ 5 PG&E/PG&E - Single Family Efficiency Upgrade Cost-effectiveness Results

Measure	Vintage	Electricity Savings (kWh)	Gas Savings (therms)	Measure Cost	Utility Cost Savings	Simple Payback	Lifecycle Benefit-Cost Ratio
Envelope & Duct Package	Pre-1978	105	102	\$3,472	\$215	16.12	1.24
	1978-1991	42	48	\$3,212	\$92	34.85	0.57
	1992-2005	36	41	\$3,212	\$79	40.63	0.49
R-38 Attic Insulation	Pre-1978	49	36	\$2,273	\$80	28.54	0.70
	1978-1991	15	16	\$2,013	\$32	62.07	0.32
	1992-2005	14	15	\$2,013	\$29	68.90	0.29
Duct Sealing	Pre-1978	46	52	\$240	\$107	2.24	8.93
	1978-1991	16	18	\$240	\$36	6.70	2.98
	1992-2005	15	17	\$240	\$33	7.17	2.79
Cool Roof	Pre-1978	-5	-25	\$635	-\$45	-14.14	-1.42
	1978-1991	-14	-18	\$635	-\$36	-17.72	-1.13
	1992-2005	-15	-19	\$635	-\$36	-17.70	-1.13
Windows	Pre-1978	81	76	\$9,810	\$160	61.19	0.33
Water Heating Package	All Vintages	0	19	\$208	\$33	6.40	3.14
LED Lamp vs. CFL	All Vintages	1.2	0	\$3.99	\$0.29	13.88	4.48

Table 22: CZ 5 PG&E/PG&E - Multifamily Efficiency Upgrade Cost-effectiveness Results (Per Unit)

Measure	Vintage	Electricity Savings (kWh)	Gas Savings (therms)	Measure Cost	Utility Cost Savings	Simple Payback	Lifecycle Benefit-Cost Ratio
Envelope & Duct Package	Pre-1978	45	36	\$1,054	\$260	4.06	5.76
	1978-1991	13	15	\$987	\$19	53.03	0.46
	1992-2005	10	13	\$987	\$15	64.74	0.38
R-38 Attic Insulation	Pre-1978	22	10	\$594	\$226	2.63	8.85
	1978-1991	7	5	\$526	\$7	76.62	0.31
	1992-2005	5	5	\$526	\$6	87.62	0.28
Duct Sealing	Pre-1978	20	19	\$120	\$234	0.51	45.53
	1978-1991	5	4	\$120	\$5	21.88	1.11
	1992-2005	3	4	\$120	\$5	26.51	0.92
Cool Roof	Pre-1978	7	-6	\$184	\$203	0.91	25.55
	1978-1991	3	-3	\$184	-\$2	-75.95	-0.33
	1992-2005	-1	-3	\$184	-\$4	-45.73	-0.53
Windows	Pre-1978	59	52	\$5,873	\$280	20.98	1.12
Water Heating Package	All Vintages	0	16	\$168	\$21	8.07	3.04
LED Lamp vs. CFL	All Vintages	1.2	0	\$3.99	\$0.29	13.88	4.48



Climate Zone 5 – PG&E/SoCalGas: The envelope and duct package is cost-effective for multifamily homes built before 1978. For single family homes built before 2006 and multifamily homes built between 1978 and 1991 duct sealing alone is cost-effective. Cool roof upgrades are cost-effective for multifamily homes built before 1978 but are not cost-effective for single family homes. Window replacements are not cost-effective.

Note: Grey rows indicate option is not cost effective.

Table 23: CZ 5 PG&E/SoCalGas - Single Family Efficiency Upgrade Cost-effectiveness Results

Measure	Vintage	Electricity Savings (kWh)	Gas Savings (therms)	Measure Cost	Utility Cost Savings	Simple Payback	Lifecycle Benefit-Cost Ratio
Envelope & Duct Package	Pre-1978	105	102	\$3,472	\$165	20.98	1.00
	1978-1991	42	48	\$3,212	\$69	46.38	0.45
	1992-2005	36	41	\$3,212	\$60	53.86	0.39
R-38 Attic Insulation	Pre-1978	49	36	\$2,273	\$61	37.07	0.56
	1978-1991	15	16	\$2,013	\$24	83.94	0.25
	1992-2005	14	15	\$2,013	\$22	92.44	0.23
Duct Sealing	Pre-1978	46	52	\$240	\$82	2.92	7.20
	1978-1991	16	18	\$240	\$27	9.04	2.32
	1992-2005	15	17	\$240	\$25	9.51	2.21
Cool Roof	Pre-1978	-5	-25	\$635	-\$34	-18.44	-1.16
	1978-1991	-14	-18	\$635	-\$28	-22.95	-0.92
	1992-2005	-15	-19	\$635	-\$28	-22.62	-0.93
Windows	Pre-1978	81	76	\$9,810	\$125	78.62	0.27
Water Heating Package	All Vintages	0	19	\$208	\$26	7.95	2.69
LED Lamp vs. CFL	All Vintages	1.2	0	\$3.99	\$0.29	13.88	4.48

Table 24: CZ 5 PG&E/SoCalGas - Multifamily Efficiency Upgrade Cost-effectiveness Results (Per Unit)

Measure	Vintage	Electricity Savings (kWh)	Gas Savings (therms)	Measure Cost	Utility Cost Savings	Simple Payback	Lifecycle Benefit-Cost Ratio
Envelope & Duct Package	Pre-1978	45	36	\$1,054	\$216	4.89	4.80
	1978-1991	13	15	\$987	\$19	53.03	0.48
	1992-2005	10	13	\$987	\$15	64.74	0.40
R-38 Attic Insulation	Pre-1978	22	10	\$594	\$182	3.26	7.07
	1978-1991	7	5	\$526	\$7	76.62	0.33
	1992-2005	5	5	\$526	\$6	87.62	0.29
Duct Sealing	Pre-1978	20	19	\$120	\$191	0.63	36.87
	1978-1991	5	4	\$120	\$5	21.88	1.16
	1992-2005	3	4	\$120	\$5	26.51	0.97
Cool Roof	Pre-1978	7	-6	\$184	\$159	1.16	19.64
	1978-1991	3	-3	\$184	-\$2	-75.95	-0.36
	1992-2005	-1	-3	\$184	-\$4	-45.73	-0.56
Windows	Pre-1978	59	52	\$5,873	\$236	24.87	0.95
Water Heating Package	All Vintages	0	16	\$168	\$21	8.07	3.22
LED Lamp vs. CFL	All Vintages	1.2	0	\$3.99	\$0.29	13.88	4.48



Climate Zone 6: The envelope and duct package is not cost-effective for single family or multifamily homes. For single family homes built before 1978 and multifamily homes built before 1992 duct sealing alone is cost-effective. Cool roof upgrades are cost-effective for multifamily homes built before 1992 but are not cost-effective for single family homes. Window replacements are not cost-effective.

Note: Grey rows indicate option is not cost effective.

Table 25: CZ 6 - Single Family Efficiency Upgrade Cost-effectiveness Results

Measure	Vintage	Electricity Savings (kWh)	Gas Savings (therms)	Measure Cost	Utility Cost Savings	Simple Payback	Lifecycle Benefit-Cost Ratio
Envelope & Duct Package	Pre-1978	455	54	\$3,472	\$211	19.98	0.78
	1978-1991	144	22	\$3,212	\$69	56.35	0.28
	1992-2005	95	19	\$3,212	\$47	81.42	0.19
R-38 Attic Insulation	Pre-1978	373	25	\$2,273	\$150	18.68	0.83
	1978-1991	122	9	\$2,013	\$50	49.70	0.31
	1992-2005	80	9	\$2,013	\$33	73.83	0.21
Duct Sealing	Pre-1978	114	23	\$240	\$65	4.38	3.54
	1978-1991	33	6	\$240	\$18	16.35	0.95
	1992-2005	19	6	\$240	\$12	23.93	0.65
Cool Roof	Pre-1978	195	-15	\$635	\$44	19.31	0.80
	1978-1991	100	-9	\$635	\$25	34.16	0.45
	1992-2005	53	-10	\$635	\$7	134.99	0.11
Windows	Pre-1978	393	5	\$9,810	\$132	93.50	0.17
Water Heating Package	All Vintages	0	19	\$208	\$26	9.05	1.72
LED Lamp vs. CFL	All Vintages	1.2	0	\$3.99	\$0.25	15.73	3.95

Table 26: CZ 6 - Multifamily Efficiency Upgrade Cost-effectiveness Results (Per Unit)

Measure	Vintage	Electricity Savings (kWh)	Gas Savings (therms)	Measure Cost	Utility Cost Savings	Simple Payback	Lifecycle Benefit-Cost Ratio
Envelope & Duct Package	Pre-1978	164	18	\$1,054	\$67	19.24	0.98
	1978-1991	58	5	\$987	\$24	51.43	0.37
	1992-2005	47	4	\$987	\$18	68.16	0.28
R-38 Attic Insulation	Pre-1978	107	7	\$594	\$39	18.98	1.00
	1978-1991	41	2	\$526	\$14	45.11	0.42
	1992-2005	35	2	\$526	\$12	53.10	0.36
Duct Sealing	Pre-1978	68	7	\$120	\$29	5.12	3.69
	1978-1991	32	1	\$120	\$12	13.00	1.46
	1992-2005	20	1	\$120	\$7	22.40	0.84
Cool Roof	Pre-1978	82	-3	\$184	\$21	11.31	1.67
	1978-1991	60	-1	\$184	\$17	13.54	1.40
	1992-2005	45	-1	\$184	\$12	20.06	0.94
Windows	Pre-1978	321	6	\$5,873	\$101	73.32	0.26
Water Heating Package	All Vintages	0	16	\$168	\$19	9.78	1.93
LED Lamp vs. CFL	All Vintages	1.2	0	\$3.99	\$0.25	15.73	3.95



Climate Zone 7: The envelope and duct package is not cost-effective for single family or multifamily homes. For multifamily homes built before 1978 a combination of the duct sealing and R-38 attic insulation upgrades are cost effective. For single family homes built before 1978 and multifamily homes built between 1978 and 1991 duct sealing alone is cost-effective. Cool roof upgrades are cost-effective for single family homes built before 1978 and multifamily homes built before 1992. Window replacements are not cost-effective.

Note: Grey rows indicate option is not cost effective.

Table 27: CZ 7 - Single Family Efficiency Upgrade Cost-effectiveness Results

Measure	Vintage	Electricity Savings (kWh)	Gas Savings (therms)	Measure Cost	Utility Cost Savings	Simple Payback	Lifecycle Benefit-Cost Ratio
Envelope & Duct Package	Pre-1978	314	31	\$3,472	\$209	20.63	0.75
	1978-1991	85	11	\$3,212	\$57	68.80	0.23
	1992-2005	64	10	\$3,212	\$41	96.06	0.16
R-38 Attic Insulation	Pre-1978	272	16	\$2,273	\$168	16.91	0.92
	1978-1991	76	6	\$2,013	\$46	54.75	0.28
	1992-2005	59	6	\$2,013	\$33	75.36	0.21
Duct Sealing	Pre-1978	66	11	\$240	\$52	5.68	2.74
	1978-1991	17	2	\$240	\$12	24.50	0.63
	1992-2005	9	2	\$240	\$7	41.18	0.38
Cool Roof	Pre-1978	150	-11	\$635	\$66	12.43	1.25
	1978-1991	65	-6	\$635	\$26	32.16	0.48
	1992-2005	41	-7	\$635	\$9	100.28	0.15
Windows	Pre-1978	293	-7	\$9,810	\$151	82.91	0.19
Water Heating Package	All Vintages	0	19	\$208	\$30	7.92	1.96
LED Lamp vs. CFL	All Vintages	1.2	0	\$3.99	\$0.33	12.01	5.17

Table 28: CZ 7 - Multifamily Efficiency Upgrade Cost-effectiveness Results (Per Unit)

Measure	Vintage	Electricity Savings (kWh)	Gas Savings (therms)	Measure Cost	Utility Cost Savings	Simple Payback	Lifecycle Benefit-Cost Ratio
Envelope & Duct Package	Pre-1978	98	8	\$1,054	\$68	19.21	0.98
	1978-1991	40	1	\$987	\$10	59.54	0.32
	1992-2005	25	1	\$987	\$5	101.52	0.19
R-38 Attic Insulation	Pre-1978	66	3	\$594	\$47	15.72	1.20
	1978-1991	30	1	\$526	\$0	44.99	0.42
	1992-2005	20	1	\$526	\$0	71.64	0.26
Duct Sealing	Pre-1978	28	2	\$120	\$27	5.54	3.41
	1978-1991	21	0.13	\$120	\$21	14.56	1.30
	1992-2005	12	0.08	\$120	\$12	29.36	0.64
Cool Roof	Pre-1978	46	-3	\$184	\$29	8.01	2.36
	1978-1991	47	-0.35	\$184	\$15	10.96	1.73
	1992-2005	29	-0.35	\$184	\$9	20.10	0.94
Windows	Pre-1978	235	-1	\$5,873	\$114	65.55	0.29
Water Heating Package	All Vintages	0	16	\$168	\$24	7.98	2.37
LED Lamp vs. CFL	All Vintages	1.2	0	\$3.99	\$0.33	12.01	5.17



Climate Zone 8: The envelope and duct package is cost-effective for single family built before 1978 and multifamily homes built before 1992. For single family homes built between 1978 and 2005 and multifamily homes built between 1992 and 2005 duct sealing alone is cost-effective. Cool roof upgrades are cost-effective for all single family and multifamily homes built before 2006. Window replacements are not cost-effective.

Note: Grey rows indicate option is not cost effective.

Table 29: CZ 8 - Single Family Efficiency Upgrade Cost-effectiveness Results

Measure	Vintage	Electricity Savings (kWh)	Gas Savings (therms)	Measure Cost	Utility Cost Savings	Simple Payback	Lifecycle Benefit-Cost Ratio
Envelope & Duct Package	Pre-1978	850	39	\$3,472	\$312	11.14	1.72
	1978-1991	359	17	\$3,212	\$132	24.30	0.79
	1992-2005	311	15	\$3,212	\$119	26.98	0.71
R-38 Attic Insulation	Pre-1978	590	18	\$2,273	\$201	11.28	1.69
	1978-1991	266	8	\$2,013	\$92	21.90	0.87
	1992-2005	248	8	\$2,013	\$90	22.33	0.85
Duct Sealing	Pre-1978	307	17	\$240	\$120	2.00	9.60
	1978-1991	122	5	\$240	\$46	5.21	3.65
	1992-2005	84	4	\$240	\$34	7.14	2.68
Cool Roof	Pre-1978	389	-10	\$635	\$108	5.89	3.13
	1978-1991	266	-7	\$635	\$78	8.12	2.28
	1992-2005	219	-8	\$635	\$66	9.67	1.90
Windows	Pre-1978	723	4	\$9,810	\$222	44.12	0.43
Water Heating Package	All Vintages	0	19	\$208	\$25	8.22	2.60
LED Lamp vs. CFL	All Vintages	1.2	0	\$3.99	\$0.29	13.83	4.49

Table 30: CZ 8 - Multifamily Efficiency Upgrade Cost-effectiveness Results (Per Unit)

Measure	Vintage	Electricity Savings (kWh)	Gas Savings (therms)	Measure Cost	Utility Cost Savings	Simple Payback	Lifecycle Benefit-Cost Ratio
Envelope & Duct Package	Pre-1978	312	13	\$1,054	\$103	10.21	2.28
	1978-1991	139	4	\$987	\$46	21.31	1.08
	1992-2005	123	3	\$987	\$42	23.65	0.98
R-38 Attic Insulation	Pre-1978	157	5	\$594	\$48	12.29	1.89
	1978-1991	73	2	\$526	\$23	23.28	0.99
	1992-2005	69	1	\$526	\$22	23.73	0.97
Duct Sealing	Pre-1978	171	5	\$120	\$57	2.10	11.02
	1978-1991	83	1	\$120	\$27	4.45	5.15
	1992-2005	64	1	\$120	\$22	5.56	4.12
Cool Roof	Pre-1978	149	-2	\$184	\$40	4.64	4.88
	1978-1991	115	-1	\$184	\$33	5.56	4.10
	1992-2005	99	-1	\$184	\$29	6.29	3.62
Windows	Pre-1978	519	5	\$5,873	\$149	39.50	0.58
Water Heating Package	All Vintages	0	16	\$168	\$20	8.54	3.04
LED Lamp vs. CFL	All Vintages	1.2	0	\$3.99	\$0.29	13.83	4.49



Climate Zone 9: The envelope and duct package is cost-effective for single family built before 1992 and multifamily homes built before 2006. For single family homes built between 1992 and 2005 duct sealing alone is cost-effective. Cool roof upgrades are cost-effective for all single family and multifamily homes built before 2006. Window replacements are not cost-effective.

Note: Grey rows indicate option is not cost effective.

Table 31: CZ 9 - Single Family Efficiency Upgrade Cost-effectiveness Results

Measure	Vintage	Electricity Savings (kWh)	Gas Savings (therms)	Measure Cost	Utility Cost Savings	Simple Payback	Lifecycle Benefit-Cost Ratio
Envelope & Duct Package	Pre-1978	1,101	51	\$3,472	\$392	8.86	2.17
	1978-1991	493	23	\$3,212	\$171	18.77	1.02
	1992-2005	432	20	\$3,212	\$156	20.55	0.93
R-38 Attic Insulation	Pre-1978	649	22	\$2,273	\$215	10.55	1.81
	1978-1991	305	11	\$2,013	\$98	20.45	0.93
	1992-2005	299	10	\$2,013	\$102	19.74	0.96
Duct Sealing	Pre-1978	466	23	\$240	\$174	1.38	13.91
	1978-1991	199	7	\$240	\$70	3.41	5.57
	1992-2005	142	6	\$240	\$54	4.44	4.30
Cool Roof	Pre-1978	457	-12	\$635	\$122	5.22	3.53
	1978-1991	319	-8	\$635	\$87	7.30	2.53
	1992-2005	267	-9	\$635	\$75	8.44	2.19
Windows	Pre-1978	941	9	\$9,810	\$285	34.43	0.55
Water Heating Package	All Vintages	0	19	\$208	\$25	8.21	2.60
LED Lamp vs. CFL	All Vintages	1.2	0	\$3.99	\$0.29	13.60	4.57

Table 32: CZ 9 - Multifamily Efficiency Upgrade Cost-effectiveness Results (Per Unit)

Measure	Vintage	Electricity Savings (kWh)	Gas Savings (therms)	Measure Cost	Utility Cost Savings	Simple Payback	Lifecycle Benefit-Cost Ratio
Envelope & Duct Package	Pre-1978	418	17	\$1,054	\$135	7.84	2.97
	1978-1991	201	6	\$987	\$65	15.12	1.53
	1992-2005	168	5	\$987	\$54	18.23	1.27
R-38 Attic Insulation	Pre-1978	186	6	\$594	\$57	10.46	2.22
	1978-1991	89	3	\$526	\$27	19.15	1.21
	1992-2005	79	2	\$526	\$24	21.48	1.08
Duct Sealing	Pre-1978	245	8	\$120	\$78	1.53	15.13
	1978-1991	122	1	\$120	\$38	3.17	7.24
	1992-2005	95	1	\$120	\$30	4.04	5.68
Cool Roof	Pre-1978	179	-3	\$184	\$45	4.06	5.58
	1978-1991	138	-2	\$184	\$37	4.96	4.58
	1992-2005	111	-2	\$184	\$30	6.20	3.66
Windows	Pre-1978	673	8	\$5,873	\$188	31.28	0.74
Water Heating Package	All Vintages	0	16	\$168	\$19	8.81	2.95
LED Lamp vs. CFL	All Vintages	1.2	0	\$3.99	\$0.29	13.60	4.57



Climate Zone 10 – SCE/SoCalGas: The envelope and duct package is cost-effective for single family and multifamily homes built before 2006. Cool roof upgrades are cost-effective for all single family and multifamily homes built before 2006. Window replacements are not cost-effective.

Note: Grey rows indicate option is not cost effective.

Table 33: CZ 10 SCE/SoCalGas - Single Family Efficiency Upgrade Cost-effectiveness Results

Measure	Vintage	Electricity Savings (kWh)	Gas Savings (therms)	Measure Cost	Utility Cost Savings	Simple Payback	Lifecycle Benefit-Cost Ratio
Envelope & Duct Package	Pre-1978	1,354	57	\$3,472	\$470	7.39	2.59
	1978-1991	597	25	\$3,212	\$206	15.62	1.22
	1992-2005	516	22	\$3,212	\$180	17.81	1.07
R-38 Attic Insulation	Pre-1978	729	24	\$2,273	\$235	9.66	1.98
	1978-1991	338	11	\$2,013	\$110	18.29	1.04
	1992-2005	332	11	\$2,013	\$109	18.53	1.03
Duct Sealing	Pre-1978	617	25	\$240	\$221	1.09	17.63
	1978-1991	248	8	\$240	\$89	2.69	7.06
	1992-2005	186	7	\$240	\$69	3.50	5.44
Cool Roof	Pre-1978	555	-13	\$635	\$143	4.43	4.16
	1978-1991	377	-9	\$635	\$105	6.05	3.06
	1992-2005	315	-10	\$635	\$86	7.41	2.49
Windows	Pre-1978	1,178	11	\$9,810	\$349	28.07	0.67
Water Heating Package	All Vintages	0	19	\$208	\$25	8.24	2.59
LED Lamp vs. CFL	All Vintages	1.2	0	\$3.99	\$0.30	13.28	4.68

Table 34: CZ 10 SCE/SoCalGas - Multifamily Efficiency Upgrade Cost-effectiveness Results (Per Unit)

Measure	Vintage	Electricity Savings (kWh)	Gas Savings (therms)	Measure Cost	Utility Cost Savings	Simple Payback	Lifecycle Benefit-Cost Ratio
Envelope & Duct Package	Pre-1978	526	19	\$1,054	\$170	6.20	3.75
	1978-1991	250	7	\$987	\$79	12.49	1.85
	1992-2005	207	6	\$987	\$66	14.90	1.55
R-38 Attic Insulation	Pre-1978	221	7	\$594	\$70	8.52	2.72
	1978-1991	106	3	\$526	\$32	16.44	1.41
	1992-2005	91	3	\$526	\$29	18.31	1.26
Duct Sealing	Pre-1978	317	9	\$120	\$103	1.16	19.88
	1978-1991	152	2	\$120	\$46	2.61	8.82
	1992-2005	119	1	\$120	\$39	3.11	7.38
Cool Roof	Pre-1978	215	-3	\$184	\$57	3.22	7.03
	1978-1991	163	-2	\$184	\$43	4.31	5.27
	1992-2005	129	-2	\$184	\$35	5.21	4.36
Windows	Pre-1978	840	10	\$5,873	\$235	24.97	0.92
Water Heating Package	All Vintages	0	16	\$168	\$20	8.59	3.03
LED Lamp vs. CFL	All Vintages	1.2	0	\$3.99	\$0.30	13.28	4.68



Climate Zone 10 – SDG&E: The envelope and duct package is cost-effective for all single family and multifamily homes built before 2006. Cool roof upgrades are cost-effective for all single family and multifamily homes built before 2006. Window replacements are cost-effective for single family and multifamily homes built before 1978.

Note: Grey rows indicate option is not cost effective.

Table 35: CZ 10 SDG&E - Single Family Efficiency Upgrade Cost-effectiveness Results

Measure	Vintage	Electricity Savings (kWh)	Gas Savings (therms)	Measure Cost	Utility Cost Savings	Simple Payback	Lifecycle Benefit-Cost Ratio
Envelope & Duct Package	Pre-1978	1,354	57	\$3,472	\$800	4.34	4.37
	1978-1991	597	25	\$3,212	\$359	8.95	2.12
	1992-2005	516	22	\$3,212	\$317	10.13	1.87
R-38 Attic Insulation	Pre-1978	729	24	\$2,273	\$405	5.61	3.38
	1978-1991	338	11	\$2,013	\$193	10.40	1.82
	1992-2005	332	11	\$2,013	\$195	10.31	1.83
Duct Sealing	Pre-1978	617	25	\$240	\$377	0.64	29.78
	1978-1991	248	8	\$240	\$155	1.55	12.20
	1992-2005	186	7	\$240	\$120	2.00	9.47
Cool Roof	Pre-1978	555	-13	\$635	\$272	2.33	7.98
	1978-1991	377	-9	\$635	\$195	3.26	5.71
	1992-2005	315	-10	\$635	\$164	3.87	4.80
Windows	Pre-1978	1,178	11	\$9,810	\$631	15.56	1.21
Water Heating Package	All Vintages	0	19	\$208	\$30	6.87	3.01
LED Lamp vs. CFL	All Vintages	1.2	0	\$3.99	\$0.50	8.02	7.75

Table 36: CZ 10 SDG&E - Multifamily Efficiency Upgrade Cost-effectiveness Results (Per Unit)

Measure	Vintage	Electricity Savings (kWh)	Gas Savings (therms)	Measure Cost	Utility Cost Savings	Simple Payback	Lifecycle Benefit-Cost Ratio
Envelope & Duct Package	Pre-1978	526	19	\$1,054	\$298	3.54	6.52
	1978-1991	250	7	\$987	\$141	6.98	3.30
	1992-2005	207	6	\$987	\$116	8.54	2.70
R-38 Attic Insulation	Pre-1978	221	7	\$594	\$120	4.95	4.65
	1978-1991	106	3	\$526	\$57	9.21	2.50
	1992-2005	91	3	\$526	\$48	10.89	2.11
Duct Sealing	Pre-1978	317	9	\$120	\$180	0.67	34.43
	1978-1991	152	2	\$120	\$84	1.43	16.04
	1992-2005	119	1	\$120	\$67	1.79	12.77
Cool Roof	Pre-1978	215	-3	\$184	\$103	1.78	12.79
	1978-1991	163	-2	\$184	\$80	2.30	9.91
	1992-2005	129	-2	\$184	\$62	2.95	7.72
Windows	Pre-1978	840	10	\$5,873	\$427	13.76	1.67
Water Heating Package	All Vintages	0	16	\$168	\$25	6.79	3.71
LED Lamp vs. CFL	All Vintages	1.2	0	\$3.99	\$0.50	8.02	7.75



Climate Zone 11: The envelope and duct package is cost-effective for all single family and multifamily homes built before 2006. Cool roof upgrades are cost-effective for all single family and multifamily homes built before 2006. Window replacements are cost-effective for single family and multifamily homes built before 1978.

Note: Grey rows indicate option is not cost effective.

Table 37: CZ 11 - Single Family Efficiency Upgrade Cost-effectiveness Results

Measure	Vintage	Electricity Savings (kWh)	Gas Savings (therms)	Measure Cost	Utility Cost Savings	Simple Payback	Lifecycle Benefit-Cost Ratio
Envelope & Duct Package	Pre-1978	1,827	120	\$3,472	\$774	4.48	4.27
	1978-1991	858	55	\$3,212	\$358	8.96	2.13
	1992-2005	770	48	\$3,212	\$324	9.93	1.92
R-38 Attic Insulation	Pre-1978	795	47	\$2,273	\$318	7.15	2.68
	1978-1991	383	22	\$2,013	\$152	13.24	1.44
	1992-2005	396	22	\$2,013	\$158	12.76	1.50
Duct Sealing	Pre-1978	982	61	\$240	\$415	0.58	33.10
	1978-1991	434	20	\$240	\$174	1.38	13.77
	1992-2005	355	18	\$240	\$147	1.64	11.65
Cool Roof	Pre-1978	624	-14	\$635	\$161	3.93	4.71
	1978-1991	440	-10	\$635	\$118	5.40	3.44
	1992-2005	369	-10	\$635	\$99	6.41	2.89
Windows	Pre-1978	1,568	45	\$9,810	\$554	17.71	1.07
Water Heating Package	All Vintages	0	19	\$208	\$34	6.06	3.32
LED Lamp vs. CFL	All Vintages	1.2	0	\$3.99	\$0.35	11.53	5.39

Table 38: CZ 11 - Multifamily Efficiency Upgrade Cost-effectiveness Results (Per Unit)

Measure	Vintage	Electricity Savings (kWh)	Gas Savings (therms)	Measure Cost	Utility Cost Savings	Simple Payback	Lifecycle Benefit-Cost Ratio
Envelope & Duct Package	Pre-1978	728	44	\$1,054	\$296	3.57	6.53
	1978-1991	363	19	\$987	\$139	7.09	3.27
	1992-2005	315	16	\$987	\$119	8.29	2.79
R-38 Attic Insulation	Pre-1978	268	13	\$594	\$102	5.80	4.00
	1978-1991	131	6	\$526	\$49	10.75	2.15
	1992-2005	118	6	\$526	\$43	12.10	1.91
Duct Sealing	Pre-1978	473	25	\$120	\$186	0.65	36.02
	1978-1991	231	7	\$120	\$82	1.47	15.72
	1992-2005	196	6	\$120	\$69	1.74	13.25
Cool Roof	Pre-1978	245	-4	\$184	\$66	2.76	8.21
	1978-1991	189	-2	\$184	\$53	3.44	6.61
	1992-2005	156	-2	\$184	\$45	4.13	5.51
Windows	Pre-1978	1,107	33	\$5,873	\$387	15.19	1.52
Water Heating Package	All Vintages	0	16	\$168	\$29	5.76	4.26
LED Lamp vs. CFL	All Vintages	1.2	0	\$3.99	\$0.35	11.53	5.39



Climate Zone 12: The envelope and duct package is cost-effective for all single family and multifamily homes built before 2006. Cool roof upgrades are cost-effective for all single family and multifamily homes built before 2006. Window replacements are cost-effective for multifamily homes built before 1978 but are not cost-effective for single family homes.

Note: Grey rows indicate option is not cost effective.

Table 39: CZ 12 - Single Family Efficiency Upgrade Cost-effectiveness Results

Measure	Vintage	Electricity Savings (kWh)	Gas Savings (therms)	Measure Cost	Utility Cost Savings	Simple Payback	Lifecycle Benefit-Cost Ratio
Envelope & Duct Package	Pre-1978	1,209	109	\$3,472	\$579	6.00	3.21
	1978-1991	540	51	\$3,212	\$263	12.23	1.57
	1992-2005	471	45	\$3,212	\$229	14.02	1.37
R-38 Attic Insulation	Pre-1978	674	43	\$2,273	\$285	7.97	2.40
	1978-1991	318	20	\$2,013	\$136	14.78	1.29
	1992-2005	317	20	\$2,013	\$135	14.88	1.28
Duct Sealing	Pre-1978	532	55	\$240	\$272	0.88	21.82
	1978-1991	216	20	\$240	\$107	2.24	8.57
	1992-2005	155	18	\$240	\$83	2.89	6.67
Cool Roof	Pre-1978	479	-16	\$635	\$121	5.26	3.50
	1978-1991	332	-12	\$635	\$87	7.33	2.51
	1992-2005	273	-12	\$635	\$69	9.17	2.00
Windows	Pre-1978	1,090	43	\$9,810	\$420	23.34	0.81
Water Heating Package	All Vintages	0	19	\$208	\$34	6.05	3.32
LED Lamp vs. CFL	All Vintages	1.2	0	\$3.99	\$0.34	11.80	5.26

Table 40: CZ 12 - Multifamily Efficiency Upgrade Cost-effectiveness Results (Per Unit)

Measure	Vintage	Electricity Savings (kWh)	Gas Savings (therms)	Measure Cost	Utility Cost Savings	Simple Payback	Lifecycle Benefit-Cost Ratio
Envelope & Duct Package	Pre-1978	465	40	\$1,054	\$211	5.01	4.67
	1978-1991	223	18	\$987	\$94	10.50	2.22
	1992-2005	187	15	\$987	\$79	12.45	1.87
R-38 Attic Insulation	Pre-1978	199	11	\$594	\$80	7.40	3.14
	1978-1991	97	6	\$526	\$37	14.03	1.65
	1992-2005	88	6	\$526	\$35	15.14	1.53
Duct Sealing	Pre-1978	276	22	\$120	\$123	0.98	23.87
	1978-1991	134	7	\$120	\$51	2.34	9.87
	1992-2005	103	5	\$120	\$40	2.96	7.81
Cool Roof	Pre-1978	188	-4	\$184	\$51	3.63	6.23
	1978-1991	146	-3	\$184	\$42	4.42	5.13
	1992-2005	117	-3	\$184	\$33	5.49	4.13
Windows	Pre-1978	785	31	\$5,873	\$294	19.96	1.16
Water Heating Package	All Vintages	0	16	\$168	\$28	6.08	4.03
LED Lamp vs. CFL	All Vintages	1.2	0	\$3.99	\$0.34	11.80	5.26



Climate Zone 13: The envelope and duct package is cost-effective for all single family and multifamily homes built before 2006. Cool roof upgrades are cost-effective for all single family and multifamily homes built before 2006. Window replacements are cost-effective for single family and multifamily homes built before 1978.

Note: Grey rows indicate option is not cost effective.

Table 41: CZ 13 - Single Family Efficiency Upgrade Cost-effectiveness Results

Measure	Vintage	Electricity Savings (kWh)	Gas Savings (therms)	Measure Cost	Utility Cost Savings	Simple Payback	Lifecycle Benefit-Cost Ratio
Envelope & Duct Package	Pre-1978	2,047	98	\$3,472	\$790	4.39	4.34
	1978-1991	964	45	\$3,212	\$370	8.68	2.20
	1992-2005	877	39	\$3,212	\$339	9.48	2.01
R-38 Attic Insulation	Pre-1978	940	37	\$2,273	\$338	6.72	2.83
	1978-1991	451	18	\$2,013	\$162	12.43	1.53
	1992-2005	463	17	\$2,013	\$168	11.97	1.59
Duct Sealing	Pre-1978	1,072	50	\$240	\$418	0.57	33.16
	1978-1991	480	17	\$240	\$181	1.33	14.29
	1992-2005	403	16	\$240	\$156	1.54	12.32
Cool Roof	Pre-1978	729	-15	\$635	\$186	3.41	5.45
	1978-1991	516	-11	\$635	\$138	4.60	4.04
	1992-2005	441	-11	\$635	\$117	5.41	3.43
Windows	Pre-1978	1,604	41	\$9,810	\$547	17.94	1.06
Water Heating Package	All Vintages	0	19	\$208	\$34	6.09	3.30
LED Lamp vs. CFL	All Vintages	1.2	0	\$3.99	\$0.34	11.60	5.35

Table 42: CZ 13 - Multifamily Efficiency Upgrade Cost-effectiveness Results (Per Unit)

Measure	Vintage	Electricity Savings (kWh)	Gas Savings (therms)	Measure Cost	Utility Cost Savings	Simple Payback	Lifecycle Benefit-Cost Ratio
Envelope & Duct Package	Pre-1978	805	36	\$1,054	\$298	3.54	6.55
	1978-1991	407	16	\$987	\$144	6.85	3.37
	1992-2005	353	13	\$987	\$126	7.85	2.94
R-38 Attic Insulation	Pre-1978	317	10	\$594	\$110	5.42	4.26
	1978-1991	158	5	\$526	\$54	9.82	2.35
	1992-2005	141	5	\$526	\$49	10.77	2.14
Duct Sealing	Pre-1978	510	20	\$120	\$185	0.65	35.73
	1978-1991	254	6	\$120	\$85	1.42	16.22
	1992-2005	214	5	\$120	\$73	1.64	13.98
Cool Roof	Pre-1978	283	-4	\$184	\$76	2.42	9.37
	1978-1991	220	-3	\$184	\$62	2.99	7.62
	1992-2005	183	-3	\$184	\$52	3.54	6.42
Windows	Pre-1978	1,127	30	\$5,873	\$380	15.47	1.49
Water Heating Package	All Vintages	0	16	\$168	\$27	6.13	4.00
LED Lamp vs. CFL	All Vintages	1.2	0	\$3.99	\$0.34	11.60	5.35



Climate Zone 14 – SCE/SoCalGas: The envelope and duct package is cost-effective for all single family and multifamily homes built before 2006. Cool roof upgrades are cost-effective for all single family and multifamily homes built before 2006. Window replacements are cost-effective for multifamily homes built before 1978 but are not cost-effective for single family homes.

Note: Grey rows indicate option is not cost effective.

Table 43: CZ 14 SCE/SoCalGas - Single Family Efficiency Upgrade Cost-effectiveness Results

Measure	Vintage	Electricity Savings (kWh)	Gas Savings (therms)	Measure Cost	Utility Cost Savings	Simple Payback	Lifecycle Benefit-Cost Ratio
Envelope & Duct Package	Pre-1978	1,832	121	\$3,472	\$680	5.10	3.80
	1978-1991	844	55	\$3,212	\$316	10.18	1.90
	1992-2005	746	48	\$3,212	\$285	11.28	1.71
R-38 Attic Insulation	Pre-1978	816	43	\$2,273	\$276	8.22	2.35
	1978-1991	388	21	\$2,013	\$134	15.07	1.28
	1992-2005	394	20	\$2,013	\$140	14.36	1.34
Duct Sealing	Pre-1978	967	63	\$240	\$366	0.66	29.52
	1978-1991	417	21	\$240	\$154	1.56	12.34
	1992-2005	333	19	\$240	\$130	1.84	10.44
Cool Roof	Pre-1978	631	-19	\$635	\$147	4.32	4.23
	1978-1991	427	-14	\$635	\$108	5.88	3.12
	1992-2005	359	-14	\$635	\$94	6.79	2.69
Windows	Pre-1978	1,527	36	\$9,810	\$475	20.66	0.92
Water Heating Package	All Vintages	0	19	\$208	\$26	8.02	2.66
LED Lamp vs. CFL	All Vintages	1.2	0	\$3.99	\$0.31	13.03	4.77

Table 44: CZ 14 SCE/SoCalGas - Multifamily Efficiency Upgrade Cost-effectiveness Results (Per Unit)

Measure	Vintage	Electricity Savings (kWh)	Gas Savings (therms)	Measure Cost	Utility Cost Savings	Simple Payback	Lifecycle Benefit-Cost Ratio
Envelope & Duct Package	Pre-1978	731	45	\$1,054	\$259	4.07	5.78
	1978-1991	364	19	\$987	\$125	7.90	2.96
	1992-2005	310	16	\$987	\$107	9.23	2.53
R-38 Attic Insulation	Pre-1978	273	12	\$594	\$91	6.52	3.59
	1978-1991	134	6	\$526	\$44	11.94	1.95
	1992-2005	118	6	\$526	\$39	13.41	1.74
Duct Sealing	Pre-1978	467	25	\$120	\$162	0.74	31.67
	1978-1991	227	7	\$120	\$73	1.64	14.14
	1992-2005	188	6	\$120	\$62	1.93	11.99
Cool Roof	Pre-1978	250	-5	\$184	\$61	3.02	7.46
	1978-1991	188	-3	\$184	\$50	3.71	6.11
	1992-2005	152	-3	\$184	\$40	4.56	4.95
Windows	Pre-1978	1,080	26	\$5,873	\$329	17.86	1.30
Water Heating Package	All Vintages	0	16	\$168	\$22	7.76	3.35
LED Lamp vs. CFL	All Vintages	1.2	0	\$3.99	\$0.31	13.03	4.77



Climate Zone 14 – SDG&E: The envelope and duct package is cost-effective for all single family and multifamily homes built before 2006. Cool roof upgrades are cost-effective for all single family and multifamily homes built before 2006. Window replacements are cost-effective for single family and multifamily homes built before 1978.

Note: Grey rows indicate option is not cost effective.

Table 45: CZ 14 SDG&E - Single Family Efficiency Upgrade Cost-effectiveness Results

Measure	Vintage	Electricity Savings (kWh)	Gas Savings (therms)	Measure Cost	Utility Cost Savings	Simple Payback	Lifecycle Benefit-Cost Ratio
Envelope & Duct Package	Pre-1978	1,832	121	\$3,472	\$1,098	3.16	6.04
	1978-1991	844	55	\$3,212	\$523	6.14	3.11
	1992-2005	746	48	\$3,212	\$460	6.98	2.73
R-38 Attic Insulation	Pre-1978	816	43	\$2,273	\$452	5.03	3.79
	1978-1991	388	21	\$2,013	\$223	9.04	2.11
	1992-2005	394	20	\$2,013	\$228	8.85	2.15
Duct Sealing	Pre-1978	967	63	\$240	\$593	0.40	47.14
	1978-1991	417	21	\$240	\$259	0.93	20.51
	1992-2005	333	19	\$240	\$213	1.12	16.92
Cool Roof	Pre-1978	631	-19	\$635	\$285	2.23	8.31
	1978-1991	427	-14	\$635	\$206	3.09	6.01
	1992-2005	359	-14	\$635	\$170	3.72	4.97
Windows	Pre-1978	1,527	36	\$9,810	\$815	12.04	1.57
Water Heating Package	All Vintages	0	19	\$208	\$30	6.83	3.03
LED Lamp vs. CFL	All Vintages	1.2	0	\$3.99	\$0.50	7.98	7.78

Table 46: CZ 14 SDG&E - Multifamily Efficiency Upgrade Cost-effectiveness Results (Per Unit)

Measure	Vintage	Electricity Savings (kWh)	Gas Savings (therms)	Measure Cost	Utility Cost Savings	Simple Payback	Lifecycle Benefit-Cost Ratio
Envelope & Duct Package	Pre-1978	731	45	\$1,054	\$431	2.45	9.49
	1978-1991	364	19	\$987	\$209	4.72	4.90
	1992-2005	310	16	\$987	\$174	5.66	4.09
R-38 Attic Insulation	Pre-1978	273	12	\$594	\$154	3.87	5.99
	1978-1991	134	6	\$526	\$73	7.18	3.22
	1992-2005	118	6	\$526	\$63	8.36	2.77
Duct Sealing	Pre-1978	467	25	\$120	\$272	0.44	52.62
	1978-1991	227	7	\$120	\$125	0.96	23.98
	1992-2005	188	6	\$120	\$103	1.16	19.86
Cool Roof	Pre-1978	250	-5	\$184	\$114	1.61	14.12
	1978-1991	188	-3	\$184	\$87	2.12	10.73
	1992-2005	152	-3	\$184	\$69	2.68	8.47
Windows	Pre-1978	1,080	26	\$5,873	\$570	10.30	2.24
Water Heating Package	All Vintages	0	16	\$168	\$26	6.54	3.85
LED Lamp vs. CFL	All Vintages	1.2	0	\$3.99	\$0.50	7.98	7.78



Climate Zone 15: The envelope and duct package is cost-effective for all single family and multifamily homes built before 2006. Cool roof upgrades are cost-effective for all single family and multifamily homes built before 2006. Window replacements are cost-effective for single family and multifamily homes built before 1978.

Note: Grey rows indicate option is not cost effective.

Table 47: CZ 15 - Single Family Efficiency Upgrade Cost-effectiveness Results

Measure	Vintage	Electricity Savings (kWh)	Gas Savings (therms)	Measure Cost	Utility Cost Savings	Simple Payback	Lifecycle Benefit-Cost Ratio
Envelope & Duct Package	Pre-1978	4,141	23	\$3,472	\$1,116	3.11	6.04
	1978-1991	2,041	8	\$3,212	\$559	5.75	3.27
	1992-2005	1,877	7	\$3,212	\$526	6.10	3.08
R-38 Attic Insulation	Pre-1978	1,483	12	\$2,273	\$386	5.89	3.20
	1978-1991	740	5	\$2,013	\$192	10.49	1.79
	1992-2005	769	5	\$2,013	\$204	9.88	1.90
Duct Sealing	Pre-1978	2,494	9	\$240	\$680	0.35	53.24
	1978-1991	1,182	2	\$240	\$331	0.73	25.86
	1992-2005	1,039	1	\$240	\$299	0.80	23.41
Cool Roof	Pre-1978	1184	-5	\$635	\$296	2.15	8.72
	1978-1991	854	-3	\$635	\$223	2.84	6.59
	1992-2005	751	-3	\$635	\$201	3.15	5.93
Windows	Pre-1978	3,214	4	\$9,810	\$840	11.68	1.61
Water Heating Package	All Vintages	0	19	\$208	\$24	8.71	2.45
LED Lamp vs. CFL	All Vintages	1.2	0	\$3.99	\$0.30	13.26	4.68

Table 48: CZ 15 - Multifamily Efficiency Upgrade Cost-effectiveness Results (Per Unit)

Measure	Vintage	Electricity Savings (kWh)	Gas Savings (therms)	Measure Cost	Utility Cost Savings	Simple Payback	Lifecycle Benefit-Cost Ratio
Envelope & Duct Package	Pre-1978	1,663	7	\$1,054	\$445	2.37	9.67
	1978-1991	863	2	\$987	\$227	4.35	5.26
	1992-2005	762	1	\$987	\$195	5.07	4.51
R-38 Attic Insulation	Pre-1978	574	3	\$594	\$156	3.82	6.00
	1978-1991	285	1	\$526	\$77	6.87	3.33
	1992-2005	254	1	\$526	\$64	8.20	2.79
Duct Sealing	Pre-1978	1,128	3	\$120	\$299	0.40	57.10
	1978-1991	565	0.34	\$120	\$148	0.81	28.15
	1992-2005	501	0.20	\$120	\$129	0.93	24.54
Cool Roof	Pre-1978	455	-1	\$184	\$113	1.63	14.00
	1978-1991	351	-0.49	\$184	\$88	2.09	10.92
	1992-2005	296	-0.45	\$184	\$72	2.54	9.00
Windows	Pre-1978	2,237	4	\$5,873	\$581	10.11	2.26
Water Heating Package	All Vintages	0	16	\$168	\$19	8.91	2.92
LED Lamp vs. CFL	All Vintages	1.2	0	\$3.99	\$0.30	13.26	4.68



Climate Zone 16: The envelope and duct package is cost-effective for all single family and multifamily homes built before 2006. Cool roof upgrades are cost-effective for multifamily homes built before 2006 but are not cost-effective for single family homes. Window replacements are cost-effective for multifamily homes built before 1978 but are not cost-effective for single family homes.

Note: Grey rows indicate option is not cost effective.

Table 49: CZ 16 - Single Family Efficiency Upgrade Cost-effectiveness Results

Measure	Vintage	Electricity Savings (kWh)	Gas Savings (therms)	Measure Cost	Utility Cost Savings	Simple Payback	Lifecycle Benefit-Cost Ratio
Envelope & Duct Package	Pre-1978	635	231	\$3,472	\$620	5.60	3.52
	1978-1991	286	119	\$3,212	\$307	10.46	1.89
	1992-2005	240	107	\$3,212	\$271	11.87	1.66
R-38 Attic Insulation	Pre-1978	407	76	\$2,273	\$269	8.43	2.31
	1978-1991	176	38	\$2,013	\$126	15.97	1.22
	1992-2005	155	36	\$2,013	\$117	17.22	1.14
Duct Sealing	Pre-1978	236	128	\$240	\$307	0.78	25.32
	1978-1991	103	60	\$240	\$141	1.70	11.65
	1992-2005	79	55	\$240	\$125	1.92	10.34
Cool Roof	Pre-1978	232	-31	\$635	\$21	29.70	0.51
	1978-1991	153	-23	\$635	\$11	56.27	0.24
	1992-2005	107	-22	\$635	-\$3	-213.69	-0.18
Windows	Pre-1978	267	162	\$9,810	\$376	26.11	0.76
Water Heating Package	All Vintages	0	19	\$208	\$33	6.37	3.15
LED Lamp vs. CFL	All Vintages	1.2	0	\$3.99	\$0.31	12.94	4.80

Table 50: CZ 16 - Multifamily Efficiency Upgrade Cost-effectiveness Results (Per Unit)

Measure	Vintage	Electricity Savings (kWh)	Gas Savings (therms)	Measure Cost	Utility Cost Savings	Simple Payback	Lifecycle Benefit-Cost Ratio
Envelope & Duct Package	Pre-1978	243	88	\$1,054	\$236	4.48	5.36
	1978-1991	119	45	\$987	\$104	9.45	2.53
	1992-2005	98	38	\$987	\$84	11.80	2.03
R-38 Attic Insulation	Pre-1978	115	22	\$594	\$76	7.81	3.04
	1978-1991	56	11	\$526	\$34	15.48	1.53
	1992-2005	49	10	\$526	\$30	17.31	1.37
Duct Sealing	Pre-1978	131	54	\$120	\$138	0.87	27.75
	1978-1991	63	22	\$120	\$55	2.20	10.87
	1992-2005	47	20	\$120	\$43	2.80	8.56
Cool Roof	Pre-1978	100	-9	\$184	\$16	11.57	1.83
	1978-1991	79	-6	\$184	\$15	11.88	1.83
	1992-2005	60	-6	\$184	\$11	16.92	1.27
Windows	Pre-1978	173	113	\$5,873	\$257	22.83	1.06
Water Heating Package	All Vintages	0	16	\$168	\$28	6.01	4.08
LED Lamp vs. CFL	All Vintages	1.2	0	\$3.99	\$0.31	12.94	4.80





DRAFT Non-Residential Building Energy Efficiency Regulations

Encinitas Municipal Code Section 23.12.110

What projects are affected?

City Council Ordinance 2021-13, adopted by City Council on _____, effects all **existing** non-residential, certain multi-unit residential, and hotel/motel building **additions of 1,000 sq. ft. or alterations with a permit value of at least \$200,000.** The ordinance is effective on _____, 2021 as part of EMC Section 23.12.110.

What are the requirements?

Energy Efficiency:

If a project includes Outdoor Lighting, it must use as least ONE of the following measures for all applicable components of the project:

1. Outdoor lighting that is not greater than 90% of the allowed outdoor lighting power and a color temperature no higher than 3000K for hardscape lighting within Title 24, Part 6, Section 140.7;
2. Service water heating for restaurants that comply with Section 140.5 of the California Energy Code;
3. Warehouse dock seal doors required where dock doors are adjacent to conditioned spaces; or
4. Daylight design power adjustment device(s) installed per Title 24, Part 6, Section 140.3(d).

Steel Framing:

Projects with steel framing must maximize energy efficiency to avoid thermal bridging, as specified in Section A5.213.1 of the 2019 California Green Building Standards Code.

Are there any exceptions?

The Energy Efficiency requirement only applies to applicable projects that include Outdoor Lighting within their scope of work. Where a project does not include Outdoor Lighting, this requirement does not apply.

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CITY OF ENCINITAS

DRAFT Building Solar Photovoltaic Regulations

Encinitas Municipal Code Section 23.12.080



What projects are affected?

City Council Ordinance 2021-13, adopted by City Council on _____, effects all **new** nonresidential, certain multi-unit residential, and hotel/motel buildings as well as all **existing** non-residential, certain multi-unit residential, and hotel/motel buildings **additions that increase total roof area by at least 1,000 sq. ft. or alterations with a permit value of at least \$1,000,000 that affect at least 75% of gross floor area.** The ordinance is effective on _____, 2021 as part of EMC Section 23.12.080.

What are the requirements?

Required solar photovoltaic (PV) equipment shall be sized according to ONE of the following methods:

1) Based on Gross Floor Area of Building:

Gross floor area $\geq$ 10,000 sq. ft.: at least 15 kilowatts direct current (kWdc) per 10,000 sq. ft. of gross floor area.

Note: PV system size = 15 kWdc X (Gross Area / 10,000 sq. ft.) where resulting product shall be rounded to nearest whole number. For example, an applicant with a 126,800 sq. ft. building shall install a minimum 191 kWdc PV system; or

Gross floor area < 10,000 sq. ft.: a minimum size of 5 kWdc.

Note: Applicants are encouraged to right-size PV systems based on buildings' electrical demand to improve system's cost effectiveness. Applicants should also ensure that the PV system meets electrical corporation net energy metering (NEM) requirements, if applicable.

2) Based on Time Dependent Valuation (TDV):

The installed PV system must offset 80% of the building's TDV energy on an annual basis. Total building TDV energy use shall include both conditioned and unconditioned space and be calculated using modeling software or other methods approved by the Development Services Director or their designee.

Are there any exceptions?

- 1) The requirement may be waived or reduced:
 - a. On a case-by-case basis, where it is determined that there are sufficient practical challenges that make compliance infeasible, including: Building site location; Limited rooftop availability; Shading from nearby structures, topography, or vegetation; or Structural load limitations.
 - b. By the maximum extent necessary, if it is determined that this requirement through the use of alternative on-site renewable generation, such as wind energy systems.
- 2) Applicants may comply:
 - a. By voluntarily installing ground mounted PV; or
 - b. By enrolling in a local utility provider's renewable energy portfolio program that provides the greatest available percentage of electrical power from renewable energy sources.
- 3) Greenhouse structures used for commercial cultivation, educational purposes, or the conservancy of plants or animals are exempted from this requirement.
- 4) Aesthetic exterior only façade alterations are excluded from the permit valuation calculation.

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CITY OF ENCINITAS

DRAFT Residential Building Energy Efficiency Regulations



Encinitas Municipal Code Section 23.12.080

What projects are affected?

City Council Ordinance 2021-13, adopted by City Council on _____, effects all **existing** residential building **additions or alterations with a permit value of \$50,000 or higher.** The ordinance is effective on _____, 2021 as part of EMC Section 23.12.080.

What are the requirements?

The following lists the requirements for Single-family and Multi-family residential projects by age of the building:

1. Additions or Alterations to Single-family residential buildings built before 1978 shall include one of the following:
 - a. Duct Sealing; or
 - b. Cool Roof.
2. Additions or Alterations to Single-family residential buildings built between 1978-present shall include one of the following:
 - a. Lighting Package; or
 - b. Water Heating Package.
3. Additions and alterations to Multi-family residential buildings built before 1978 shall include attic insulation with a minimum of R-38 rating.
4. Additions and alterations to Multi-family residential buildings built between 1978 and 1990 shall include one of the following:
 - a. Duct Sealing; or
 - b. Cool Roof.
5. Additions and alterations to Multi-family residential buildings built after 1991 shall include one of the following:
 - a. Lighting Package; or
 - b. Water Heating Package.

Are there any exceptions?

These requirements do not apply to residential buildings that receive a rating of seven (7) or higher on the U.S. Department of Energy's Home Energy Score rating system based upon an assessment by a Home Energy Score Certified Assessor, to the satisfaction of the Development Services Director or their designee. The insulation requirement does not apply to residential dwellings that 1) lack vented attic spaces; 2) have existing attic insulation levels greater than R-5; 3) or are currently unconditioned for space heating and cooling.

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CITY OF ENCINITAS
DRAFT New Building Electrification Regulations
Encinitas Municipal Code Section 23.12.080



What projects are affected?

City Council Ordinance 2021-13, adopted by City Council on _____, effects all **new** residential **and** nonresidential buildings. The ordinance is effective on _____, 2021 as part of EMC Section 23.12.080.

What are the requirements?

All new residential and nonresidential buildings are required to be all-electric unless an exception applies. All-electric is defined as:

A building that has no natural gas or propane plumbing installed within the building and there is no gas meter connection, and that uses electricity as the source of energy for its space heating, water heating, cooking appliances, and clothes drying appliances. All Electric Buildings may include solar thermal pool heating.

Are there any exceptions?

The following exceptions allow natural gas and propose plumbing to be installed along with a gas meter connection as specified:

1. Essential Facilities: Facilities defined by California Health & Safety Code § 16007 and Title 24, Part 1, Chapter 4, including facilities defined by CBC Part 2 Section 202.
2. Non-residential Buildings containing a For-profit Restaurant: the applicant must demonstrate:
 - a. Business-related reason to cook with a flame;
 - b. This need cannot be reasonably achieved with an electric fuel source; and
 - c. The applicant has employed methods to mitigate the greenhouse gas impacts of the gas fueled appliance onsite by reducing energy use equal to or greater than the expected annual GHG emissions from the Therms consumed onsite.
3. Documented Significant Utility Cost to Applicant that is 20% or more for new all-electric service compared to new service for electricity and natural gas to serve the same peak load. This applies only where utility service currently exists.

If an exception applies, the building must be as Electric-Ready as feasible for future electric appliance installation based on the City's Design Guideline for Electric-Ready Buildings and Electric Readiness Equivalencies.

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Climate Action Plan Consistency Checklist

The City of Encinitas (City) Climate Action Plan (CAP) outlines strategies and measures that the City will undertake to achieve its proportional share of State greenhouse gas (GHG) emissions reduction targets. The purpose of the CAP Consistency Checklist (Checklist) is to provide a streamlined review process for all proposed development projects that are subject to local CAP-related building requirements, Encinitas Municipal Code (EMC) Chapter 23.12, Sections 23.12.080 and 23.12.110 of Chapter 23.12 (Ordinance 2021-13).

Checklist Procedures

General procedures for Checklist compliance and review are described below. Specific guidance is also provided under each of the questions in the Checklist.

- The specific applicable requirements outlined in the Checklist shall be required as conditions of project approval.
- The project must provide written documentation and supporting evidence that demonstrate how the proposed project would implement each applicable Checklist requirement described herein to the satisfaction of the Development Services Department.
- If a measure is deemed not applicable for reasons other than those outlined in each question or if an exemption does not apply, supporting evidence must be provided and would be subject to City approval. A project may be determined to be inconsistent with the CAP if lack of compliance is deemed to be not supported by credible evidence.
- Development projects requiring discretionary review that cannot demonstrate consistency with the CAP using this Checklist shall prepare a separate, project-level GHG analysis as part of the CEQA document prepared for the project.

CEQA Applicability

Analysis of GHG emissions and potential climate change impacts from new development is required under California Environmental Quality Act (CEQA). The City's CAP is a qualified greenhouse gas (GHG) emissions reduction plan in accordance with State CEQA Guidelines Section 15183.5. Pursuant to CEQA Guidelines Sections 15064(h)(3), 15130(d), and 15183(b), a project's incremental contribution to a cumulative GHG emissions effect may be determined not to be cumulatively considerable if it complies with the requirements of a CAP. Projects that are consistent with the CAP, as determined through the use of this Checklist, may rely on the CAP for the cumulative impact analysis of GHG emissions. Projects that are not consistent with the CAP must prepare a comprehensive project-specific analysis of GHG emissions, including quantification of existing and projected GHG emissions and incorporation of the measures in this Checklist to the extent feasible. Cumulative GHG impacts would be significant for any project that is not consistent with the CAP or Ordinance 2021-13.

Application Information

Contact Information

Project No. and Name: _____

Property Address and _____

APN: _____

Applicant Name and Co.: _____

Contact Phone: _____ Contact Email: _____

Was a consultant retained to complete this checklist? ☐ Yes ☐ No

If Yes, complete the following:

Consultant Name: _____ Contact
Phone: _____

Company Name: _____ Contact Email: _____

Project Information

1. What is the size of the project site (acres)? _____

2. Identify all applicable proposed land uses:

☐ Residential (indicate # of single-family dwelling units): _____

☐ Residential (indicate # of multi-family dwelling units): _____

☐ Commercial (indicate total square footage): _____

☐ Industrial (indicate total square footage): _____

☐ Other (describe): _____

3. Provide a description of the project proposed. This description should match the basic project description used for the CEQA document. The description may be attached to the Checklist if there are space constraints.

CAP Measures Consistency

The goal of the CAP consistency review process is to evaluate a project's consistency with the applicable strategies and measures of the CAP and City Ordinance 2021-13. Each Checklist item is associated with a specific GHG reduction measure in the City's CAP. "N/A" should only be checked based on the direction provided in each Checklist Item question. All projects for which the measure is applicable must demonstrate that they would implement measures consistent with the Checklist Item, or fully substantiate how the item would be infeasible for project implementation. "N/A" responses are subject to City review and approval. If "No" is provided as a response to a question, the project would be determined to be inconsistent with the CAP and City Ordinance 2021-13 and result in a significant GHG impact.

Residential Land Uses		
Please skip to the nonresidential land use section if the project does not propose any residential uses.		
Checklist Item (Check the appropriate box and provide an explanation and supporting documentation for your answer)	Yes	No
1. All Electric New Buildings (CAP Measure BE-2 / EMC 23.12.080, Section 100.0)	☐	☐
a) Is the project considered a low-rise residential land use?	☐	☐
b) Is the project considered a high-rise residential land use? If "No" was selected above in questions 1(a)-(b), please skip to Residential Land Uses question 2.	☐	☐
c) If "Yes" was selected above in questions 1(a)-(b), will the project use electricity as the source of energy for: - space heating, - water heating, - cooking appliances, and - clothes drying appliances?	☐	☐
d) If the requirement above in question 1(c) cannot be met, do one of the following exceptions apply? - Residential buildings may contain non-electric cooking appliances, pool and spa water heater(s), and/or outdoor fireplaces (including in common areas). - High-rise multi-family building served by a common, central water heater, may contain non-electric water heating appliances.	☐ ☐	☐ ☐

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Residential Land Uses

Please skip to the nonresidential land use section if the project does not propose any residential uses.

Checklist Item (Check the appropriate box and provide an explanation and supporting documentation for your answer)	Yes	No
e) If one of the above exceptions apply above in question 1(d), will the project comply with 2019 Building Energy Efficiency Standards and install electrical conduit and wiring sufficient to operate electrical appliances?	☐	☐

Please substantiate answer selections for Residential Land Uses question 1:

2. Building Efficiency

(CAP Measures BE-1 & BE-2 / EMC 23.12.080, Section 150.2)

- a) Is the project an existing multi-family residence with a permit application valued at \$50,000 or greater?

If **“No”** is selected above, please skip to Residential Land Uses question 2(b).

- If the project was built *before 1978*, will the project install R-38 attic insulation?
- If the project was built *between 1978-1990*, will the project install either duct sealing or cool roofs?
- If the project was built *in or after 1978*, will the project install light packages with screw in LED Lamps or Vacancy Sensors. Or will the project install water heating packaging with either R-6 installation on appliances with a 20 or more-gallon capacity, R-3 installation on water pipes, or upgraded sink and shower fittings?

- b) Is the project an existing single-family residence with a permit application valued at \$50,000 or greater?

If “**No**” is selected above, please skip to Residential Land Uses question 2(c).

- If the project was built *before 1978*, will the project install either duct sealing or cool roofs?

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Residential Land Uses

Please skip to the nonresidential land use section if the project does not propose any residential uses.

Checklist Item (Check the appropriate box and provide an explanation and supporting documentation for your answer)	Yes	No
▪ If the project was built <i>in or after 1978</i>, will the project install light packages with screw in LED Lamps or Vacancy Sensors? Or will the project install water heating packaging with either R-6 installation on appliances with a 20 or more-gallon capacity, R-3 installation on water pipes, or upgraded sink and shower fittings?	☐	☐
c) If the requirements above in questions 2(a)-(b) cannot be met, do one of the following exceptions apply? ▪ Buildings that receive a rating of seven (7) or higher on the U.S. Department of Energy's Home Energy Score rating system based upon an assessment by a Home Energy Score Certified Assessor. ▪ The attic insulation minimum requirement shall not apply to residential dwellings that are not currently conditioned for space heating and cooling.	☐ ☐	☐ ☐

Please substantiate answer selections for Residential Land Uses question 2:

3. Solar Photovoltaic (CAP Measure RE-2 / EMC 23.12.080, Section 120.10)		
a) Is the project considered a new high-rise residential land use?	☐	☐
b) Is the project an existing use that proposes roof additions by at least 1,000 Square Feet?	☐	☐
c) Is the project an existing use with a building permit value of at least \$1 million and an addition of at least 75% of the floor area? If “No” was selected above in questions 3(a)-(c), no further answers are required.	☐	☐

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Residential Land Uses

Please skip to the nonresidential land use section if the project does not propose any residential uses.

Checklist Item (Check the appropriate box and provide an explanation and supporting documentation for your answer)	Yes	No
d) If “ Yes ” was selected above in questions 3(a)-(c), will the project install solar photovoltaics based on one of the following requirements? Please describe below.		
▪ Building gross floor area less than 10,000 square feet with a minimum 5 kWdc system.	☐	☐
▪ Building gross floor area greater than or equal to 10,000 square feet with a 15 kWdc system per 10,000 square feet.	☐	☐
▪ Offset 80 percent of the building’s time dependent value energy on an annual basis.	☐	☐
e) If the requirements above in question 3(d) cannot be met, do one of the following exceptions apply?		
▪ Practical challenges to make satisfaction of the requirements infeasible.	☐	☐
▪ Alternate on-site renewable source used to satisfy measure.	☐	☐
▪ Application on commercial greenhouses.	☐	☐
▪ Procurement of renewable electricity.	☐	☐
▪ Ground mounted solar installations as voluntary alternative.	☐	☐
▪ Excludes value of aesthetic exterior alterations from permit valuation.	☐	☐

Please substantiate answer selections for Residential Land Uses question 3:

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Nonresidential Land Uses		
Please see section above if the project proposes residential uses.		
Checklist Item (Check the appropriate box and provide an explanation and supporting documentation for your answer)	Yes	No
1. All Electric New Buildings (CAP Measures BE-3 & BE-4 / EMC 23.12.080, Section 100.0) a) Is the project considered a nonresidential use or a hotel/motel? If “No” was selected above, please skip to nonresidential land use question 2.	☐	☐
b) If “Yes” was selected above in question 1(a) will the project use electricity as the source of energy for: - space heating - water heating - cooking appliances - clothes drying appliances	☐	☐
c) If the requirements above in question 1(b) cannot be met, do one of the following exceptions apply? - Essential facilities defined by the California Building Code Part 2 Section 202 - Significant utility upgrades	☐ ☐	☐ ☐
Please substantiate answer selections for Nonresidential Land Uses question 1:		
2. Building Efficiency (CAP Measures BE-3 & BE-4 / EMC 23.12.110(D)) a) Is the project an existing nonresidential building with a 1,000 square feet addition or permit application valued at least \$200,000?	☐	☐
b) Is the project an existing hotel/motel with a 1,000 square feet addition or permit application valued at least \$200,000? If “No” was selected in questions 2(a)-(b), please skip to nonresidential land use question 3.	☐	☐

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Nonresidential Land Uses

Please see section above if the project proposes residential uses.

Checklist Item (Check the appropriate box and provide an explanation and supporting documentation for your answer)	Yes	No
c) If “ Yes ” was selected above in questions 2(a)-(b), will the project install at least <i>one</i> of the following? ▪ Outdoor lighting no greater than 90 percent of the Allowed Lighting Power specified under Title 24, Part 6, Section 140.7. ▪ Service water heating in restaurants that comply with California Energy Code Section 140.5. ▪ Warehouse dock seal doors adjacent to conditioned or indirectly conditioned spaces. ▪ Daylight design power adjustment factors that comply with Title 24, Part 6, Section 140.3(d).	☐ ☐ ☐ ☐	☐ ☐ ☐ ☐
d) Does the project contain a(n) elevator(s), escalator(s), or steel framing? If “ No ” was selected above, please skip to nonresidential land use question 2(f).	☐	☐
e) If project contains a(n) elevator(s), escalator(s), or steel framing will it comply with the requirements outlined in Ordinance 2021-13, Sections A5.212 – A5.213?	☐	☐
f) If the requirements above in questions 2(c) or 2(e) cannot be met, do one of the following exceptions apply? ▪ Outdoor Lighting color temperature requirement is not applicable to the applications identified in the exceptions to Section 140.7(a) nor to the applications identified as “specific applications” in Section 140.7(b)(2) and Table 140.7.	☐	☐

Please substantiate answer selections for Nonresidential Land Uses question 2:

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Nonresidential Land Uses

Please see section above if the project proposes residential uses.

Checklist Item (Check the appropriate box and provide an explanation and supporting documentation for your answer)	Yes	No
3. Solar Photovoltaic (CAP Measure RE-3 / EMC 23.12.080, Section 120.10)		
a) Is the project considered a new nonresidential use or hotel/motel?	☐	☐
b) Is the project a roof addition by at least 1,000 square feet?	☐	☐
c) Is the project an existing use with a building permit application valued at least \$1 million and an addition of at least 75% of the floor area? If “ No ” was selected above in questions 3(a)-(c), no further answers are required.	☐	☐
d) If “ Yes ” was selected above in questions 3(a)-(c), will the project install solar photovoltaics based on one of the following requirements? Please describe below. ▪ Building gross floor area less than 10,000 square feet with a minimum 5 kWdc system. ▪ Building gross floor area greater than or equal to 10,000 square feet with a 15 kWdc system per 10,000 square feet. ▪ Offset 80 percent of the building’s time dependent value energy on an annual basis.	☐ ☐ ☐	☐ ☐ ☐
e) If the requirements above in question 3(d) cannot be met, do one of the following exceptions apply? ▪ Practical challenges to make satisfaction of the requirements infeasible. ▪ Alternate on-site renewable source used to satisfy measure. ▪ Application on commercial greenhouses. ▪ Procurement of renewable electricity. ▪ Ground mounted solar installations as voluntary alternative. ▪ Excludes value of aesthetic exterior alterations from permit valuation.	☐ ☐ ☐ ☐ ☐ ☐	☐ ☐ ☐ ☐ ☐ ☐

Please substantiate answer selections for Nonresidential Land Uses question 3:

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Nonresidential Land Uses

Please see section above if the project proposes residential uses.

Checklist Item

(Check the appropriate box and provide an explanation and supporting documentation for your answer)

Yes

No
