CITY COUNCIL AGENDA REPORT

Meeting Date: November 21, 2019

From: John Swiecki, Community Development Director

Subject: Introduction of Draft Ordinance 643

COMMUNITY GOAL/RESULT

Safe Community - Residents and visitors will experience a sense of safety.

Ecological Sustainability - Brisbane will be a leader in setting policies and practicing service delivery innovations that promote ecological sustainability.

PURPOSE

To adopt the most recent version of the California Building Standards Codes (Code of Regulations, Title 24 or CBC) and the International Property Maintenance Code, including local fire, building energy, and electric vehicle reach codes.

RECOMMENDATION

Introduce Ordinance 643.

BACKGROUND

On November 7th, City Council reviewed draft Ordinance No. 643 and after discussion continued consideration of this matter to tonight's meeting. The City Council specifically directed staff to provide information regarding Mountain View's Reach Code, and to research the implications of a natural gas prohibition on cannabis businesses. Both issues are discussed below.

DISCUSSION

Reach Code Purpose

As was discussed briefly in the November 7 City Council Report, the new proposed Reach Code provisions are focused on reducing greenhouse gas emissions by requiring electric vehicle infrastructure and substantially reducing fossil fuel usage by prohibiting natural gas in new construction, with limited exceptions. Inasmuch as much of the discussion at the last City Council meeting focused on the natural gas prohibition, Attachment 3 of this staff report provides additional background as to the value and importance of prohibiting or limiting natural gas usage to help achieve GHG reduction targets.

Mountain View Reach Codes:

On November 12th, the City of Mountain View adopted a reach code similar to Brisbane's proposed reach code in regard to building electrification. There are some differences which are discussed below. Mountain View's reach code is provided as Attachment 5 for reference purposes.

Single family residence and duplexes: Mountain View's ordinance prohibits the use of natural gas in new construction of single family homes and duplexes, while Brisbane's draft code allows for gas for cooking and/or fireplaces.

Commercial kitchens: For nonresidential new construction, Mountain View's reach code would require building electrification, with exceptions allowed for *"for-profit kitchen of a restaurant where the style of cooking cannot be achieved with an electric fuel source or other option in order to operate the kitchen; and when utilized, the developer shall provide installed prewiring for future use of electric appliances."* This exception is similar to Brisbane's draft exception provision, *"… that non-electric building components are essential as a core component of the intended building use, such as a barbeque-themed restaurant, pizza oven, etc …"*

Other exemptions: Mountain View provides exceptions to the building electrification requirements for specific building occupancy classifications referenced in the California Building Code. Specifically these include factory and laboratory occupancy groups F, H and L. Within these occupancy classifications the exemption are further limited to *"building areas where research, experiments, and measurements in medical and life sciences are performed and/or stored"*.

The application of Mountain View's ordinance could mean that an individual building devoted to life sciences could contain space (laboratories) that is subject to the reach code while other portions of the building (office) are exempt. The proposed exemption for life sciences in Brisbane's draft ordinance (modelled after Menlo Park's ordinance) is broader in that it identifies a broad land use category and would apply on a whole-building basis, not to the individual building code occupancy groups that might occur within the building.

Cannabis Businesses: As directed at the last City Council meeting, staff contacted the two cannabis manufacturing businesses that are in the process of opening businesses in Brisbane, Peninsula Distribution Solutions LLC and Caliva. Both companies provided responses and identified three separate stages of the manufacturing process- extraction, infusion and packaging/labeling. Extraction is a process by which the purity of the cannabis product is improved and which is achieved as a self-contained process using products other than natural gas, such as propane, butane, etc.,. Infusion refers to the process of creating the edible products, relieving balms, etc. They indicated that the use of natural gas is typically preferred over electricity for infusion for cost reasons, not technical feasibility. Packaging and labeling was not indicated as having as significant need for natural gas.

Note that the City's draft reach code already allows for an exception to be granted based on cost considerations. Instead of creating a new blanket exemption for cannabis businesses, staff believes the process set forth in the draft ordinance represents a suitable and reasonable approach to address the needs of a manufacturer with an infusion component.

As a reminder the reach code provisions apply only to new buildings. The approved businesses referenced above are tenants in existing buildings not subject to whatever reach code provisions are adopted.

Draft Ordinance

The draft ordinance attached to this staff report has only been revised to incorporate the California Building Code appendices which were read into the record at the last meeting. Potential modifications to the ordinance as discussed at the last City Council meeting such as blanket exemptions for commercial kitchens and/or cannabis businesses were not included in the draft ordinance, but can be added at the discretion of the City Council.

FISCAL IMPACT

None.

MEASURE OF SUCCESS

Application of updated standards to comply with State law and implementation of measures to help meet the goals of the City's Climate Action Plan.

ATTACHMENTS

1. Draft City Ordinance No. 643
2. City Council Agenda Report of November 7, 2019
3. Climate Implications of Reach Code Alternatives
4. City of Menlo Park Staff Memo "All-electric commercial kitchen"
5. City of Mountain View Draft Reach Code for Building Electrification

John Swiecki

John Swiecki, Community Development Director

Clay Holstine, City Manager

ATTACHMENT 1

(Note: Redlines are included, following the meeting of 11/07/2019.)

---Draft ---

ORDINANCE NO. 643

AN ORDINANCE OF THE CITY OF BRISBANE TO AMEND BRISBANE MUNICIPAL CODE TITLE 15, BUILDINGS AND CONSTRUCTION, CHAPTER 15.04, ADOPTION OF CONSTRUCTION CODES AND CHAPTER 15.44, FIRE PREVENTION CODE - ADOPTING THE 2019 CALIFORNIA BUILDING STANDARDS CODES (CBC) AND THE 2018 INTERNATIONAL PROPERTY MAINTENANCE CODE, WITH CERTAIN LOCAL MODIFICATIONS TO THE FIRE CODE; REPLACEMENT OF CHAPTER 15.81, ENERGY CONSERVATION AND GENERATION WITH ON-SITE ENERGY GENERATION AND ADDING CHAPTER 15.83, BUILDING ELECTRIFICATION THEREBY AMENDING THE CALIFORNIA BUILDING ENERGY EFFICIENCY STANDARDS TO INCLUDE LOCAL MODIFICATIONS REQUIRING SOLAR PROVISIONS AND BUILDING ELECTRIFICATION PROVISIONS FOR NEW BUILDINGS; AND ADDING CHAPTER 15.84 ELECTRIC VEHICLE INFRASTRUCTURE

THE CITY COUNCIL OF THE CITY OF BRISBANE HEREBY ORDAINS AS FOLLOWS:

SECTION 1: The City Council finds and determines that:

A. The actions contained in this ordinance comply with the California Environmental Quality Act (CEQA), being categorically exempt per CEQA Section 15308, Actions by Regulatory Agencies for Protection of the Environment.

B. The 2019 Edition of the California Building Code (CBC) becomes effective state-wide on January 1, 2020 and City's adoption of the CBC is necessary in that it allows for enforcement of the CBC under existing and subsequently adopted enforcement provisions of the Brisbane Municipal Code.

C. By reason of the following climatic, geographical, topographical, and community conditions, it is necessary to adopt certain local amendments to the California Fire Code in order to provide a high level of fire and life safety for all persons who live and work within the City of Brisbane and to adequately protect both public and private property within the City:

1. Certain hillside areas of the City are characterized by heavy vegetation and close proximity of structures to the vegetation and each other. These areas contain narrow, winding streets, with steep grades and congested parking and traffic, making access difficult for fire apparatus and equipment in the event of emergency. Numerous dwellings located within the upper hillsides can only be reached by means of private access ways which may not be adequately constructed or maintained for access by Fire Department vehicles.

2. There are several natural conditions that affect the risk of fire damage within the City, including the following:

a. Brisbane is located near the San Andreas Fault and is subject to seismic activity that could potentially ignite fires throughout the City.

b. Brisbane regularly experiences strong winds, with average velocities ranging from approximately 15 to 25 miles per hour and reaching high velocities of 50 miles per hour. These winds may significantly contribute to the spread of fire and will increase the difficulty of fire suppression work.

c. The hillside areas of the City are constructed on the east slope of San Bruno Mountain, immediately adjacent to a protected habitat conservation area which is subject to wildland fires. During recent years several wildland fires have threatened the safety of persons and property located near these areas.

D. The City adopted a Climate Action Plan on September 17, 2015, which includes the goal of reducing carbon emissions from fossil fuels to help curb global warming. Methods include increasing substituting renewable energy for fossil fuel energy sources. The following are primary means to reduce fossil fuel emissions:

i. Building electrification versus use of fossil fuels.
ii. Power generation via solar energy.
iii. Reduction in the fossil fuel emissions from transportation

E. Use of fossil fuel vehicles is a primary contributor to transportation emissions and availability of EV charging infrastructure is a critical component to EV adoption over the continued use of fossil fuel reliant vehicles. Additionally, provision of EV charging infrastructure is most cost effective as part of new development projects versus as building/site retrofit projects.

F. The California Energy Code 2019 Edition, Title 24, Part 6 of the California Code of Regulations includes provisions which reduce building energy consumption. However additional measures are warranted based on the following:

1. The amendment to include a local energy code is justified based on climatic conditions.
2. Energy efficient buildings promote public health and welfare by reducing carbon emissions and providing for lower cost and more sustainable buildings.
3. Sea level rise as a result of global warming poses a threat to certain low lying lands since Brisbane is situated adjacent to the San Francisco Bay and installing solar for energy generation on non-residential buildings and requiring building electrification, instead of allowing the use of fossil fuels, will help curb greenhouse gas emissions, which contribute to global warming.

G. The City of Menlo Park has adopted a building energy reach code ordinance, referencing the State-wide Cost Effectiveness Study, and has provided that code to the California Energy Commission (CEC). Menlo Park's reach code serves as a model ordinance to Brisbane's building energy reach code, with the state's cost effectiveness studies included by reference, "2019 Cost-effectiveness Study: Low-Rise Residential New Construction", prepared by Frontier Energy, Inc and Misti Bruceri & Associates, LLC, dated July 17, 2019, and "2019 Nonresidential New Construction Reach Code Cost Effectiveness Study", prepared by TRC and EnergySoft, dated July 15, 2019. The Menlo Park model includes building electrification for residential and non-

residential buildings and solar for non-residential buildings. The City of Menlo Park ordinance is used as a model for Brisbane's ordinance for the following reasons.

1. The City of Brisbane is within the same CEC climate zone.
2. The building type assumptions for the City of Menlo Park are transferrable to Brisbane as the Menlo Park model accounts for buildings of different sizes.
3. The provisions of the ordinance can be readily implemented, given the prescriptive nature of the provisions affecting only new construction.
4. For projects where special circumstances warrant an exemption, an administrative exemption may be granted by the building official.

H. In 2017, Brisbane adopted an energy reach code, which included cool roof and solar energy provisions for both residential and non-residential new development and the following is noted:

1. Brisbane's previously adopted residential solar energy provisions have been superseded by the California Energy Code.
2. Brisbane's non-residential solar energy provisions are equivalent to those now adopted by the City of Menlo Park and go together with the building electrification requirements. These provisions remain applicable to Brisbane.
3. Brisbane's previously adopted cool roof provisions have been superseded by the increasing requirements for roof top solar power generation.

SECTION 2: Section 15.04.010 of the Brisbane Municipal Code is amended to read as follows:

15.04.010 - Purpose and authority.

The purpose of this chapter is to adopt by reference the 2019 Edition of the California Building Standards Code, Title 24 of the California Code of Regulations. This chapter is also adopted to provide minimum requirements and standards for the protection of the public safety, health, property and welfare of the City of Brisbane. This chapter is adopted under the authority of Government Code Section 38660 and Section 50022.2 and Health and Safety Code Section 18941.5.

SECTION 3: Section 15.04.040 of the Brisbane Municipal Code is amended to read as follows:

15.04.040 - Adoption of Construction Codes.

A. Title 24 of the California Code of Regulations, 2019 Edition of the California Building Standards Code, is hereby adopted by reference and incorporated in this code, including the following parts:

1. 2019 California Administrative Code, Title 24, Part 1.
2. 2019 California Building Code, Volumes 1 and 2, based on the 2018 International Building Code (ICC), Title 24, Part 2.
3. 2019 California Residential Code, based on the 2018 Edition International Residential Code (ICC), Title 24, together with those omission, amendments, exceptions and additions thereto as amended in Part 3 of the California Building Standards Code, California Code of Regulations Title 24.

4. 2019 California Electrical Code, based on the 2017 Edition National Electric Code as published by the National Fire Protection Association (NFPA), Title 24, Part 3.
5. 2019 California Mechanical Code, based on the 2018 Uniform Mechanical Code as published by the International Association of Plumbing and Mechanical Officials (IAPMO), including all appendix chapters, Title 24, Part 4.
6. 2019 California Plumbing Code, based upon the 2018 Uniform Plumbing Code as published by the International Association of Plumbing and Mechanical Officials (IAPMO), including all appendix chapters, Title 24, Part 5.
7. 2019 California Energy Code, Title 24, Part 6. 3. (See also, local Energy Code provisions in Chapter 15.81 and 15.83.)
8. 2019 California Historical Building Code, Title 24, Part 8.
9. For adoption of the 2019 California Fire Code, Title 24, Part 9, and modifications thereof, see Chapter 15.44 of this title.
10. 2019 California Existing Building Code based on the 2018 International Existing Building Code Edition, published by the International Code Council, together with those omissions, amendments, exceptions and additions thereto as amended in Part 10 of the California Building Standards Code, California Code of Regulations Title 24.
11. 2019 California Green Building Standards Code, Title 24, Part 11.
12. 2019 California Referenced Standards Code, Title 24, Part 12.
13. 2019 California Residential Code Appendix H Patio Covers, Appendix J Existing Building and Structures, Appendix K Sound Transmission, and Appendix V Swimming Pool Safety Act.
~~12.~~14. 2019 California Building Code Appendix G Flood Resistant Construction, Appendix I Patio Covers, and Appendix J Grading.

B. The 2018 International Property Maintenance Code is hereby adopted by reference and incorporated in this code.

SECTION 4: Chapter 15.44 Fire Prevention Code of the Brisbane Municipal Code is replaced in its entirety to read to read as follows:

Chapter 15.44 - FIRE PREVENTION CODE

15.44.010 - Adoption of fire prevention code.

The Fire Prevention Code for the City of Brisbane shall be the 2018 Edition of the International Fire Code and the 2019 Edition of the California Fire Code, including Appendices B, C, D, F, and L (collectively, hereinafter referred to as the "Fire Code"), as promulgated by the International Code Council, and the same is hereby adopted and incorporated herein by reference, subject to the modifications as contained in this Chapter 15.44. Two (2) copies of the fire code have been filed for use and examination by the public, one copy being located at Brisbane City Hall and the other copy being located at the fire administration office.

15.44.020 - Title of chapter.

This chapter shall be known as the "fire prevention code of the city" for the administration and enforcement of the fire code.

15.44.030 - Section 104.2 amended—Applications and permits.

Section 104.2 of the fire code is amended by adding the following paragraphs at the end of said section:

Except as otherwise determined by the Fire Marshall, plans submitted in support of an application for a building permit to construct all buildings or structures within the City of Brisbane shall be submitted to the Fire Department for review and approval to determine conformance with applicable fire and life safety requirements.

No portion of any equipment intended to be covered by earth or by enclosure within permanent portions of a building or structure shall be enclosed until inspected and approved by the Fire Marshal, or appointed

Fire Department staff. An inspection shall be requested prior to covering or enclosing of any such equipment. Such request shall be made not less than forty-eight (48) hours prior to the estimated time of the desired inspection.

15.44.040 - Section 105.7.17 added—Permit fees.

Section 105.7.17 is added to the fire code, to read as follows:

105.7.17 Permit fees. The Fire Department shall be authorized to charge such fees and costs for services performed pursuant to the Fire Code as may be established from time to time by ordinance or resolution of the City Council.

15.44.050 - Section 503.2.5 amended—Dead ends.

Section 503.2.5 of the fire code is amended by adding the following paragraph to the end of said section: Dead-end fire apparatus access roads in excess of one hundred fifty feet (150′) in length shall be provided with a minimum turnaround clear radius of fifty-two feet (52′), or other turnaround as approved by the Fire Marshal.

15.44.060 - Section 503.3 amended—Marking.

Section 503.3 of the fire code is amended by adding the following paragraph to the end of said section: Where fire lanes on private property have been designated by the Fire Marshal, curbs shall be painted red on the side or sides of the street or access route where parking is prohibited and no parking signs or other appropriate notice prohibiting obstructions, as approved by the Fire Marshal, shall be provided and maintained by the owner. No parking signs shall read as follows:

FIRE LANE
NO PARKING OR STOPPING
CVC SEC. 22500.1
PARKED VEHICLES MAY BE TOWED
AT VEHICLE OWNER'S EXPENSE

15.44.070 - Section 507.5.7 added—Fire Hydrants and water supply.

Section 507.5.7 is added to the fire code, to read as follows:

507.5.7 Hydrants. All new fire hydrants shall be UL listed, or equivalent, wet barrel type having a minimum of two 2 ½" and one 4 ½" outlets, all equipped with national standard threads (Clow 860, or approved equivalent). The minimum fire service main size permitted is six inches (6").

15.44.080 - Section 903 amended—Automatic sprinkler systems.

Section 903 of the fire code is amended in its entirety to read as follows:
903 Automatic fire extinguishing systems.

(a) Notwithstanding any other provisions of this Code or any other code or ordinance of the City of Brisbane, automatic fire sprinkler systems, approved by the Fire Marshal, shall be installed in the following buildings and structures that are classified as new construction:

1. For all occupancies except R-3 occupancies: Any new building or structure, regardless of size, except stand alone, uninhabitable buildings, garages and sheds having a floor area of less than 400 square feet.

2. For all R-3 occupancies: Any new single-family or duplex structure, excluding any detached accessory structure that does not constitute habitable space having a floor area of less than 400 square feet.

(b) When additions or alterations made to an existing building fall within the requirements under Brisbane Municipal Code Section 15.08.140, an automatic fire sprinkler system shall be provided for the entire building.

(c) Other Areas. An automatic fire sprinkler system shall be installed in all garbage compartments, rubbish and linen chutes, linen rooms, incinerator compartments, dumb waiter shafts, and storage rooms when located in all occupancies except Group R, Division 3. An accessible indicating shut off valve shall also be installed.

(d) Condominium Conversions. An automatic fire sprinkler system shall be installed for all condominium conversions.

(e) Where automatic fire sprinkler systems are required to be installed, the following additional requirements shall also be satisfied, as applicable:

1. A minimum of three (3) copies of plans and specifications for automatic sprinkler installations, plus water supply calculations, shall be provided to the Fire Department for review and approval prior to commencement of the installation work.

2. All required automatic sprinkler systems shall be approved by the Fire Department.

3. All acceptance tests and such periodic tests as required by the Fire Marshall or pursuant to NFPA Pamphlets No. 13, 13D, 13R and/or Subchapter 5, Title 19, California Code of Regulations, shall be conducted and, where applicable, witnessed by a representative of the Fire Department.

4. An approved exterior visual fire alarm device may be required for buildings that have numerous fire department connections (FDC's). Type and locations will be determined by the Fire Department. Such visual alarm devices are not to replace the exterior audible device, but to assist fire suppression personnel as to location(s) of systems which require pumping operations.

15.44.090 - Section 5608.1 amended—Fireworks prohibited.

Section 5608.1 of the fire code is amended by adding the following paragraph to the end of the first paragraph:

The possession, storage, sale, use or discharge of fireworks including California State Fire Marshal approved "safe and sane" fireworks are prohibited within the City of Brisbane.

15.44.100 - Section 904.2 amended—Where required.

Section 904.2 of the fire code is amended by adding the following subsection after subsection 904.2.2 Commercial hood and duct systems:

904.2.3 Floor markings. The location(s) of all cooking appliances that are protected by an approved automatic fire extinguishing system shall be permanently identified either by a wall mounted "approved" appliance floor plan or marked on the floor in a manner approved by the Fire Marshal.

15.44.110 - Section 907.8.1 amended—Maintenance required.

Section 907.8.1 of the fire code is amended by adding the following paragraph at the end of said section: Owners and operators of group R-1 occupancies shall provide documentation to the Fire Department, such as annual inspection forms, which confirm that all smoke detection devices and equipment within apartment units are installed and are in good operating condition.

15.44.120 - Section 304.1.4 added—Removal of waste materials and combustible vegetation.

Section 304.1.4 is added to the fire code, to read as follows:

304.1.4 Removal of waste materials and combustible vegetation.

(a) Notice to Remove. The Bureau of Fire Prevention is authorized to notify the owner of any roof, court, yard, vacant lot or open space within the City of Brisbane or its jurisdiction, or the agent of such owner, to properly dispose of such wastepaper, hay, grass, straw, weeds, litter, combustible or flammable waste, waste petroleum products, vines and other growth or rubbish of any kind located on such owner's property which is dangerous to public safety, health or welfare or is deemed a fire hazard by the Department. Such notice shall inform the owner or the owner’s agent that should the wastepaper, hay, grass, straw, weeds, litter, combustible or flammable waste, waste petroleum products, vines and other growth or rubbish of any kind not be removed as required, then it will be removed by the City and the cost of said removal shall in accordance with this chapter be assessed as a lien on the property to be collected with the next regular tax bill.

Such notice shall be by certified mail, addressed to said owner at the owner’s last known address, as revealed by the tax rolls, and such additional address as may be known by the officer making the order.

(b) Action Upon Non-compliance. Upon failure, neglect or refusal of any owner or agent so notified to properly dispose of such wastepaper, hay, grass, straw, weeds, litter, combustible or flammable waste, waste petroleum products, vines or other growth or rubbish of any kind dangerous to the public health, safety and welfare within fifteen (15) days after receipt of written notice provided for in subsection (a) above, or within fifteen (15) days after the date of such notice in the event the same is returned to the Fire Prevention Bureau because of its inability to make delivery thereof provided the same was properly addressed to the last known address of such owner, as provided in subsection (a) of this section, or agent, the Fire Prevention Bureau is hereby authorized to refer this non-compliance to the City Manager to have the City pay for disposing of such wastepaper, hay, grass, straw, weeds, litter, combustible or flammable

waste, waste petroleum products, vines and other growth or rubbish that endangers property or is liable to be fired.

(c) Charge Included in Tax Bill. When the City has effected the removal of dangerous or hazardous conditions from property as noted in subsection (a) or has paid for its removal, the actual cost thereof, plus accrued interest at the rate of ten percent (10%) per annum from the date of the completion of the work, if not paid for by such owner prior thereto, shall be charged to the owner of such property on the next regular tax bill forwarded to such owner, and said charge shall be due and payable by said owner at the time of payment of such bill.

(d) Acreage Maintained. Any person who owns, leases, controls, operates or maintains any building or structure in, upon, or adjoining any mountainous area or forest-covered lands, brush-covered lands or grass covered lands or any land or acreage covered with flammable material shall maintain around and adjacent to such building or structure a fire break for a distance of not less than thirty (30) feet or to the property line, whichever shall be less. Any person who owns open acreage shall maintain a thirty (30) foot fire break around the perimeter of his acreage as may be directed by the Fire Marshall.

(e) Remedies Cumulative. That the remedies set forth in this section are in addition to any other remedies available to the City as set forth in its ordinances and resolutions and the statutes of the State of California.

(f) Other Regulations. In addition to the remedies set forth herein, the City Council may adopt such other additional, appropriate resolutions and ordinances establishing procedures and regulations for the regulation, control and abatement of waste materials, weeds and other matters constituting a fire and/or safety hazard.

15.44.130 - Section 709 added—Roof coverings.

Section 709 is added to the fire code, to read as follows:

709 Roof coverings. Roof coverings on all buildings shall be fire retardant non-wood materials and shall comply with the standards of the California Building Code, Class A or B, prepared or built-up roofing. Re-roofing of existing buildings which occurs within any twelve (12) month period shall comply with the foregoing requirement if the re-roofing involves fifty percent (50%) or more of the roof area in the case of a non-wood roof or ten percent (10%) or more of the roof area in the case of a wood roof.

15.44.140 - Section 5301.1 amended—Scope.

Section 5301.1 of the fire code is amended by adding the following paragraph at the end of the first paragraph:

The storage of compressed natural gas is prohibited in all areas of the City except for the following subareas as identified in the General Plan for the City of Brisbane: Northeast Bayshore, Southeast Bayshore, Crocker Park, Beatty, and the Baylands when the storage container or tank is located at least 200 (two hundred) feet from the closest property line of a property occupied by a residence or school. Notwithstanding the foregoing, the Fire Marshal may grant a permit for storage of compressed natural gas in other areas of the City if the Fire Marshal determines, in each case, that the storage is required for the conduct of a lawful use upon the property, will not constitute a safety hazard, and will otherwise comply with all applicable provisions of this Code and all other ordinances, rules and regulations of the City. The Fire Marshal may impose such conditions and requirements upon the issuance of the permit as the Fire Marshal deems necessary or appropriate.

15.44.150 - Section 5601.2 amended—General.

Section 5601.2 of the fire code is amended by adding the following paragraph at the end of said section:

The storage of explosives and blasting agents is prohibited in all areas of the City, except that the Fire Marshal may grant a permit to allow such storage if the Fire Marshal determines, in each case, that the storage is required for the conduct of a lawful use upon the property, will not constitute a safety hazard, and will otherwise comply with all applicable provisions of this Code and all other ordinances, rules and regulations of the City. The Fire Marshal may impose such conditions and requirements upon the issuance of the permit as the Fire Marshal deems necessary or appropriate.

15.44.160 - Section 5704.1 amended—General.

Section 5704.1 of the fire code is amended by adding the following paragraph at the end of said section:

The storage of flammable or combustible liquids in outside aboveground tanks is prohibited in all areas of the City except for the following subareas as identified in the General Plan for the City of Brisbane: Northeast Bayshore, Southeast Bayshore, Crocker Park, Beatty, and the Baylands when the storage container or tank is located at least 200 (two hundred) feet from the closest property line of a property occupied by a residence or school. Notwithstanding the foregoing, the Fire Marshal may grant a permit for such storage in other areas of the City if the Fire Marshal determines, in each case, that the storage is required for the conduct of a lawful use upon the property, will not constitute a safety hazard, and will otherwise comply with all applicable provisions of this Code and all other ordinances, rules and regulations of the City. The Fire Marshal may impose such conditions and requirements upon the issuance of the permit as the Fire Marshal deems necessary or appropriate.

15.44.170 - Section 6104.2 amended—Maximum capacity within established limits.

Section 6104.2 of the fire code is amended by adding the following paragraph at the end of the first paragraph of said section:

The aggregate storage of liquefied petroleum gas at any one installation in excess of five hundred (500) gallons (1893 L) is prohibited in all areas of the City except for the following subareas as identified in the General Plan for the City of Brisbane: Northeast Bayshore, Southeast Bayshore, Crocker Park, Beatty, and the Baylands when the storage container or tank is located at least 200 (two hundred) feet from the closest property line of a property occupied by a residence or school. Notwithstanding the foregoing, the Fire Marshal may grant a permit for such storage in other areas of the City if the Fire Marshal determines, in each case, that the storage is required for the conduct of a lawful use upon the property, will not constitute a safety hazard, and will otherwise comply with all applicable provisions of this Code and all other ordinances, rules and regulations of the City. The Fire Marshal may impose such conditions and requirements upon the issuance of the permit as the Fire Marshal deems necessary or appropriate.

15.44.180 - Section 914.3.9 added—Firefighter breathing air replenishment system.

Section 914 of the fire code is amended by adding the following paragraph:

Section 914.3.9 Firefighter breathing air replenishment system. All Group B and Group R occupancies, each having floors used for human occupancy located more than seventy-five feet (75') above the lowest level of fire department vehicular access, shall be equipped with an approved rescue air replenishment

system as per Appendix L. Such a system shall provide an adequate pressurized fresh air supply through a permanent piping system for the replenishment of portable life sustaining air equipment carried by fire department, rescue, and other personnel in the performance of their duties. Location and specifications or access stations to, and the installation of, such air replenishment systems shall be in accordance with the requirements of the fire chief.

15.44.190 - Section 903.2.21 added—Sprinkler protection of car stackers.

Section 903.2.21 of the fire code is added to read:

Sections 903.2.21 Purpose: To establish requirements for sprinkler protection of car stackers not specifically addressed in NFPA 13.

Section 903.2.21 – Car Stackers

Parking garage areas containing car stackers shall be protected by an automatic wet-pipe sprinkler system designed to Extra Hazard Group 1. In addition, non-extended coverage standard sidewall sprinklers listed for Ordinary Hazard shall be provided under each parking level, including the bottom level if the stacker is provided with a pit. Each sidewall sprinkler shall cover an area of 80 sq. ft. or less.

The area of application may be reduced from the required 2500 sq. ft. to as low as 1500 sq. ft. if

1. 1-hour fire rated walls are provided to separate the car stacker areas from the standard parking stalls,
2. The car stacker areas are divided up into 1500 sq. ft. areas via 1-hour fire rated walls, and
3. One-hour fire rated walls are provided to separate the car stacker areas from any other areas in the garage.

One-hour fired rated walls are not required in the driveway areas. For the hydraulic calculation, flow from all sprinklers, upright or pendent sprinklers at ceiling and all sidewall sprinklers at all levels, located in the area of application shall be included in the calculation.

15.44.200 - Section D102.2 added—Access to exterior door.

Section D102.2 of the fire code is added to read as follows:

Section D102.2 Fire department access shall extend to within 50 feet (15 m) of at least one exterior door that can be opened from the outside and that provides access to the interior of the building.

15.44.210 - Section D102.3 added—Large building access.

Section amendment Appendix D Section D102.

Section D102.3 of the fire code is added to read as follows:

Large Buildings—Fire department access roads shall be provided such that any portion of the facility or any portion of an exterior wall of the first story of the building is located not more than 150 ft. (46 m) from fire department access roads as measured by an approved route around the exterior of the building or facility.

15.44.220 - Section D102.4 added—Access Road Clearance.

Section 4-3.124—Amendment Appendix D Section D102.

Section D102.4 is added to read as follows:
Fire department access roads shall have an unobstructed vertical clearance of not less than 13 ft. 6 in. (4.1 m.).

15.44.230 - Amendment to Appendix D of Section D102—Access Road Exceptions.

An Exception is added to Appendix D of Section D102 of the fire code to read as follows:
Exception: When a fire department access road cannot be installed due to location on the property, topography, waterways, nonnegotiable grades, or other similar conditions the authority having jurisdiction shall be authorized to require fire protection features in addition to those already required.

15.44.240 - Amendment to Appendix D of Section D101—Definition—Fire Apparatus access road.

Appendix D of the Fire Code is amended by adding Section D101.2 to read as follows:

D101.2—Definition Fire Apparatus Access Road. A road that provides fire apparatus access from a fire station to at facility, building or portion thereof. This is a general term inclusive of all other terms such as but not limited to fire lane, public street, private street, parking lot lane, access roadway and driveway.

15.44.250 - Amendment of Appendix D, section D103.7 added—Marking.

Appendix D of the fire code is amended by adding Section D103.7 to read:

D103.7—Marking. Where fire lanes on private property have been designated by the Fire Marshall, curbs shall be painted red on the side or sides of the street or access route where parking is prohibited and no parking signs or other appropriate notice prohibiting obstructions, as approved by the Fire Marshall, shall be provided and maintained by the owner.

15.44.260 - Violations of fire code—Penalties.

The violation of any of the provisions of the fire code adopted by this chapter, or any permit issued thereunder, shall constitute a misdemeanor, punishable by the fines, penalties and enforcement provisions set forth in Chapters 1.14, 1.16 and 1.18 of this code.

SECTION 5: Chapter 15.81, "Energy Conservation and Generation" is replaced in its entirety to read as follows:

Chapter 15.81 – On-Site Energy Generation

15.81.010 - Title.

This chapter shall be known as the City of Brisbane On-site Energy Generation Ordinance.

15.81.020 - Authority.

The building official or the building official's designee shall have the authority to enforce the provisions of this chapter.

15.81.030 - Coordination with state energy regulations.

This chapter does not replace the most recent edition of the Building Energy Efficiency Standards for Residential and Non-residential Buildings, Title 24, Part 6 of the California Code of Regulation as adopted by the City in Chapter 15.04 of this Title,("Energy Code"). This Chapter 15.81 amends the energy code to place additional provisions on new residential and nonpresidential development projects. To the extent the provisions of this chapter conflict with any current or subsequently adopted provisions of the energy code, then the most energy conserving provisions shall supersede and control.

15.81.040 - Definitions.

Definitions of terms are as provided in the energy code.

15.81.050 - Solar installation—Local amendment to state energy code.

Subchapter 2 of the Energy Code—All Occupancies—Mandatory Requirements for the Manufacture, Construction and Installation of Systems, Equipment, and Building Components is amended to include:

Solar photovoltaic systems shall be installed on both non-residential and residential building types as follows:

A. New Non-residential and High Rise Residential buildings:

1. Buildings with less than 10,000 square feet of gross floor area shall provide a minimum of a 3 kilowatt photovoltaic system.

2. Buildings with 10,000 square feet or more of gross floor area shall provide a minimum of a 5 kilowatt photovoltaic system.

3. Exception: As an alternative to a solar photovoltaic system listed above, a solar hot water system (solar thermal) may be substituted for all or part of the photovoltaic system, upon submittal of written documentation demonstrating at least the equivalent energy savings to the otherwise required photovoltaic system, subject to approval by the Building Official.

B. New Single Family and Low-Rise Residential Buildings shall comply with the requirements of Title 24, Part 6 of the California Code of Regulation, Section 150.1(c)14, as adopted by the City in Chapter 15.04:

C. New Mixed-use Buildings:

1. Mixed-use buildings shall provide the minimum sized photovoltaic system for both the residential and non-residential components of the building (i.e.: residential and non-residential minimum requirements are considered additive).

15.81.060 - Infeasibility exemption.

If an applicant believes that circumstances exist that make it infeasible to meet the requirements of this chapter, the applicant may request an exemption via written request to the building official. In applying for the exemption, the burden is on the applicant to demonstrate infeasibility to the satisfaction of the building official. Infeasibility exemption may be granted on the basis of site specific cost effectiveness study information or other site or project specific factors.

SECTION 6: Chapter 15.83, "Building Electrification" is added to read as follows:

Chapter 15.83 Building Electrification

15.83.010 - Title.

This chapter shall be known as the City of Brisbane Building Electrification Ordinance.

15.83.020 - Authority.

The building official or the building official's designee shall have the authority to enforce the provisions of this chapter.

15.83.020 - Coordination with state energy regulations.

This chapter does not replace the most recent edition of the Building Energy Efficiency Standards for Residential and Non-residential Buildings, Title 24, Part 6 of the California Code of Regulation as adopted by the City in Chapter 15.04 of this Title,("Energy Code"). This Chapter 15.83 amends the energy code to place additional provisions on new residential and nonpresidential development projects. To the extent the provisions of this chapter conflict with any current or subsequently adopted provisions of the energy code, then the most energy conserving provisions shall supersede and control.

15.83.030 - Purpose.

The purpose of this chapter is to reduce greenhouse gas emissions through the electrification of new buildings and reduction in the use of fossil fuels.

15.83.040 - Application.

This chapter applies to the permitting of all new residential and new non-residential development projects. It does not apply to portable equipment, such as barbeques, with gas supplied by a self-contained, portable fuel tank.

15.83.050 - Definitions:

For the purposes of this chapter, the following definitions shall apply:

A. **Appliance:** "Appliance" means an installed, energy using device or equipment used for basic residential or non-residential task, such as cooking range, refrigerator and dishwasher.

B. **All Electric Building:** "All Electric Building" means a building requiring power that has no natural gas, propane or other fossil fuel plumbing installed within the building and instead uses electricity as the source for its building systems and appliances, such as space heating and/or cooling, water heating, cooking appliances and clothes drying appliances. All electric buildings may include solar thermal water heating.

C. **Building System:** "Building System" means the building's installed air conditioning, space heating, lighting, water heating and similar equipment to be utilized throughout the building.

D. **Life Science Building:** "Life Science Building" means a building where research, experiments and measurement in medical and life sciences are performed and/or stored requiring examination of fine details. The building may include a combination of scientific work areas and the supporting offices.

15.83.060 Building Requirements

A. **New residential development.** New residential construction shall comply with the following provisions:

1. **Electric Building Standards:**
   a. New residential buildings shall be all electric.

2. **Exceptions:** The following exceptions apply:

   a. Residences may include non-electric cooking appliances and fireplaces. Where a non-electric cooking appliance is to be used, the appliance location shall also be pre-wired for future electric appliance installation, with electrical capacity and the reserved circuit breaker space for each appliance identified.

   b. The applicant may submit a written request for a financial hardship exception, subject to Building Official approval. In such cases, it shall be demonstrated that the costs, including short and long term operating costs, would be more expensive under the ordinance provisions.

B. New non-residential development. New non-residential construction shall comply with the following provisions:

1. Electric Building Standards:

   a. New non-residential buildings shall be all electric.

2. **Exceptions:** The following exceptions apply:

   a. Life science buildings.

   b. Other building types where it can be demonstrated in writing, subject to Building Official approval, that non-electric building components are essential as a core component of the intended building use, such as a barbeque-themed restaurant, pizza oven, etc. and the use could not reasonably be accommodated by electric building systems or appliances.

c. The applicant may submit a written request for a financial hardship exception, subject to Building Official approval. In such cases, it shall be demonstrated that the costs, including short and long term operating costs, would be more expensive under the ordinance provisions.

SECTION 7: Chapter 15.84 "Electric Vehicle Infrastructure" is added to read as follows:

Chapter 15.84 – Electric Vehicle Infrastructure

15.84.010 - Title.

This chapter shall be known as the City of Brisbane Electric Vehicle Infrastructure Ordinance.

15.84.020 - Authority.

The building official or the building official's designee shall have the authority to enforce the provisions of this chapter.

15.84.030 - Purpose.

The purpose of this chapter is to provide for electric vehicle charging infrastructure as part of new development projects.

15.84.040 - Application.

This chapter applies to the permitting of all new residential and new non-residential development projects.

15.84.050 – Coordination with state codes

This chapter does not replace the most recent edition of the California Building Code, Title 24, as adopted by the City in Chapter 15.04 of this Code. This chapter 15.84 amends the state code, to place additional requirements on new residential and nonresidential development projects. To the extent the provisions of this chapter conflict with any current or subsequently adopted state code provisions, then the most energy conserving provisions shall supersede and control.

15.84.060 - Definitions:

For the purposes of this chapter, the following definitions shall apply:

A. EV Capable Parking Space: "EV Capable Parking Space" means a parking space linked to a listed electrical panel with sufficient capacity to provide at least 110/120 volts and 20 amperes to the parking space. The following shall be addressed in designating an EV Capable Parking Space:

a. Where, following construction, a parking space would not otherwise be readily linked (or accessible) to the electrical panel, raceways linking the electrical panel and the parking space shall be required in order to be considered EV capable. Determination of linked or accessibility shall be at the discretion of the Building Official.

b. Inaccessibility (not considered EV Capable) generally includes such cases as, where underground trenching would be required or where penetrations to walls, floors, or other partitions would be required for future installation of branch circuits.

c. The panel circuit directory shall identify the overcurrent protective device space(s) reserved for EV charging as "EV CAPABLE."

d. Raceways shall be at least 1" in diameter and may be sized for multiple circuits as allowed by the California Electrical Code. Construction documents shall indicate future completion of raceway from the panel to the parking space, via the installed inaccessible raceways.

B. Level 1 EV Ready Circuit Parking Space: "Level 1 EV Ready Circuit Parking Space" means a parking space served by a complete electric circuit with a minimum of 110/120 volt, 20-ampere capacity including electrical panel capacity, overprotection device. The following shall be addressed in designating a Level 1 EV Ready Circuit Parking Space:

1. Raceways shall be a minimum 1" diameter and may be sized for multiple circuits as allowed by the California Electrical Code.

2. Wiring shall be included and either
    i. A receptacle labelled "Electric Vehicle Outlet" with at least a ½" font adjacent to the parking space, or
    ii. Electric vehicle supply equipment (EVSE).

C. Level 2 EV Ready Circuit Parking Space: "Level 2 EV Ready Circuit Parking Space" means a parking space served by a complete electric circuit with 208/240 volt, 40-ampere capacity including electrical panel capacity, overprotection device. The following shall be addressed in designating a Level 2 EV Ready Circuit Parking Space:

1. It is to be a minimum 1" diameter raceway that may include multiple circuits as allowed by the California Electrical Code.

2. Wiring shall be included and either:
    i. A receptacle labelled "Electric Vehicle Outlet" with at least a ½" font adjacent to the parking space, or

    ii. Electric vehicle supply equipment (EVSE) with a minimum output of 30 amperes.

D. Electric Vehicle Charging Station (EVCS): "Electric Vehicle Charging Station (EVCS)" means a parking space that includes installation of electric vehicle supply equipment (EVSE) with a minimum output of 30 amperes connected to a Level 2 EV Ready Circuit. EVCS installation may be used to satisfy a Level 2 EV Ready Circuit requirement.

E. New Development or New Construction: "New development or new construction" means construction or reconstruction of a principal structure on a site, to which the parking standards provided in Chapter 17.34 would be applied. Based on the Building Official's determination, it may include buildings that have been substantially demolished and reconstructed consistent with Chapter 17.38 – Nonconforming Uses and Structures.

F. Parking Space: "Parking Space" means an area designed and marked for parking an automobile and recognized by the Building Official towards meeting the minimum parking standards for a site as set forth in Chapter 17.34.

15.84.070 Residential Requirements

New residential construction shall comply with the following provisions:

B. New single family residences, duplexes and townhouses.

3. EV Standards:

a. For each dwelling unit, where two or more parking spaces are required, at least one Level 2 EV Ready Circuit and one Level 1 EV Ready Circuit is to be installed.

b. Where only one parking space is required per unit, per Chapter 17.34, only one Level 2 EV Ready Circuit shall be required.

4. **Exceptions:** The following exceptions apply, subject to Building Official approval:

d. A reduction in the EV standards may be allowed, if requested in writing by the applicant based on demonstration that the provisions of this section would render the development project infeasible due to associated utility costs. Documentation is to take into account short term and long term cost analysis to the satisfaction of the Building Official.

C. **New multifamily dwellings.** The following provisions apply to multifamily developments whether parking spaces are assigned or unassigned to individual units:

1. EV Standards:

a. A minimum of one Level 2 EV Ready Circuit Parking Space per unit shall be provided.
b. A minimum of 50 percent of required guest spaces shall be Electric Vehicle Charging Station (EVCS) Parking Spaces

2. **Exceptions:** The following exceptions apply, subject to Building Official approval:

a. Where less than one parking space per unit is required per Chapter 17.34, the provision of Level 2 EV Ready Circuit Parking Space shall apply only to the parking required per Chapter 17.34. This section does not alter the required minimum number of parking spaces as provided in Chapter 17.34.

b. When more than 20 multifamily dwelling units are constructed on a building site, load balancing systems may be installed. In such cases, the panel capacity must average a minimum of 16 amperes per EV space. Load balancing systems may be installed to increase the number of EV chargers or the amperage or voltage beyond the minimum required.

c. A reduction in the EV standards may be allowed, if requested in writing by the applicant based on demonstration that the provisions of this section would render the development project infeasible due to associated utility costs. However, the maximum feasible amount of EV infrastructure shall be provided. Documentation is to take into account short term and long term cost analysis to the satisfaction of the Building Official.

15.84.080 Non-Residential Requirements

New nonresidential construction shall comply with the following provisions:

A. Building Uses with Lower Parking Turnover Rates: For buildings designed for primarily low parking turnover uses, such as Administrative Office, R&D, Industrial, Hotels and School Uses, the following provisions apply to construction of new buildings, as determined by the Building Official. These building uses typically have longer average parking durations as compared to those included in Section 17.84.080.B.

3. EV Standards:

a. A total of 50% of the parking spaces required per Chapter 17.34 shall be EV, as follows:
   i. When 10 or more parking spaces are required to be constructed, 15% of the required parking spaces on site shall be equipped with Level 2 EVCS;
   ii. An additional 10% shall be provided with at least Level 2 EV Ready Circuits; and
   iii. An additional 25% shall be at least Level 1 EV Capable.

a. Rounding: Calculations for the required minimum number of spaces equipped with Level 2 EVCS, Level 1 EV Ready spaces and EV Capable spaces shall all be rounded up to the nearest whole number

4. **Exceptions:** The following exceptions apply, subject to Building Official approval:

a. A reduction in the EV standards may be allowed, if requested in writing by the applicant based on demonstration that the provisions of this section would render the development project infeasible due to associated utility costs. However, the maximum feasible amount of EV infrastructure shall be provided. Documentation is to take into account short term and long term cost analysis to the satisfaction of the Building Official.

b. The Building Official may apply EV Space Standards provided in Section 15.84.080.B to uses listed in this section where the applicant has adequately demonstrated that the specific use applied for fits with the Higher Parking Turnover Rates.

B. Building Uses with Higher Parking Turnover Rates: The following provisions apply to construction of new buildings designed for the primary uses of restaurant, retail, meeting

halls, gyms, commercial recreation, professional office and similar, as determined by the Building Official. These building uses typically have shorter average parking durations as compared to those included in Section 17.84.080.A.

1. EV Standards:

b. A total of 25% of the parking spaces required per Chapter 17.34 shall be EV, as follows:

i. When 10 or more parking spaces are required to be constructed, 15% of the required parking spaces on site shall be equipped with Level 2 EVCS;
ii. An additional 10% shall be at least Level 1 EV Ready.

a. Rounding: Calculations for the required minimum number of spaces equipped with Level 2 EVCS and Level 1 EV Ready spaces shall be rounded up to the nearest whole number.

2. **Exceptions:** The following exceptions apply, subject to Building Official approval:

a. A reduction in the EV standards may be allowed, if requested in writing by the applicant based on demonstration that the provisions of this section would render the development project infeasible due to associated utility costs. However, the maximum feasible amount of EV infrastructure shall be provided. Documentation is to take into account short term and long term cost analysis to the satisfaction of the Building Official.

b. Installation of each Direct Current Fast Charger with the capacity to provide at least 80 kW output may substitute for 6 Level 2 EVCS and 5 EV Ready spaces after a minimum of 6 Level 2 EVCS and 5 Level 1 EV Ready spaces are installed.

SECTION 8: If any section, subsection, sentence, clause or phrase of this Ordinance is for any reason held by a court of competent jurisdiction to be invalid or unconstitutional, such decision shall not affect the validity of the remaining portions of this Ordinance. The City Council of the City of Brisbane hereby declares that it would have passed this Ordinance and each section, subsection, sentence, clause and phrase thereof, irrespective of the fact that one or more sections, subsections, sentences, clauses or phrases may be held invalid or unconstitutional.

SECTION 9: This Ordinance shall be in full force and effect on January 1, 2020 after its passage and adoption, except that the provisions of Section 7 pertaining to Building Electrification shall be in effect following approval by the California Energy Commission.

* * *

The above and foregoing Ordinance was regularly introduced and after the waiting time required by law, was thereafter passed and adopted at a regular meeting of the City Council of the City of Brisbane held on the ~~twenty first day of November 2019~~twelfth day of December 2019, by the following vote:

AYES:

NOES:
ABSENT:
ABSTAIN:

_____
Mayor

ATTEST:

_____
City Clerk

APPROVED AS TO FORM:

_____
City Attorney

CITY COUNCIL AGENDA REPORT

Meeting Date: November 7, 2019

From: John Swiecki, Community Development Director

Subject: Introduction of Draft Ordinance 643

COMMUNITY GOAL/RESULT

Safe Community - Residents and visitors will experience a sense of safety.

Ecological Sustainability - Brisbane will be a leader in setting policies and practicing service delivery innovations that promote ecological sustainability.

PURPOSE

To adopt the most recent version of the California Building Standards Codes (Code of Regulations, Title 24 or CBC) and the International Property Maintenance Code, including local fire, building energy, and electric vehicle reach codes.

RECOMMENDATION

Introduce Ordinance 643.

BACKGROUND

Every three years a new set of construction codes is published by the State. Local adoption of these codes allows the City to enforce them under the authority of the Municipal Code, and to adopt local modifications. Whether or not a city elects to adopt the state codes by local ordinance, the state codes automatically become effective January 1, 2019.

The last Code adoption cycle was in 2016 when the City amended Chapter 15.04 of the Municipal Code, to adopt the 2016 Edition of the California Building Standards Code. At the same time, the City amended other chapters within Title 15 as local reach codes pertaining to fire protection, building demolition/construction waste recycling and energy generation.

DISCUSSION

Building Code and Property Maintenance Code Adoption: The proposed ordinance would adopt the following construction codes by updating Brisbane Municipal Code Chapter 15.04, Adoption of Construction Codes, or Section 3 of the draft ordinance:

1. 2019 California Administrative Code, Title 24, Part 1.
2. 2019 California Building Code, Volumes 1 and 2, based on the 2018 International Building Code (ICC), Title 24, Part 2.
3. 2019 California Residential Code, based on the 2018 Edition International Residential Code (ICC), Title 24, together with those omission, amendments, exceptions and additions thereto as amended in Part 3 of the California Building Standards Code, California Code of Regulations Title 24.
4. 2019 California Electrical Code, based on the 2017 Edition National Electric Code as published by the National Fire Protection Association (NFPA), Title 24, Part 3.
5. 2019 California Mechanical Code, based on the 2018 Uniform Mechanical Code as published by the International Association of Plumbing and Mechanical Officials (IAPMO), including all appendix chapters, Title 24, Part 4.
6. 2019 California Plumbing Code, based upon the 2018 Uniform Plumbing Code as published by the International Association of Plumbing and Mechanical Officials (IAPMO), including all appendix chapters, Title 24, Part 5.
7. 2019 California Energy Code, Title 24, Part 6. 3. (See also, local Energy Code provisions in Chapter 15.81 and 15.83.)
8. 2019 California Historical Building Code, Title 24, Part 8.
9. For adoption of the 2019 California Fire Code, Title 24, Part 9, and modifications thereof, see Chapter 15.44 of this title.
10. 2019 California Existing Building Code based on the 2018 International Existing Building Code Edition, published by the International Code Council, together with those omissions, amendments, exceptions and additions thereto as amended in Part 10 of the California Building Standards Code, California Code of Regulations Title 24.
11. 2019 California Green Building Standards Code, Title 24, Part 11.
12. 2019 California Referenced Standards Code, Title 24, Part 12.

Additionally, in order to keep current with property maintenance provisions, it is recommended that the 2018 International Property Maintenance Code be adopted to replace the 2015 edition.

As indicated above, adoption of the above referenced codes would allow the City to enforce the above listed codes under the authority of the Brisbane Municipal Code.

To supplement the updated state codes noted above, it is proposed that the City adopt several local modifications, known as 'reach codes' to address local fire hazards as well as energy and greenhouse gas emissions.

Fire Code: Since 2007, the City has adopted local modifications to the Fire Code addressing such items as automatic fire sprinklers on certain structures, fire access turnarounds on dead end roads, removal of combustible materials from property, limitations on storage of explosives and flammable liquids, and other provisions. Local modifications to the Fire Code are again proposed in BMC Chapter 15.44 of the attached draft ordinance. In this cycle, the proposed

updates suggested by North County Fire Authority are clarification or reorganization edits and do not substantively change the existing ordinance.

In order to modify the standard fire codes, a local jurisdiction must make finding(s) that the modification is required due to climatic, geographical, topographical or other conditions. These findings have been made in past years based on Brisbane's heavily vegetated hillsides; narrow, steep public streets and private access-ways; proximity to the San Andreas Fault; exposure to strong winds; and location immediately adjacent to protected habitat conservation areas subject to wildland fires. Although the findings for the reach codes have been made in past years, they are repeated here since the fire code update is part of the draft ordinance.

The Fire Code amendments are included as Section 4 of the draft ordinance.

Energy and Reduction of Greenhouse Gas Emissions Codes: With each new edition of the CBC, the codes have become increasing rigorous in providing for more energy efficient buildings. This is largely to meet the state's goals in reducing greenhouse gas (GHG) emissions, ultimately with the aim of providing for zero net energy (ZNE) new buildings. Energy efficiencies are achieved through provisions on such things as the building envelope, HVAC systems and lighting. The improvements in residential building energy efficiencies for new construction were estimated by the state to yield energy use reductions of 50 percent versus the 2016 CBC. Non-residential construction was estimated to yield a 30 percent reduction in energy use. One notable new requirement with the 2019 CBC is that new single family residences will now be required to have solar energy generation on-site to meet the projected electrical energy demands. Multi-family residential and non-residential buildings would not have that solar requirement under the 2019 CBC.

Individual cities may undertake additional measures, as reach codes, to further renewable energy use and GHG reductions. Three energy/GHG related reach codes are proposed with this update cycle. These are outlined below and described further as follows:

- **Replacement of BMC Chapter 15.81 Energy Conservation and Generation with a new Chapter 15.81 On-Site Energy Generation is proposed for consistency with the state codes and consistency with Brisbane's proposed building electrification reach code. This is included in the draft ordinance Section 5.**

<u>BMC Chapter 15.81 - On-Site Energy Generation:</u> Brisbane adopted BMC Chapter 15.81 during the 2016 CBC update cycle, which requires that new residential and non-residential buildings include solar energy generation and in certain cases cool roofs may also be required.

The 2019 state code requires new single family residences to meet their projected electrical energy use with solar energy, which goes further than the City's current code provisions requiring solar for single family residences. However, the state Code does not require solar generation for multi-family and non-residential development. As such, it is proposed that BMC Section 15.81 be revised to apply only to multi-family and non-residential development, and

that single family residential development be subject to state code requirements. The existing provisions for multi-family and non-residential development would remain as-is. The cool roof provisions would also be removed from the chapter since they have been superseded by the state building envelop requirements. Also, note that there is an existing provision in the Municipal Code that allows for solar thermal (water heating) to substitute for the photovoltaic system. That would be updated to ensure that such a substitution would result in at least the equivalent energy savings to the otherwise required photovoltaic system

Proposed BMC Chapters 15.81 and 15.86 will require California Energy Commission adoption following City Council adoption including a cost effectiveness study which demonstrates that these revisions are economically feasible for developers to implement. The cost effectiveness study is included by reference with web-links provided in the attachments.

- **A new BMC Chapter 15.83 Building Electrification for new residential and non-residential development is included in the draft ordinance as Section 6.**

BMC Chapter 15.83 - Building Electrification: In addition to solar power generation, building electrification is an important step in further reducing GHG emissions. There are different degrees of building electrification that can be achieved, ranging from the full prohibition of natural gas to allowing natural gas but requiring certain systems such as home heating and air conditioning to be electrified. In the 2019 CBC, new buildings would not be prohibited from the use of natural gas, but building electrification is considered a reasonable prescriptive reach code.

It is proposed that the City adopt electrification reach code provisions similar to those adopted by the City of Menlo Park. The proposed electrification provisions include:

- New Residential Buildings – 3 Stories or Less: New low-rise residential buildings would be required to be all electric, except cooking appliances and fireplaces. For cooking appliances, if gas is to be installed by the builder, an electric outlet would also be required at the location of the appliance, to allow easy change over from gas to electric in the future. Note that an allowance was made for gas cooking and gas fireplaces as a consumer choice issue. At the same time, these two building components are relatively low energy use items in the home. It is anticipated that given the incremental increase in cost for gas infrastructure for these two building components, most builders will opt for all electric buildings.

- New Mid-to-High Rise Residential & All Non-residential Buildings: These buildings would be required to be all-electric, except that life science buildings may use natural gas. Life science buildings were not included in the cost effectiveness study and were reported to have special building system requirements that would require the use of gas at this time.

- Exceptions to the code could be approved by the Building Official, based on demonstration that the provisions of the code would not be cost effective or that the non-electric components of are essential as a core component of the intended business use.

Benefits associated with recommended electrification reach code provisions include:

1. The provisions would directly reduce the use of fossil fuels and thereby GHG emissions.
2. The provisions are easily understood versus performance based provisions that rely on energy use modeling for compliance.
3. Building electrification goes hand-in-hand with Brisbane's existing/proposed solar energy generation provisions for use of renewable energy.
4. Electrical building systems and appliances are readily available.
5. Cost modeling has been done that shows these systems to be cost effective. The cost effectiveness studies are referenced in the draft ordinance for both residential and non-residential building types.
6. It would help reduce the installation of costly fossil fuel infrastructure that may become obsolete.

- **A new BMC Chapter 15.84 Electric Vehicle Infrastructure for new residential and non-residential development is included in the draft ordinance as Section 7.**

<u>BMC Chapter 15.84 - EV Charging Infrastructure:</u> Vehicles powered by fossil fuels are another primary source of GHG emissions. In our area, vehicle owners are showing an increase in the adoption of electric vehicles. As reported by San Mateo County, the number of registered plug-in vehicles in the county increased from 2017 to 2018 by 36 percent. By comparison, registrations for vehicles powered by fossil fuels grew by only 2 percent that year. The availability of EV charging infrastructure is a critical component to EV adoption. As demand for EV charging increases, it is significantly more expensive to retrofit charging infrastructure than to install it in new construction. Given those considerations, ensuring that newly constructed residential and non-residential parking has ample EV charging capability will promote EV adoption while reducing long-term costs of EV infrastructure installation.

While the state's new minimum requirements for EV charging infrastructure are a step forward, it is unlikely that the state's minimum requirements for multi-family dwellings and non-residential buildings will keep pace with expected EV growth through 2030. New state requirements provide for just 10 percent of the parking space to be capable of supporting future EV charging stations for multifamily developments. Single family dwellings and duplexes are to have one EV capable space. For nonresidential new development, only 6 percent of the required parking must be Level 2 EV capable (see description below).

The city's proposed EV infrastructure reach code is intended to provide additional charging infrastructure to better accommodate projected future demand. It is based on a model ordinance prepared by the County Office of Sustainability and Peninsula Clean Energy.

For purposes of clarification, there are various levels of readiness when it comes to EV charging infrastructure. Key terms used in the ordinance are defined below:

- EV capable: A parking space linked to an electrical panel with capacity to provide 110/120 volts and 20 amperes to the space

- EV Ready: A parking space served by a complete circuit to the space, with Level 1 being 110/120 volts and 20 amperes and Level 2 being 208/240 volt and 40 amperes.

- Electrical Vehicle Charging Station (EVCS) is a parking space with the complete charging equipment at Level 2 or greater.

The proposed reach code includes the following provisions:

Residential Uses:

- New Single family homes- At least one Level 2 EV Ready circuit to allow for easy installation of EV chargers as needed.

- Multifamily dwellings- At least one Level 2 EV ready space per unit and 50 percent of required guest spaces shall be Electric Vehicle Charging Station (EVCS) Parking Spaces.

Non-residential uses:

Low turnover uses, such as administrative offices, would have 50% of the parking spaces required by BMC Chapter 17.34 would be EV, as follows:

- ✓ When 10 or more parking spaces are required to be constructed, 15% of the required parking spaces on site would need to be equipped with Level 2 Electric Vehicle Charging Stations (EVCS);
- ✓ An additional 10% would be provided with at least Level 2 EV Ready Circuits; and
- ✓ An additional 25% shall be at least Level 1 EV Capable.

High turnover uses, such as retail and restaurant uses, would have 25% of the parking spaces required by Chapter 17.34 would be EV, as follows:

- ✓ When 10 or more parking spaces are required to be constructed, 15% of the required parking spaces on would be equipped with Level 2 EVCS;
- ✓ An additional 10% would be at least Level 1 EV Ready.

- ✓ Installation of Direct Current Fast Charger with the capacity to provide at least 80 kW output may substitute for a certain number of the Level 2 EVCS and EV Ready spaces.

Exceptions to the code could be approved by the Building Official, based on demonstration that the provisions of the code would render the development project infeasible due to associated utility costs.

Note that the draft ordinance was prepared collaboratively between the Planning, Building, Public Works and Fire Departments and in consultation with the City Attorney. The draft provisions contained in the Energy Generation, Building Electrification and EV Infrastructure ordinances were also presented to the Planning Commission and the Open Space and Ecology Committee for review and comments. Both bodies expressed their support of the proposed provisions. Also, in advance of the Planning Commission meeting, staff provided notices to the approximately 30 design/construction contractors that are listed in the local Chamber of Commerce directory.

At this time of this writing, three letters have been received regarding the proposed reach codes. PG&E and IBEW Local Union 617 expressed support of building electrification. Western Propane Gas Association expressed concern over disincentivizing the use of propane. Note that the code would not apply to the use of portable equipment such as barbeques and the fixed home systems and appliances in Brisbane are not served by propane but rather by natural gas and electric infrastructure.

FISCAL IMPACT

None.

MEASURE OF SUCCESS

Application of updated standards to comply with State law and implementation of measures to help meet the goals of the City's Climate Action Plan.

ATTACHMENTS

1. ~~Draft City Ordinance No. 643~~ Provided Separately
2. "Redline" of the Update to the BMC Chapter 15.81 on Energy Generation
3. "2019 Cost-effectiveness Study: Low-Rise Residential New Construction", by Frontier Energy, Inc and Misti Bruceri & Associates, LLC, dated July 17, 2019
4. "2019 Nonresidential New Construction Reach Code Cost Effectiveness Study", by TRC and EnergySoft, dated July 15, 2019
5. Correspondence

John Swiecki

John Swiecki, Community Development Director

Clay Holstine, City Manager

~~**Chapter 15.81, "Energy Conservation and Generation"**~~

Chapter 15.81 – On-Site Energy Generation

15.81.010 - Title.

This chapter shall be known as the City of Brisbane On-site Energy ~~Conservation and~~ Generation Ordinance.

15.81.020 - Authority.

The building official or the building official's designee shall have the authority to enforce the provisions of this chapter.

15.81.030 - Coordination with state energy regulations.

This chapter does not replace the most recent edition of the Building Energy Efficiency Standards for Residential and Non-residential Buildings, Title 24, Part 6 of the California Code of Regulation as adopted by the City in Chapter 15.04 of this Title,("Energy Code"). This Chapter 15.81 amends the energy code to place additional provisions on new residential and nonpresidential development projects. To the extent the provisions of this chapter conflict with any current or subsequently adopted provisions of the energy code, then the most energy conserving provisions shall supersede and control.

15.81.040 - Definitions.

Definitions of terms are as provided in the energy code.

~~**15.81.040 - Cool roofs - Local amendment to energy code.**~~

~~- Share Link~~
~~- Print~~
~~- Download (docx)~~
~~- Email~~
~~- Compare~~

~~Section 110.8(i)l of the Energy Code, Mandatory Requirements for Insulation, Roofing Products and Radiant Barriers, is amended as follows:~~

~~The requirements of Section 110.8(i)l supersede the thermal emittance and aged solar reflectance requirements of Sections 140.1, 140.2, 140.3(a)1, 141.0(b)2B, 150.1(c)11, 150.2(b)1H or 150.2(b) of the Energy Code. A roofing products thermal emittance and aged solar reflectance shall be certified and labeled according to the requirements of Section 10-113 of the Energy Code, and meet the following requirements:~~

~~A. New Non-residential Buildings:~~

~~1. Low-sloped roofs shall have:~~

~~a. A minimum aged solar reflectance of 0.70 and a minimum thermal emittance of 0.85; or~~

~~b. A minimum Solar Reflectance Index (SRI) of 85.~~

~~2. Exceptions:~~

~~a. Roof constructions that have a thermal mass with a weight of at least 25 pounds per square foot over the roof membrane are exempt from the minimum requirements for solar reflectance and thermal emittance or SRI.~~

~~b. An aged solar reflectance less than 0.70 is allowed provided the maximum roof/ceiling U-factor in Table 140.3-B of the Energy Code is not exceeded.~~

~~c. Roof area covered by building integrated photovoltaic panels and building integrated solar thermal panels is exempt from the minimum requirements for solar reflectance and thermal emittance or SRI.~~

~~B. New High-rise residential buildings, hotels and motels:~~

~~1. Low-sloped roofs shall have:~~

~~a. A minimum aged solar reflectance of 0.70 and a minimum thermal emittance of 0.85; or~~

~~b. A minimum Solar Reflectance Index (SRI) of 85.~~

~~2. Exceptions:~~

~~a. Roof constructions that have a thermal mass with a weight of at least 25 pounds per square foot over the roof membrane are exempt from the minimum requirements for solar reflectance and thermal emittance or SRI.~~

~~b. Roof area covered by building integrated photovoltaic panels and building integrated solar thermal panels is exempt from the minimum requirements for solar reflectance and thermal emittance or SRI.~~

~~C. New Low-rise residential buildings:~~

~~1. Low-sloped roofs shall have:~~

~~a. A minimum aged solar reflectance of 0.70 and a minimum thermal emittance of 0.85 or a minimum SRI of 85:~~

~~2. Exceptions:~~

~~a. Roof constructions that have a thermal mass over the roof membrane with a weight of at least 25 pounds per square foot over the roof membrane are exempt from the minimum requirements for solar reflectance and thermal emittance or SRI.~~

~~b. Roof area covered by building integrated photovoltaic panels and building integrated solar thermal panels is exempt from the minimum requirements for solar reflectance and thermal emittance or SRI.~~

15.81.050 - Solar installation—Local amendment to state energy code.

Subchapter 2 of the Energy Code—All Occupancies—Mandatory Requirements for the Manufacture, Construction and Installation of Systems, Equipment, and Building Components is amended to include:

Solar photovoltaic systems shall be installed on both non-residential and residential building types as follows:

A. New Non-residential and High Rise Residential buildings:

1. Buildings with less than 10,000 square feet of gross floor area shall provide a minimum of a 3 kilowatt photovoltaic system.

2. Buildings with 10,000 square feet or more of gross floor area shall provide a minimum of a 5 kilowatt photovoltaic system.

3. Exception: As an alternative to a solar photovoltaic system ~~all of the building types~~ listed above ~~may provide,~~ a solar hot water system (solar thermal) ~~with a minimum collector of 40 square feet~~ may be substituted for all or part of the photovoltaic system, upon submittal of written documentation demonstrating at least the equivalent energy savings to the otherwise required photovoltaic system, subject to approval by the Building Official.

~~2. Multifamily buildings of 3 to 16 units shall provide a minimum of a 2 kilowatt photovoltaic system.~~

~~3. Multifamily buildings of 17 units or more shall provide a minimum of a 3 kilowatt photovoltaic system.~~

B. New Single Family and Low-Rise Residential Buildings shall comply with the requirements of Title 24, Part 6 of the California Code of Regulation, Section 150.1(c)14, as adopted by the City in Chapter 15.04:

C. New Mixed-use Buildings:

1. Mixed-use buildings shall provide the minimum sized photovoltaic system for both the residential and non-residential components of the building (i.e.: residential and non-residential minimum requirements are considered additive).

15.81.060 - Infeasibility exemption.

If an applicant believes that circumstances exist that make it infeasible to meet the requirements of this chapter, the applicant may request an exemption via written request to the building official. In applying for the exemption, the burden is on the applicant to demonstrate infeasibility to the satisfaction of the building official. Infeasibility exemption may be granted on the basis of site specific cost effectiveness study information or other site or project specific factors.

CALIFORNIA ENERGY CODES & STANDARDS

A STATEWIDE UTILITY PROGRAM

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: July 17, 2019

LEGAL NOTICE

This report was prepared by Pacific Gas and Electric Company and funded by the California utility customers under the auspices of the California Public Utilities Commission.

Table of Contents

Acronyms 5
1 Introduction 1
2 Methodology and Assumptions 1
2.1 Building Prototypes 1
2.2 Measure Analysis 3
2.2.1 Federal Preemption 4
2.2.2 Energy Design Rating 4
2.2.3 Energy Efficiency Measures 5
2.3 Package Development 8
2.3.1 Solar Photovoltaics (PV) 8
2.3.2 Energy Storage (Batteries) 8
2.4 Incremental Costs 9
2.5 Cost-effectiveness 13
2.5.1 On-Bill Customer Lifecycle Cost 13
2.5.2 TDV Lifecycle Cost 15
2.6 Electrification Evaluation 15
2.7 Greenhouse Gas Emissions 18
3 Results 18
3.1 PV and Battery System Sizing 19
3.2 Single Family Results 21
3.2.1 GHG Emission Reductions 26
3.3 Multifamily Results 26
3.3.1 GHG Emission Reductions 32
3.4 Electrification Results 32
3.4.1 Single Family 33
3.4.2 Multifamily 33
4 Conclusions & Summary 41
5 References 44
Appendix A – California Climate Zone Map 46
Appendix B – Utility Tariff Details 47
Appendix C – Single Family Detailed Results 57
Appendix D – Single Family Measure Summary 61
Appendix E – Multifamily Detailed Results 68
Appendix F – Multifamily Measure Summary 72
Appendix G – Results by Climate Zone 79

List of Tables

Table 1: Prototype Characteristics 2
Table 2: Characteristics of the Mixed Fuel vs All-Electric Prototype 3
Table 3: Lifetime of Water Heating & Space Conditioning Equipment Measures 9
Table 4: Incremental Cost Assumptions 10
Table 5: IOU Utility Tariffs Applied Based on Climate Zone 14
Table 6: Incremental Costs – All-Electric Compared to a Mixed Fuel Home 16
Table 7: PV & Battery Sizing Details by Package Type 20
Table 8: Single Family Package Lifetime Incremental Costs 22
Table 9: Single Family Package Cost-Effectiveness Results for the Mixed Fuel Case [1,2] 23
Table 10: Single Family Package Cost-Effectiveness Results for the All-Electric Case[1,2] 24
Table 11: Multifamily Package Incremental Costs per Apartment 28
Table 12: Multifamily Package Cost-Effectiveness Results for the Mixed Fuel Case[1,2] 29
Table 13: Multifamily Package Cost-effectiveness Results for the All-Electric Case[1,2] 30
Table 14: Single Family Electrification Results 34
Table 15: Comparison of Single Family On-Bill Cost Effectiveness Results with Additional PV 36
Table 16: Multifamily Electrification Results 38
Table 17: Comparison of Multifamily On-Bill Cost Effectiveness Results with Additional PV 39
Table 18: Summary of Single Family Target EDR Margins 43
Table 19: Summary of Multifamily Target EDR Margins 43
Table 20: PG&E Baseline Territory by Climate Zone 48
Table 21: SCE Baseline Territory by Climate Zone 51
Table 22: SoCalGas Baseline Territory by Climate Zone 53
Table 23: SDG&E Baseline Territory by Climate Zone 54
Table 24: Real Utility Rate Escalation Rate Assumptions 56
Table 25: Single Family Mixed Fuel Efficiency Package Cost-Effectiveness Results 57
Table 26: Single Family Mixed Fuel Efficiency & PV/Battery Package Cost-Effectiveness Results 58
Table 27: Single Family All-Electric Efficiency Package Cost-Effectiveness Results 59
Table 28: Single Family All-Electric Efficiency & PV-PV/Battery Package Cost-Effectiveness Results 60
Table 29: Single Family Mixed Fuel Efficiency – Non-Preempted Package Measure Summary 61
Table 30: Single Family Mixed Fuel Efficiency – Equipment, Preempted Package Measure Summary 62
Table 31: Single Family Mixed Fuel Efficiency & PV/Battery Package Measure Summary 63
Table 32: Single Family All-Electric Efficiency – Non-Preempted Package Measure Summary 64
Table 33: Single Family All-Electric Efficiency – Equipment, Preempted Package Measure Summary 65
Table 34: Single Family All-Electric Efficiency & PV Package Measure Summary 66
Table 35: Single Family All-Electric Efficiency & PV/Battery Package Measure Summary 67
Table 36: Multifamily Mixed Fuel Efficiency Package Cost-Effectiveness Results 68
Table 37: Multifamily Mixed Fuel Efficiency & PV/Battery Package Cost-Effectiveness Results 69
Table 38: Multifamily All-Electric Efficiency Package Cost-Effectiveness Results 70
Table 39: Multifamily All-Electric Efficiency & PV-PV/Battery Package Cost-Effectiveness Results 71
Table 40: Multifamily Mixed Fuel Efficiency – Non-Preempted Package Measure Summary 72
Table 41: Multifamily Mixed Fuel Efficiency – Equipment, Preempted Package Measure Summary 73
Table 42: Multifamily Mixed Fuel Efficiency & PV/Battery Package Measure Summary 74
Table 43: Multifamily All-Electric Efficiency – Non-Preempted Package Measure Summary 75
Table 44: Multifamily All-Electric Efficiency – Equipment, Preempted Package Measure Summary 76
Table 45: Multifamily All-Electric Efficiency & PV Package Measure Summary 77
Table 46: Multifamily All-Electric Efficiency & PV/Battery Package Measure Summary 78
Table 47: Single Family Climate Zone 1 Results Summary 80
Table 48: Multifamily Climate Zone 1 Results Summary 81

Table 49: Single Family Climate Zone 2 Results Summary 82
Table 50: Multifamily Climate Zone 2 Results Summary 83
Table 51: Single Family Climate Zone 3 Results Summary 84
Table 52: Multifamily Climate Zone 3 Results Summary 85
Table 53: Single Family Climate Zone 4 Results Summary 86
Table 54: Multifamily Climate Zone 4 Results Summary 87
Table 55: Single Family Climate Zone 5 PG&E Results Summary 88
Table 56: Multifamily Climate Zone 5 PG&E Results Summary 89
Table 57: Single Family Climate Zone 5 PG&E/SoCalGas Results Summary 90
Table 58: Multifamily Climate Zone 5 PG&E/SoCalGas Results Summary 91
Table 59: Single Family Climate Zone 6 Results Summary 92
Table 60: Multifamily Climate Zone 6 Results Summary 93
Table 61: Single Family Climate Zone 7 Results Summary 94
Table 62: Multifamily Climate Zone 7 Results Summary 95
Table 63: Single Family Climate Zone 8 Results Summary 96
Table 64: Multifamily Climate Zone 8 Results Summary 97
Table 65: Single Family Climate Zone 9 Results Summary 98
Table 66: Multifamily Climate Zone 9 Results Summary 99
Table 67: Single Family Climate Zone 10 SCE/SoCalGas Results Summary 100
Table 68: Multifamily Climate Zone 10 SCE/SoCalGas Results Summary 101
Table 69: Single Family Climate Zone 10 SDGE Results Summary 102
Table 70: Multifamily Climate Zone 10 SDGE Results Summary 103
Table 71: Single Family Climate Zone 11 Results Summary 104
Table 72: Multifamily Climate Zone 11 Results Summary 105
Table 73: Single Family Climate Zone 12 Results Summary 106
Table 74: Multifamily Climate Zone 12 Results Summary 107
Table 75: Single Family Climate Zone 13 Results Summary 108
Table 76: Multifamily Climate Zone 13 Results Summary 109
Table 77: Single Family Climate Zone 14 SCE/SoCalGas Results Summary 110
Table 78: Multifamily Climate Zone 14 SCE/SoCalGas Results Summary 111
Table 79: Single Family Climate Zone 14 SDGE Results Summary 112
Table 80: Multifamily Climate Zone 14 SDGE Results Summary 113
Table 81: Single Family Climate Zone 15 Results Summary 114
Table 82: Multifamily Climate Zone 15 Results Summary 115
Table 83: Single Family Climate Zone 16 Results Summary 116
Table 84: Multifamily Climate Zone 16 Results Summary 117

List of Figures

Figure 1: Graphical description of EDR scores (courtesy of Energy Code Ace) 5
Figure 2: B/C ratio comparison for PV and battery sizing 20
Figure 3: Single family Total EDR comparison 25
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) 25
Figure 5: Single family greenhouse gas emissions comparison 26
Figure 6: Multifamily Total EDR comparison 31
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) 31
Figure 8: Multifamily greenhouse gas emissions comparison 32

Figure 9: B/C ratio results for a single family all-electric code compliant home versus a mixed fuel code compliant home..... 36
Figure 10: B/C ratio results for the single family Efficiency & PV all-electric home versus a mixed fuel code compliant home 37
Figure 11: B/C ratio results for the single family neutral cost package all-electric home versus a mixed fuel code compliant home 37
Figure 12: B/C ratio results for a multifamily all-electric code compliant home versus a mixed fuel code compliant home 40
Figure 13: B/C ratio results for the multifamily Efficiency & PV all-electric home versus a mixed fuel code compliant home 40
Figure 14: B/C ratio results for the multifamily neutral cost package all-electric home versus a mixed fuel code compliant home 41
Figure 15: Map of California Climate Zones (courtesy of the California Energy Commission) 46

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 (Horii 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 (ft^2) 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 ft^2 = (45% x 2,100 ft^2) + (55% x 2,700 ft^2)

[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/Cooling[1]	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

[1]Equipment efficiencies are equal to minimum federal appliance efficiency standards.
[2]The 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.
[3]UEF = uniform energy factor. HPWH = heat pump water heater. SF = single family. MF = multifamily.
[4]CBECC-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 Micropas[3] 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.

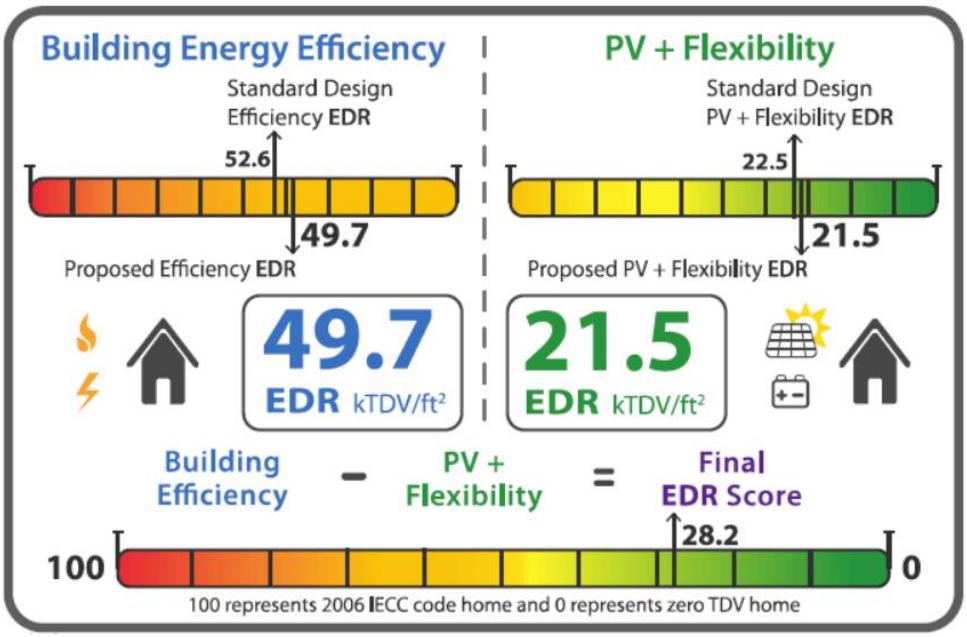


Figure 1: Graphical description of EDR scores (courtesy of Energy Code Ace[5])

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

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

Equation 2

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

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 point[8], 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 case[10]
- 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/ft^2 for 3 ACH50 & $0.207/ft^2 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/ft^2 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/ft^2), R-19 ($0.78/ft^2) and R-30 ($1.61/ft^2) 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/ft^2 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

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

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

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

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

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

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 Disadvantages 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)***

[1]Low 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.
[2]Typical 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 rules[15] 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 2.06[16] 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 CO_2 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 CO_2-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.

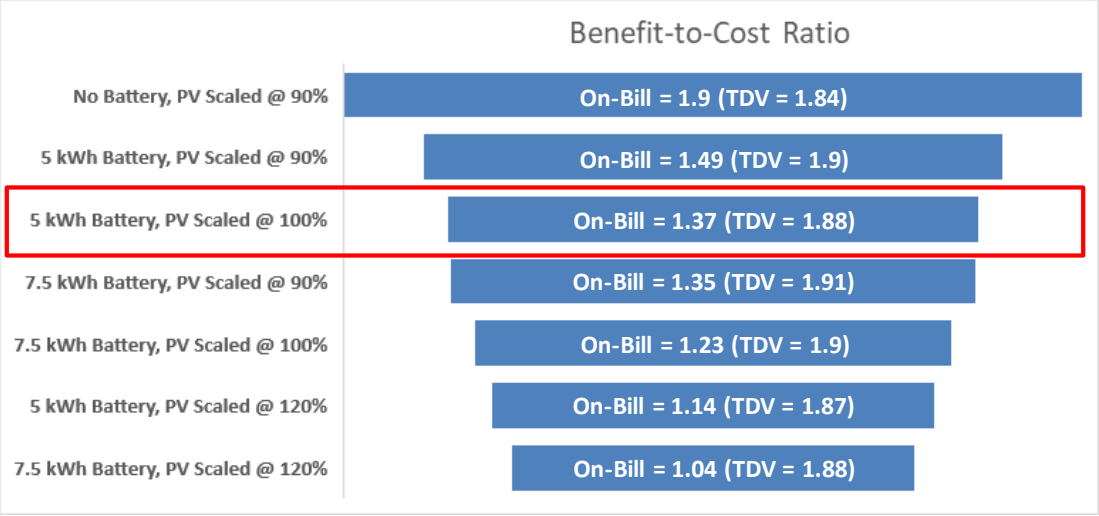


Figure 2: B/C ratio comparison for PV and battery sizing

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]

		Efficiency							Efficiency & PV/Battery			
		Non-Preempted			Equipment - Preempted			Target				Target
CZ	Utility	Efficiency EDR Margin	On-Bill B/C Ratio	TDV B/C Ratio	Efficiency EDR Margin	On-Bill B/C Ratio	TDV B/C Ratio	Efficiency EDR Margin	Total EDR Margin	On-Bill B/C Ratio	TDV B/C Ratio	Total EDR 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.

[2]Information 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]

		Efficiency							Efficiency & PV				Efficiency & PV/Battery			
		Non-Preempted			Equipment - Preempted			Target								
CZ	Utility	Efficiency EDR Margin	On-Bill B/C Ratio	TDV B/C Ratio	Efficiency EDR Margin	On-Bill B/C Ratio	TDV B/C Ratio	Efficiency EDR Margin	Total EDR Margin	On-Bill B/C Ratio	TDV B/C Ratio	Target Total EDR Margin	Total EDR Margin	On-Bill B/C Ratio	TDV B/C Ratio	Target Total EDR Margin
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	2.78	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	1.3	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.

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

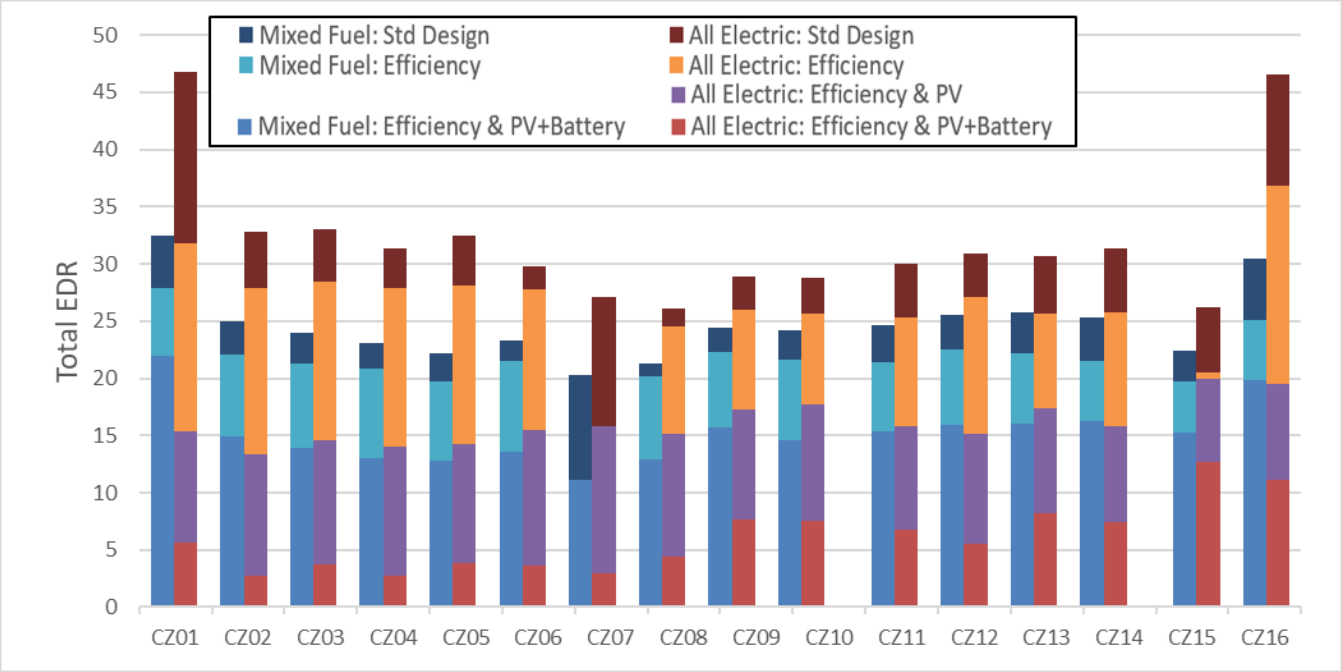


Figure 3: Single family Total EDR comparison

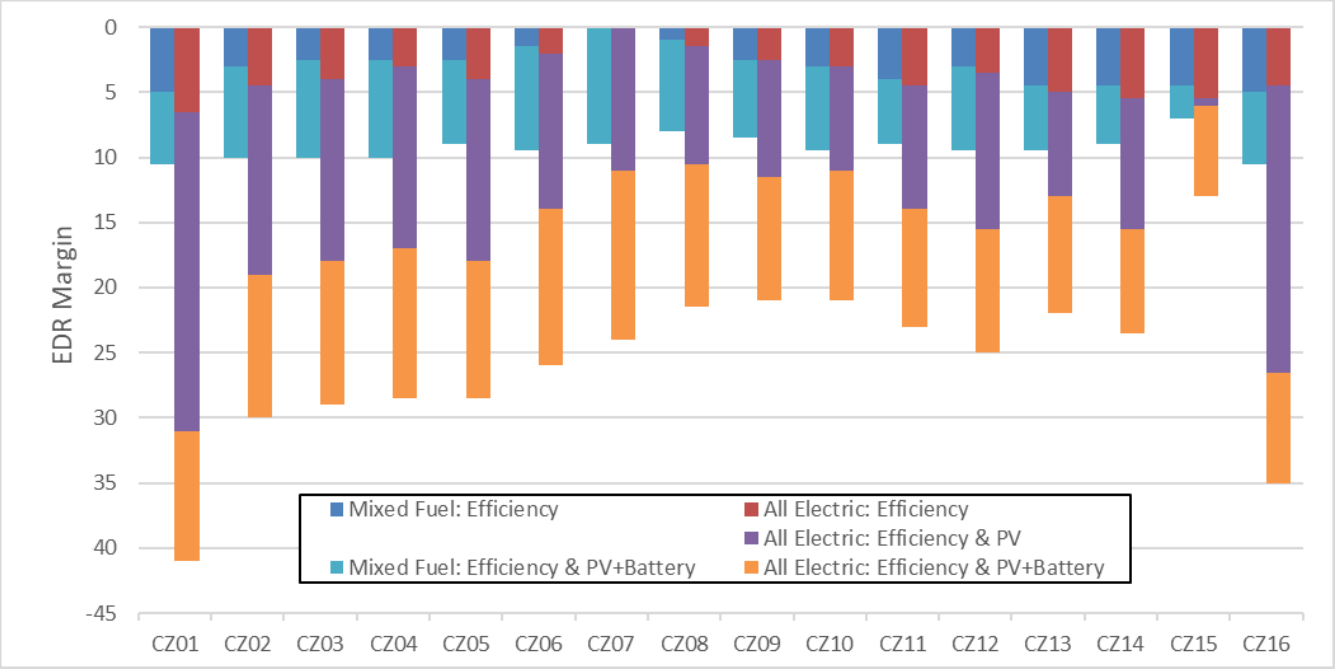


Figure 4: Single family EDR Margin comparison (based on Efficiency EDR Margin for the Efficiency packages and the Total EDR Margin for the Efficiency & PV and Efficiency & PV+Battery packages)

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/ ft^2. 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/ft^2, 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/ft^2 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.

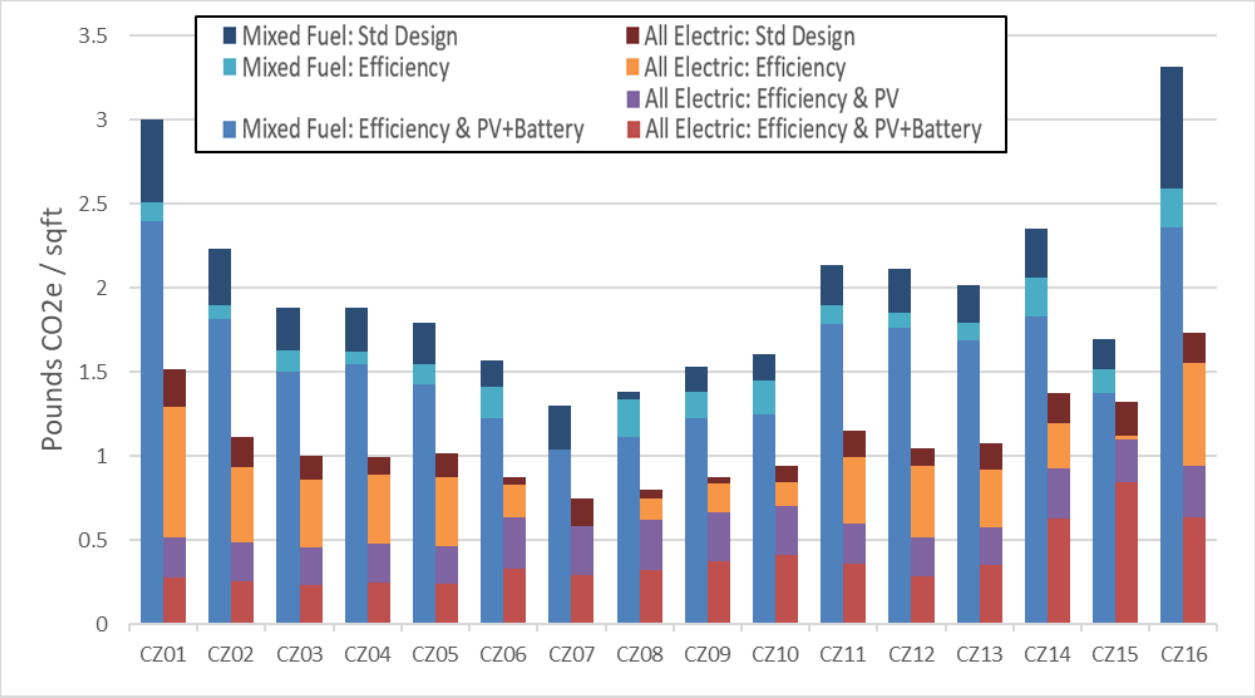


Figure 5: Single family greenhouse gas emissions comparison

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]

		Efficiency							Efficiency & PV/Battery			
		Non-Preempted			Equipment - Preempted			Target				Target
CZ	Utility	Efficiency EDR Margin	On-Bill B/C Ratio	TDV B/C Ratio	Efficiency EDR Margin	On-Bill B/C Ratio	TDV B/C Ratio	Efficiency EDR Margin	Total EDR Margin	On-Bill B/C Ratio	TDV B/C Ratio	Total EDR 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.

[2]Information 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]

		Efficiency							Efficiency & PV				Efficiency & PV/Battery			
		Non-Preempted			Equipment - Preempted											
CZ	Utility	Efficiency EDR Margin	On-Bill B/C Ratio	TDV B/C Ratio	Efficiency EDR Margin	On-Bill B/C Ratio	TDV B/C Ratio	Target Efficiency EDR Margin	Total EDR Margin	On-Bill B/C Ratio	TDV B/C Ratio	Target Total EDR Margin	Total EDR Margin	On-Bill B/C Ratio	TDV B/C Ratio	Target Total EDR Margin
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.

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

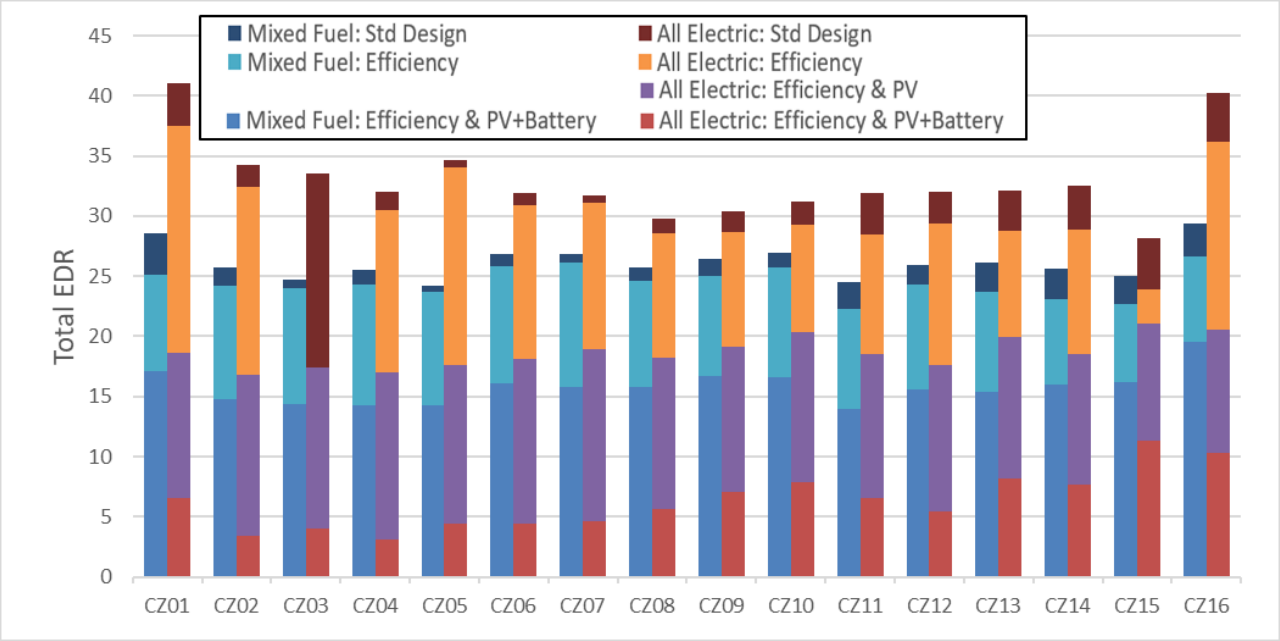


Figure 6: Multifamily Total EDR comparison

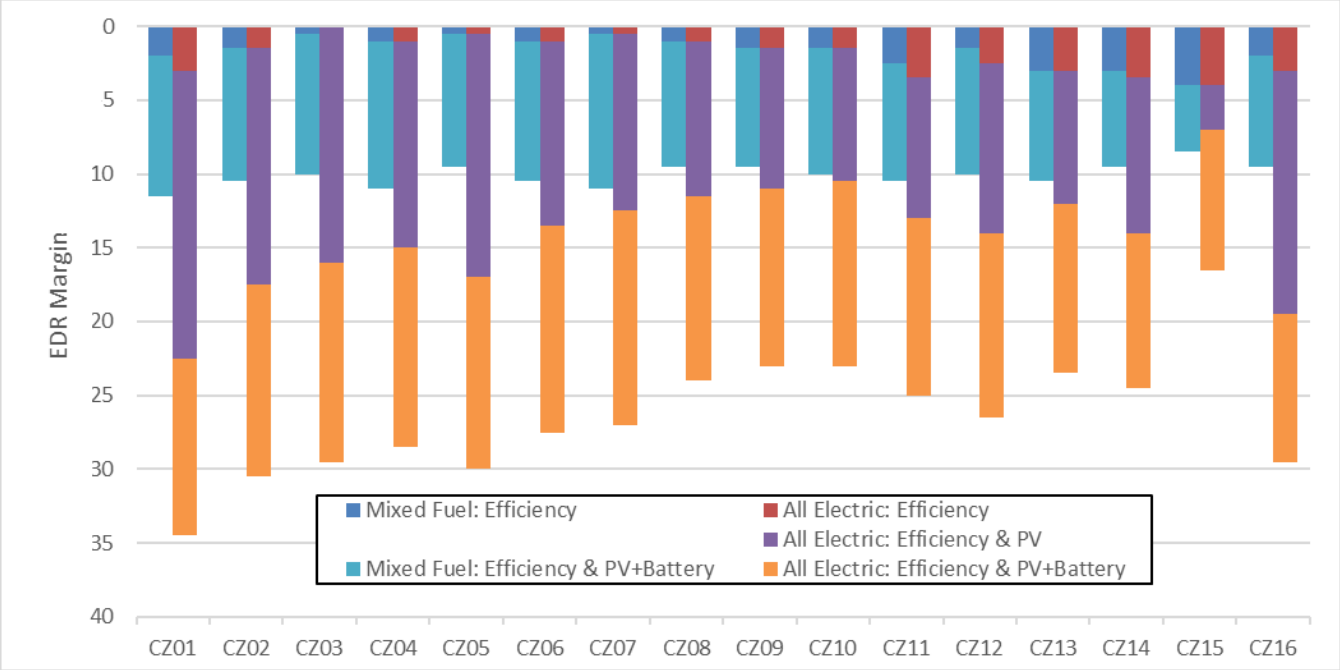


Figure 7: Multifamily EDR Margin comparison (based on Efficiency EDR Margin for the Efficiency packages and the Total EDR Margin for the Efficiency & PV and Efficiency & PV+Battery packages)

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/ ft^2. 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/ft^2, 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/ft^2 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.

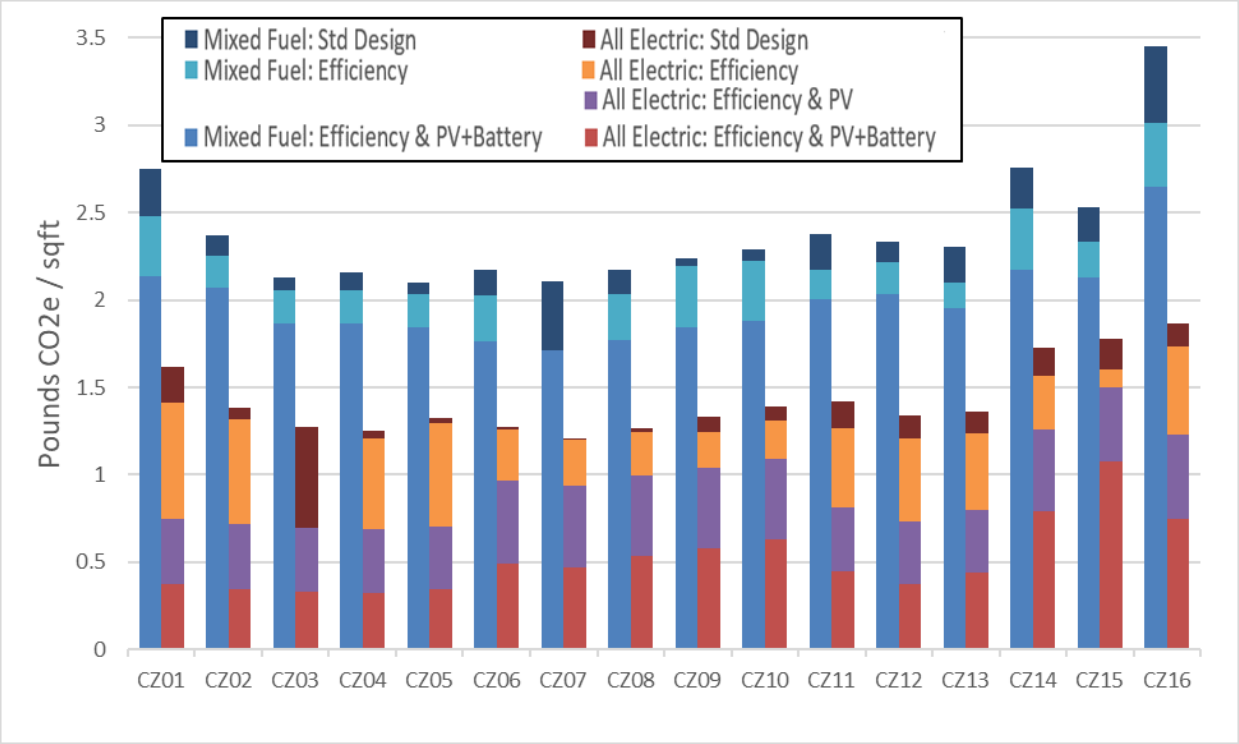


Figure 8: Multifamily greenhouse gas emissions comparison

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 climates 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		
CZ	Utility	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
	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		
CZ	Utility	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
	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

[1]Red 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

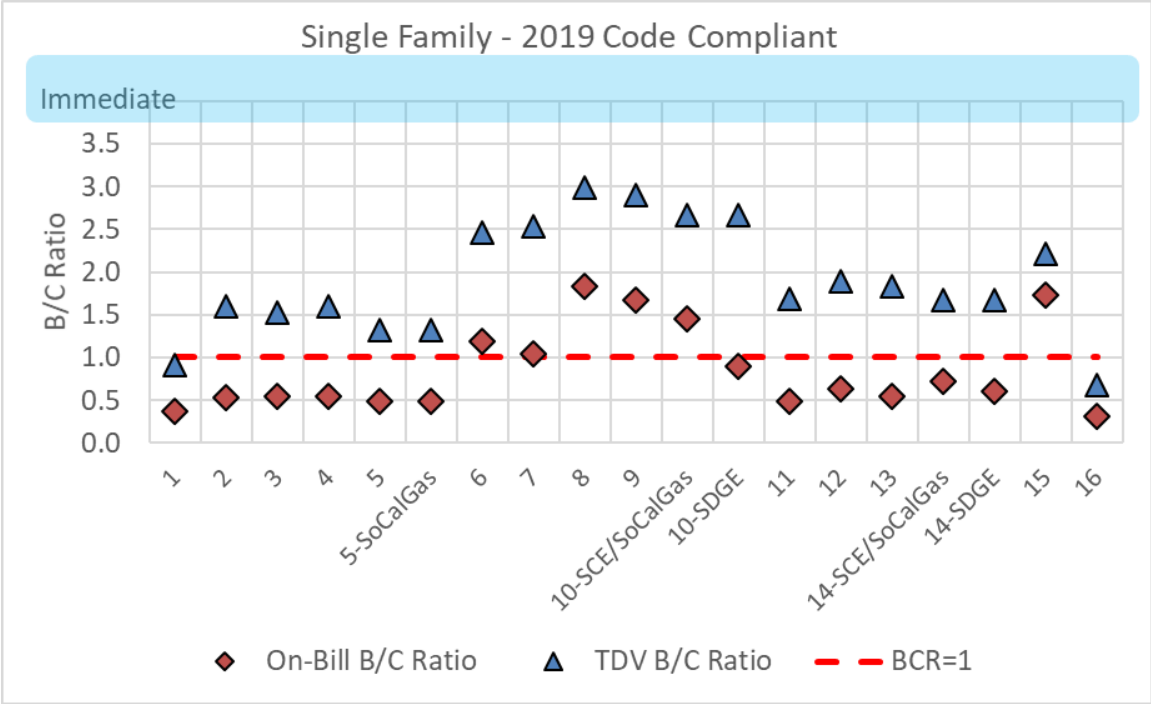


Figure 9: B/C ratio results for a single family all-electric code compliant home versus a mixed fuel code compliant home

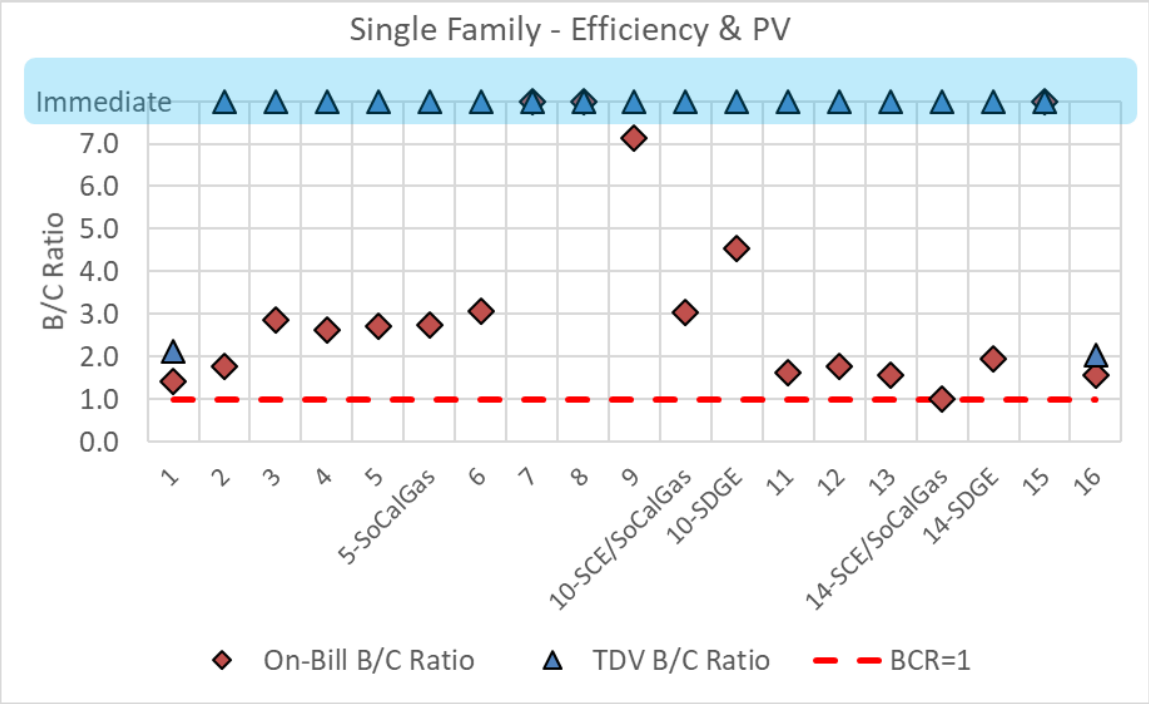


Figure 10: B/C ratio results for the single family Efficiency & PV all-electric home versus a mixed fuel code compliant home

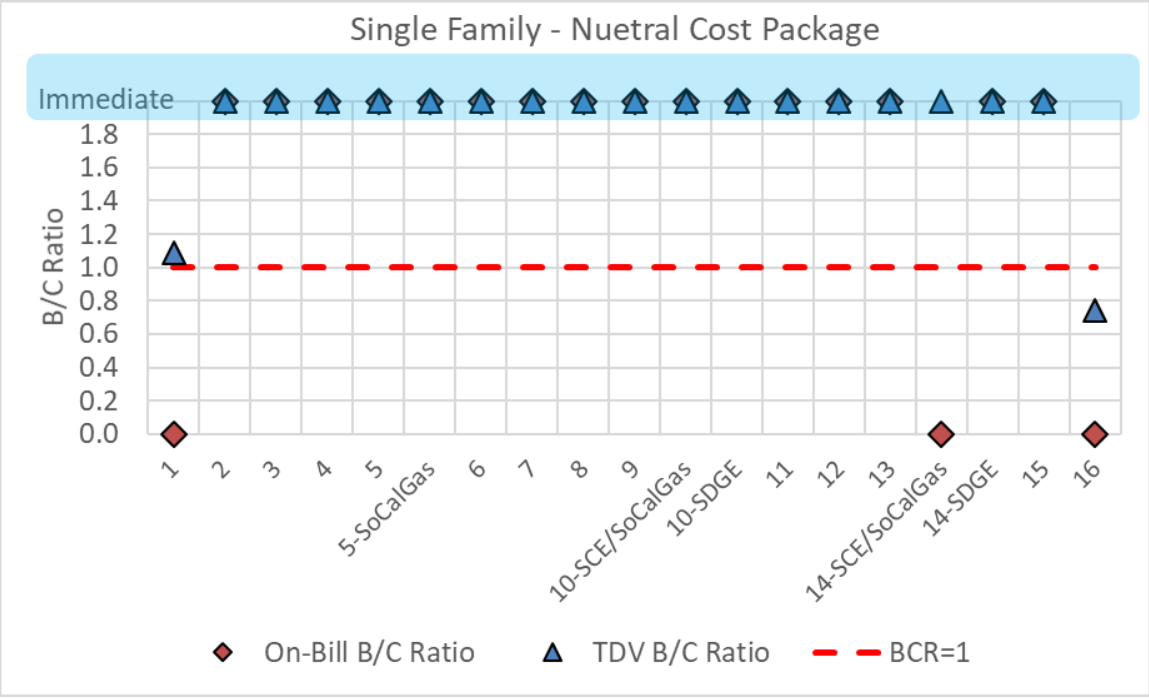


Figure 11: B/C ratio results for the single family neutral cost package all-electric home versus a mixed fuel code compliant home

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		
CZ	Utility	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
	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		
CZ	Utility	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
	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

[1]Red 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)

		Neutral Cost				Min. Cost Effectiveness			
CZ	Utility	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

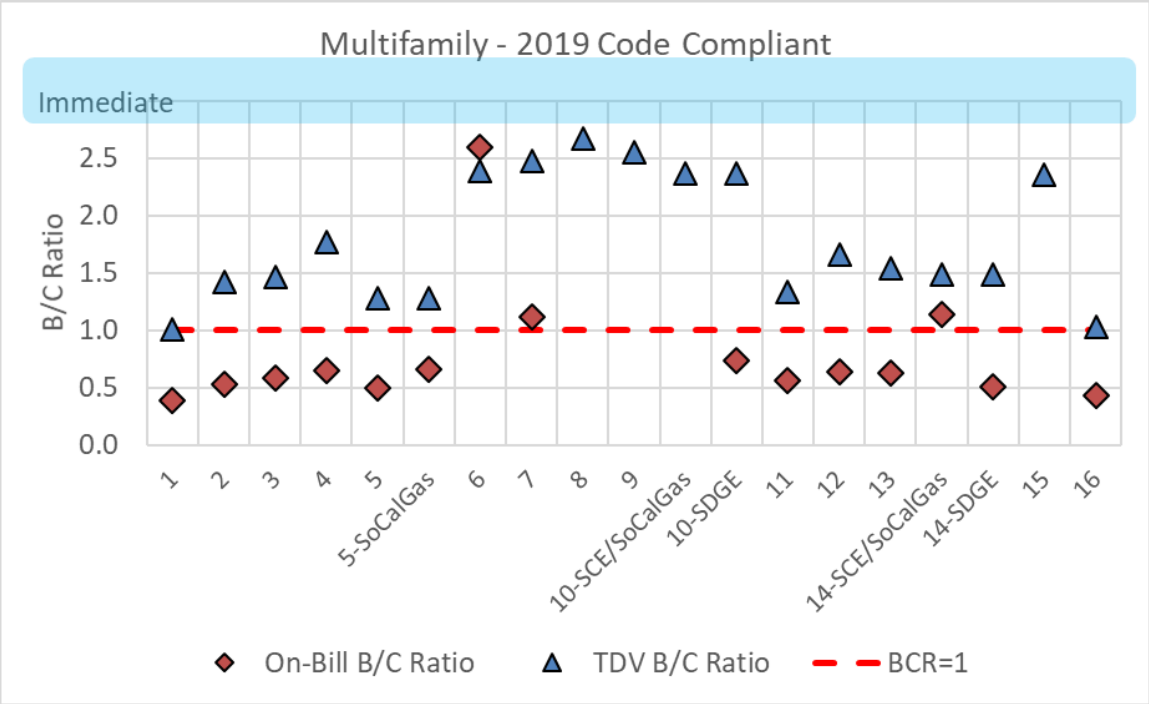


Figure 12: B/C ratio results for a multifamily all-electric code compliant home versus a mixed fuel code compliant home

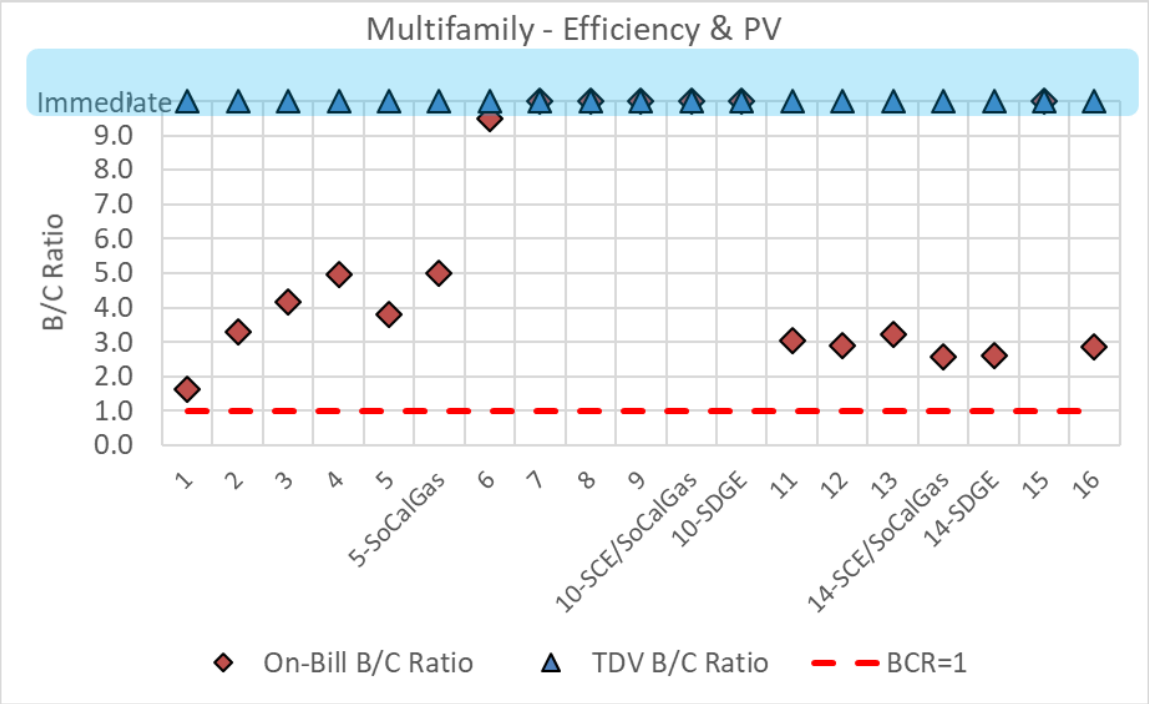


Figure 13: B/C ratio results for the multifamily Efficiency & PV all-electric home versus a mixed fuel code compliant home

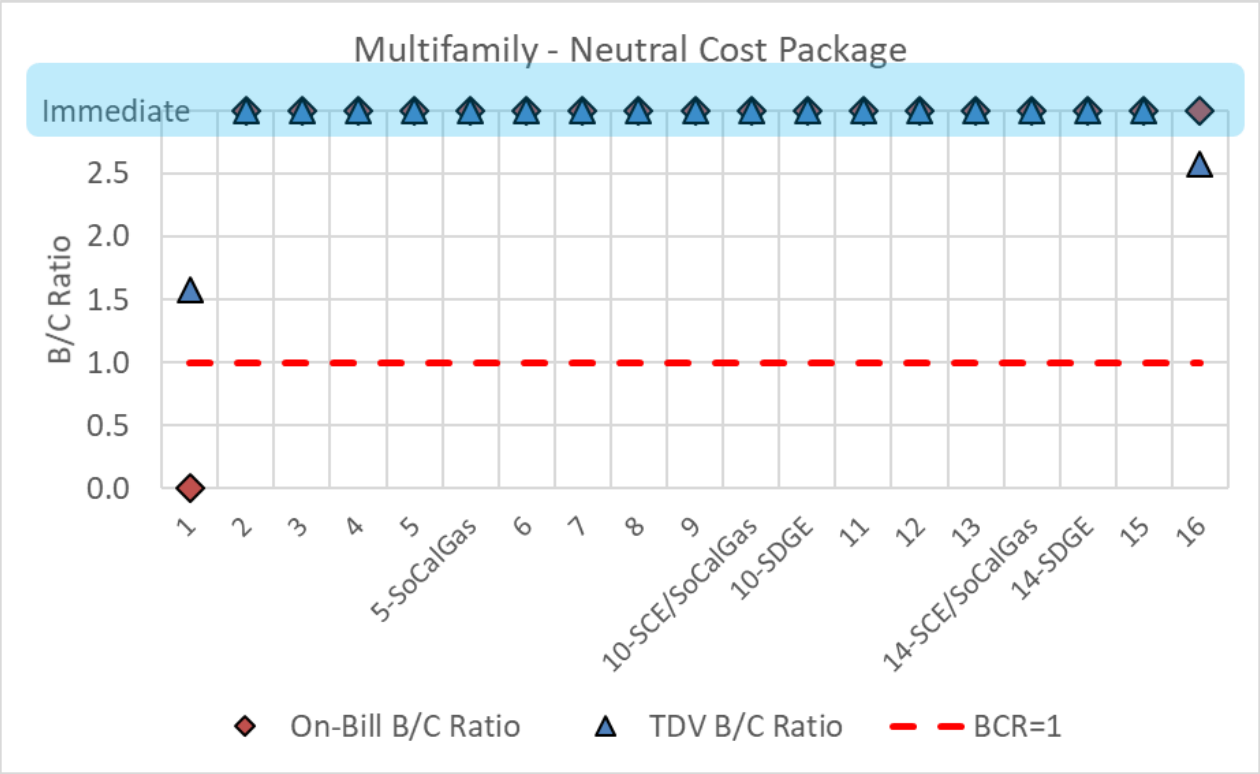


Figure 14: B/C ratio results for the multifamily neutral cost package all-electric home versus a mixed fuel code compliant home

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/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 Disadvantages 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

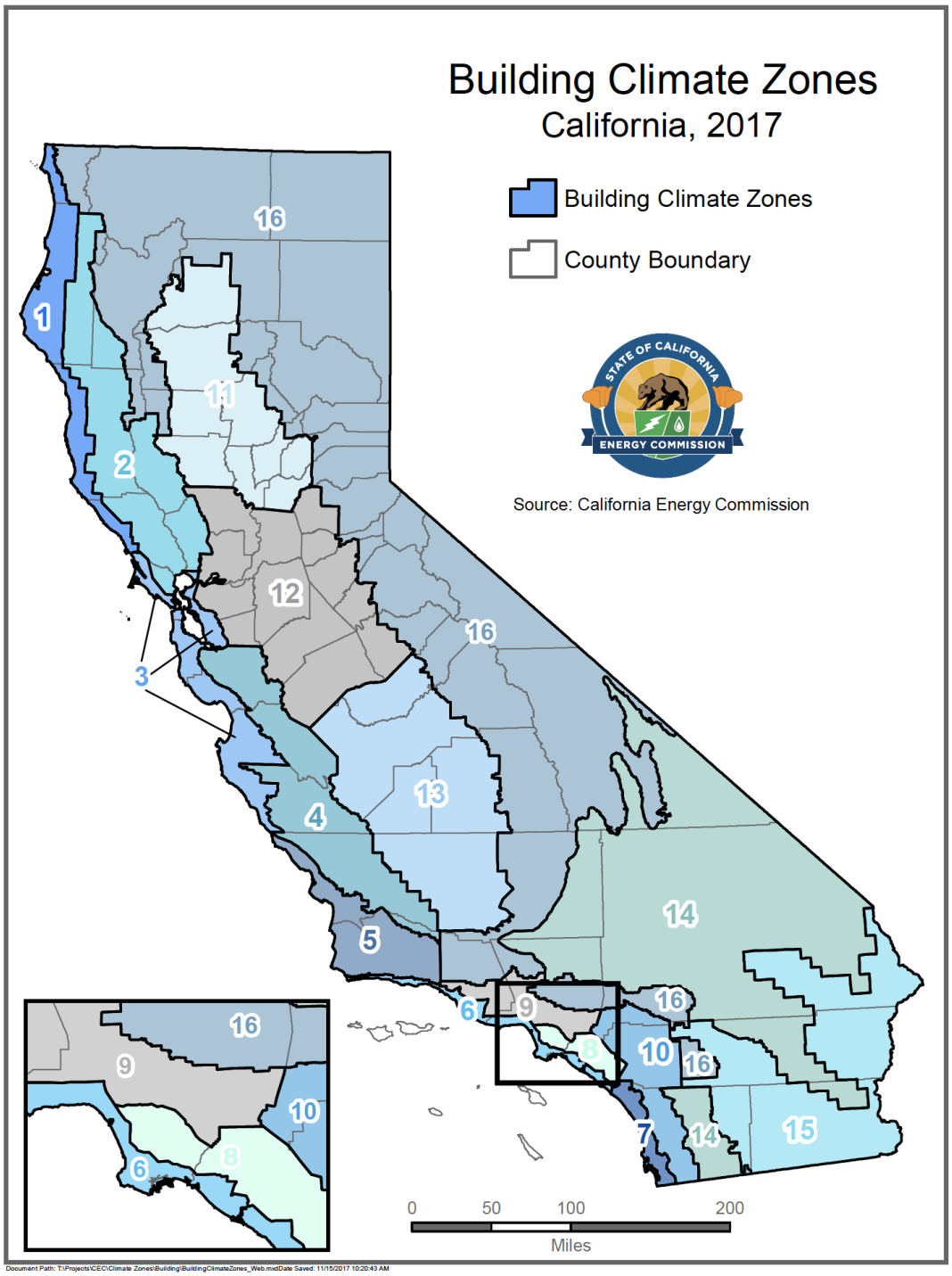


Figure 15: Map of California Climate Zones (courtesy of the California Energy Commission[17])

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

Appendix B – Utility Tariff Details

PG&E 48
SCE 51
SoCalGas 53
SDG&E 54
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/] (Non-CARE)	
				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

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

ELECTRIC SCHEDULE E-TOU Sheet 4
RESIDENTIAL TIME-OF-USE SERVICE

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

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

GAS SCHEDULE G-1 Sheet 1
RESIDENTIAL SERVICE

APPLICABILITY: This rate schedule[1] 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:

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

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)

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

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 Sheet 1
RESIDENTIAL SERVICE
(Includes GR, GR-C and GT-R Rates)

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	GR	GR-C	GT-R	
Customer Charge, per meter per day:	16.438¢	16.438¢	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.
1C6

ISSUED BY
Dan Skopec
Vice President
Regulatory Affairs

(TO BE INSERTED BY CAL. PUC)
SUBMITTED Jan 7, 2019
EFFECTIVE Jan 10, 2019
RESOLUTION NO. G-3351

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

SDGE

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 Sheet 2
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 R
Off-Peak	0.29562 R	0.00503 R	0.11235 R	0.41300 R
Super Off-Peak	0.29562 R	0.00503 R	0.05739 R	0.35804 R
Winter:				
On-Peak	0.32037 R	0.00503 R	0.07618 R	0.40158 R
Off-Peak	0.32037 R	0.00503 R	0.06762 R	0.39302 R
Super Off-Peak	0.32037 R	0.00503 R	0.05812 R	0.38352 R
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)

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.

SDGE
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 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

		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	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	11	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	12	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	11	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	15	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	11	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	22	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

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

">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	12	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	12	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	13	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	16	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	8	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	39	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

		BASECASE				Efficiency & PV							Efficiency & PV/Battery						
CZ	Utility	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	1.5	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	1.5
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	1.6	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	1.7
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	1.7	1.7
5	PG&E/SoCalGas	32.5	12	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	1.7	1.7
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	1.5
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	1.6
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	1.5
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	1.2	1.6
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	1.2	1.6
10	SDG&E	28.8	12	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	1.5	1.6
11	PG&E	30.0	13	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	1.7
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	16	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	1.6
14	SCE/SoCalGas	31.3	8	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	39	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	1.6
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	1.6

">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

VVLDCS – 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

VVLDCS – Verified Low Leakage Ducts in Conditioned Space

Table 31: Single Family Mixed Fuel Efficiency & PV/Battery 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 + 5 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 + 5 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 + 5 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 + 5 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 + 5 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 + 5 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 + 5 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 + 5 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 + 5 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 + 5 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 + 5 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 + 5 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 + 5 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 + 5 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 + 5 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 + 5 batt

VVLDCS – 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

VVLDCS – 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

VVLDCS – Verified Low Leakage Ducts in Conditioned Space

Table 35: Single Family All-Electric Efficiency & PV/Battery 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	1.0 PV scaling + 5 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 + 5 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 + 5 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 + 5 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 + 5 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 + 5 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 + 5 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 + 5 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 + 5 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 + 5 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 + 5 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 + 5 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 + 5 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 + 5 batt
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	1.0 PV scaling + 5 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 + 5 batt

VVLDCS – 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	11	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	12	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	11	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	15	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	11	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	22	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

		BASECASE				Efficiency & PV/Battery						
CZ	Utility	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	1.3
02	PG&E	25.7	12	2.4	13.9	14.8	10.9	16.9%	2.1	14.2	0.2	1.8
03	PG&E	24.7	10	2.1	13.5	14.4	10.3	10.7%	1.9	13.9	0.1	1.6
04	PG&E	25.5	8	2.2	13.6	14.3	11.2	15.7%	1.9	13.9	0.2	1.8
05	PG&E	24.2	10	2.1	12.6	14.3	9.9	9.4%	1.8	13.1	0.2	1.6
05	PG&E/SoCalGas	24.2	10	2.1	12.6	14.3	9.9	9.4%	1.8	13.1	0.2	1.6
06	SCE/SoCalGas	26.8	10	2.2	13.9	16.1	10.7	10.0%	1.8	14.2	0.6	1.5
07	SDG&E	26.8	5	2.1	13.2	15.8	11.0	7.3%	1.7	13.6	0.0	1.6
08	SCE/SoCalGas	25.7	10	2.2	14.6	15.8	9.9	13.4%	1.8	14.9	0.8	1.5
09	SCE/SoCalGas	26.4	13	2.2	14.7	16.7	9.7	15.2%	1.8	14.9	1.0	1.7
10	SCE/SoCalGas	27.0	10	2.3	15.1	16.6	10.4	13.7%	1.9	15.3	1.1	1.8
10	SDG&E	27.0	11	2.3	15.1	16.6	10.4	13.7%	1.9	15.3	0.3	1.8
11	PG&E	24.5	12	2.4	16.6	14.0	10.5	19.9%	2.0	16.7	0.4	1.8
12	PG&E	25.9	11	2.3	14.9	15.6	10.3	17.8%	2.0	15.2	0.3	2.0
13	PG&E	26.1	15	2.3	17.5	15.4	10.7	20.1%	2.0	17.5	0.4	1.8
14	SCE/SoCalGas	25.6	11	2.8	14.6	16.0	9.6	20.8%	2.2	14.7	1.2	1.5
14	SDG&E	25.6	22	2.8	14.6	16.0	9.6	20.8%	2.2	14.7	0.6	1.5
15	SCE/SoCalGas	25.0	11	2.5	21.6	16.2	8.8	18.9%	2.1	20.9	1.4	1.9
16	PG&E	29.4	22	3.5	13.4	19.5	9.9	19.3%	2.7	14.1	0.5	1.4

"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

		BASECASE					Non-Preempted								Equipment - Preempted							
CZ	Utility	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	12	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	12	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	13	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	16	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	8	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	39	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	1.4	1.5
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	1.8
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	1.4	1.7
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	1.4	1.9
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	1.5	1.8
05	PG&E/SoCalGas	34.7	12	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	1.5	1.8
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	1.3	1.7
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	1.3	1.7
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	1.3	1.7
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	1.4	1.8
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	1.8
10	SDG&E	31.2	12	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	1.5	1.8
11	PG&E	31.9	13	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	1.5	1.9
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	1.8
13	PG&E	32.1	16	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	1.8
14	SCE/SoCalGas	32.5	8	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	1.9
14	SDG&E	32.5	39	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	1.8	1.9
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	1.4	1.9
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	1.7	1.8

">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 + 22 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 + 22 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 + 22 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 + 22 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 + 22 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 + 22 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 + 22 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 + 22 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 + 22 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 + 22 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 + 22 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 + 22 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 + 22 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 + 22 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 + 22 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 + 22 batt

VLLDCS – Verified Low-Leakage Ducts in Conditioned Space

Table 43: Multifamily All-Electric 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	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	Infiltratio	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 + 22 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 + 22 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 + 22 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 + 22 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 + 22 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 + 22 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 + 22 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 + 22 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 + 22 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 + 22 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 + 22 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 + 22 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 + 22 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 + 22 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 + 22 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 + 22 batt

VLLDCS – Verified Low-Leakage Ducts in Conditioned Space

Appendix G – Results by Climate Zone

Climate Zone 1 80
Climate Zone 2 82
Climate Zone 3 84
Climate Zone 4 86
Climate Zone 5 PG&E 88
Climate Zone 5 PG&E/SoCalGas 90
Climate Zone 6 92
Climate Zone 7 94
Climate Zone 8 96
Climate Zone 9 98
Climate Zone 10 SCE/SoCalGas 100
Climate Zone 10 SDGE 102
Climate Zone 11 104
Climate Zone 12 106
Climate Zone 13 108
Climate Zone 14 SCE/SoCalGas 110
Climate Zone 14 SDGE 112
Climate Zone 15 114
Climate Zone 16 116

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	$4,788	0.96	1.79
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	$24,247	1.48	1.43
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	3,160	0	18.0	2.97	0.95	2.04	($6,372)	1.08	>1

[1]All reductions and incremental costs relative to the **mixed fuel** code compliant home.
[2]All reductions and incremental costs relative to the **all-electric** code compliant home.
[3]All 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 cots 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).
[4]This 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.
[5]Positive 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	$2,807	0.39	1.33
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	$8,632	1.38	1.47
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

[1]All reductions and incremental costs relative to the **mixed fuel** code compliant home.
[2]All reductions and incremental costs relative to the **all-electric** code compliant home.
[3]All 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 cots 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).
[4]This 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.
[5]Positive 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	$4,871	0.53	1.73
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	$17,610	1.41	1.48
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

[1]All reductions and incremental costs relative to the **mixed fuel** code compliant home.
[2]All reductions and incremental costs relative to the **all-electric** code compliant home.
[3]All 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 cots 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).
[4]This 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.
[5]Positive 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	$2,125	0.20	1.81
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	$6,546	1.44	1.82
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

[1]All reductions and incremental costs relative to the **mixed fuel** code compliant home.
[2]All reductions and incremental costs relative to the **all-electric** code compliant home.
[3]All 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 cots 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).
[4]This 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.
[5]Positive 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	$4,915	0.42	1.53
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	$13,857	1.56	1.64
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

[1]All reductions and incremental costs relative to the **mixed fuel** code compliant home.
[2]All reductions and incremental costs relative to the **all-electric** code compliant home.
[3]All 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 cots 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).
[4]This 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.
[5]Positive 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	$1,991	0.12	1.61
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	$6,057	1.38	1.71
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

[1]All reductions and incremental costs relative to the **mixed fuel** code compliant home.
[2]All reductions and incremental costs relative to the **all-electric** code compliant home.
[3]All 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 cots 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).
[4]This 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.
[5]Positive 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	$4,911	0.33	1.64
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	$14,141	1.52	1.67
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

[1]All reductions and incremental costs relative to the **mixed fuel** code compliant home.
[2]All reductions and incremental costs relative to the **all-electric** code compliant home.
[3]All 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 cots 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).
[4]This 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.
[5]Positive 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	$2,141	0.19	1.82
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	$5,914	1.37	1.86
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

[1]All reductions and incremental costs relative to the **mixed fuel** code compliant home.
[2]All reductions and incremental costs relative to the **all-electric** code compliant home.
[3]All 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 cots 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).
[4]This 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.
[5]Positive 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	$4,911	0.41	1.46
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	$13,525	1.65	1.70
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

[1]All reductions and incremental costs relative to the **mixed fuel** code compliant home.
[2]All reductions and incremental costs relative to the **all-electric** code compliant home.
[3]All 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 cots 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).
[4]This 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.
[5]Positive 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	$1,985	0.17	1.58
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	$6,026	1.50	1.77
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

[1]All reductions and incremental costs relative to the **mixed fuel** code compliant home.
[2]All reductions and incremental costs relative to the **all-electric** code compliant home.
[3]All 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 cots 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).
[4]This 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.
[5]Positive 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	$4,911	0.35	1.46
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	$13,525	1.65	1.70
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

[1]All reductions and incremental costs relative to the **mixed fuel** code compliant home.
[2]All reductions and incremental costs relative to the **all-electric** code compliant home.
[3]All 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 cots 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).
[4]This 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.
[5]Positive 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	$1,985	0.16	1.58
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	$6,026	1.50	1.77
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

[1]All reductions and incremental costs relative to the **mixed fuel** code compliant home.
[2]All reductions and incremental costs relative to the **all-electric** code compliant home.
[3]All 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 cots 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).
[4]This 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.
[5]Positive 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	$4,367	0.95	1.42
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	$11,513	1.20	1.50
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

[1]All reductions and incremental costs relative to the **mixed fuel** code compliant home.
[2]All reductions and incremental costs relative to the **all-electric** code compliant home.
[3]All 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 cots 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).
[4]This 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.
[5]Positive 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	$2,007	0.64	1.55
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	$5,303	1.28	1.67
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

[1]All reductions and incremental costs relative to the **mixed fuel** code compliant home.
[2]All reductions and incremental costs relative to the **all-electric** code compliant home.
[3]All 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 cots 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).
[4]This 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.
[5]Positive 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	$3,506	0.07	1.52
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	$9,413	1.32	1.56
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

[1]All reductions and incremental costs relative to the **mixed fuel** code compliant home.
[2]All reductions and incremental costs relative to the **all-electric** code compliant home.
[3]All 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 cots 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).
[4]This 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.
[5]Positive 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	$1,900	0.04	1.61
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	$4,916	1.26	1.71
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

[1]All reductions and incremental costs relative to the **mixed fuel** code compliant home.
[2]All reductions and incremental costs relative to the **all-electric** code compliant home.
[3]All 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 cots 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).
[4]This 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.
[5]Positive 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	$3,944	1.10	1.48
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	$10,493	1.14	1.49
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

[1]All reductions and incremental costs relative to the **mixed fuel** code compliant home.
[2]All reductions and incremental costs relative to the **all-electric** code compliant home.
[3]All 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 cots 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).
[4]This 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.
[5]Positive 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	$2,066	0.84	1.50
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	$4,962	1.31	1.68
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

[1]All reductions and incremental costs relative to the **mixed fuel** code compliant home.
[2]All reductions and incremental costs relative to the **all-electric** code compliant home.
[3]All 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 cots 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).
[4]This 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.
[5]Positive 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	$4,263	1.11	1.66
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	$10,932	1.16	1.60
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

[1]All reductions and incremental costs relative to the **mixed fuel** code compliant home.
[2]All reductions and incremental costs relative to the **all-electric** code compliant home.
[3]All 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 cots 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).
[4]This 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.
[5]Positive 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	$1,947	1.03	1.71
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	$4,949	1.35	1.77
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

[1]All reductions and incremental costs relative to the **mixed fuel** code compliant home.
[2]All reductions and incremental costs relative to the **all-electric** code compliant home.
[3]All 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 cots 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).
[4]This 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.
[5]Positive 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	$4,999	1.00	1.64
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	$11,606	1.16	1.58
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

[1]All reductions and incremental costs relative to the **mixed fuel** code compliant home.
[2]All reductions and incremental costs relative to the **all-electric** code compliant home.
[3]All 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 cots 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).
[4]This 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.
[5]Positive 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	$2,089	1.12	1.79
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	$5,108	1.35	1.78
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

[1]All reductions and incremental costs relative to the **mixed fuel** code compliant home.
[2]All reductions and incremental costs relative to the **all-electric** code compliant home.
[3]All 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 cots 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).
[4]This 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.
[5]Positive 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	$1,648.10	0.80	1.33
	Efficiency-Equipment	(0)	209	3.0	(0.06)	1.45	0.16	$593.40	2.64	3.84
	Efficiency & PV/Battery	(12)	217	9.5	0.03	1.25	0.36	$4,999.50	0.64	1.64
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	$1,772.82	1.08	1.52
	Efficiency-Equipment	2,563	0	3.0	0.00	0.85	0.10	$948.63	2.62	3.19
	Efficiency & PV	762	0	11.0	1.17	0.70	0.24	$6,405.39	1.68	1.50
	Efficiency & PV/Battery	(6)	0	21.0	1.74	0.41	0.53	$11,606.13	1.48	1.58
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

[1]All reductions and incremental costs relative to the **mixed fuel** code compliant home.
[2]All reductions and incremental costs relative to the **all-electric** code compliant home.
[3]All 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 cots 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).
[4]This 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.
[5]Positive 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	$278.06	1.09	1.69
	Efficiency-Equipment	(0)	102	2.5	(0.04)	2.13	0.16	$249.93	2.60	3.27
	Efficiency & PV/Battery	(6)	108	10.0	0.03	1.88	0.41	$2,088.94	0.27	1.79
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	$360.62	1.53	2.00
	Efficiency-Equipment	1,369	0	1.5	0.00	1.31	0.08	$360.85	2.05	1.98
	Efficiency & PV	450	0	10.5	0.60	1.09	0.30	$2,370.68	2.12	1.79
	Efficiency & PV/Battery	(4)	0	23.0	0.93	0.63	0.76	$5,107.56	1.52	1.78
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

[1]All reductions and incremental costs relative to the **mixed fuel** code compliant home.
[2]All reductions and incremental costs relative to the **all-electric** code compliant home.
[3]All 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 cots 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).
[4]This 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.
[5]Positive 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	$6,503	0.39	1.64
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	$16,555	1.54	1.66
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

[1]All reductions and incremental costs relative to the **mixed fuel** code compliant home.
[2]All reductions and incremental costs relative to the **all-electric** code compliant home.
[3]All 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 cots 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).
[4]This 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.
[5]Positive 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	$2,663	0.43	1.77
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	$6,472	1.48	1.89
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

[1]All reductions and incremental costs relative to the **mixed fuel** code compliant home.
[2]All reductions and incremental costs relative to the **all-electric** code compliant home.
[3]All 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 cots 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).
[4]This 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.
[5]Positive 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	$5,045	0.48	1.89
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	$17,064	1.33	1.53
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

[1]All reductions and incremental costs relative to the **mixed fuel** code compliant home.
[2]All reductions and incremental costs relative to the **all-electric** code compliant home.
[3]All 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 cots 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).
[4]This 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.
[5]Positive 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	$2,106	0.34	1.98
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	$6,656	1.31	1.76
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

[1]All reductions and incremental costs relative to the **mixed fuel** code compliant home.
[2]All reductions and incremental costs relative to the **all-electric** code compliant home.
[3]All 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 cots 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).
[4]This 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.
[5]Positive 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	$6,432	0.39	1.69
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	$16,283	1.45	1.59
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

[1]All reductions and incremental costs relative to the **mixed fuel** code compliant home.
[2]All reductions and incremental costs relative to the **all-electric** code compliant home.
[3]All 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 cots 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).
[4]This 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.
[5]Positive 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	$2,649	0.43	1.82
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	$6,362	1.41	1.82
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

[1]All reductions and incremental costs relative to the **mixed fuel** code compliant home.
[2]All reductions and incremental costs relative to the **all-electric** code compliant home.
[3]All 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 cots 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).
[4]This 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.
[5]Positive 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	$5,004	1.45	1.92
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	$15,872	1.40	1.65
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

[1]All reductions and incremental costs relative to the **mixed fuel** code compliant home.
[2]All reductions and incremental costs relative to the **all-electric** code compliant home.
[3]All 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 cots 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).
[4]This 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.
[5]Positive 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	$2,669	1.21	1.53
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	$6,093	1.42	1.86
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	0.7	1.41	1.35	$0	>1	>1

[1]All reductions and incremental costs relative to the **mixed fuel** code compliant home.
[2]All reductions and incremental costs relative to the **all-electric** code compliant home.
[3]All 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 cots 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).
[4]This 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.
[5]Positive 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	$5,004	1.36	1.92
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	$15,872	1.73	1.65
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

[1]All reductions and incremental costs relative to the **mixed fuel** code compliant home.
[2]All reductions and incremental costs relative to the **all-electric** code compliant home.
[3]All 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 cots 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).
[4]This 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.
[5]Positive 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	$2,669	0.57	1.53
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	$6,093	1.77	1.86
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

[1]All reductions and incremental costs relative to the **mixed fuel** code compliant home.
[2]All reductions and incremental costs relative to the **all-electric** code compliant home.
[3]All 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 cots 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).
[4]This 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.
[5]Positive 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	$5,521	1.25	1.65
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	$10,860	1.22	1.61
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

[1]All reductions and incremental costs relative to the **mixed fuel** code compliant home.
[2]All reductions and incremental costs relative to the **all-electric** code compliant home.
[3]All 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 cots 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).
[4]This 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.
[5]Positive 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	$2,317	1.45	1.91
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	$4,732	1.42	1.91
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

[1]All reductions and incremental costs relative to the **mixed fuel** code compliant home.
[2]All reductions and incremental costs relative to the **all-electric** code compliant home.
[3]All 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 cots 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).
[4]This 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.
[5]Positive 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 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)	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	$6,877	0.93	1.47
All-Electric[2]	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	$22,315	1.75	1.58
Mixed Fuel to All-Electric[3]	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

[1]All reductions and incremental costs relative to the **mixed fuel** code compliant home.
[2]All reductions and incremental costs relative to the **all-electric** code compliant home.
[3]All 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 cots 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).
[4]This 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.
[5]Positive 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	$2,741	0.52	1.41
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	$7,245	1.71	1.76
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

[1]All reductions and incremental costs relative to the **mixed fuel** code compliant home.
[2]All reductions and incremental costs relative to the **all-electric** code compliant home.
[3]All 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 cots 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).
[4]This 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.
[5]Positive values indicate an increase in PV capacity relative to the Standard Design.

CALIFORNIA ENERGY CODES & STANDARDS
A STATEWIDE UTILITY PROGRAM

Title 24, Parts 6 and 11
Local Energy Efficiency Ordinances

2019 Nonresidential New Construction Reach Code Cost Effectiveness Study

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

Prepared by:
TRC
EnergySoft

Last Modified: July 15, 2019

LEGAL NOTICE

This report was prepared by Southern California Edison Company (SCE) and funded by the California utility customers under the auspices of the California Public Utilities Commission.

Neither SCE nor any of its employees makes any warranty, express or implied; or assumes any legal liability or responsibility for the accuracy, completeness or usefulness of any data, information, method, product, policy or process disclosed in this document; or represents that its use will not infringe any privately-owned rights including, but not limited to, patents, trademarks or copyrights.

Table of Contents

1 Introduction 1
2 Methodology and Assumptions 3
2.1 Building Prototypes 3
2.2 Cost Effectiveness 5
3 Measure Description and Cost 7
3.1 Energy Efficiency Measures 7
3.1.1 Envelope 1
3.1.2 HVAC and SWH 1
3.1.3 Lighting 2
3.2 Solar Photovoltaics and Battery Measures 6
3.2.1 Solar Photovoltaics 6
3.2.2 Battery Storage 8
3.2.3 PV-only and PV+Battery Packages 9
3.3 All Electric Measures 9
3.3.1 HVAC and Water Heating 9
3.3.2 Infrastructure Impacts 13
3.4 Preempted High Efficiency Appliances 15
3.5 Greenhouse Gas Emissions 15
4 Results 16
4.1 Cost Effectiveness Results – Medium Office 17
4.2 Cost Effectiveness Results – Medium Retail 26
4.3 Cost Effectiveness Results – Small Hotel 34
4.4 Cost Effectiveness Results – PV-only and PV+Battery 43
5 Summary, Conclusions, and Further Considerations 48
5.1 Summary 48
5.2 Conclusions and Further Considerations 51
6 Appendices 53
6.1 Map of California Climate Zones 53
6.2 Lighting Efficiency Measures 54
6.3 Drain Water Heat Recovery Measure Analysis 54
6.4 Utility Rate Schedules 55
6.5 Mixed Fuel Baseline Energy Figures 56
6.6 Hotel TDV Cost Effectiveness with Propane Baseline 58
6.7 PV-only and PV+Battery-only Cost Effectiveness Results Details 62
6.7.1 Cost Effectiveness Results – Medium Office 62
6.7.2 Cost Effectiveness Results – Medium Retail 72
6.7.3 Cost Effectiveness Results – Small Hotel 81
6.8 List of Relevant Efficiency Measures Explored 90

List of Figures

Figure 1. Measure Category and Package Overview 2
Figure 2. Prototype Characteristics Summary 4
Figure 3. Utility Tariffs used based on Climate Zone 6
Figure 4. Energy Efficiency Measures - Specification and Cost....3
Figure 5. Medium Office – Annual Percent kWh Offset with 135 kW Array 6
Figure 6. Medium Retail – Annual Percent kWh Offset with 110 kW Array....7
Figure 7. Small Hotel – Annual Percent kWh Offset with 80 kW Array 7
Figure 8. Medium Office Upfront PV Costs....8
Figure 9. All-Electric HVAC and Water Heating Characteristics Summary....10
Figure 10. Medium Office HVAC System Costs 11
Figure 11. Medium Retail HVAC System Costs 12
Figure 12. Small Hotel HVAC and Water Heating System Costs 13
Figure 13. Medium Office Electrical Infrastructure Costs for All-Electric Design 14
Figure 14. Natural Gas Infrastructure Cost Savings for All-Electric Prototypes....15
Figure 15. High Efficiency Appliance Assumptions 15
Figure 16. Package Summary....16
Figure 17. Cost Effectiveness for Medium Office Package 1A – Mixed-Fuel + EE 19
Figure 18. Cost Effectiveness for Medium Office Package 1B – Mixed-Fuel + EE + PV + B....20
Figure 19. Cost Effectiveness for Medium Office Package 1C – Mixed-Fuel + HE 21
Figure 20. Cost Effectiveness for Medium Office Package 2 – All-Electric Federal Code Minimum 22
Figure 21. Cost Effectiveness for Medium Office Package 3A – All-Electric + EE 23
Figure 22. Cost Effectiveness for Medium Office Package 3B – All-Electric + EE + PV + B 24
Figure 23. Cost Effectiveness for Medium Office Package 3C – All-Electric + HE 25
Figure 24. Cost Effectiveness for Medium Retail Package 1A – Mixed-Fuel + EE....27
Figure 25. Cost Effectiveness for Medium Retail Package 1B – Mixed-Fuel + EE + PV + B....28
Figure 26. Cost Effectiveness for Medium Retail Package 1C – Mixed-Fuel + HE....29
Figure 27. Cost Effectiveness for Medium Retail Package 2 – All-Electric Federal Code Minimum....30
Figure 28. Cost Effectiveness for Medium Retail Package 3A – All-Electric + EE....31
Figure 29. Cost Effectiveness for Medium Retail Package 3B – All-Electric + EE + PV + B....32
Figure 30. Cost Effectiveness for Medium Retail Package 3C – All-Electric + HE 33
Figure 31. Cost Effectiveness for Small Hotel Package 1A – Mixed-Fuel + EE 36
Figure 32. Cost Effectiveness for Small Hotel Package 1B – Mixed-Fuel + EE + PV + B 37
Figure 33. Cost Effectiveness for Small Hotel Package 1C – Mixed-Fuel + HE....38
Figure 34. Cost Effectiveness for Small Hotel Package 2 – All-Electric Federal Code Minimum 39
Figure 35. Cost Effectiveness for Small Hotel Package 3A – All-Electric + EE 40
Figure 36. Cost Effectiveness for Small Hotel Package 3B – All-Electric + EE + PV + B 41
Figure 37. Cost Effectiveness for Small Hotel Package 3C – All-Electric + HE....42
Figure 38. Cost Effectiveness for Medium Office - PV and Battery 45
Figure 39. Cost Effectiveness for Medium Retail - PV and Battery....46
Figure 40. Cost Effectiveness for Small Hotel - PV and Battery....47
Figure 41. Medium Office Summary of Compliance Margin and Cost Effectiveness 49
Figure 42. Medium Retail Summary of Compliance Margin and Cost Effectiveness....50
Figure 43. Small Hotel Summary of Compliance Margin and Cost Effectiveness....51
Figure 44. Map of California Climate Zones....53
Figure 45. Impact of Lighting Measures on Proposed LPDs by Space Function 54
Figure 46. Utility Tariffs Analyzed Based on Climate Zone – Detailed View....55

Figure 47. Medium Office – Mixed Fuel Baseline 56
Figure 48. Medium Retail – Mixed Fuel Baseline....57
Figure 49. Small Hotel – Mixed Fuel Baseline 58
Figure 50. TDV Cost Effectiveness for Small Hotel, Propane Baseline – Package 2 All-Electric Federal Code Minimum....59
Figure 51. TDV Cost Effectiveness for Small Hotel, Propane Baseline – Package 3A (All-Electric + EE) 60
Figure 52. TDV Cost Effectiveness for Small Hotel, Propane Baseline – Package 3B (All-Electric + EE + PV) 60
Figure 53. TDV Cost Effectiveness for Small Hotel, Propane Baseline – Package 3C (All Electric + HE) 61
Figure 54. Cost Effectiveness for Medium Office - Mixed Fuel + 3kW PV 64
Figure 55. Cost Effectiveness for Medium Office – Mixed Fuel + 3kW PV + 5 kWh Battery 65
Figure 56. Cost Effectiveness for Medium Office – Mixed Fuel + 135kW PV 66
Figure 57. Cost Effectiveness for Medium Office – Mixed Fuel + 135kW PV + 50 kWh Battery 67
Figure 58. Cost Effectiveness for Medium Office– All-Electric + 3kW PV 68
Figure 59. Cost Effectiveness for Medium Office – All-Electric + 3kW PV + 5 kWh Battery 69
Figure 60. Cost Effectiveness for Medium Office – All-Electric + 135kW PV 70
Figure 61. Cost Effectiveness for Medium Office – All-Electric + 135kW PV + 50 kWh Battery 71
Figure 62. Cost Effectiveness for Medium Retail – Mixed-Fuel + 3kW PV....73
Figure 63. Cost Effectiveness for Medium Retail – Mixed Fuel + 3kW PV + 5 kWh Battery....74
Figure 64. Cost Effectiveness for Medium Retail – Mixed-Fuel + 110kW PV 75
Figure 65. Cost Effectiveness for Medium Retail – Mixed-Fuel + 110 kW PV + 50 kWh Battery....76
Figure 66. Cost Effectiveness for Medium Retail – All-Electric + 3kW PV 77
Figure 67. Cost Effectiveness for Medium Retail – All-Electric + 3kW PV + 5 kWh Battery....78
Figure 68. Cost Effectiveness for Medium Retail – All-Electric + 110kW PV 79
Figure 69. Cost Effectiveness for Medium Retail – All-Electric + 110kW PV + 50 kWh Battery 80
Figure 70. Cost Effectiveness for Small Hotel – Mixed Fuel + 3kW PV 82
Figure 71. Cost Effectiveness for Small Hotel – Mixed Fuel + 3kW PV + 5 kWh Battery 83
Figure 72. Cost Effectiveness for Small Hotel - Mixed Fuel +80kW PV....84
Figure 73. Cost Effectiveness for Small Hotel – Mixed Fuel + 80kW PV + 50 kWh Battery 85
Figure 74. Cost Effectiveness for Small Hotel – All-Electric + 3kW PV....86
Figure 75. Cost Effectiveness for Small Hotel – All-Electric + 3kW PV + 5 kWh Battery....87
Figure 76. Cost Effectiveness for Small Hotel – All-Electric + 80kW PV....88
Figure 77. Cost Effectiveness for Small Hotel – All-Electric + 80kW PV + 50 kWh Battery....89
Figure 78. List of Relevant Efficiency Measures Explored 90

1 Introduction

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

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

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

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

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

Figure 1. Measure Category and Package Overview

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

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

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

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

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

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

higher minimum efficiencies than the federal standards require, the focus of this study is to identify and evaluate cost-effective packages that do not include high efficiency equipment. However, because high efficiency appliances are often the easiest and most affordable measures to increase energy performance, this study provides an analysis of high efficiency appliances for informational purposes. While federal preemption would limit a reach code, in practice, builders may install any package of compliant measures to achieve the performance requirements, including higher efficiency appliances that are federally regulated.

2 Methodology and Assumptions

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

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

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

2.1 Building Prototypes

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

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

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

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

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

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

Figure 2. Prototype Characteristics Summary

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

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

2.2 Cost Effectiveness

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

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

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

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

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

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

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

Figure 3. Utility Tariffs used based on Climate Zone

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

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

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

- **Net Present Value (NPV)**: The Reach Code Team uses net savings (NPV benefits *minus* NPV costs) as the cost effectiveness metric. If the net savings of a measure or package is positive, it is considered cost effective. Negative savings represent net costs. A measure that has negative energy cost benefits (energy cost increase) can still be cost effective if the costs to implement the measure are more negative (i.e., material and maintenance cost savings).
- **Benefit-to-Cost Ratio (B/C)**: Ratio of the present value of all benefits to the present value of all costs over 15 years (NPV benefits *divided by* NPV costs). The criteria for cost effectiveness is a B/C greater than 1.0. A value of one indicates the savings over the life of the measure are equivalent to the incremental cost of that measure.

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

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

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

3 Measure Description and Cost

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

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

3.1 Energy Efficiency Measures

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

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

3.1.1 Envelope

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

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

3.1.2 HVAC and SWH

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

3.1.3 Lighting

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

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

Figure 4. Energy Efficiency Measures - Specification and Cost

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

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

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

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

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

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

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

3.2 Solar Photovoltaics and Battery Measures

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

3.2.1 Solar Photovoltaics

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

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

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

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

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

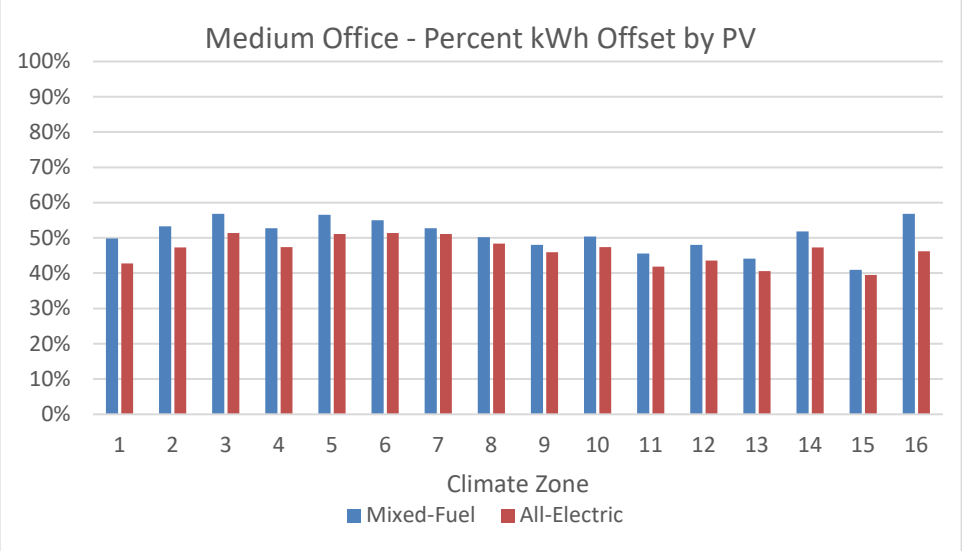


Figure 6. Medium Retail – Annual Percent kWh Offset with 110 kW Array

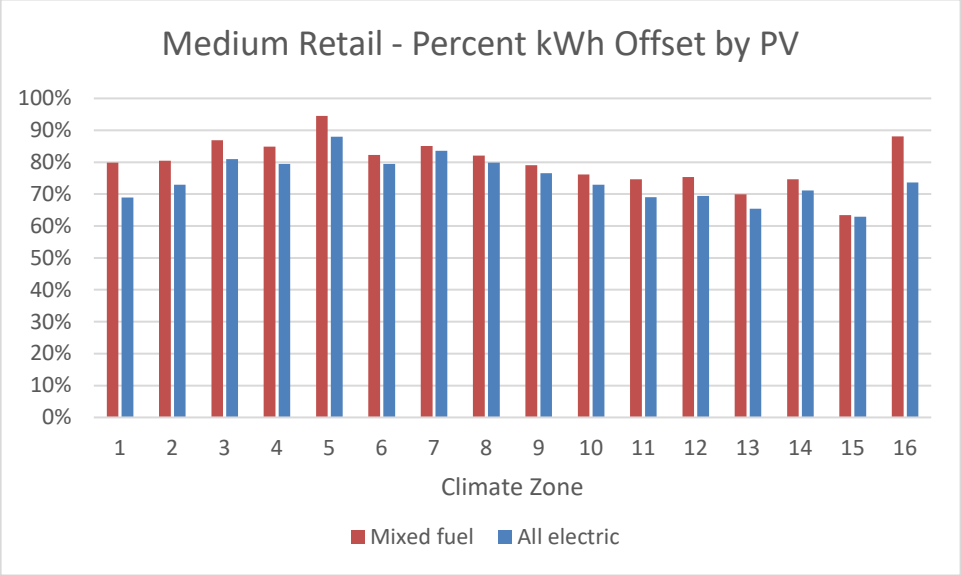
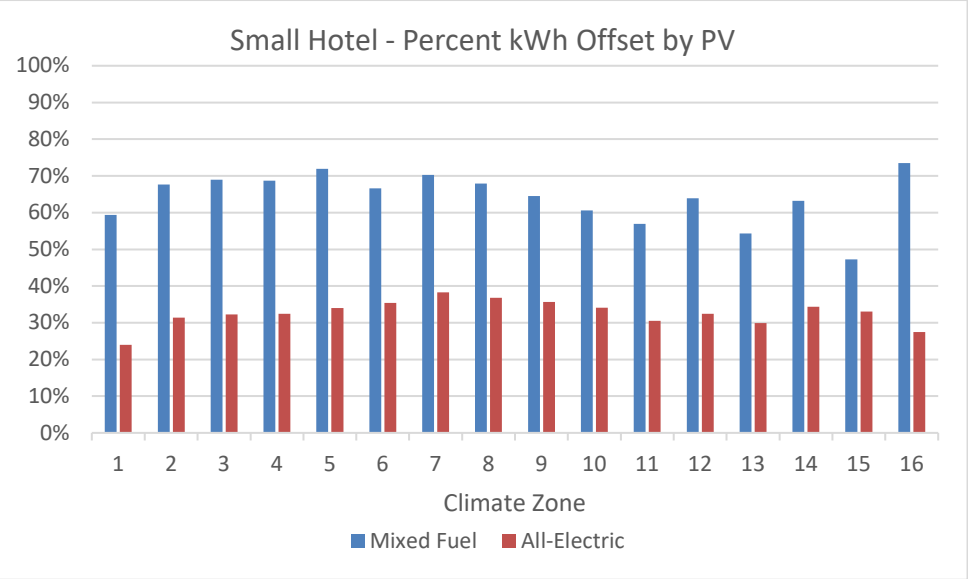


Figure 7. Small Hotel – Annual Percent kWh Offset with 80 kW Array



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

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

Figure 8. Medium Office Upfront PV Costs

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

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

3.2.2 *Battery Storage*

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

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

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

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

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

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

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

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

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

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

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

3.2.3 PV-only and PV+Battery Packages

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

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

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

3.3 All Electric Measures

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

3.3.1 HVAC and Water Heating

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

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

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

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

3.3.1.1 Medium Office

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

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

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

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

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

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

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

Figure 10. Medium Office HVAC System Costs

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

3.3.1.2 Medium Retail

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

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

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

Figure 11. Medium Retail HVAC System Costs

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

3.3.1.3 Small Hotel

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

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

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

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

Figure 12. Small Hotel HVAC and Water Heating System Costs

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

3.3.2 *Infrastructure Impacts*

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

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

3.3.2.1 Electrical Panel Sizing and Wiring

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

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

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

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

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

3.3.2.2 Natural Gas

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

The Reach Code Team determined that for a new construction building with natural gas piping, there is a service line (branch connection) from the natural gas main to the building meter. In the medium office prototype, natural gas piping is routed to the boiler. The Reach Code Team assumed that the boiler is on the first floor, and that 30 feet of piping is required from the connection to the main to the boiler. The Reach Code Team assumed 1" corrugated stainless steel tubing (CSST) material is used for the plumbing distribution. The Reach Code Team included costs for a natural gas plan review, service extension, and a gas meter, as shown in Figure 14 below. The natural gas plan review cost is based on information received from the City of Palo Alto Utilities. The meter costs are from PG&E and include both material and labor. The service extension costs are based on guidance from PG&E, who noted that the cost range is highly varied and that there is no "typical" cost, with costs being highly dependent on length of extension, terrain, whether the building is in a developed or undeveloped area, and number of buildings to be served. While an actual service extension cost is highly uncertain, the team believes the costs assumed in this analysis are within a reasonable range based on a sample range of costs provided by PG&E. These costs assume development in a previously developed area.

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

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

3.4 Preempted High Efficiency Appliances

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

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

Figure 15. High Efficiency Appliance Assumptions

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

3.5 Greenhouse Gas Emissions

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

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

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

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

4 Results

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

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

Figure 16. Package Summary

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

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

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

The TDV and on-bill based cost effectiveness results are presented in terms of B/C ratio and NPV in this section. What constitutes a 'benefit' or a 'cost' varies with the scenarios because both energy savings and incremental construction costs may be negative depending on the package. Typically, utility bill savings are categorized as a 'benefit' while incremental construction costs are treated as 'costs.' In cases where both construction costs are negative and utility bill savings are negative, the construction cost savings are treated as the 'benefit' while the utility bill negative savings are as the 'cost.'

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

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

4.1 Cost Effectiveness Results – Medium Office

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

4.2 Cost Effectiveness Results – Medium Retail

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

4.3 Cost Effectiveness Results – Small Hotel

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

5 Summary, Conclusions, and Further Considerations

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

5.1 Summary

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

- Cells highlighted in green depict a positive compliance margin 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.

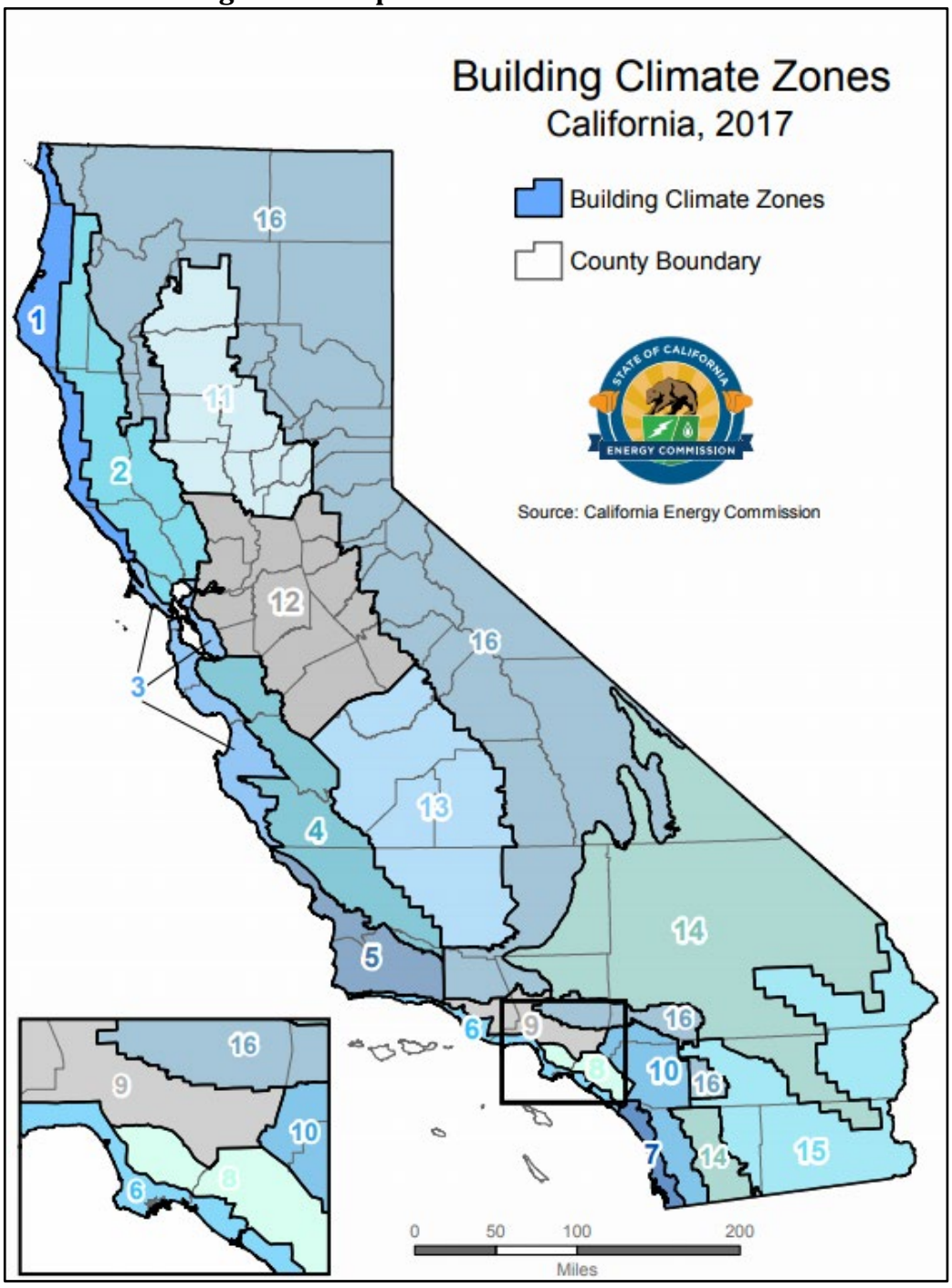
3. High efficiency appliances triggering federal preemption do not achieve as high compliance margins as the other efficiency measures analyzed in this study. Cost effectiveness appears to be dependent on the system type and building type. Nonetheless, specifying high efficiency equipment will always 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

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

6.3 Drain Water Heat Recovery Measure Analysis

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

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

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

6.4 Utility Rate Schedules

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

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

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

6.5 Mixed Fuel Baseline Energy Figures

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

Figure 47. Medium Office – Mixed Fuel Baseline

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

Figure 48. Medium Retail – Mixed Fuel Baseline

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

Figure 49. Small Hotel – Mixed Fuel Baseline

Climate Zone	Utility	Electricity Consumption (kWh)	Natural Gas Consumption (Therms)	Electricity Cost	Natural Gas Cost	Compliance TDV	GHG Emissions (lbs)
Small Hotel Mixed Fuel Baseline							
CZ01	PG&E	184,234	3,893	$43,188	$5,247	155	340,491
CZ02	PG&E	214,022	2,448	$70,420	$3,572	202	293,056
CZ03	PG&E	199,827	1,868	$47,032	$2,871	165	284,217
CZ04	PG&E	208,704	1,706	$66,980	$2,681	187	281,851
CZ04-2	CPAU	208,704	1,706	$36,037	$2,681	187	281,851
CZ05	PG&E	195,864	1,746	$45,983	$2,697	155	281,183
CZ05-2	SCG	195,864	1,746	$45,983	$2,342	155	281,183
CZ06	SCE	211,123	1,002	$36,585	$1,591	183	244,664
CZ06-2	LA	211,123	1,002	$21,341	$1,591	183	244,664
CZ07	SDG&E	211,808	522	$75,486	$4,055	178	233,884
CZ08	SCE	212,141	793	$36,758	$1,373	190	236,544
CZ08-2	LA	212,141	793	$21,436	$1,373	190	236,544
CZ09	SCE	227,340	970	$40,083	$1,560	218	242,296
CZ09-2	LA	227,340	970	$23,487	$1,560	218	242,296
CZ10	SDG&E	235,465	1,262	$87,730	$4,700	228	255,622
CZ10-2	SCE	235,465	1,262	$41,000	$1,853	228	255,622
CZ11	PG&E	234,560	2,415	$76,670	$3,547	244	282,232
CZ12	PG&E	228,958	2,309	$75,084	$3,426	234	270,262
CZ12-2	SMUD	228,958	2,309	$32,300	$3,426	234	270,262
CZ13	PG&E	242,927	1,983	$81,995	$3,034	258	284,007
CZ14	SDG&E	264,589	1,672	$97,581	$5,059	277	283,287
CZ14-2	SCE	264,589	1,672	$46,217	$2,172	277	283,287
CZ15	SCE	290,060	518	$50,299	$1,083	300	260,378
CZ16	PG&E	212,204	4,304	$67,684	$5,815	197	358,590
CZ16-2	LA	212,204	4,304	$20,783	$5,815	197	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

Pacific Gas and Electric Company

Robert S. Kenney
Vice President
State and Regulatory Affairs

P. O. Box 77000
San Francisco, CA 94177-00001
Mail Code B23A
(415) 973-2500
Robert.Kenney@pge.com

October 31, 2019

VIA EMAIL TO: councilmembers@ci.brisbane.ca.us

Mayor Madison Davis
City of Brisbane
50 Park Place
Brisbane, CA, 94005

Dear Honorable Mayor Davis and Councilmembers:

Pacific Gas and Electric Company (PG&E) is proud to provide electric and natural gas service to the City of Brisbane of this commitment, PG&E welcomes the opportunity to support the City of Brisbane's efforts to promote efficient, all-electric new construction, when it is cost-effective.

PG&E strongly supports California's climate and clean air goals. We recognize that achieving these goals requires a range of approaches and tools, including increasing the use of energy-efficient electric appliances in buildings when cost-effective. PG&E welcomes the opportunity to avoid investments in new gas assets that might later prove underutilized as local governments and the state work together to realize long-term decarbonization objectives. With all this in mind, PG&E supports local government policies that promote all-electric new construction when cost effective.

Beyond new construction, PG&E believes a multi-faceted approach is needed to cost-effectively achieve California's broader economy-wide long-term GHG reduction objectives, including both electrification and decarbonizing the gas system with renewable natural gas and hydrogen. As California's decarbonization policies evolve, PG&E will continue to ensure the safe and reliable operation of the electric and gas systems to continue supporting the customers that depend on us.

PG&E appreciates the partnership with the City of Brisbane during its policy development process, which allows us to prepare for the future and continue providing the best service possible to customers. PG&E continuously forecasts load in its service territory and implements upgrades to the distribution grid to meet the demand. PG&E fully expects to meet the needs that all-electric buildings will require. PG&E remains ready to engage with our customers, local government, businesses, and community members to meet their needs safely, reliably, affordably, and with clean energy.

PG&E looks forward to continuing to work with the City of Brisbane to accomplish its policy goals.

Thank you, and have a safe day.

Sincerely,

Robert S. Kenney
Vice President

cc: Adrienne Etherton, Sustainability Management Analyst, Public Works Department
City of Brisbane [aetherton@brisbaneca.org]
Darin Cline, Sr. Manager, Government Relations, PG&E [Darin.Cline@pge.com]

IBEW LOCAL UNION 617

1701 LESLIE STREET
SAN MATEO, CA 94402

POWERING SAN MATEO COUNTY
SINCE 1908

(650) 574-4239
FAX (650) 574-1408

September 23, 2019

Re: 2019 California Energy Code – Local Amendments (Reach Codes)

Dear City Council Member:

Each local government is required by law to adopt new changes to the California Building Standards Code every three years (known as code cycles) proposed by the State. The next code cycle will take effect January 1, 2020. This creates an opportunity to simultaneously adopt optional local building code amendments (known as Reach Codes) that exceed state code standards.

Historically, cities/counties sometimes adopt amendments to the Energy (Title 24, Part 6) and California Green Building Standards – CAL Green (Title 24, Part 11) codes to meet local environmental goals or aspirations.

This creates a significant Reach Code opportunity to reduce future GHG in new buildings by discouraging or eliminating the use of natural gas. This can be accomplished by incentivizing and/or requiring new buildings to use more electric appliances to utilize the clean renewable electricity available rather than natural gas.

Cities across the region are recognizing that all-electric homes and EVs reduce production of greenhouse gases (CHG) and provide healthier and safer homes and transportation at reduced cost.

Moving to all-electric homes is an important step for our economy and IBEW Local 617 is taking aggressive steps to ensure that we have trained workforce to address this need.

The IBEW Local 617 has been training men and women as electrician's for over 100 years in San Mateo County. The training requirements to become a journeyman electrician is based on a five (5) year apprenticeship program that focuses on installation, safety, compliance with Federal, State and County Codes and design of all electrical systems. As the future unfolds, IBEW Local 617, is transforming training objectives to meet with the innovations for electrification of homes with a conscious focus on controlling cost and energy. How is this being done? Through training in smarter, controlled based devices in lighting, which consumes 48% of the energy in a home. Through training and installation of advance designs and control of HVAC systems and home appliance, which are the highest consumers of energy in homes. Through training on the installation and maintenance of solar panels that can now be integrated into the roof designs of homes. Finally, through the installation of electric vehicle charging stations, since the growth of electric cars is predicted to increase from the current 3 million to 125 million cars by 2030 according to the International Energy Agency.

Each one of these areas represent only a small portion of the training each electrician receives as an apprentice and through journeymen upgrade courses. Additionally, IBEW Local 617 journeymen meet the State of California requirements for certification to work on homes, industrial/commercial buildings, and public transportation sites and receive added certifications for specialized training on lighting controls, electric vehicle charging stations, building automations, and the list goes on.

We are pleased to be at the forefront of the effort to ensure that San Mateo County will have the workforce needed to deliver high quality electrical service and installation of innovative technologies such as heat-pump water heaters, induction stoves, and electric vehicle charging to meet these needs.

We encourage the City Council to adopt building reach codes to accelerate cleaner, safer and lower cost homes and transportation.

Thank you for your consideration of this request. If there is any way that IBEW 617 can be of assistance on this or other matters, please do not hesitate to call.

Sincerely,

David Mauro
Business Manager
IBEW LU 617

DMM:mfb
opeiu29/afl-cio

October 15, 2019

Madison Davis, Mayor
City of Brisbane
Attn: Brisbane City Council
50 Park Place
Brisbane, CA 94005
councilmembers@brisbaneca.org

SUBMITTED VIA EMAIL

RE: City of Brisbane Development of Reach Codes

Dear Mayor Madison Davis:

Thank you for the opportunity to comment on the City of Brisbane's proposed Reach Codes aimed at reducing greenhouse gas emissions in the building sector. The Western Propane Gas Association (WPGA) seeks to be a valuable contributor in both the development of these codes and the policies and procedures that may emerge as a result of these discussions.

While we applaud efforts for building decarbonization, WPGA believes that Reach Codes disincentivizing propane as a complementary fuel source to electric are fundamentally misguided. WPGA hopes that regulators will look to the example that the City of San Luis Obispo is setting with the development of their Reach Codes and recognize the value that propane provides on a number of levels.

Propane provides affordable, clean energy for low income communities as well as a vital back-up power for solar powered homes when battery power is low. Disincentivizing propane as a complementary power to solar has an unintended consequence to make solar homes more expensive and less reliable when power generation is not at peak levels.

Furthermore, there has been numerous discussions throughout California regarding planned power outages and safety black-outs. In a recent article published by Politico (PG&E begins massive power shut-off in California to avoid wildfires) it is noted that the Public Safety Power Shutoff could affect 2.4 million electricity users. Propane delivers energy resiliency for communities facing safety black-outs which can be critical for those powering life-sustaining equipment. Vulnerable citizens such as people on dialysis or simply the many individuals using electric powered wheelchairs can use propane energy for reliable power.

When looking towards the future, our industry is investing in renewable propane, derived from sustainable sources like beef tallow or vegetable oil. We hope that regulators take a more holistic view of the complementary role propane plays alongside decarbonization efforts including solar, wind and other renewable fuels.

The Western Propane Gas Association appreciates your work in this area and looks forward to working with you as the City of Brisbane and the State strive to reduce greenhouse gas emissions through comprehensive clean energy solutions.

Sincerely,

Ben Granholm
Regulatory Affairs Specialist

cc: Adrienne Etherton, Sustainability Management Analyst

ATTACHMENT 3

Climate Implications of Reach Code Alternatives

By Adrienne Etherton, Sustainability Management Analyst

The goal of building electrification reach codes is to minimize the emissions produced by new buildings and the expansion of natural gas infrastructure. Natural gas is primarily methane, a greenhouse gas (GHG) with roughly 30 times the warming potential of carbon dioxide.

In Brisbane in 2015 (the most recent GHG Inventory), building energy use accounted for 38% of local emissions, 40% of which were from natural gas usage. Unfortunately, 2015 showed an increase in gas usage over prior inventories, eliminating some of the emission reduction gains made in other areas. Meanwhile, we expect inventories after the implementation of Peninsula Clean Energy (PCE) to show a significant decrease in building electricity emissions, owing to their cleaner energy mix. PCE also has a goal to be 100 percent greenhouse gas free by 2021, which would mean all-electric buildings in Brisbane would be GHG free by 2021.

In its recent "Pathway 2045" report, Southern California Edison examined how the state can reach climate neutrality by mid-century as laid out in state goals and strongly encouraged by climate scientists. Results included 50% reduction in natural gas consumption and 70% of buildings electrified. Some hard-to-transition gas uses, like industrial processing and heavy trucking, will continue to be powered by natural gas well into the future, but where possible and cost-effective, new natural gas use should be avoided and existing use will likely need to be converted, a more costly proposition.

During the collaborative reach code development process, city staff communicated with PG&E staff who expressed concern over expansion of natural gas infrastructure. Limited or short-term use of costly infrastructure with 50+ year lifetimes poses high societal costs in the long-term as the state moves towards a decarbonized future. PG&E submitted a letter of support for our reach code (previously provided correspondence) expressing strong support for all-electric new construction where cost effective.

For low-rise residential the best path to meet our climate goals and limit the future expansion and use of natural gas would be to follow Mountain View and other cities requiring all-electric new construction, and for non-residential it's to avoid broad categorical exceptions for gas usage while providing case-by-case exemptions for those new buildings in which electrification is not feasible or cost-effective. As most existing buildings already use natural gas and are not affected by the proposed reach codes, nor are renovations or tenant improvements, there will remain many locations for businesses to continue utilizing natural gas.

CITY OF MENLO PARK

MEMORANDUM

Date: 8/27/2019
To: Mayor and Members of the City Council
From: Joanna Chen, Sustainability Specialist
Re: All-electric commercial kitchen

On July 16, City Council directed staff to pursue an all-electric reach code option for nonresidential buildings with the exception of life science buildings. An all-electric building is defined as a building that has no natural gas or propane plumbing installed within the building. This means cooking appliances cannot have gas burners. Induction cooking is two to three times more efficient than gas cooktops, making it the most energy efficient cooking appliance as proven in the Range Top Technology Assessment Report. Induction cooktops cook food faster, lose less heat in the process, and enhance the indoor air quality. According to Lawrence Berkeley National Lab, induction technology produces 30 times less indoor air pollutants than natural gas cooktops.

Induction cooking technology was introduced in 1933 and is popular in Asia and Europe. Thus, this technology is more than 80 years and will continue to advance. Despite most assumptions, the recent demand of induction cooking appliances have driven prices down and the selection up. For instance, a Frigidaire 30 inch gas cooktop costs $854.10 compared to a Frigidaire 30 inch induction cooktop for $899.10. A GE 30 inch gas cooktop costs $1,169.10 compared to a GE 30 inch induction cooktop for $1,439.10.

David Kaneda from Integral Group, which is a deep green engineering and consulting firm, is working with several projects involving all-electric commercial kitchens. A handful of professional head chefs at Michelin Star rated restaurants, including French Laundry, have switched to induction. Curtis Stone, a Michelin star chef, advocates for induction cooktops due to their heat efficiency, cooking flexibility, and easy cleaning. According to the 2018 Consumer Reports, the top ten rated cooktops are all induction stoves. The 10th rated induction cooktop earned 97 out of 100 score, whereas the top rated gas cooktop earned an 89 rating.

Figure 1. Maison Troisgros, a three-star Michelin restaurant

David noted three high-tech companies are committed to build all electric induction kitchens. LinkedIn's Sunnyvale office is net zero energy (produces enough renewable energy offset its own energy consumption to reduce the use of nonrenewable energy, such as natural gas) and has induction wok burners in the kitchens. Sonoma Academy, a nonprofit, private high school in Santa Rosa, CA, also has an all-electric commercial kitchen.

Figure 2. Induction wok burner.

In conclusion, an all-electric nonresidential building reach code option is achievable. Induction cooking is the future and is safer to operate. Not only does an induction cooktop improve the indoor air quality, but it also automatically turns off when a pot is removed. The glass surface does not get hot and an induction cooktop cannot turn on without a pan. Induction technology have advances progressively since the 1900s, so much that the cooktop has Wi-Fi and Bluetooth capabilities.

References

Range Top Technology Assessment
Report: https://fishnick.com/equipment/techassessment/5_range_tops.pdf

Lawrence Berkeley National
Lab: https://pdfs.semanticscholar.org/1570/efb2619c61da28cd547899059795d164605c.pdf

Most about Curtis Stone's perspective on induction cooktops: https://www.bosch-home.com/us/experience-bosch/heart-of-the-home/recipes/curtis-stone-recipes/why-i-love-the-bosch-induction-cooktops

Consumer Reports: https://www.consumerreports.org/cro/cooktops.htm

LinkedIn's Net Zero Energy
remodel: https://www.mercurynews.com/2016/11/29/linkedin-opens-building-company-says-is-net-zero-energy/

Sonoma Academy: https://www.wrnsstudio.com/sonoma-academy-janet-durgin-guild-commons-a-story-of-community-sustainability-and-place/

SEC. 8.20.7. - Subsection 101.10.1.1 amended.

Subsection 101.10.1.1 of the 2019 California Green Building Standards Code is amended to read as follows:

101.10.1.1 Residential projects. All residential projects (single-family and multi-family) regulated by this code must comply with Mountain View's green building requirements as listed below.

SEC. 8.20.8. - Subsection 101.10.1.1.2 amended.

Subsection 101.10.1.1.2 of the 2019 California Green Building Standards Code is amended to read as follows:

101.10.1.1.2 Residential new construction for single-family and duplexes: All residential new construction must comply with the following:

a. The mandatory measures of the 2019 California Green Building Standards Code and any Mountain View amendments;

b. Demonstrate energy compliance to meet or exceed Title 24, Part 6;

c. Shall meet the parking requirements per Table 101.10;

d. Installation of photovoltaic (PV) per Title 24, Part 6, prewired to expand system to accommodate an all-electric building to one hundred (100) percent of annual kilowatt hour (kWh) consumption offset.

e. Natural gas shall not be allowed in single family and duplexes. The following list of items shall be electric installation:

1. Space-conditioning equipment

2. Clothes dryers shall be electric

3. Cooking Appliances

4. Fireplaces and/or fire pits

f. Water-heating systems and equipment shall be electric or solar, not be fueled by natural gas;

SEC. 8.20.9. - Subsection 101.10.1.1.3 amended.

Subsection 101.10.1.1.3 of the 2019 California Green Building Standards Code is amended to read as follows:

101.10.1.1.3 Multi-Family. All residential new construction with three (3) units or more must comply with the following:

a. The mandatory measures of the 2019 California Green Building Standards Code and any Mountain View amendments;

b. Demonstrate energy compliance to meet or exceed Title 24, Part 6;

c. Shall meet the parking requirements per Table 101.10;

d. Installation of PV on fifty (50) percent of roof area;

   Exception: Per Sections 102.3, 102.3.1 and 102.3.2 of this code, a project may submit for an exception by providing documentation that the required percentage of PV installation will over-generate the kWh required to operate the proposed structure on an annual basis;

e. Space-conditioning equipment shall be electric, not be fueled by natural gas;

f. Water-heating systems and equipment shall be electric or solar, not be fueled by natural gas;

g. Clothes dryers shall be electric, not be fueled by natural gas; and

h. Cooking appliances and fireplaces shall be electric, not fueled by natural gas.

SEC. 8.20.10. - Subsection 101.10.1.2.2 added.

Subsection 101.10.1.2.2 of the 2019 California Green Building Standards Code is added to read as follows:

101.10.1.2.2. Hotel/motel new construction—All hotel/motel new construction must comply with the following:

a. The mandatory measures of the 2019 California Green Building Standards Code and any Mountain View amendments;

b. Shall meet the intent of LEED® Gold certified;

c. Shall meet the parking requirements per Table 101.10 and Table A5.106.5.3.2;

d. Shall demonstrate energy compliance to meet or exceed Title 24, Part 6;

e. Installation of PV on fifty (50) percent of roof area;

Exception: Per Sections 102.3, 102.3.1 and 102.3.2 of this code, a project may submit for an exception by providing documentation that the required percentage of PV installation will overgenerate the kWh required to operate the proposed structure on an annual basis;

f. Space-conditioning equipment shall be electric, not be fueled by natural gas;

g. Water-heating systems and equipment shall be electric or solar, not be fueled by natural gas;

h. Clothes dryers shall be electric, not be fueled by natural gas;

i. Cooking appliances shall be electric, not fueled by natural gas;

Exception: Per Sections 102.3, 102.3.1 and 102.3.2 of this code, a project may submit for an exception to install a gas-fueled cooking appliance only if the project includes a for-profit kitchen of a restaurant in which the style of cooking cannot be achieved with electric cooking appliances or any other type of cooking appliance necessary to operate the kitchen. If the exception is utilized, the project shall provide installed prewiring for future use of electric appliances.

j. Bird-safe glass shall be installed on the exterior of the structure where:

1. The structure is equal to or greater than ten thousand (10,000) square feet; or

2. The applicable precise plan requires it.

SEC. 8.20.11. - Subsection 101.10.1.2 amended.

Subsection 101.10.1.2 of the 2019 California Green Building Standards Code is amended to read as follows:

101.10.1.2. Nonresidential projects. All nonresidential projects regulated by this code must comply with Mountain View's green building requirements as listed below.

SEC. 8.20.12. - Subsection 101.10.1.2.2 amended. Subsection 101.10.1.2.2 of the 2019 California Green Building Standards Code is amended to read as follows:

101.10.1.2.2. Nonresidential new construction. All nonresidential new construction must comply with the following:

a. The mandatory measures of the 2019 California Green Building Standards Code and any Mountain View amendments;

b. Shall meet the intent of LEED® Gold certified;

c. Shall meet the parking requirements per Table 101.10 and Table A5.106.5.3.2;

d. Shall demonstrate energy compliance to meet or exceed Title 24, Part 6;

e. Installation of PV on fifty (50) percent of roof area;

Exception: Per Sections 102.3, 102.3.1 and 102.3.2 of this code, a project may submit for an exception by providing documentation that the required percentage of PV installation will overgenerate the kWh required to operate the proposed structure on an annual basis.

f. Space-conditioning equipment shall be electric, not be fueled by natural gas;

g. Water-heating systems and equipment shall be electric or solar, not be fueled by natural gas;

h. Clothes dryers shall be electric, not be fueled by natural gas; and

i. Cooking appliances, not fueled by natural gas.

Exception: Per Sections 102.3, 102.3.1 and 102.3.2 of this code, a project may submit for an exception for installation of a gas-fueled cooking appliance under the following circumstances: in a for-profit kitchen of a restaurant where the style of cooking cannot be achieved with an electric fuel source or other option in order to operate the kitchen; and, when utilized, the developer shall provide installed prewiring for future use of electric appliances.

j. F, H, L Occupancies may utilize natural gas only in building areas where research, experiments, and measurements in medical and life sciences are performed and/or stored and, when utilized, shall provide installed prewiring for future use of electric appliances.

k. Bird-safe glass shall be installed on the exterior of the structure where:

1. The structure is equal to or greater than ten thousand (10,000) square feet; or

2. The applicable precise plan requires it.

SEC. 8.20.13. - Subsection 101.10.1.3 amended.

Subsection 101.10.1.3 of the 2019 California Green Building Standards Code is amended to read as follows:

101.10.1.3 Mixed-use projects. All new mixed-use construction projects must comply with Mountain View's green building requirements and meet the requirements applicable to each primary occupancy component. See Table 101.10 for mixed-use project requirements as it applies.

SEC. 8.20.14. - Table 101.10 amended.

Table 101.10 of the 2019 California Green Building Standards Code is amended to read as follows: