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2019 Cost-Effectiveness Study:

Existing Multifamily Residential Building Upgrades

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Acronym List

ACH50 – Air Changes per Hour at 50 pascals pressure differential

AC – Air Conditioner

ACM – Alternative Calculation Method

AFUE – Annual Fuel Utilization Efficiency

A – Ampere

B/C – Benefits–to-Cost; as in Lifecycle Benefit–to–Cost Ratio

BSC –— Building Standards Commission

Btu – British thermal units

CALGreen – Title 24, Part 11

CASE – Codes and Standards Enhancement

CBECC–Res – California Building Energy Code Compliance – Residential: 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

CFL – Compact Fluorescent Lamp

CO_2e – Carbon Dioxide (CO_2)–equivalent

CPAU – City of Palo Alto Utilities

CPUC – California Public Utilities Commission

CRRC – Cool Roof Rating Council

CZ – Climate Zone

DHW – Domestic Hot Water

E3 – Energy and Environmental Economics

EDR – Energy Design Rating

EER – Energy Efficiency Ratio

ft^2 – Square foot

GHG – Greenhouse Gas

GRC – General Rate Case

gpm – Gallons per minute

HERS Rater – Home Energy Rating System Rater

HPWH – Heat Pump Water Heater

HSPF – Heating Seasonal Performance Factor

HVAC – Heating, Ventilation, and Air Conditioning

IC – Insulation Contact

IOU – Investor–Owned Utility

ITC – Income Tax Credit (federal)

kWh – Kilowatt Hour

kW_{DC} – Kilowatt Direct Current; nominal rated power of a photovoltaic system

lb(s) – Pound(s)

LCC – Lifecycle Cost

LED – Light–Emitting Diode

MF – Multifamily

NEEA – Northwest Energy Efficiency Alliance

NEM – Net Energy Metering

NPV – Net Present Value

PG&E – Pacific Gas & Electric (utility)

PV – Solar Photovoltaic

SCE – Southern California Edison (utility)

SDG&E – San Diego Gas & Electric (utility)

SEER – Seasonal Energy Efficiency Ratio

SHGC – Solar Heat Gain Coefficient

SMUD – Sacramento Municipal Utility District

TDV – Time Dependent Valuation

therm – Unit for quantity of heat that equals 100,000 Btu

Title 24 – California Code of Regulations Title 24

TOU – Time-of-Use

V – Volt

VNEM – Virtual Net Energy Metering

W – Watt

W_{DC} – Watt Direct Current

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1 Introduction

The California Codes and Standards Reach Codes program provides technical support to local governments considering adopting a local ordinance (reach code) intended to support meeting local and/or statewide energy and greenhouse gas reduction goals. The program facilitates adoption and implementation of the code when requested by local jurisdictions by providing resources such as cost effectiveness studies, model language, sample findings, and other supporting documentation. Local jurisdictions that are considering adopting ordinances may contact the program for support through its website, LocalEnergyCodes.com.

This report documents cost-effective combinations of measures that exceed the minimum state requirements, both the current 2019 Building Energy Efficiency Standards, effective January 1, 2020, and the upcoming 2022 Building Energy Efficiency Standards, effective January 1, 2023. Local jurisdictions in California may consider adopting local energy ordinances to achieve energy savings beyond what will be accomplished by enforcing building efficiency requirements that apply statewide. 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 Statewide Reach Code Team.

The focus of this study is on existing multifamily buildings and expands on a similar analysis completed for single family buildings (Statewide Reach Code Team, 2021). Each jurisdiction must establish the appropriate structure and threshold for triggering existing building reach code requirements. Some common structures include triggering the requirements at major remodels, additions, or date-certain (upgrades must be completed by a specific date). Some of these measures could be triggered with a permit for another specific measure, such as a roof replacement. The analysis includes scenarios of individual measures, as well as package upgrades, and identifies cost-effective options based on the existing conditions of buildings in all 16 California Climate Zones (CZs) (see Appendix A: Map of California Climate Zones for a graphical depiction of climate zone locations).

The California Building Energy Efficiency Standards, or Title 24, Part 6 (California Energy Commission, 2018) 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, Part 6 (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 result in buildings consuming less energy than is permitted by Title 24, Part 6. 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 analysis does not evaluate the impact of retrofit measures on Title 24, Part 6 compliance margins, as the proposed measures are required in addition to achieving compliance with all codes.

2 Methodology and Assumptions

This analysis uses two different metrics to assess cost effectiveness of the proposed upgrades. Both methodologies require estimating and quantifying the incremental costs and energy savings associated with each energy efficiency measure. 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 total 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 (natural 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, Cutter, Kapur, Arent, & Conotyannis, 2014). This is the methodology used by the Energy Commission in evaluating cost effectiveness for efficiency measures in Title 24, Part 6. TDV multipliers used in both the 2019 and 2022 Title 24, Part 6 code are evaluated and documented in this analysis.

The general approach applied in this analysis is to evaluate performance and determine cost effectiveness of various energy retrofit measures, individually and as packages, in low-rise multifamily buildings. Three unique building vintages are considered: pre-1978, 1978–1991, and 1992–2010. The vintages were defined based on review of historic Title 24, Part 6 code requirements and selecting year ranges with distinguishing features. The applied approach establishes recommendations based on existing conditions and cost effectiveness of each measure or package.

The California Building Energy Code Compliance Residential (CBECC-Res) 2019.1.3 and 2022.0.1 compliance simulation tools were used to evaluate energy savings for most measures, with the exception of those outside the code compliance scope. In these cases, a combination of the Department of Energy's BEopt software and EnergyPlus v9.3. simulation engine was used.

This analysis builds on the work completed earlier in 2021 for single family buildings (Statewide Reach Code Team, 2021) and has been updated to reflect nuances for multifamily buildings, changes in measure costs over time, current utility tariffs and updated assumptions of utility rate escalation. Energy simulations were evaluated in CBECC-Res 2019 to evaluate cost effectiveness from a TDV perspective under the 2019 Title 24, Part 6. CBECC-Res 2022 was used to evaluate cost effectiveness under the 2022 Title 24, Part 6 code as well as on-bill cost effectiveness using the updated 2022 weather files.

2.1 Building Prototypes

The Energy Commission defines building prototypes which it uses to evaluate the cost effectiveness of proposed changes to Title 24, Part 6 requirements. For this analysis, an 8-unit 2-story garden-style multifamily prototype was used. This prototype is estimated to be representative of 40 percent of the existing multifamily building stock (Statewide CASE Team, 2020a). It is a 6,960 square foot building with slab-on-grade foundation, wood framed wall construction and a sloped roof. Table 1 describes the basic characteristics of the multifamily prototype.

Table 1: Prototype Characteristics

	Multifamily Prototype
Existing Conditioned Floor Area	6,960 ft^2: (4) 780 ft^2 & (4) 960 ft^2 units
Number of Stories	2
Number of Units	8
Number of Bedrooms	12 beds: (4) 1-bed & (4) 2-bed
Window-to-Floor Area Ratio	15%

Three building vintages were evaluated to determine sensitivity of existing building performance on cost effectiveness of upgrades. For example, it is widely recognized that adding attic insulation in an older building with no insulation is cost-effective; however, newer buildings will likely have at least some existing insulation in the attic reducing the potential savings from the measure. The building characteristics for each vintage were determined based on either prescriptive requirements from Title 24, Part 6 that were in effect or standard construction practice during that time period.

Table 2 summarizes the assumptions for each of the three vintages. Additionally, the analysis assumed the following features when modeling the prototype buildings:

- Individual space conditioning and water heating systems, one per multifamily unit.
- Split-system air conditioner with natural gas furnace with an efficiency defined by year of the most recent equipment replacement (based on standard equipment lifetime).
- Small storage natural gas water heater with an efficiency defined by year of most recent equipment replacement (based on standard equipment lifetime).
- Gas cooktop, oven, and clothes dryer.

Additions are not evaluated in this analysis as they are separately addressed in Section 150.2 of Title 24, Part 6 and have unique code requirements more similar to new construction than alterations.

Table 2: Efficiency Characteristics for Three Vintage Cases

Building Component Efficiency Feature	Vintage Case		
	Pre-1978	1978-1991	1992-2010
Envelope			
Exterior Walls	2x4, 16 inch on center wood frame, R-0[a]	2x4 16 inch on center wood frame, R-11	2x4 16 inch on center wood frame, R-13
Foundation Type & Insulation	Uninsulated slab (CZ 2-15) Raised floor, R-0 (CZ 1 & 16)	Uninsulated slab (CZ 2-15) Raised floor, R-0 (CZ 1 & 16)	Uninsulated slab (CZ 2-15) Raised floor, R-19 (CZ 1 & 16)
Ceiling Insulation & Attic Type	Vented attic, R-11 @ ceiling level Vented attic, R-5 @ ceiling level (CZ 6 & 7)	Vented attic, R-19 @ ceiling level	Vented attic, R-30 @ ceiling level
Roofing Material & Color	Asphalt shingles, dark (0.10 reflectance, 0.85 emittance)	Asphalt shingles, dark (0.10 reflectance, 0.85 emittance)	Asphalt shingles, dark (0.10 reflectance, 0.85 emittance)
Radiant Barrier	No	No	No
Window Type: U-factor/SHGC[b]	Metal, single pane: 1.16/0.76	Metal, dual pane: 0.79/0.70	Vinyl, dual pane Low-E: 0.55/0.40
House Infiltration	15 ACH50	10 ACH50	7 ACH50
HVAC Equipment			
Heating Efficiency	78 AFUE (assumes 2 replacements)	78 AFUE (assumes 1 replacement)	78 AFUE
Cooling Efficiency	10 SEER (assumes 2 replacements)	10 SEER (assumes 1 replacement)	13 SEER, 11 EER
Duct Location & Details	Attic, R-2.1, 30% leakage	Attic, R-2.1, 25% leakage	Attic, R-4.2, 15% leakage
Whole Building Mechanical Ventilation	None	None	None
Water Heating Equipment			
Water Heater Efficiency	0.575 Energy Factor (assumes 2 replacements)	0.575 Energy Factor (assumes 1 replacement)	0.575 Energy Factor
Water Heater Tank	40-gallon uninsulated tank, located in exterior closet	40-gallon uninsulated tank, located in exterior closet	40-gallon uninsulated tank, located in exterior closet
Pipe Insulation	None	None	None
Hot Water Fixtures	Standard, non-low flow	Standard, non-low flow	Standard, non-low flow

[a] Pre-1978 wall modeled with R-5 cavity insulation to better simulate uninsulated wall performance with field data and not overestimate energy use.

[b] Window type selections were made based on conversations with window industry expert, Ken Nittler of Enercomp, Inc. If a technology was entering the market during the time period (e.g., Low-E during 1992-2010 or dual pane during 1978-1991) that technology was included in the analysis. This provides a conservative assumption for overall building performance and additional measures may be cost-effective for buildings with lower performing windows, for example buildings with metal single pane windows in the 1978–1991 vintage.

2.2 Efficiency Measures

The methodology used in the analyses for each of the prototypical building types begins with a design that matches the specifications as described in Table 2 for each of the three vintages. Prospective energy efficiency measures were modeled in each of the prototypes to determine the projected electricity and natural gas energy impacts relative to the baseline vintage. In some cases, measures were packaged together where justified by complementary work flows, such as attic insulation and air sealing. Unless specified otherwise, all measures were evaluated using CBECC-Res 2019.1.3 and CBECC-Res 2022.0.1.

All measures are evaluated assuming they are not otherwise required by Title 24, Part 6. For example, duct sealing is required by code whenever HVAC equipment is altered. For this analysis duct sealing was evaluated for those projects where it is not already triggered by code (i.e., no changes to the heating or cooling equipment). Where appropriate, measure requirements align with those defined in Title 24, Part 6. In some cases, cost-effective measures were identified that exceed Title 24, Part 6 requirements, such as attic insulation, cool roofs, and duct sealing.

Following are descriptions of each of the efficiency upgrade measures applied in this analysis.

2.2.1 Building Envelope/Non-Preempted Measures

Attic Insulation: Add attic insulation in buildings with vented attic spaces to meet R-49. This aligns with upcoming requirements in the 2022 Title 24, Part 6 code for altered ceilings.

Air Sealing and Weather-stripping: Apply air sealing practices throughout all accessible areas of the building. For this study, it was assumed that older vintage buildings would be leakier than newer buildings and that approximately 30 percent improvement in air leakage was achievable through air sealing of all accessible areas. For modeling purposes, it was assumed that air sealing can reduce infiltration levels from 15 to ten air changes per hour at 50 Pascals pressure difference (ACH50) in the oldest vintages (pre-1978), from ten to seven ACH50 for the 1978–1991 vintage, and from seven to five ACH50 in the 1992–2010 vintage.

Cool Roof: For steep slope roofs, install a roofing product rated by the Cool Roof Rating Council (CRRC) with an aged solar reflectance of 0.25 or higher and thermal emittance of 0.75 or higher. This measure only applies to buildings that are installing a new roof as part of the scope of the remodel; the cost and energy savings associated with this upgrade reflects the incremental step between a standard roofing product with one that is CRRC rated with an aged solar reflectance of 0.25. This is similar to cool roof requirements in 2019 Title 24, Part 6 Section 150.2(b)1Ii but assumes a higher solar reflectance.

Raised Floor Insulation: Add R-19 insulation in existing buildings with raised floors and no insulation (pre-1978 vintages). While the base case for Climate Zones 2 through 15 is evaluated with a slab-on-grade, a parallel analysis was done with an uninsulated raised floor in these climate zones to evaluate the floor insulation measure.

Wall Insulation: Blow-in R-13 wall insulation in existing buildings that currently have no insulation in the walls (pre-1978 vintages).

Window Replacement: Replace existing metal-frame windows with a non-metal dual-pane product, which has a U-factor equal to 0.30 Btu/hour-ft^2-°F or lower and a Solar Heat Gain Coefficient (SHGC) equal to 0.23 or lower, except in heating dominated climates (Climate Zones 1, 3, 5, and 16) where an SHGC of 0.35 improves overall performance. This measure was only evaluated for the two older vintages, pre-1992, which are assumed to have either single- or dual-pane, metal-frame windows. This aligns with new window requirements in 2019 Title 24, Part 6. New windows have other non-energy benefits such as reduced noise and improved occupant comfort.

Duct Sealing, New Ducts, and Duct Insulation: Air-seal all ductwork to meet the requirements of the 2019 Title 24, Part 6 Section 150.2(b)1E. For this analysis, a total duct leakage value of 15 percent (which corresponds to Option i in

the Title 24, Part 6 section referenced) was evaluated. This measure was only evaluated for the two older vintages, pre-1992, where existing leakage rates were higher than 15 percent.

Replacing existing ductwork with entirely new ductwork was also evaluated. New ductwork must meet Sections 150.2(b)1Di and 150.2(b)1Diia of the 2019 Title 24, Part 6 code, as well as R-8 duct insulation and five percent duct leakage in all climates. The prescriptive requirement for total leakage in new ducts in multifamily dwelling units per Section 150.2(b)1DiiaII is 12 percent as opposed to five percent for single family dwellings. However, under most conditions, five percent is as attainable in multifamily buildings as it is in single family. Therefore, this lower threshold is recommended.

Both duct measures were evaluated only for ducts in the vented attic at the second floor units of the 2-story prototype. CBECC-Res does not evaluate the sealing impacts for ducts in conditioned space.

Water Heater Blanket: Add R-6 insulation to the exterior of existing residential tank storage water heaters. For the analysis, the water heater was modeled within conditioned space, which is a typical configuration for older buildings. This assumption is conservative since a water heater located in unconditioned space will tend to have higher tank losses and installing a water heater blanket in those situations will result in additional savings. The energy savings for this measure reflect water heating energy savings only, and do not include any impacts to the space conditioning load, which reduces space cooling loads and increases space heating loads. The impact on space conditioning energy used is minimal and in most climate zones, except for heating dominated ones, the combination of these two impacts results in net energy savings. This measure was evaluated using EnergyPlus for individual water heaters only and does not apply to central water heating systems.

Hot Water Pipe Insulation: Insulate all accessible hot water pipes with R-3 pipe insulation. In certain buildings such as those with slab-on-grade construction where most pipes are located either underground or within the walls, most of the pipes are inaccessible. For the purposes of this analysis, a conservative assumption that only ten percent of the pipes could be insulated was applied. In buildings where pipes are in the attic, crawlspace, or are otherwise more accessible, energy savings will be higher than those presented in this analysis. This measure was evaluated using BEopt and EnergyPlus. Savings were estimated by scaling the savings estimated for single family homes in the previous reach code analysis (Statewide Reach Code Team, 2021) based on the number of anticipated occupants for the multifamily prototype relative to the single family prototype.

Low-Flow Fixtures: Upgrade sink and shower fittings to meet current Title 24, Part 11 (CALGreen) requirements, which require maximum flow rates of 1.8 gallons per minute (gpm) for showerheads and kitchen faucets, and 1.2 gpm for bathroom faucets. Baseline dwelling unit hot water use was based on BEopt assumptions, and this measure assumed the upgraded fixtures reduce flow rates by ten percent for showerheads and 20 percent for all faucets, based on a 2010 water use study (CONSOL, January 2010). This measure was evaluated using BEopt and EnergyPlus. Savings were estimated by scaling the savings estimated for single family homes in the previous reach code analysis (Statewide Reach Code Team, 2021) based on the number of anticipated occupants for the multifamily prototype relative to the single-family prototype.

LED Lighting: Replace screw-in (A-based) incandescent and CFLs lamps with light-emitting diode (LED) lamps. This analysis was conducted external to the energy model and evaluated replacement of a 13 W CFL lamp with an 11 W LED lamp operating 620 hours annually. Annual hour estimates were based on whole building average hours of operation from a 2010 lighting study by KEMA (KEMA, Inc., February 2010). Lifetime assumptions were 10,000 hours for CFLs and 25,000 hours for LED lamps. For incremental cost calculations it was assumed CFLs have a lifetime of 15 years, are installed five years prior to the retrofit, and would need to be replaced at year ten and 25.

Exterior Lighting Controls: Evaluation of exterior lighting controls was completed on a per-luminaire basis external to the energy model and assumes a screw-in photosensor control is installed in outdoor lighting luminaires. Energy savings of 12.1 kWh per year was applied based on analysis done by the Consortium for Energy Efficiency, assuming LED lamps, 2.6 hours per day of operation, and that photosensor controls reduce operating hours on average 20

percent each day (Consortium for Energy Efficiency, January 2014). Energy savings will be higher for incandescent or CFL luminaires.

2.2.2 Photovoltaics (PV) and Battery Measures

PV: Installation of on-site PV is required in the 2019 residential code for new construction but not for additions or alterations to existing buildings. This report does not focus on optimizing PV system sizing for each prototype and climate zone. For this study, the PV system was sized to the 2019 new construction standards for a 6,960 square foot building. Based on prior studies, PV system cost effectiveness was not sensitive to system sizing up to 90 percent of annual electricity use (Statewide Reach Code Team, 2019). The system is sized to offset a portion of annual building electricity use for a new construction building and avoid oversizing, which would violate net energy metering (NEM) rules in place at the time of analysis. In all cases, PV is evaluated in CBECC-Res according to the California Flexible Installation (CFI) assumptions. Table 3 summarizes the PV sizing used in the analysis.

Table 3: Multifamily PV Sizing for 6,960 ft^2 building by Climate Zone (kW_{DC})

CA Climate Zone	PV Capacity (kW_{DC})[a]	CA Climate Zone	PV Capacity (kW_{DC})[a]
1	15.68	9	15.15
2	14.08	10	15.64
3	13.33	11	17.34
4	13.76	12	15.47
5	12.55	13	18.3
6	13.97	14	15.24
7	13.18	15	22.62
8	15.04	16	13.97

[a] PV system sized using residential new construction sizing methodology based on climate zone and dwelling unit size.

Energy Storage (Batteries): This measure includes installation of batteries to allow energy generated through PV to be stored and used later, providing energy cost and resiliency benefits. This report does not focus on optimizing battery sizes or controls for each prototype and climate zone. A 16 kWh battery system for the 8-unit building was evaluated in CBECC-Res in conjunction with a PV system sized to the 2019 new construction standards. The battery system was sized based on the upcoming 2022 Title 24, Part 6 requirements for multifamily buildings four habitable stories and greater. The control type was set to “Basic” in the software with default efficiencies of 95 percent for both charging and discharging (round trip efficiency of 90 percent). The 90 percent efficiency reflects products that are available on the market today. The Basic control charges the battery anytime PV generation is greater than the building load and discharges whenever the PV system does not cover the entire building load. It discharges only to serve building loads and does not discharge to the electric grid.

The “Time-of-Use” (TOU) battery control in CBECC-Res was not applied in this analysis to comply with current interconnection rules which do not allow battery systems to be interconnected under virtual net energy metering (VNEM) and export to the grid. While batteries are allowed to export if charged entirely from on-site renewables, this has not yet been allowed under VNEM.

2.2.3 Equipment Fuel Substitution Measures – Heat Pump Replacements

The baseline for the retrofit analysis assumes a mixed-fuel baseline for all cases, with natural gas furnaces for space heating and natural gas storage tank water heaters for domestic hot water (DHW). For the fuel substitution analysis,

the natural gas appliances are replaced with heat pump equipment at the end of equipment life, when the equipment is being replaced.

Ducted Heat Pump: Replace an existing ducted natural gas furnace and air conditioner (AC) with an electric heat pump. Savings are relative to a new ducted gas furnace/AC (14 SEER, 11.7 EER, 80 AFUE). Ductwork was sealed to 15 percent total leakage as is required by code for both the gas and heat pump cases. Minimum federal efficiency and higher efficiency heat pumps were evaluated. For the first case minimum efficiencies of 14 SEER, 11.7 EER, and 8.2 HSPF were applied, and heat pump capacities were based on autosizing in the software. The high efficiency heat pump specifications were based on a Bryant[1] variable capacity unit with rated efficiencies of 22 SEER, 14 EER, and 11 HSPF. While there are many variable capacity heat pumps with comparable performance, the Bryant unit was selected as a representative example. The heating capacities at 47 and 17 degrees Fahrenheit were entered in the software for the smallest Bryant unit that satisfied the heating load based on CBECC-Res load calculations. The system sizes described in Table 4 differed by climate zone and whether the apartment was on the lower floor or upper floor of the two-story prototype. Cooling capacity is not an input in CBECC-Res and was autosized in the simulation in all cases.

Table 4: High Efficiency Heat Pump Capacity per Floor

Climate Zone	1st Floor Apartment Nominal Capacity (Tons)	2nd Floor Apartment Nominal Capacity (Tons)
1	2	2
2	2	3
3	2	2
4	2	2
5	2	2
6	2	2
7	2	2
8	2	3
9	2	3
10	2	3
11	2	4
12	2	3
13	2	4
14	2	3
15	2	5
16	2	2

Heat Pump Water Heater (HPWH): Replace an existing natural gas storage tank water heater with either a minimum efficiency (UEF 2.0) HPWH, or a HPWH that meets the Northwest Energy Efficiency Alliance (NEEA) Advanced Water Heating Specification Tier 3[2] rating. Analysis is based on the water heater located in an exterior closet, a typical configuration in the style of multifamily building represented by this 8-unit prototype. The evaluated NEEA HPWH is an 80-gallon unit with a UEF of 3.45.[3] Savings are relative to a new 50-gallon natural gas storage water heater (UEF 0.63).

[1] Bryant Evolution Extreme 24. https://www.bryant.com/en/us/products/heat-pumps/284anv/
[2] https://neea.org/our-work/advanced-water-heating-specification
[3] The 1-bed and 2-bed apartments in the multifamily prototype used in this analysis likely wouldn't require an 80-gallon HPWH. When loads can be served by a 50-gallon or 65-gallon the resultant electricity use and incremental cost will both be slightly lower and cost effectiveness will improve.

2.3 Efficiency Packages

Some of the measures described above were also evaluated as packages.

2.3.1 Envelope and Duct Packages

Five envelope and duct packages were developed as described below. Air sealing and attic insulation are very often applied as a package in building retrofits. From a performance perspective, air sealing of the boundary between the attic and living space should be addressed any time there is significant work in the attic, such as adding attic insulation and sealing or replacing ductwork. At time of building shell improvement, air sealing is an important component to be addressed. The boundary between the living space and vented attics is where a significant amount of building air leakage can occur and sealing these areas prior to covering the attic floor with insulation is both practical and effective. These measures also directly address occupant comfort, as they reduce heat transfer, and result in more consistent temperatures within the building. When ductwork is located in the attic there are synergies with addressing all three of these building aspects at the same time.

1. **R-49 Attic Insulation and Air Sealing:** This package includes attic insulation and air sealing measures, as described below.
    - R-49 attic insulation installed in attic.
    - Air sealing and weatherstripping to reduce total building air leakage by 30 percent. Target air leakage assumptions are ten ACH50 for pre-1978 vintage, seven ACH50 for 1978–1991 vintage, and five ACH50 for the 1992–2010 vintage.
2. **R-49 Attic Insulation and Duct Sealing:** This package includes attic insulation and duct sealing measures, as described below. This only applies to the pre-1978 and 1978–1991 vintage buildings since the 1992–2010 vintage base case already includes 15 percent leakage ducts.
    - R-49 attic insulation installed in attic.
    - Ductwork sealed to 15 percent of nominal airflow.

    R-49 Attic Insulation, Air Sealing, and Duct Sealing: This package includes attic insulation, air sealing, and duct sealing measures, as described below. This combination of measures is common when a whole building performance upgrade is done in combination with HVAC equipment replacement. Incorporating these measures can allow for contractor to downsize HVAC equipment by lowering heating and cooling loads in the building.
    - R-49 attic insulation installed in attic.
    - Ductwork sealed to 15 percent of nominal airflow (pre-1978 and 1978–1991 only).
    - Air sealing and weatherstripping to reduce total building air leakage by 30 percent. Target air leakage assumptions are ten ACH50 for pre-1978 vintage, seven ACH50 for 1978–1991 vintage, and five ACH50 for the 1992–2010 vintage.
4. **R-49 Attic Insulation, Air Sealing, and Entirely New Ducts:** This package is similar to Package 3 above but assumes that all existing ductwork is replaced with new R-8 ducts and sealed to new construction standards (five percent total leakage). This package assumes that if an existing HVAC system is being replaced with new ductwork, the area between the vented attic and conditioned space be air sealed and insulation added to the attic.
    - R-49 attic insulation installed in attic.

- New R-8 ductwork sealed to five percent of nominal airflow.
- Air sealing and weatherstripping to reduce total building air leakage by 30 percent. Target air leakage assumptions are ten ACH50 for pre-1978 vintage, seven ACH50 for 1978–1991 vintage, and five ACH50 for the 1992–2010 vintage.

5. **Advanced Envelope Package: Attic Insulation, Air and Duct Sealing, plus Wall Insulation and New Windows:** This package includes all the measures in Package 3, in addition to insulating exterior walls, and replacing existing single-pane windows with improved high-performance windows. This package only applies to older vintage buildings with no wall cavity insulation and single-pane windows.
   - R-49 attic insulation installed in attic.
   - Ductwork sealed to 15 percent of nominal airflow (pre-1978 and 1978-1991 only).
   - Air sealing and weatherstripping to reduce total building air leakage by 30 percent. Target air leakage assumptions are ten ACH50 for pre-1978 vintage, seven ACH50 for 1978–1991 vintage, and five ACH50 for the 1992–2010 vintage.
   - Insulate exterior walls to R-13.
   - New windows with 0.30 U-factor and 0.23 SHGC (0.35 SHGC in Climate Zones 1, 3, 5, and 16).

2.3.2 Additional Packages

Water Heating Package: Includes storage tank water heater blanket, hot water pipe insulation, and low-flow fixtures. These three water heating measures are all relatively low cost and work together to reduce building hot water energy use.[4]

PV plus Batteries: PV sized to the 2019 Title 24, Part 6 residential new construction standards and a 16 kWh battery system with Basic control.

PV plus Heat Pump: PV sized to 2019 Title 24, Part 6 residential new construction standards and one fuel substitution measure, either a ducted heat pump for space heating or heat pump water heater.

PV plus Heat Pump plus Panel Upgrade: The PV plus Heat Pump package with the additional cost included for upgrading the electric panel.

PV plus Electric Ready Measures: Includes adding electric ready measures for future replacement of natural gas furnaces and water heaters with heat pumps, along with installation of an on-site PV system. The electric ready measures include prewiring 240 V power to the furnace location in an attic or an interior closet and the water heater location in an exterior closet, and panel upgrade to allow for installation of future electric appliances at a future date.

2.4 Measure Cost

Measure costs were obtained from various sources, including prior reach code studies, past Title 24, Part 6 Codes and Standards Enhancement (CASE) work, local contractors, internet searches, past projects, and technical reports.

2.4.1 Building Envelope/Non-Preempted Measures

Table 5 summarizes the cost assumptions for the building envelope and non-preempted HVAC measures evaluated.

[4] For additional information on residential water savings measures refer to the Energy plus Water 2019 reach code report. https://localenergycodes.com/download/454/file_path/fieldList/Energy%20plus%20Water%20Cost-eff%20Report-2019-10-22.pdf

2.4.2 PV and Battery Measures

The costs for installing PV and batteries are summarized in Table 6. For PV, they include first cost to purchase and install the system, inverter replacement costs, and annual maintenance costs. Upfront solar PV system costs are reduced by the federal investment tax credit (ITC) by 26 percent based on renewal of the credit through the year 2023.

Costs for batteries include first cost and replacement at year 10 and 20, assuming a 10 year battery life. Batteries are also eligible for the ITC if they are installed at the same time as the renewable generation source and charged by a renewable energy system more than 75% of the time.

Table 5: Measure Descriptions & Cost Assumptions - Non-Preempted Measures[a]

Measure	Performance Level	Incremental Lifecycle Cost – Multifamily Unit			Source	Notes
		Pre 1978	1978 – 1991	1992 – 2010		
Wall Insulation	R-13	$1,006	N/A	N/A	Retrofit contractor[b]	$2.14/ ft² exterior wall area. Assumes installation by drilling 2-inch holes from outside.
Raised Floor Insulation	R-19	$822	N/A	N/A	Retrofit contractor[b]	$1.89/ ft² of raised floor area. Assumes installation of R-19 batt insulation when existing condition is no insulation.
Attic Insulation	R-49	$745	$625	$484	2022 Alterations CASE Report (Statewide CASE Team, 2020a)	$1.71/ ft² ceiling area to add insulation to existing R-11 insulation. $1.44/ ft² to add to existing R-19 insulation. $1.11/ ft² to add to existing R-30 insulation.
Air Sealing	10 ACH50	$448	N/A	N/A	Retrofit contractor[b]	Based on contractor quote to seal building shell and reduce building air leakage by 30%. Assumes all accessible leaks are sealed and assumes existing attic insulation is not removed.
	7 ACH50	N/A	$448	N/A		
	5 ACH50	N/A	N/A	$448		
Cool Roof	Aged Solar Reflectance ≥ 0.25	$225	$225	$225	2022 Alterations CASE Report (Statewide CASE Team, 2020a)	Based on $0.32/ ft² roof area first incremental cost for cool asphalt shingle product. Total costs assume present value of replacement at year 20 and residual cost for remaining product life at end of 30-year analysis period. Higher reflectance values for lower cost are achievable for tile roof products
Window U-factor/SHGC	0.30 U-factor 0.23 SHGC in CZs 2,4,6-15 0.35 SHGC in CZs 1,3,5,16	$5,873	N/A	N/A	Retrofit contractor[c]	Based on $45/ ft² window area installed cost.
Duct Sealing	15% nominal airflow	$260	$260	N/A	HVAC contractor	Assume ducts in attic with 1 return. Costs scaled based on pricing from contractor for SF home. ~1 hour of labor at $120/hour and $15 material for 15% leakage from a starting point of 25-30%. $125 for HERS Rater.
Entirely New Ducts	R-8 ducts, 5% duct leakage	$1,353	$1,353	$1,353	Retrofit contractor[b]	Scaled to the MF prototype based on duct layout provided for prototype single story model, and all ducts located in attic.
Water Heater Blanket	R-6	$40			Internet search of big box retailers	$20 blanket + ½-hour labor ($40.30/hour laborer rate). Six-year life assuming that the existing water heater is already part way through its life and will need to be replaced after 6 years on average.
Hot Water Pipe Insulation	3/4 inch (R-3)	$42			Internet search of big box retailers	$0.20/ft of ¾ inch pipe insulation. 10ft total + 1-hour labor ($40.30/hour common labor rate). 15-year life assumed.

Low-flow Fixtures	CALGreen	$86	Retrofit contractor[c]	Showerheads at $34.74 each + sink aerators at $5.37 each + 1-hour labor ($40.30/hour common labor rate). 1 showerheads & 2 aerators assumed. 15-year life assumed.
LED Lamp	11 W screw-in lamp	$3.99/luminaire	Internet search	$3.99 for LED dimmable A19 lamp 60 W equivalent. $1.83 for an equivalent CFL product which was used to estimate total replacement costs at years 10 and 25. Cost based on a single LED lamp replacement.
Exterior Lighting Controls	Photocell control with motion sensor	$42.58/device	Internet search	Incremental cost of $9.95, based on a screw-in photosensor control, was obtained from an on-line product search of available products. A five-year lifetime for this type of control was assumed with 5 replacements over the analysis period.

[a] Costs include contractor overhead and profit.
[b] Source: Central Valley retrofit contractor who provided upgrade estimates in 2020 for a single family home prototype
[c] Source: Retrofit contractor pricing obtained by Davis Energy Group through the Stockton Energy Challenge neighborhood retrofit program (Davis Energy Group, 2017).

Table 6: Measure Descriptions & Cost Assumptions – PV and Batteries[a]

Measure	Performance Level	Incremental Cost – Multifamily Unit			Source	Notes
		Pre 1978	1978 – 1991	1992 - 2010		
PV	Sized to 2019 New Construction Standards: System size varies by climate (1.57 - 2.83 kW per unit)	$2.74/$W_{DC}$ $4,292 - $7,734			(Barbose & Darghouth, 2019)	First costs are from LBNL's Tracking the Sun 2019 costs (Barbose & Darghouth, 2019) and represent costs for the first half of 2019 of $3.10/$W_{DC}$ for residential systems. These costs were reduced by 26% for the solar ITC, which is the average credit over years 2021-2022. 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).
Batteries	16 kWh, Basic controls	$2,274 $1,137/kWh			(Self Generation Incentive Program, 2020), (E Source Companies, 2020)	$1,000/kWh first cost in 2020 based on Self-Generation Incentive Program residential participant cost data. To estimate the first cost in future years this was reduced by 7% annually based on SDG&E's Behind-the-Meter Battery Market Study (E Source Companies, 2020). The first cost is reduced by the Residential Storage Step 7 SGIP incentive of $0.15/Wh and the solar ITC of 26%. Costs are presented as the average of 2021 and 2022. Replacement cost at year 10 and 20 calculated based on the 2020 cost of $1,000/kWh reduced by 7% annually over the next 11 years for a future value cost of $450 (present value of $335 in year 10 and $249 in year 20).

[a] Costs include contractor overhead and profit.

2.4.3 Equipment Fuel Substitution Measures – Heat Pump Equipment

The cost assumptions used for fuel substitution measures are summarized in Table 7 and Table 8. Incremental costs for the heat pump replacement measures were obtained from several sources, including a 2019 report on residential building electrification in California (Energy & Environmental Economics, April 2019), pricing information provided from Sacramento Municipal Utility District's (SMUD's) electric appliance incentive program (SMUD, 2020), online equipment pricing, and contractor outreach. Both material and labor costs are included, assuming that existing natural gas equipment is being replaced with heat pumps at the end of equipment life, at time of equipment replacement.

For both the space heating and water heating cases, costs for service panel upgrades are not included as many existing buildings have the service capacity to support converting one appliance from gas to electric. In some buildings and in cases where multiple end uses are electrified, a larger electrical panel may be necessary. There are alternate scenarios evaluated that combine heat pumps with PV system installation, both with and without a panel upgrade. Cost assumptions for electric ready measures including a panel upgrade for future equipment fuel substitution measures are included in Table 9.[5]

Ducted Heat Pump: Table 7 presents estimated costs to replace existing equipment with a heat pump instead of a minimum efficiency natural gas furnace and AC. It is assumed there is no incremental labor except in providing new 240 V electrical service to the air handler location.

The lifetime for the heat pump, furnace, and air conditioner are based on the Database for Energy Efficient Resources (DEER) (California Public Utilities Commission, 2021a). In DEER, heat pump and air conditioner measures are assigned an effective useful lifetime (EUL) of 15 years and a furnace an EUL of 20 years. The heating and cooling system components are typically replaced at the same time when one reaches the end of its life and the other is near it. Therefore, it is assumed that both the furnace and air conditioner are replaced at the same time at year 17.5, halfway between 15 and 20 years. Present value replacement costs are included in the LCC.

The base case assumes that an existing AC is replaced. In mild climates, where AC may not be installed, there will be additional costs for installing an outdoor unit, refrigerant lines, and condensate drain pan.

Table 7: HVAC Measure Cost Assumptions – Electric Replacements

	Gas Furnace/AC	14 SEER Heat Pump	22 SEER Heat Pump	Notes
First Cost	$8,545	$8,731	$10,725	Equipment costs from on-line sources and HVAC contractors for 2-ton unit. Other supply and labor costs from 2019 report on residential building electrification in California (Energy & Environmental Economics, April 2019). First cost includes disposal, electrical upgrade, and labor costs.
Replacement Cost (Future Value)	$8,545	$6,433	$8,028	Future total replacement costs for the heat pumps are reduced by 20%[6] to account for cost reductions because

[5] In some cases when electrifying larger buildings or many buildings throughout a neighborhood, transformers may require upgrading. This is outside the scope of this analysis.

[6] Limited data on expected cost decreases in heat pumps over time are available. Instead, the Reach Code Team relied on recent solar PV trends. According to NREL's 2020 PV cost benchmark report (National Renewable Energy Laboratory, 2021) residential installed PV costs declined by 4.6 percent annually on average between 2014 and 2020. Installed residential PV capacity in the United States has increased by 335 percent between 2015 and 2020 according to 2021 Solar Market Insight Report (Solar Energy Industries Association, 2021). Data from AHRI (AHRI, 2021) reports an increase of United States shipments of air-to-air heat pumps of 151 percent between the same time period (2015-2020). The 4.6 percent growth rate was scaled to account for the different increases in market penetration (4.6% * 151%/335% = 2.1%). Over the 15 year expected useful life of the heat pump, the 2.1 percent annual decrease results in an estimated 31 percent total decrease. To be conservative and not overestimate cost

	Gas Furnace/AC	14 SEER Heat Pump	22 SEER Heat Pump	Notes
				of a maturing market and electrical upgrade costs are removed.
Replacement Cost (Present Value)	$5,094	$4,129	$5,153	Based on 17.5-year lifetime for gas furnace/AC, 15-year lifetime for heat pumps, and 3% discount rate.
Remaining Value at Year 30	($1,006)	$0	$0	Residual value of the gas furnace/AC to account for the remaining life at end of 30-year analysis period.
Total Lifecycle Cost	$12,633	$12,859	$15,878	
Incremental Cost	-	$227	$3,245	

Heat Pump Water Heater (HPWH): Table 8 presents estimated costs for the replacement of a natural gas storage water heater with a HPWH. Costs include all material and installation labor including providing new 240 V electrical service to the water heater location. Total installed costs are based on data from SMUD's HPWH incentive program between 2018 and 2020 (Sacramento Municipal Utility District, 2020). Equipment replacement costs are included based on an equipment life of 15 years for both the base case gas water heater and the HPWH. Present value replacement costs are included in the LCC.

Table 8: Water Heating Measure Cost Assumptions – Electric Replacements

Item	Gas Storage Water Heater	2.0 UEF HPWH	NEEA Tier 3 HPWH	Notes
First Cost	$1,600	$4,018	$4,155	First cost based on 2018-2020 costs from SMUD incentive program for NEEA Tier 3 HPWH (Sacramento Municipal Utility District, 2020). 2.0 UEF first cost assumes 90% of equipment cost compared to NEEA Tier 3 unit based on on-line product research. Includes equipment cost, electrical upgrade, permitting, and labor.
Replacement Cost (Future Value)	$1,600	$1,874	$1,943	Future replacement cost assumes the same labor for the gas and HPWH case. HPWH replacement equipment costs are reduced by 50% to account for cost reductions because of a maturing market.
Replacement Cost (Present Value)	$1,027	$1,203	$1,247	Based on 15-year lifetime and 3% discount rate.
Total Lifecycle Cost	$2,627	$5,221	$5,402	
Incremental Cost	-	$2,594	$2,775	

Electric Ready: Table 9 presents electric ready measure costs. Appliance pre-wiring costs assume materials and labor for prewiring 240 V, 30 A dedicated circuits to the existing furnace location in an attic or interior closet and the water heater location in an exterior closet. Panel upgrade costs are based on upgrading to 200 A service to allow for electric appliance installation at a future date.

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decreases this was reduced by about one third to arrive at the 20 percent assumption applied in this analysis. If annual heat pump installations increase beyond the 30 percent annual increase assumed based on this data (151%/5 = 30%), which is likely if electrification goals across the United States are met, cost reductions could be much higher.

Table 9: Electric Ready Measure Cost Assumptions

Measure	Incremental Cost	Notes
Appliance pre-wire	$455 per appliance. $910 total for space and water heating	$125 parts, $330 labor. (Energy & Environmental Economics, April 2019)
Panel upgrade	$3,181	(TRC, 2016)

2.5 Cost Effectiveness

Cost effectiveness was evaluated for all climate zones and is presented based on both TDV energy, using the Energy Commission's LCC methodology, and an On-Bill, customer-based 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 base case assumptions.

Additional analysis included evaluating the measures using both the 2019 and 2022 TDV multipliers. The 2022 weather files were also used to evaluate On-Bill energy performance. The 2022 weather files were updated in 2019 and are considered to better represent conditions now and in the future. They tend to increase cooling and reduce space heating energy use, based on recent warming trends throughout the state.

Cost effectiveness is presented using both lifecycle NPV savings and benefit-to-cost (B/C) ratio metrics, which represent 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.

- **NPV Savings:** NPV benefits minus NPV costs is reported as a 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).
- **B/C Ratio:** Ratio of the present value of all benefits to the present value of all costs over 30 years (NPV benefits divided by NPV costs). The criteria for cost effectiveness is a B/C ratio greater than one. A value of one indicates the NPV of the savings over the life of the measure is equivalent to the NPV of the lifetime incremental cost of that measure. A value greater than one represents a positive return on investment. The B/C ratio is calculated according to Equation 1.

Equation 1

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

Improving the efficiency of a project often requires an initial incremental investment. In most cases the benefit is represented by annual On-Bill utility or TDV savings, and the cost by incremental first cost and replacement costs. 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). In cases where both construction costs and energy-related savings are negative, the construction cost savings are treated as the 'benefit' while the increased energy costs are the 'cost.' In cases where a measure or package is cost-effective immediately (i.e., upfront construction cost savings and lifetime energy cost savings), B/C ratio cost effectiveness is represented by ">1". Because of these situations, NPV savings are also reported, which, in these cases, are positive values.

The lifetime costs or benefits are calculated according to Equation 2.

Equation 2

$$\text{NPV of lifetime cost or benefit} = \sum_{t=0}^{n} \frac{(Annual\ cost\ or\ benefit)_t}{(1+r)^t}$$

Where:

- *n* = analysis term in years
- *r* = discount rate

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

- Analysis term of 30 years except:
  - 15-year analysis term for the water heating package
- Real discount rate of three percent

2.5.1 On-Bill LCC

Residential utility rates at the time of the analysis were applied to calculate utility costs for all cases and determine On-Bill cost effectiveness for the proposed measures and packages. The Statewide Reach Code Team obtained the recommended utility rates from each IOU based on the assumption that the reach codes go into effect in 2020. First-year utility costs were calculated using hourly electricity and natural gas output from CBECC-Res and applying the utility tariffs summarized in Table 10. Appendix B: Utility Rate Schedules includes details on the utility rate schedules used for this study. The applicable residential TOU rate was applied to all cases. For cases with PV generation, the approved NEM2 tariffs were applied along with minimum daily use billing and mandatory non-bypassable charges. Future changes to the NEM tariffs are likely and the CPUC has issued a proposed decision with suggested changes that is expected to be finalized in 2022.[7]

Utility rates were applied to each climate zone based on the predominant IOU serving the population of each zone according to Table 10. 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 municipal utility rates were also evaluated: SMUD in Climate Zone 12 and City of Palo Alto Utilities (CPAU) in Climate Zone 4.

Table 10: Utility Tariffs Applied Based on Climate Zone

Climate Zones	Electric/Gas Utility	Electricity	Natural Gas
1-5, 11-13, 16	PG&E	E-TOU-C	G1
5	PG&E/SoCalGas	E-TOU-C	GR
6, 8-10, 14, 15	SCE/SoCalGas	TOU-D-4-9	GR
7, 10, 14	SDG&E	D TOU-DR1	GR
12	SMUD/PG&E	R-TOD (RT02)	G1
4	CPAU	E-1	G-2

Source: Utility websites, see Appendix B: Utility Rate Schedules for details on the tariffs applied.

A comparison of utility bill costs and subsequent cost savings from the measures evaluated in this study was conducted across TOU, tiered, and CARE rates. The TOU rates are described in Table 10 while the tiered rates are in Table 11. The CARE discount was evaluated for the TOU and tiered electricity tariffs and the gas tariffs in Table 10.

[7] https://www.cpuc.ca.gov/nemrevisit

Table 11: IOU Tiered Tariffs Applied Based on Climate Zone

Climate Zones	Electric Utility	Electricity Tiered Tariff
1-5, 11-13, 16	PG&E	E-1
6, 8-10, 14, 15	SCE	D
7, 10, 14	SDG&E	DR

Source: Utility websites, see Appendix B: Utility Rate Schedules for details on the tariffs applied.

Utility rates are assumed to escalate over time, using assumptions from the California Public Utilities Commission (CPUC) 2021 En Banc hearings on utility costs through 2030 (California Public Utilities Commission, 2021b). Escalation rates through the remainder of the 30-year evaluation period are based on the escalation rate assumptions within the 2022 TDV factors. See Appendix B: Utility Rate Schedules - Escalation Assumptions for details.

In calculating On-Bill cost effectiveness, incremental first costs are assumed to be financed into a mortgage or loan with a 30-year loan term and four percent interest rate. The only exceptions are the lighting measures. These are low-cost measures that are more likely than the other measures evaluated to be installed by the owner or occupant and are not assumed to be financed. Present value of replacement cost is included for measures with equipment lifetimes less than the evaluation period.

2.5.2 TDV LCC

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. Both 2019 and proposed 2022 TDV values were used and are based on long term discounted costs of 30 years for all residential measures. The CBECC-Res simulation software results are expressed in terms of TDV kBtu and normalized by area (per sq ft). The present value of the energy cost savings in dollars is calculated by multiplying the TDV kBtu savings by a NPV factor, also developed by the Energy Commission. The 30-year NPV factor $0.173/TDV kBtu, used for both 2019 and 2022 Title 24, Part 6 code cycles for residential buildings, was used. As with 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 3. In calculating TDV cost effectiveness, incremental first costs were not assumed to be financed into a mortgage or loan.

Equation 3

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

2.5.2.1 2019 and 2022 TDV Differences

There were key changes to the 2022 TDV methodology as compared to the 2019 TDV, including the major updates below:

- Updated weather files to reflect historical data from recent years.
- New load profiles representing building and transportation electrification and renewable generation.
- Addition of internalized cost streams to account for carbon emissions.
- Shaped retail rate adjustment partially scaled to hourly marginal cost of service.

- Addition of non-combustion emissions from methane and refrigerant leakage.

The impact of these key changes for electricity TDV are lower values during the mid-day that correspond with an abundance of solar production and a shift of the peak TDV to later in the day as a result of increasing levels of rooftop PV systems. However, the overall magnitude of the 2022 TDV does not increase significantly relative to 2019 TDV. For natural gas TDV there is a large increase in magnitude with the 2022 TDV being roughly 70 percent higher than in 2019. This is driven by the new retail rate forecast, increased fixed costs for maintaining the distribution system, and the new carbon cost component. Additional details about 2022 TDV are described in the final 2022 TDV methodology (California Energy Commission, May 2020).

The updated weather files represent an updated dataset based on historical weather sampled from recent years (1998-2017) to reflect the impacts of climate change. Cooling loads increase significantly, particularly for the mild climates zones where cooling energy use was previously low. Heating loads decrease on average 30 percent across all climate zones. The weather files used for the 2019 code cycle had not been updated since the 2013 code cycle and represented data only up until 2009. The Energy Commission and the Statewide Reach Code Team contend that the updated 2022 weather files better reflect changing climate conditions in California. Therefore, the 2022 files are used for all the analysis reported in this study.

2.6 Greenhouse Gas (GHG) Emissions Reductions

Equivalent CO2 emission reductions were calculated based on outputs from the CBECC-Res 2022.0.1 simulation software. GHG emissions resulting from electricity use 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 9.9 pounds (lbs) per therm is used. To compare the mixed-fuel and all-electric cases side-by-side, GHG emissions are calculated in CBECC-Res and presented as lbs CO2-equivalent (CO2e) emissions for the evaluated prototype.

3 Results

The primary objective of the evaluation is to identify cost-effective energy upgrade measures and packages for existing multifamily buildings, to support the design of local ordinances requiring upgrades, which may be triggered by different events, such as at the time of a significant remodel or addition. Cost-effectiveness analysis was completed for all climate zones based on multifamily prototype designs representing building features commonly used during each of three vintages. Table 13 through Table 18 summarize cost effectiveness of efficiency measures and packages. Cost-effectiveness analysis was evaluated using both On-Bill and TDV cost-effectiveness criteria described in Section 2.5. Detailed cost-effectiveness analysis results, along with energy savings are presented in Appendix D: Cost-Effectiveness Detail by Climate Zone in Table 29 through Table 112 by climate zone and building vintage. Site energy savings, cost savings, measure cost, and cost effectiveness including lifecycle B/C ratio and NPV of savings are provided. For climate zones that are served by multiple utilities, where cost effectiveness may differ based on applicable utility rates, cost-effectiveness results are reported for both applicable utility territories.

Where measures are dependent on climate zone and building vintage (envelope efficiency measures), cost effectiveness is reported for each vintage and climate zone. Some measure results do not differ between the vintages such as LED lamp replacement and water heating upgrades. The water heating and LED lighting measures are cost-effective in all cases and are presented as a single line-item in each climate zone.

Cost effectiveness by metric for each climate zone and building vintage is represented by labor and color in Table 13 through Table 18 as summarized in Table 12.

Table 12: Results Table Legend

Cost Effectiveness	Label
Cost-effective both On-Bill and TDV	Both
Cost-effective TDV only, not On-Bill	TDV
Cost-effective On-Bill only, not TDV	On-Bill
Not cost-effective On-Bill or TDV	N/A

Unless called out specifically, TDV cost effectiveness is based on the 2019 TDV, using the 2019 version of CBECC-Res software. On-Bill cost effectiveness reflects savings based on the 2022 weather files.

The On-Bill results presented in Sections 3.1 through 3.5 reflect the mostly TOU tariffs described in Table 10. The Statewide Reach Code Team analyzed the impacts to utility costs and On-Bill cost-effectiveness when tiered and CARE utility rates are applied. CARE rates are approximately 35 percent lower than standard rates for electricity and 20 percent for natural gas. These results are presented in Section 3.6.

3.1 Building Envelope/Non-Preempted Measures

A summary of the cost effectiveness of individual efficiency measures is summarized in Table 13 based on both the On-Bill and 2019 TDV metrics.

R-49 Attic Insulation: R-49 attic insulation is cost-effective based on either On-Bill or TDV in pre-1992 vintage buildings except some coastal climates (Climate Zones 1, 3 and 5 through 7), and not cost-effective in 1992-2010 buildings because of lower energy savings.

Air Sealing: Reducing building leakage by 30 percent alone is only cost-effective in a few cases in the hotter and colder climates.

Duct Sealing: Duct sealing to 15 percent of nominal airflow has the best economics of the envelope/duct measures in most climates and vintages and is cost-effective everywhere except Climate Zone 5 in 1978-1991 vintage buildings. This measure was not evaluated for 1992-2010 vintage buildings because the base case already assumed 15 percent duct leakage.

New Ducts: Replacing old ductwork with new R-8 ducts sealed to five percent of nominal airflow is not as cost effective as sealing existing leaky ducts but is still cost-effective in many cases. It is not cost-effective in Climate Zones 1, 3, 5, and 6 in any vintage and is only cost-effective in a handful of climate zones in 1992-2010 vintage buildings.

Cool Roof: Cool roof is cost-effective for all vintages in Climate Zones 4 and 8 through 15. It is also cost-effective for buildings built before 1992 in Climate Zone 2, 6, 7, and 16.

Wall Insulation: Blowing in wall insulation into exterior walls is only practical in older buildings with no insulation installed in the wall cavities and was only evaluated for the pre-1978 vintage. It is cost-effective On-Bill and TDV in Climate Zones 1, 2, 4 in PG&E territory, and 10 through 16, and it is additionally cost-effective based on only TDV in Climate Zones 3, 4 in CPAU territory, 5, 8, and 9.

Floor Insulation: Insulating existing raised floors is only practical in older buildings with no insulation installed in the floor and was only evaluated for the pre-1978 vintage. It is cost-effective only in a few cases, in Climate Zones 1, 5, 11, 14, 15, and 16.

Window Replacement: Window replacements are only cost-effective in buildings built before 1992 in Climate Zones 10 through 15 in certain cases.

Table 13: Summary of Multifamily Efficiency Measures – On-Bill & 2019 TDV

Climate Zone		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Utility		PG&E	PG&E	PG&E	PG&E / CPAU	PG&E / SCG	SCE	SDG&E	SCE	SCE	SCE / SDGE	PG&E	PG&E / SMUD	PG&E	SCE / SDGE	SCE	PG&E
R-49 Attic Insulation	Pre-1978	Both	Both	TDV	Both	TDV	Both	Both	Both	Both	Both	Both	Both	Both	Both	Both	Both
	1978-1991	N/A	Both	N/A	Both / TDV	N/A	N/A	N/A	On-Bill	TDV	Both	Both	Both / TDV	Both	Both	Both	Both
	1992-2010	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Air Sealing	Pre-1978	Both	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	TDV	Both	Both / TDV	Both	Both	Both	Both
	1978-1991	Both	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	Both	TDV	TDV	TDV / Both	TDV	Both
	1992-2010	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	TDV	N/A	N/A	N/A
Duct Sealing	Pre-1978	Both	Both	Both	Both	Both	Both	Both	Both	Both	Both	Both	Both	Both	Both	Both	Both
	1978-1991	Both	Both	TDV	Both	N/A	Both	Both	Both	Both	Both	Both	Both	Both	Both	Both	Both
New Ducts	Pre-1978	N/A	Both	N/A	Both / TDV	N/A	N/A	On-Bill	Both	Both	Both	Both	Both	Both	Both	Both	Both
	1978-1991	N/A	TDV	N/A	Both / TDV	N/A	N/A	N/A	Both	Both	Both	Both	Both	Both	Both	Both	Both
	1992-2010	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	TDV	N/A	Both	TDV / Both	Both	N/A

Climate Zone		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Utility		PG&E	PG&E	PG&E	PG&E / CPAU	PG&E / SCG	SCE	SDG&E	SCE	SCE	SCE / SDGE	PG&E	PG&E / SMUD	PG&E	SCE / SDGE	SCE	PG&E
Cool Roof	Pre-1978	N/A	Both	N/A	Both	N/A	Both	Both	Both	Both	Both	Both	Both	Both	Both	Both	On-Bill
	1978-1991	N/A	Both	N/A	Both / TDV	N/A	Both	Both	Both	Both	Both	Both	Both	Both	Both	Both	On-Bill
	1992-2010	N/A	N/A	N/A	TDV	N/A	N/A	N/A	Both	Both	Both	Both	Both / TDV	Both	Both	Both	N/A
Insulate Walls	Pre-1978	Both	Both	TDV	Both / TDV	TDV	N/A	N/A	TDV	TDV	Both	Both	Both	Both	Both	Both	Both
Insulate Floor	Pre-1978	Both	N/A	N/A	N/A	TDV	N/A	N/A	N/A	N/A	N/A	Both	N/A	N/A	TDV / Both	Both	Both
Windows	Pre-1978	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A / On-Bill	Both	On-Bill / N/A	Both	On-Bill	Both	N/A
	1978-1991	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A / On-Bill	On-Bill	N/A	On-Bill	N/A / On-Bill	Both	N/A

3.2 Envelope and Duct Packages

Cost effectiveness of the various envelope and duct packages are summarized in Table 14 based on both the On-Bill and 2019 TDV metrics. Cost effectiveness is better in older vintage buildings where potential for heating and cooling savings are higher.

1. **R-49 Attic Insulation and Air Sealing:** Increasing attic insulation to R-49 and air sealing the building is cost-effective based on either On-Bill or TDV in all climates in pre-1978 buildings, and everywhere except Climate Zones 3 through 9 in 1978–1991 vintage buildings. Air sealing and attic insulation are less cost-effective in newer vintages and in mild climates where heating and cooling energy use is lower.

2. **R-49 Attic Insulation and Duct Sealing:** Increasing attic insulation to R-49 and duct sealing is cost-effective both On-Bill and TDV in all climates except Climate Zones 1, 3, 5, and 6 in 1978–1991 vintage buildings.

3. **R-49 Attic Insulation, Air Sealing, and Duct Sealing:** Duct sealing is more cost-effective than air sealing and attic insulation measures. Packaging these measures provides improved cost effectiveness relative to these measures on their own. This package of measures is cost-effective based on either On-Bill or TDV in all climates in pre-1978 buildings, and everywhere except Climate Zones 1, 3 and 5 through 7 in 1978–1991 vintage buildings. The package is less cost-effective in newer vintages and in mild climates where heating and cooling energy use is lower.

4. **R-49 Attic Insulation, Air Sealing, and New Ducts:** Replacing ducts is less cost-effective than sealing existing leaky ducts so this package is generally less cost-effective than Package 3. This package of measures is cost-effective based on either On-Bill or TDV in all climates in pre-1978 buildings except in Climate Zones 3 and 5, and everywhere except Climate Zones 1, 3 and 5 through 7 in 1978–1991 vintage buildings. The package is less cost-effective in newer vintages and in mild climates where heating and cooling energy use is lower.

5. **Advanced Envelope Package - R-49 Attic Insulation, Air Sealing, and Duct Sealing, plus Wall Insulation and New Windows:** This package only applies to pre-1978 buildings without wall insulation. It is cost-effective On-Bill in Climate Zones 10 in SDG&E territory, 11, 12 in PG&E territory, and 13 through 16. Additionally, it is cost-effective only based on TDV in Climate Zones 10 in SCE territory and 12 in SMUD territory.

3.3 Water Heating and Lighting Measures/Packages

Cost effectiveness of water heating and lighting measures are also summarized in Table 14.

Water Heating Package – Water Heater Blanket, Hot Water Pipe Insulation, and Low-Flow Fixtures: The package including these three water heating measures is cost-effective On-Bill in all climate zones and vintages. Cost effectiveness was evaluated on a customer On-Bill basis only. TDV cost effectiveness was not evaluated because the evaluation period was less than the 30-year evaluation period used for TDV.

Lighting Measures – LED Lamps and Exterior Photocell Control: Replacing either an existing CFL or incandescent lamp with an LED lamp is cost-effective in all climate zones and vintages. The lighting results in Appendix D: Cost-Effectiveness Detail by Climate Zone report cost effectiveness for replacement of CFLs with LED lamps. Savings for exterior photocell controls assume LED luminaires. Exterior photocell controls are cost-effective On-Bill in all cases except in Climate Zone 4 with CPAU rates and Climate Zone 12 with SMUD rates, where they are cost-effective only based on TDV.

Table 14: Summary of Multifamily Efficiency Packages – On-Bill & 2019 TDV

Climate Zone		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Utility		PG&E	PG&E	PG&E	PG&E / CPAU	PG&E / SCG	SCE	SDG&E	SCE	SCE	SCE / SDGE	PG&E	PG&E / SMUD	PG&E	SCE / SDGE	SCE	PG&E
R-49 Attic & Air Sealing	Pre-1978	Both	Both	TDV	Both / TDV	TDV	TDV	On-Bill	Both	Both	Both	Both	Both	Both	Both	Both	Both
	1978-1991	Both	Both	N/A	N/A	N/A	N/A	N/A	N/A	N/A	Both / TDV	Both	Both / TDV	Both	Both	Both	Both
	1992-2010	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
R-49 Attic & Duct Sealing Package	Pre-1978	Both	Both	Both	Both	Both / TDV	Both	Both	Both	Both	Both	Both	Both	Both	Both	Both	Both
	1978-1991	N/A	Both	N/A	Both / TDV	N/A	N/A	On-Bill	Both	Both	Both	Both	Both	Both	Both	Both	Both
R-49, Air Sealing & Duct Sealing Package	Pre-1978	Both	Both	TDV	Both	TDV	Both	On-Bill	Both	Both	Both	Both	Both	Both	Both	Both	Both
	1978-1991	N/A	Both	N/A	Both / TDV	N/A	N/A	N/A	Both	TDV	Both	Both	Both	Both	Both	Both	Both
	1992-2010	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
R-49, Air Sealing & New Ducts Package	Pre-1978	On-Bill	Both	N/A	Both / TDV	N/A	TDV	On-Bill	Both	Both	Both	Both	Both	Both	Both	Both	Both
	1978-1991	N/A	TDV	N/A	TDV	N/A	N/A	N/A	Both	Both	Both	Both	Both / TDV	Both	Both	Both	Both
	1992-2010	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	TDV	N/A	N/A / TDV	N/A

Climate Zone		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Utility		PG&E	PG&E	PG&E	PG&E / CPAU	PG&E / SCG	SCE	SDG&E	SCE	SCE	SCE / SDGE	PG&E	PG&E / SMUD	PG&E	SCE / SDGE	SCE	PG&E
Advanced Envelope Package	Pre- 1978	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	TDV / Both	Both	Both / TDV	Both	Both	Both	Both
Water Heating Package	All Vintages	On-Bill	On-Bill	On-Bill	On-Bill	On-Bill	On-Bill	On-Bill	On-Bill	On-Bill	On-Bill	On-Bill	On-Bill	On-Bill	On-Bill	On-Bill	On-Bill
LED Lamps	All Vintages	Both	Both	Both	Both	Both	Both	Both	Both	Both	Both	Both	Both	Both	Both	Both	Both
Exterior Photosensor	All Vintages	Both	Both	Both	Both / TDV	Both	Both	Both	Both	Both	Both	Both	Both / TDV	Both	Both	Both	Both

3.4 PV and Batteries

For this analysis, a PV system sized to offset the electricity use per the 2019 new construction standards by climate zone was evaluated. On-Bill and 2019 TDV cost effectiveness for PV and PV with batteries are summarized in Table 15. Cost effectiveness for PV is not affected much by building vintage. Both a PV system alone and a paired PV and battery system are cost-effective based on both On-Bill and TDV in all cases.

PV: PV systems are cost-effective in all climate zones and vintages based on both an On-Bill and TDV basis. 30-year On-Bill net benefits exceed $5,000 across all the IOU scenarios, but cost effectiveness is lower under both CPAU and SMUD municipal utility rates. Figure 1 summarizes both customer On-Bill and TDV lifecycle net benefits. PV cost effectiveness is not very sensitive to system size until the PV system size approaches net zero on an annual basis, or with very small systems which are more costly per kilowatt.

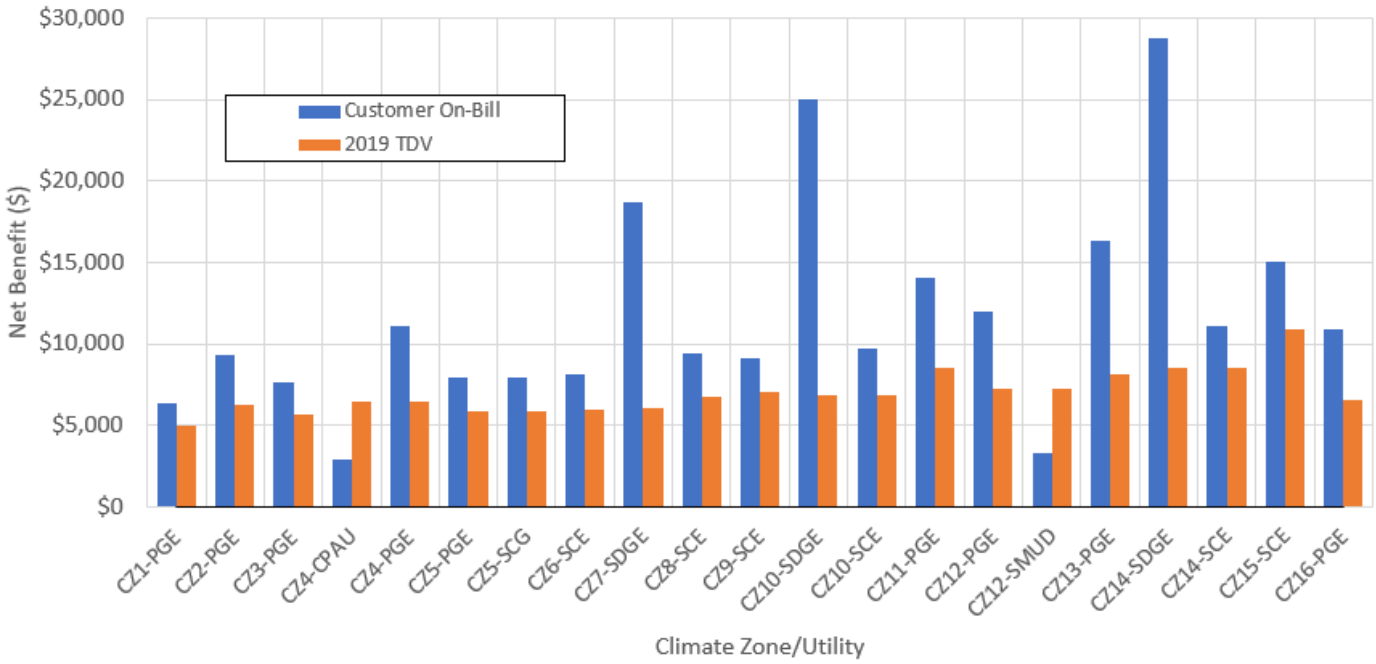

Figure 1: Net benefit - rooftop PV system sized to new construction standards (2-4 kW): 1978-1991.

PV and Batteries: Pairing a 2 kWh battery storage system (16 kWh for the 8-unit building) with a PV system sized to the 2019 new construction sizing criteria is cost-effective in all climate zones and vintages. Figure 2 and Figure 3 summarize customer On-Bill and TDV lifecycle net benefits for PV and Battery for the pre-1978 vintage and the 1992-2010 vintage, respectively.

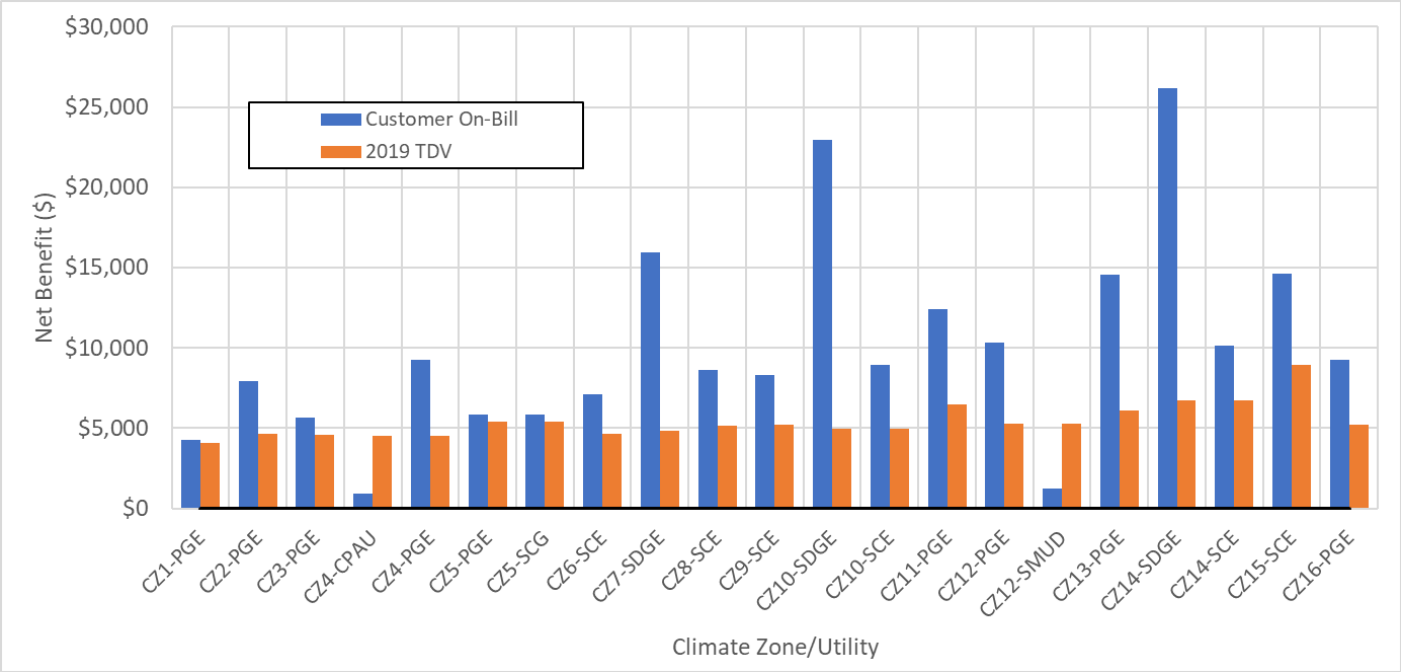

Figure 2: Net benefit - rooftop PV + 16 kWh battery: pre-1978.

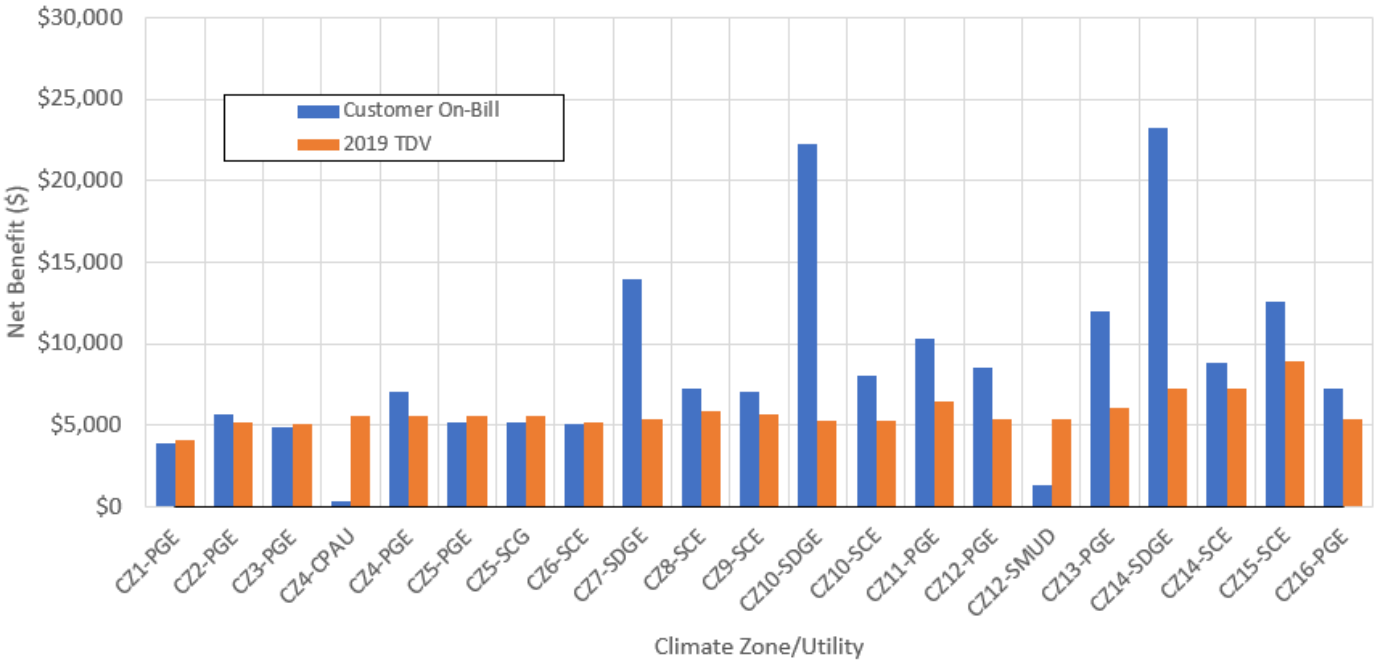

Figure 3: Net benefit - rooftop PV + 16 kWh battery: 1992-2010.

Table 15: Summary of Multifamily PV & Batteries – On-Bill & 2019 TDV

Climate Zone		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Utility		PG&E	PG&E	PG&E	PG&E / CPAU	PG&E / SCG	SCE	SDG&E	SCE	SCE	SCE / SDGE	PG&E	PG&E / SMUD	PG&E	SCE / SDGE	SCE	PG&E
PV	All Vintages	Both	Both	Both	Both	Both	Both	Both	Both	Both	Both	Both	Both	Both	Both	Both	Both
PV + Battery	All Vintages	Both	Both	Both	Both	Both	Both	Both	Both	Both	Both	Both	Both	Both	Both	Both	Both

3.5 Equipment Fuel Substitution Measures

On-Bill and TDV (both 2019 and 2022) cost effectiveness for electric fuel substitution measures are summarized in Table 16 and Table 17. Cost-effectiveness for these measures is not as sensitive to building vintage as the building envelope and duct measures but HVAC heat pump installations in newer vintage buildings tend to be more cost-effective than in older vintage buildings.

Heat Pump at HVAC Replacement: Cost-effectiveness of replacing a ducted furnace and air conditioner with a minimum efficiency ducted air-source heat pump is limited. It is cost-effective On-Bill in SMUD territory with SMUD's favorable electricity rates relative to natural gas rates. It is also cost-effective On-Bill with newer vintage buildings in Climate Zone 15. In all other climates, shifting from natural gas to electricity for space heating results in both an increase in incremental lifecycle installed cost and utility costs. Incremental first costs are similar between a heat pump and gas furnace/AC, but because the assumed average equipment lifetime is 15 years for a heat pump compared to 17.5 years for the gas furnace/AC, lifetime incremental costs are slightly higher than first costs for heat pumps. TDV cost effectiveness is very different under the 2019 and 2022 metrics, and results are more favorable under the 2022 TDV and the upgrade is cost-effective based on 2022 TDV for a few scenarios. Figure 4 compares lifecycle net benefit of the heat pump installation based on customer On-Bill, 2019 TDV, and 2022 TDV for the 1978-1991 vintage building.

Cost effectiveness for a scenario without AC in the gas base case is not shown. In mild climates without AC, the higher incremental costs do not justify heat pump replacement unless the project is planning on installing AC at replacement.

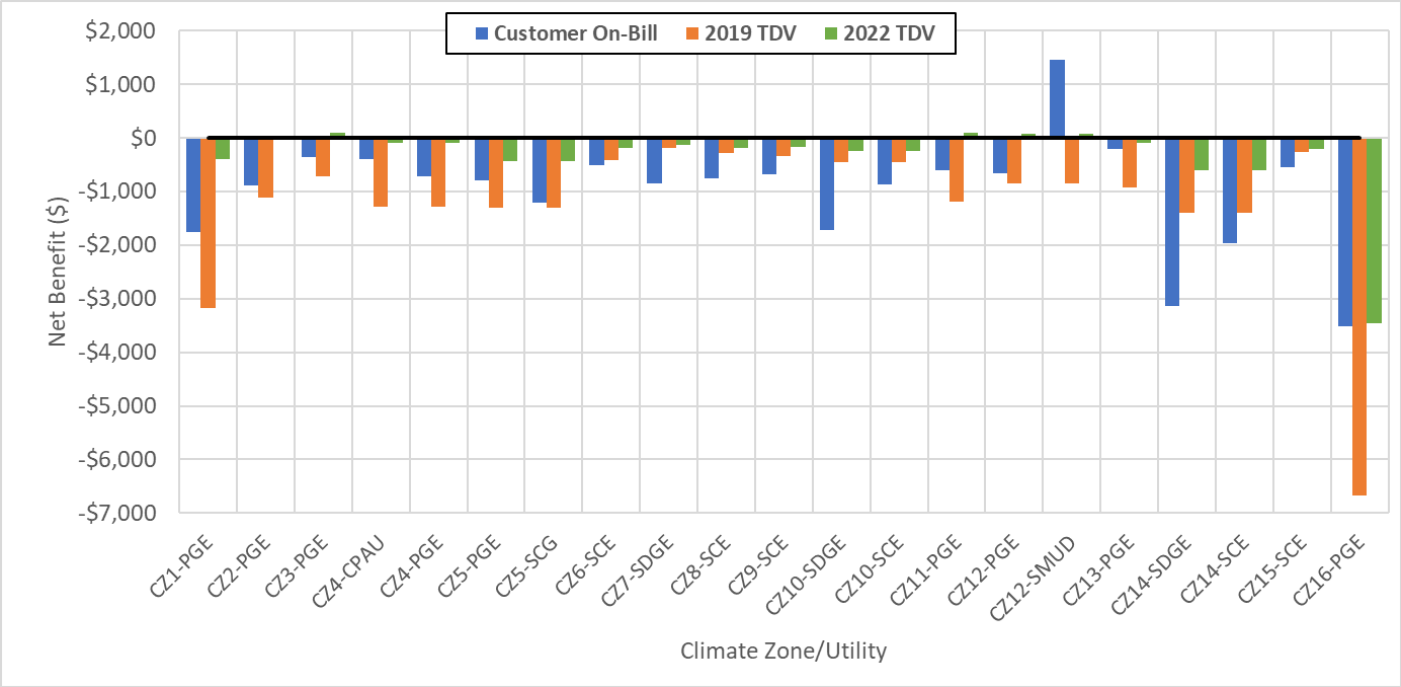

Figure 4: Net benefit – minimum efficiency heat pump at HVAC replacement: 1978-1991.

High-Efficiency Heat Pump at HVAC Replacement: Cost-effectiveness of replacing a ducted furnace and air conditioner with a high-efficiency, 22 SEER, 11 HSPF ducted air-source heat pump is also limited. Higher efficiency provides operating cost savings in most cases, but incremental costs are also higher. It is cost-effective On-Bill only in Climate Zone 15 across all vintages and in Climate Zones 12 in SMUD territory and 13 in the pre-1978 vintage.

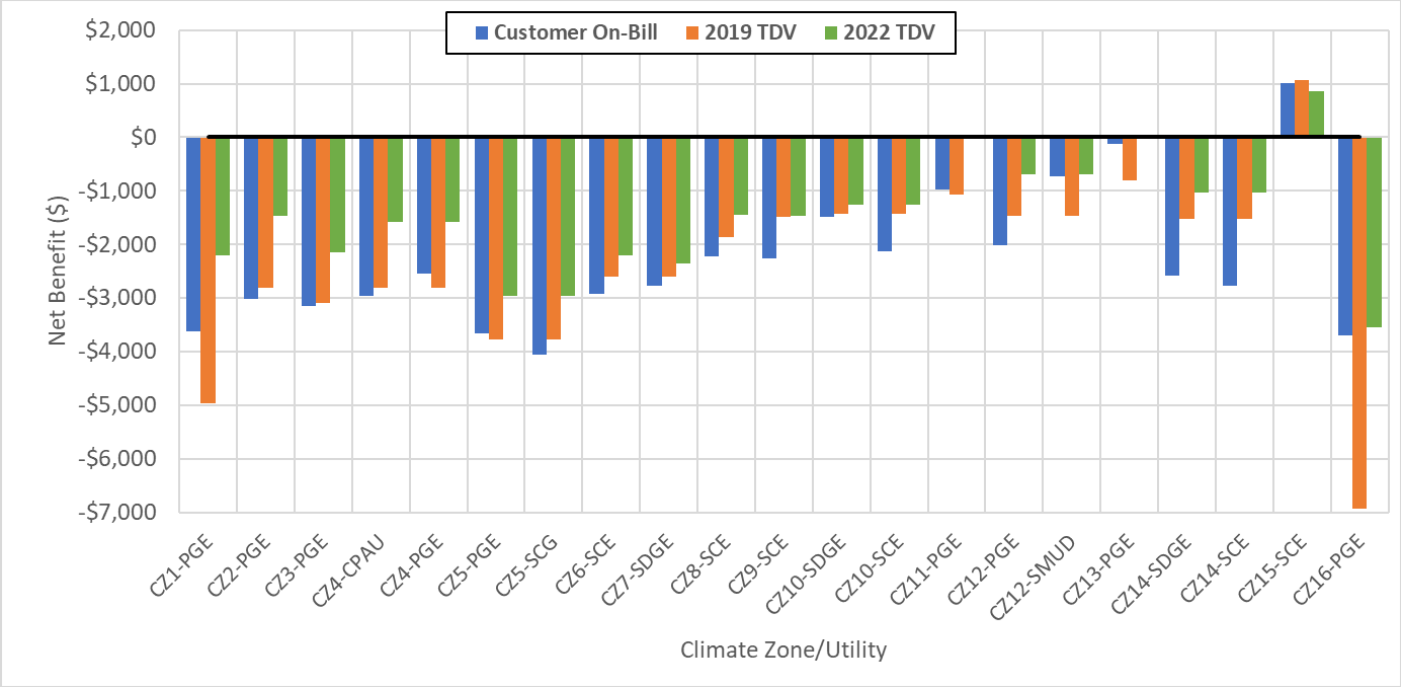

Figure 5: Net benefit – high-efficiency heat pump at HVAC replacement: 1978-1991.

HVAC Heat Pump + PV: Combining heat pump installation with a new PV system when replacing natural gas furnace/AC increases first costs but improves cost effectiveness substantially (see Figure 6 and Table 17). PV offsets additional electricity used by the heat pump, resulting in net energy cost savings and On-Bill cost effectiveness in all cases. Adding the $3,181 cost to upgrade the main service panel, the combination of these measures is still cost-effective in most cases (see Figure 7).

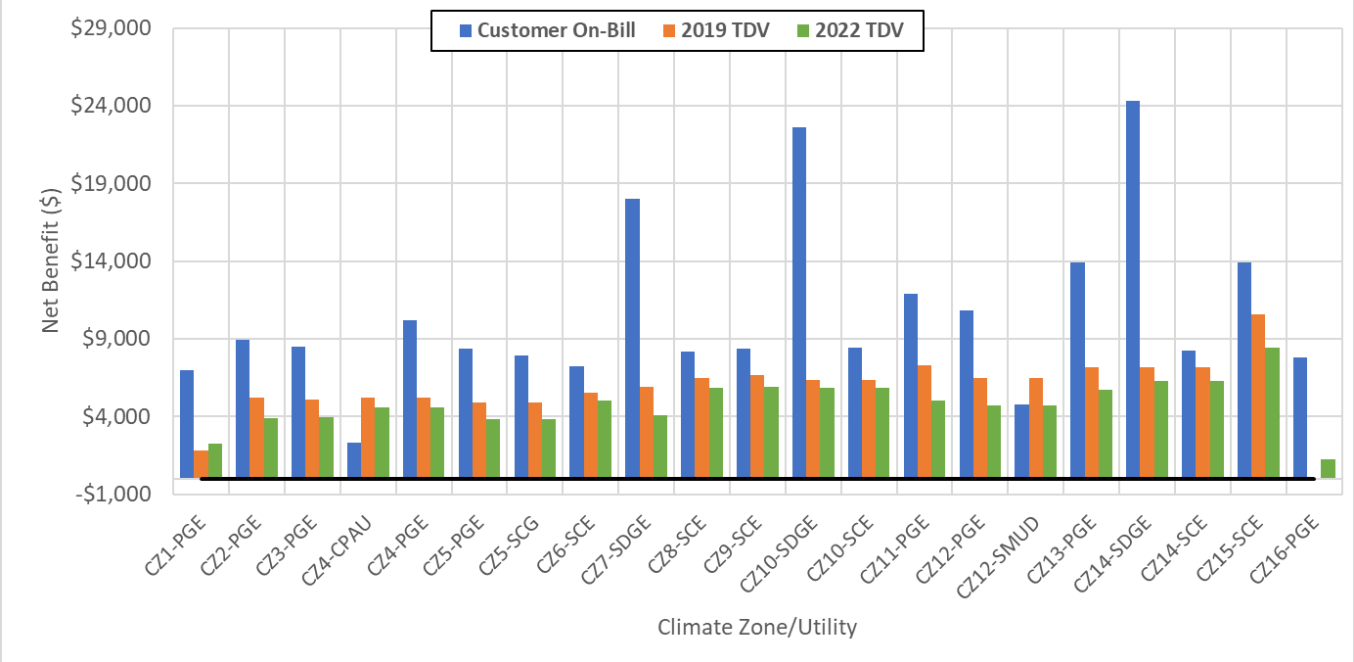

Figure 6: Net benefit – min efficiency heat pump at HVAC replacement + PV: 1978-1991.

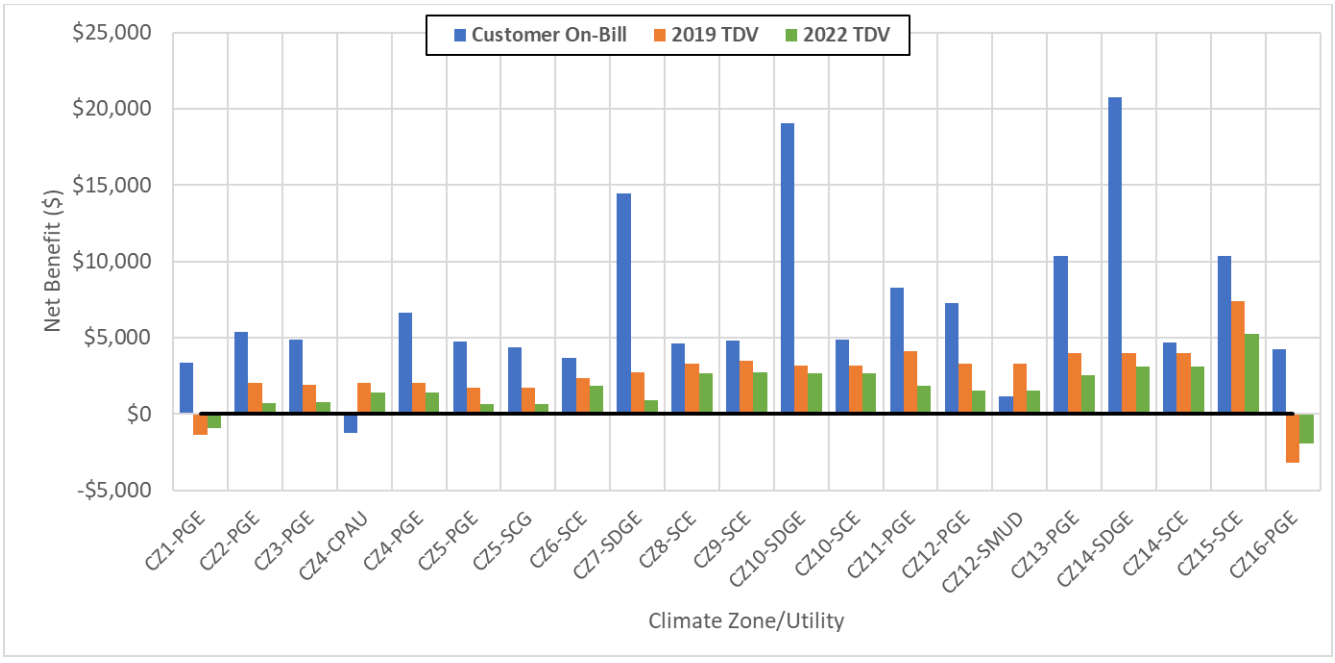

Figure 7: Net benefit – min efficiency heat pump at HVAC replacement + PV + panel upgrade: 1978-1991.

Heat Pump at DHW Replacement: Cost effectiveness of replacing a natural gas storage water heater with a minimum efficiency HPWH is limited under customer On-Bill and 2019 TDV metrics. Due to higher incremental costs and operating costs relative to natural gas storage water heaters, it is only cost-effective On-Bill in SMUD territory due to the favorable electricity utility rates relative to natural gas rates. A HPWH is cost-effective in all climate zones except 1 and 16 based on 2022 TDV economics. Figure 8 compares lifecycle net benefit of the HPWH installation for customer On-Bill, 2019 TDV, and 2022 TDV, showing how cost effectiveness is positive for most climates based on 2022 TDV.

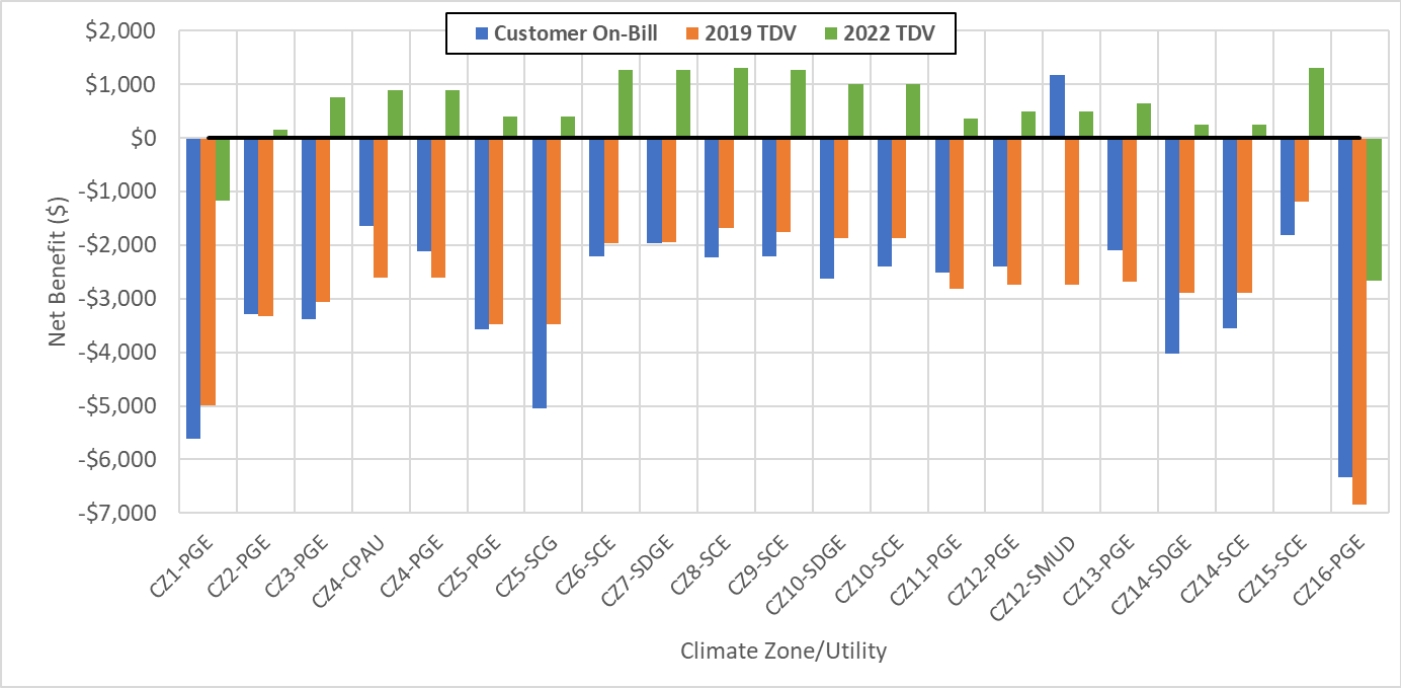

Figure 8: Net benefit – minimum efficiency HPWH at DHW replacement: 1978-1991.

High-Efficiency Heat Pump at DHW Replacement: Cost effectiveness improves when replacing a natural gas storage water heater with a NEEA Tier 3 HPWH but still is limited under customer On-Bill and 2019 TDV metrics. Higher efficiency equipment results in operating cost savings in most cases, but due to higher incremental costs it is only cost-effective On-Bill in SMUD territory. Similar to the minimum efficiency HPWH case, the high-efficiency HPWH is cost-effective based on 2022 TDV in all climate zones except 16. Figure 9 compares lifecycle net benefit of the HPWH installation for customer On-Bill, 2019 TDV, and 2022 TDV, showing how cost effectiveness is positive for most climates based on 2022 TDV.

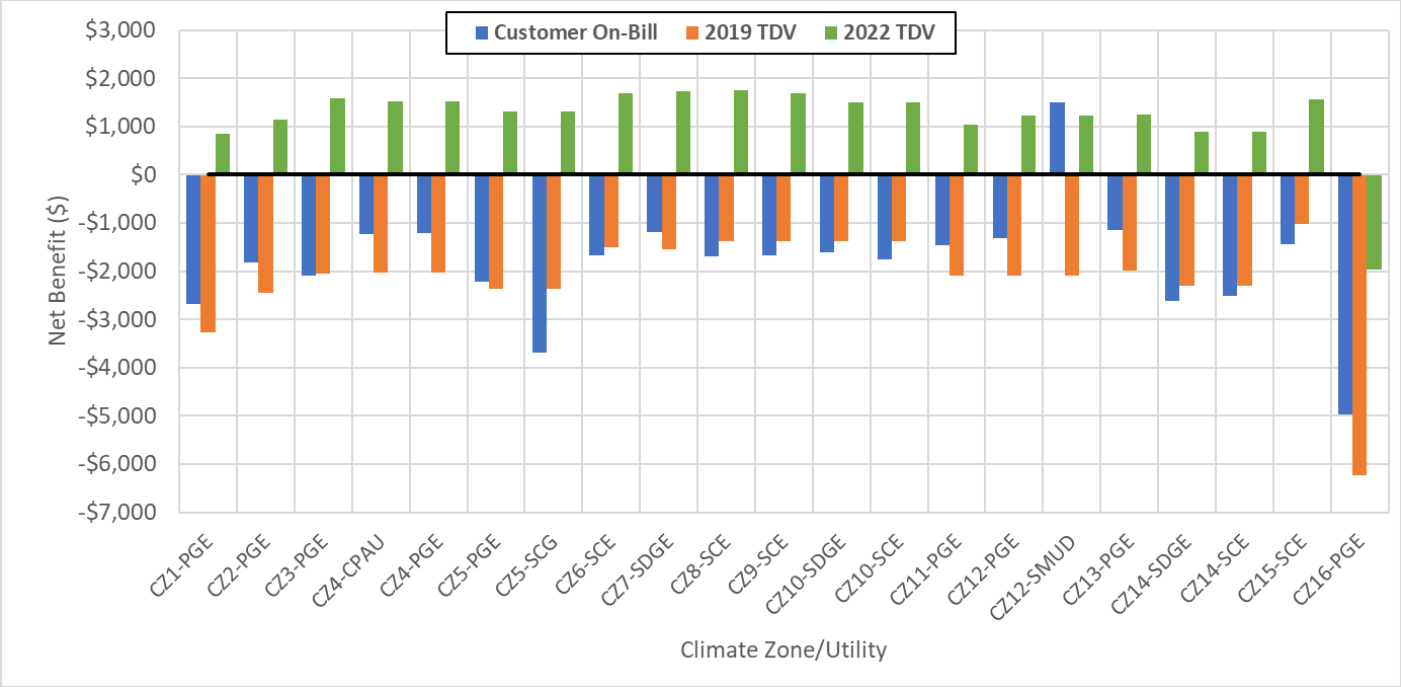

Figure 9: Net benefit – high-efficiency HPWH at DHW replacement: 1978-1991.

HPWH + PV: Combining installation of PV with a HPWH at the time of water heater replacement increases first costs but improves On-Bill cost effectiveness (see Figure 10 and Table 17). PV offsets additional electricity used by the HPWH, resulting in net energy cost savings and positive customer On-Bill cost effectiveness in all cases. If the $3,181 cost to upgrade the main service panel is included in the first cost, the combination of these measures is still cost-effective in most cases (see Figure 11).

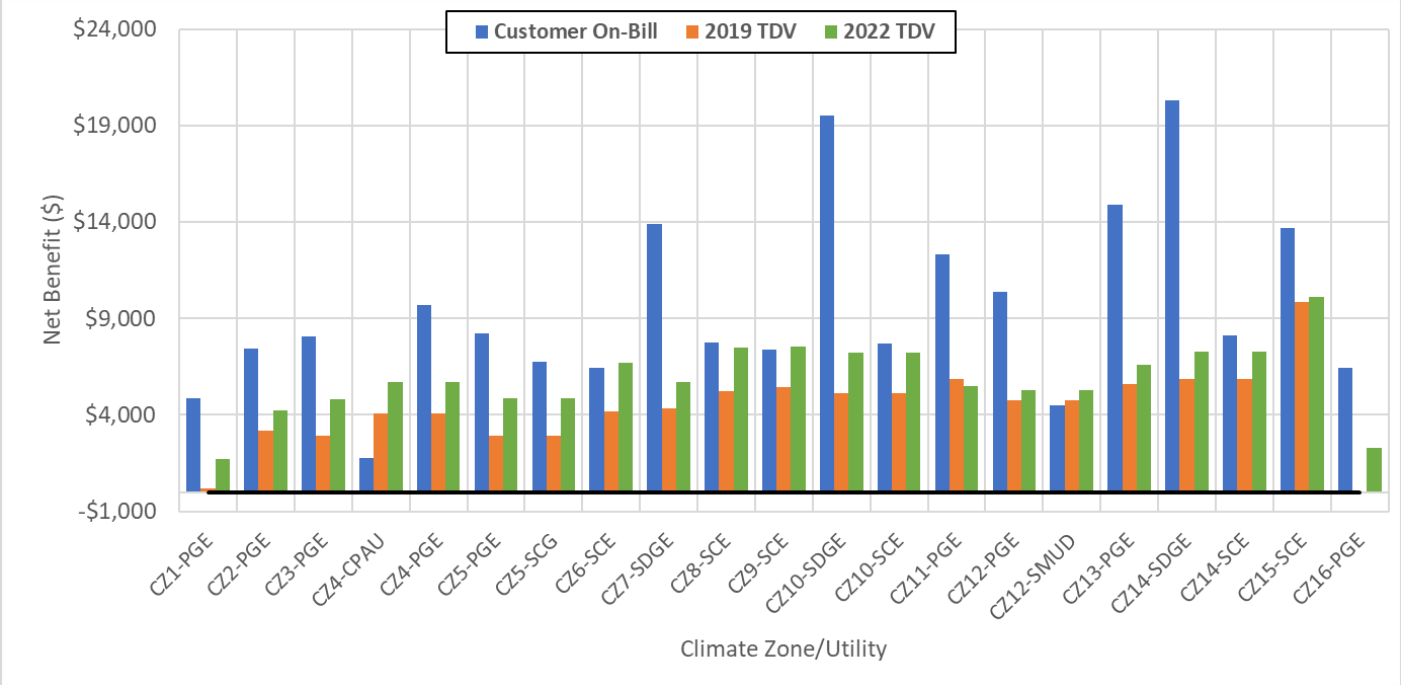

Figure 10: Net benefit – min efficiency HPWH at DHW replacement + PV: 1978-1991.

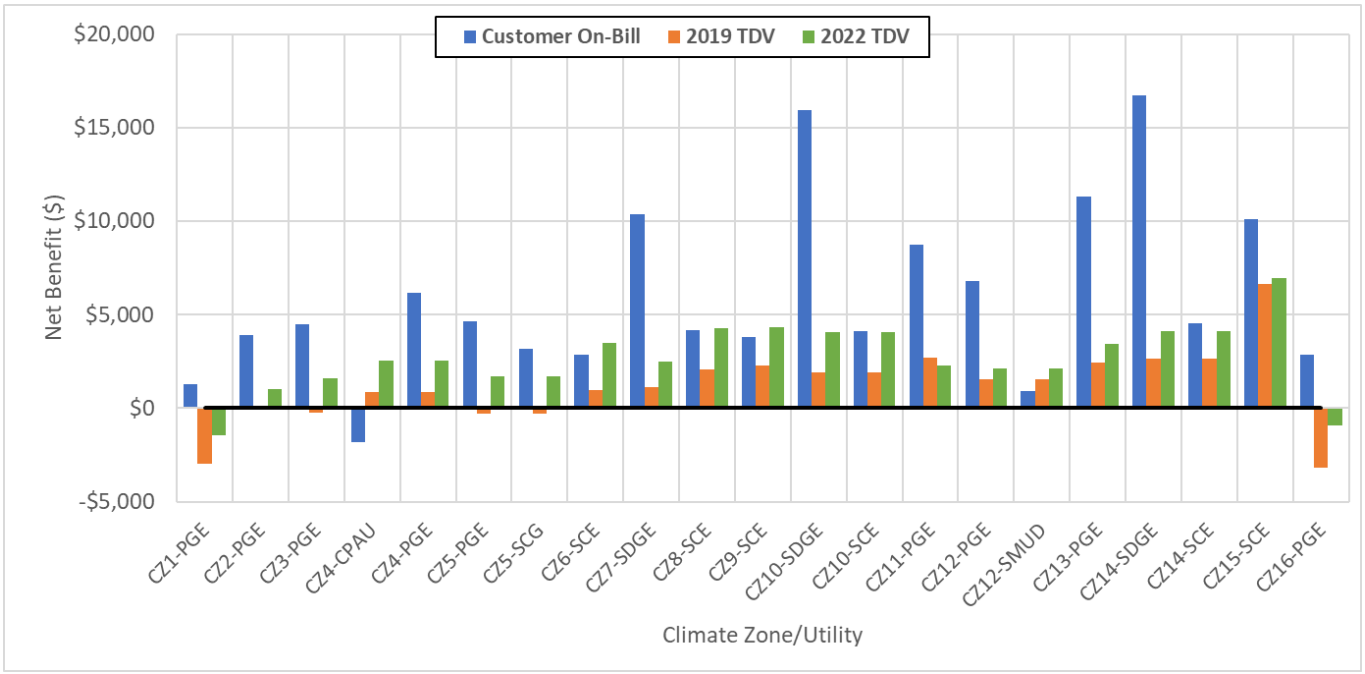

Figure 11: Net benefit – min efficiency HPWH at DHW replacement + PV + Panel Upgrade: 1978-1991.

Table 16: Summary of Multifamily Equipment Fuel Substitution– On-Bill & TDV – Federal Minimum Efficiency

Climate Zone		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Utility		PG&E	PG&E	PG&E	PG&E / CPAU	PG&E / SCG	SCE	SDG&E	SCE	SCE	SCE / SDGE	PG&E	PG&E / SMUD	PG&E	SCE / SDGE	SCE	PG&E
		Heat Pump at HVAC Replacement															
2019 TDV	Pre-1978	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A / On-Bill	N/A	N/A	N/A	N/A
	1978-1991	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A / On-Bill	N/A	N/A	N/A	N/A
	1992-2010	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A / On-Bill	N/A	N/A	On-Bill	N/A
2022 TDV	Pre-1978	N/A	TDV	TDV	TDV	N/A	N/A	N/A	N/A	N/A	N/A	TDV	TDV / Both	TDV	N/A	N/A	N/A
	1978-1991	N/A	TDV	TDV	N/A	N/A	N/A	N/A	N/A	N/A	N/A	TDV	TDV / Both	N/A	N/A	N/A	N/A
	1992-2010	N/A	N/A	TDV	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A / On-Bill	N/A	N/A	On-Bill	N/A
		HPWH at DHW Replacement															
2019 TDV	Pre-1978	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A / On-Bill	N/A	N/A	N/A	N/A
	1978-1991	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A / On-Bill	N/A	N/A	N/A	N/A
	1992-2010	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A / On-Bill	N/A	N/A	N/A	N/A
2022 TDV	Pre-1978	N/A	TDV	TDV	TDV	TDV	TDV	TDV	TDV	TDV	TDV	TDV	TDV / Both	TDV	TDV	TDV	N/A
	1978-1991	N/A	TDV	TDV	TDV	TDV	TDV	TDV	TDV	TDV	TDV	TDV	TDV / Both	TDV	TDV	TDV	N/A
	1992-2010	N/A	TDV	TDV	TDV	TDV	TDV	TDV	TDV	TDV	TDV	TDV	TDV / Both	TDV	TDV	TDV	N/A

Table 17: Summary of Multifamily Equipment Fuel Substitution + PV – On-Bill & TDV – Federal Minimum Efficiency

Climate Zone		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Utility		PG&E	PG&E	PG&E	PG&E / CPAU	PG&E / SCG	SCE	SDG&E	SCE	SCE	SCE / SDGE	PG&E	PG&E / SMUD	PG&E	SCE / SDGE	SCE	PG&E
		Heat Pump + PV at HVAC Replacement															
2019 TDV	Pre-1978	Both	Both	Both	Both	Both	Both	Both	Both	Both	Both	Both	Both	Both	Both	Both	On-Bill
	1978-1991	Both	Both	Both	Both	Both	Both	Both	Both	Both	Both	Both	Both	Both	Both	Both	On-Bill
	1992-2010	Both	Both	Both	Both	Both	Both	Both	Both	Both	Both	Both	Both	Both	Both	Both	Both
2022 TDV	Pre-1978	Both	Both	Both	Both	Both	Both	Both	Both	Both	Both	Both	Both	Both	Both	Both	Both
	1978-1991	Both	Both	Both	Both	Both	Both	Both	Both	Both	Both	Both	Both	Both	Both	Both	Both
	1992-2010	Both	Both	Both	Both	Both	Both	Both	Both	Both	Both	Both	Both	Both	Both	Both	Both
		HPWH + PV at DHW Replacement															
2019 TDV	Pre-1978	Both	Both	Both	Both	Both	Both	Both	Both	Both	Both	Both	Both	Both	Both	Both	On-Bill
	1978-1991	Both	Both	Both	Both	Both	Both	Both	Both	Both	Both	Both	Both	Both	Both	Both	On-Bill
	1992-2010	Both	Both	Both	Both	Both	Both	Both	Both	Both	Both	Both	Both	Both	Both	Both	On-Bill
2022 TDV	Pre-1978	Both	Both	Both	Both	Both	Both	Both	Both	Both	Both	Both	Both	Both	Both	Both	Both
	1978-1991	Both	Both	Both	Both	Both	Both	Both	Both	Both	Both	Both	Both	Both	Both	Both	Both
	1992-2010	Both	Both	Both	Both	Both	Both	Both	Both	Both	Both	Both	Both	Both	Both	Both	Both

PV and Electric Readiness Measures: Electric ready measures do not result in any energy savings, but combining electric ready measures with installation of PV provides a path to finance needed prewiring and service panel upgrades and reduce fuel substitution costs when appliances are replaced at end of useful life (see Figure 12 and Table 18). Upgrading the main service panel and pre-wiring for future space and water heating heat pumps with installation of a PV system is cost-effective On-Bill in all cases except in Climate Zone 4 with CPAU rates and Climate Zone 12 with SMUD rates due to reduced cost effectiveness of PV with those municipal rates. It is cost-effective based on TDV in all climate zones.

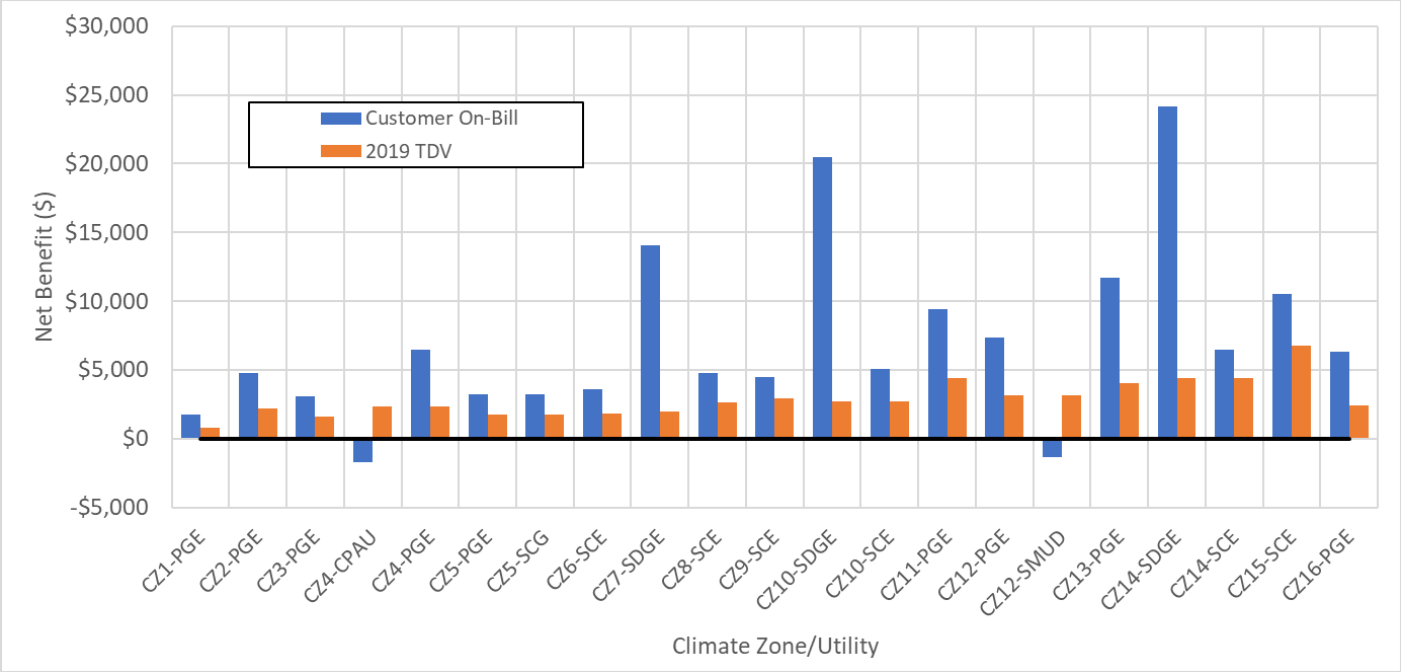

Figure 12: Net benefit – PV and electric readiness: 1978-1991.

Table 18: Summary of Multifamily Electric Ready Measures at PV Install – On-Bill & 2019 TDV

Climate Zone		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Utility		PG&E	PG&E	PG&E	PG&E / CPAU	PG&E / SCG	SCE	SDG&E	SCE	SCE	SCE / SDGE	PG&E	PG&E / SMUD	PG&E	SCE / SDGE	SCE	PG&E
2019 TDV	Pre-1978	Both	Both	Both	Both / TDV	Both	Both	Both	Both	Both	Both	Both	Both / TDV	Both	Both	Both	Both
	1978-1991	Both	Both	Both	Both / TDV	Both	Both	Both	Both	Both	Both	Both	Both / TDV	Both	Both	Both	Both
	1992-2010	Both	Both	Both	Both / TDV	Both	Both	Both	Both	Both	Both	Both	Both / TDV	Both	Both	Both	Both

3.6 TOU, Tiered, and CARE Tariff Comparison

The following results compare IOU utility cost savings for one efficiency, one electrification, and one solar PV measure in existing multifamily homes across TOU, tiered, and CARE tariffs. Table 10 and Table 11 describe the tariffs that were applied. A CARE discount was evaluated for both the TOU and tiered electricity tariffs as well as the gas tariffs.

Applying the residential tiered and TOU electricity rates result in very similar energy costs, within 10% annually throughout the state. In most climate zones, costs using tiered rates are slightly lower than with the TOU rate. CARE rates are 30-35% lower than standard tiered or TOU electricity rates and 20% lower than natural gas rates. Reduced monthly energy costs from the CARE rate structure impacts cost-effectiveness depending on the energy savings profile of the measure.

Figure 13 through Figure 15 present results for a pre-1978 multifamily dwelling unit for an attic insulation upgrade from R-11 to R-49. The first figure shows annual utility costs (gas and electricity) with R-49 attic insulation. The last two figures present first year utility cost savings and 30-year net present value for the efficiency upgrade.

Observations:

- The CARE tariff substantially reduces utility costs and as a result reduces the cost savings from the efficiency upgrade. Generally, the tariff selected does not impact the cost-effective outcome. However, in one instance (Climate Zone 6) the measure is not cost-effective under a CARE tariff where it is under a non-CARE tariff.
- Annual utility costs are lower under a tiered tariff than a TOU tariff in most climate zones. In Climate Zones 1, 3, and 5 (PG&E) the tiered tariff results in slightly higher costs than the TOU. Reduced energy costs and cost savings associated with a tiered rate reduce cost-effectiveness (except Climate Zone 1).

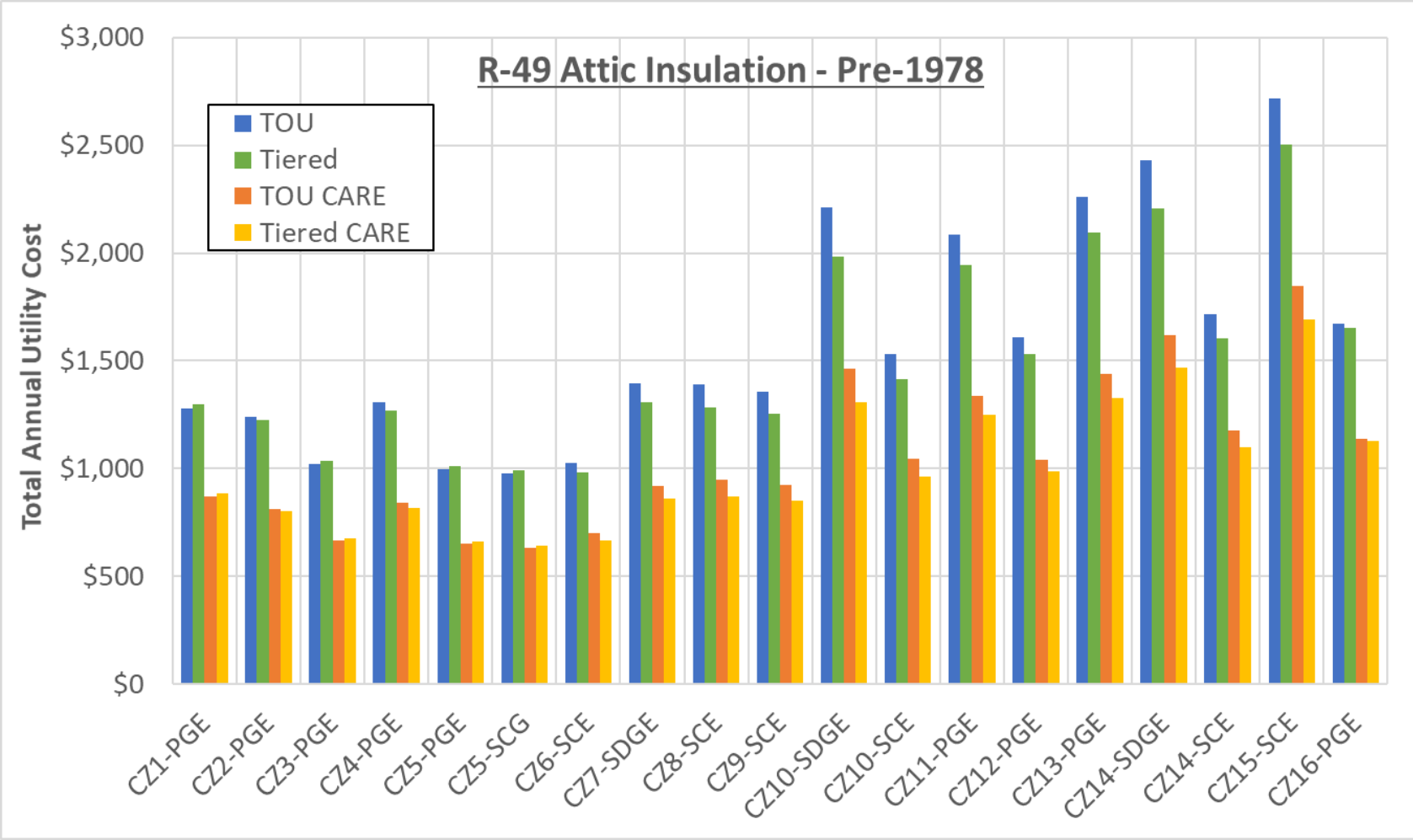

Figure 13: First year total utility costs after R-49 attic insulation upgrade.

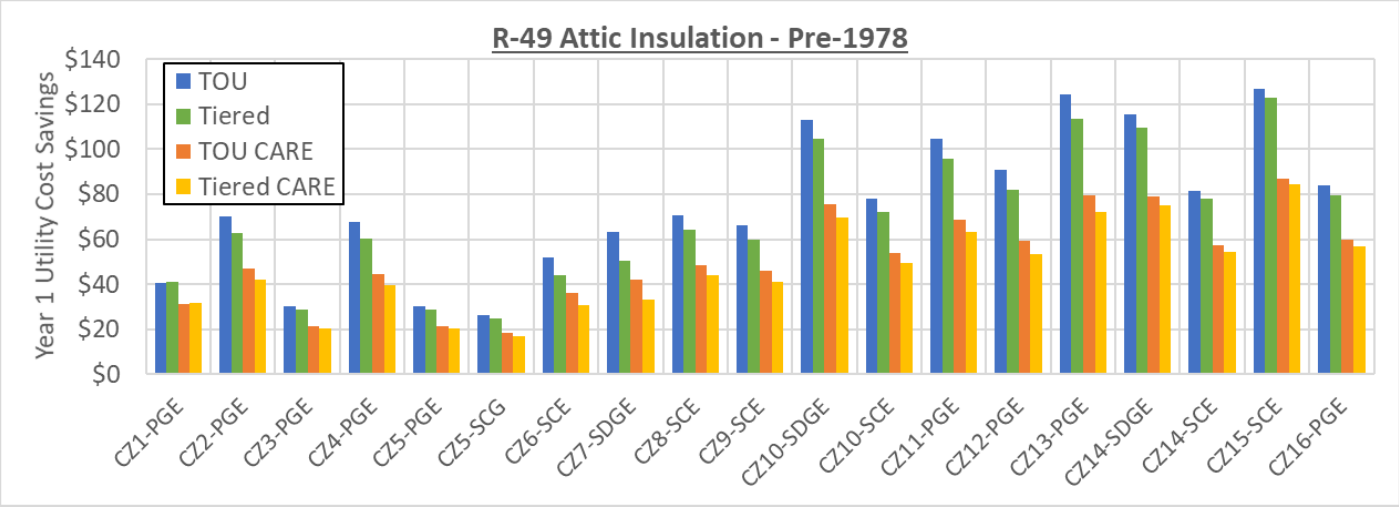

Figure 14: First year utility cost savings for adding R-49 attic insulation compared to existing R-11.

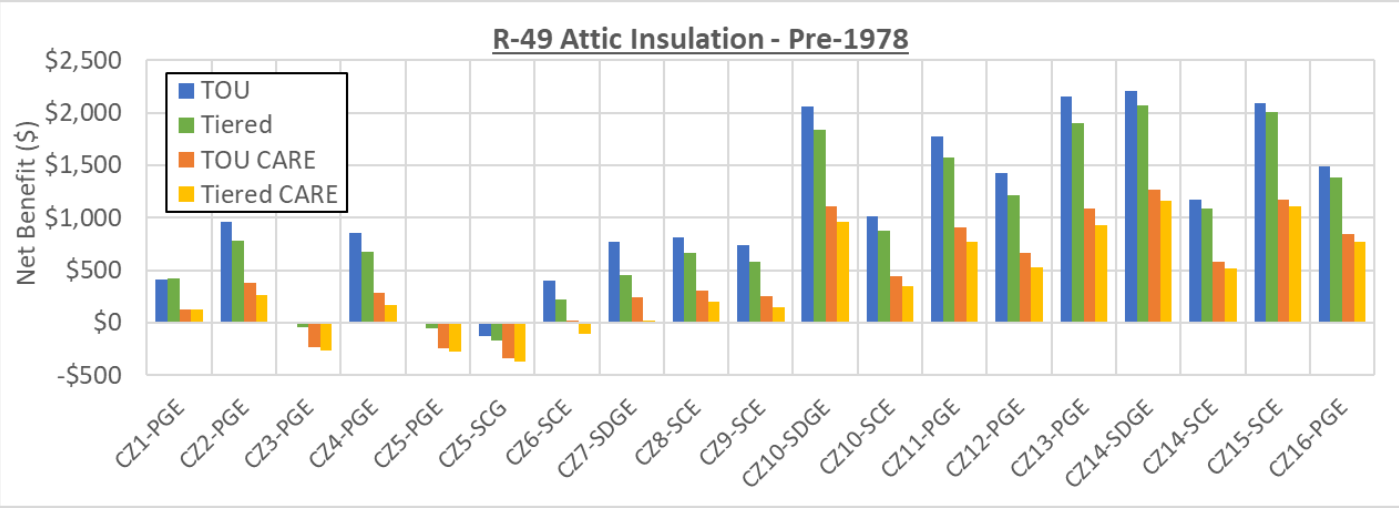

Figure 15: 30-year net present value for adding R-49 attic insulation compared to existing R-11.

Figure 16 through Figure 18 present results for a fuel substitution measure for a pre-1978 multifamily dwelling unit. This measure covers installation of a split ducted heat pump in place of a ducted gas furnace and air conditioner at time of replacement. The first figure shows annual utility costs after the replacement. The last two figures present first year utility cost savings and 30-year net present value for the heat pump upgrade.

Observations:

- The CARE tariff reduces electricity costs more than natural gas utility costs. As a result, the increase in utility cost when switching from gas to electric heating (based on the current rates) is lower and the cost-effectiveness improves with a CARE tariff versus non-CARE. In some instances, total utility costs decrease enough that in Climate Zones 1, 3, 11, 12, & 13 the cost-effectiveness outcome is changed for the measure, and it is cost effective under a CARE tariff while not under a non-CARE tariff.
    - While not shown, the trends for the heat pump at DHW replacement measure are similar. However, because the incremental cost for the water heating measure is much more than for the space heating measure there is no shift in cost-effectiveness conclusions. The measure is not cost effective under either the non-CARE or CARE tariffs.
- Annual utility costs are lower under a tiered than a TOU tariff in Climate Zones 4 and 6 through 15. The opposite is true in the other climate zones. In all cases annual TOU and tiered costs are within 10%. When switching from gas to electric heating utility costs increase, but the increase is less and therefore the cost-effectiveness improves under a TOU tariff compared to a tiered tariff in every climate zone exception Climate Zone 15.

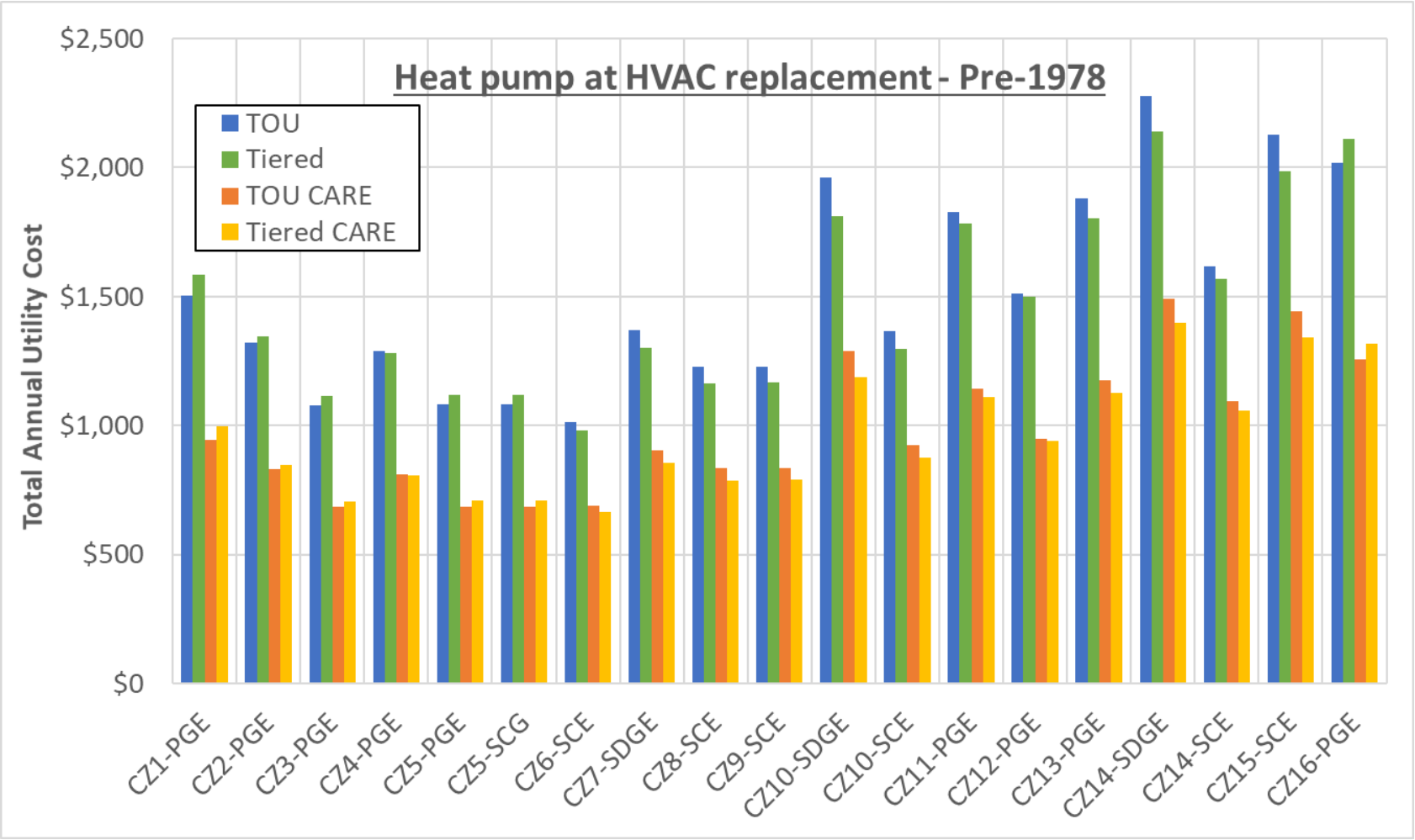

Figure 16: First year annual utility cost after replacement of gas furnace with a split heat pump.

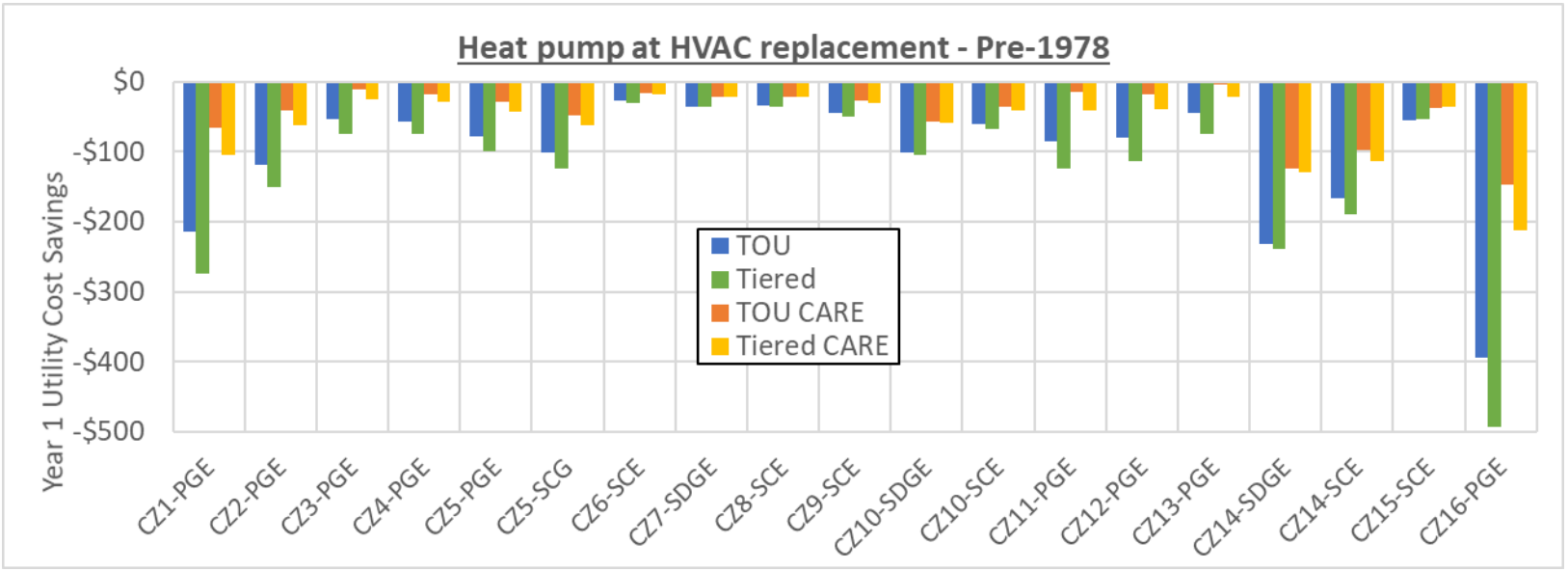

Figure 17: First year utility cost savings for a minimum efficiency heat pump compared to gas furnace and A/C.

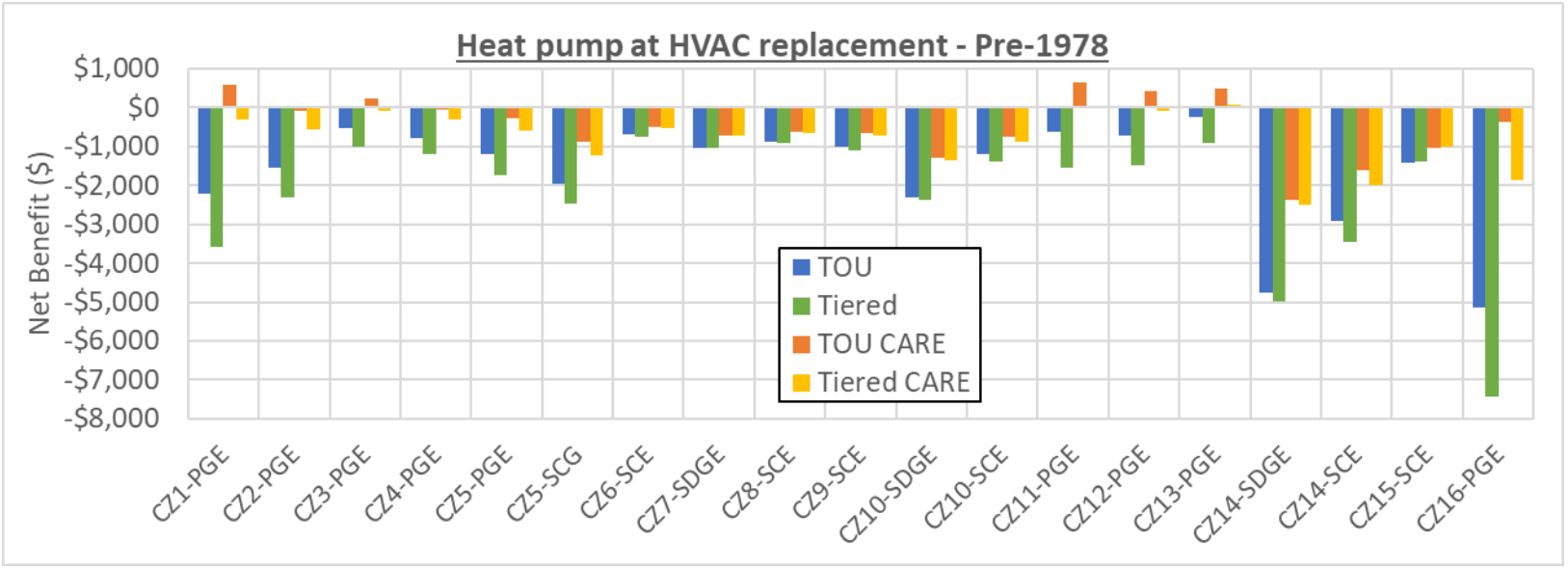

Figure 18: 30-year net present value for a minimum efficiency heat pump compared to gas furnace and A/C.

Figure 19 through Figure 21 present results for the PV system measure for a pre-1978 multifamily dwelling unit. the PV system was sized to the 2019 new construction standards for a 6,960 square foot building (see Table 3 for sizing details). The first figure shows annual utility costs after the replacement. The last two figures present first year utility cost savings and 30-year net present value for the heat pump upgrade.

Observations:

- Across all scenarios this measure is cost effective.
- Similar to the attic insulation case, the CARE tariff substantially reduces utility costs and as a result reduces the cost savings from the addition of a PV system. However, the tariff selected does not impact the cost-effective outcome.
- Annual utility costs are lower under a tiered than a TOU tariff in all climate zones. In PG&E and SDG&E territories, annual electricity costs are about 15 percent lower with the tiered than the TOU tariffs. In SCE territory, the difference is much larger and the tiered electricity costs are on average about 40 percent lower. This is because the baseline rate under SCE's tiered tariff is quite low and with a PV system it's likely all the electricity use is under the baseline threshold.

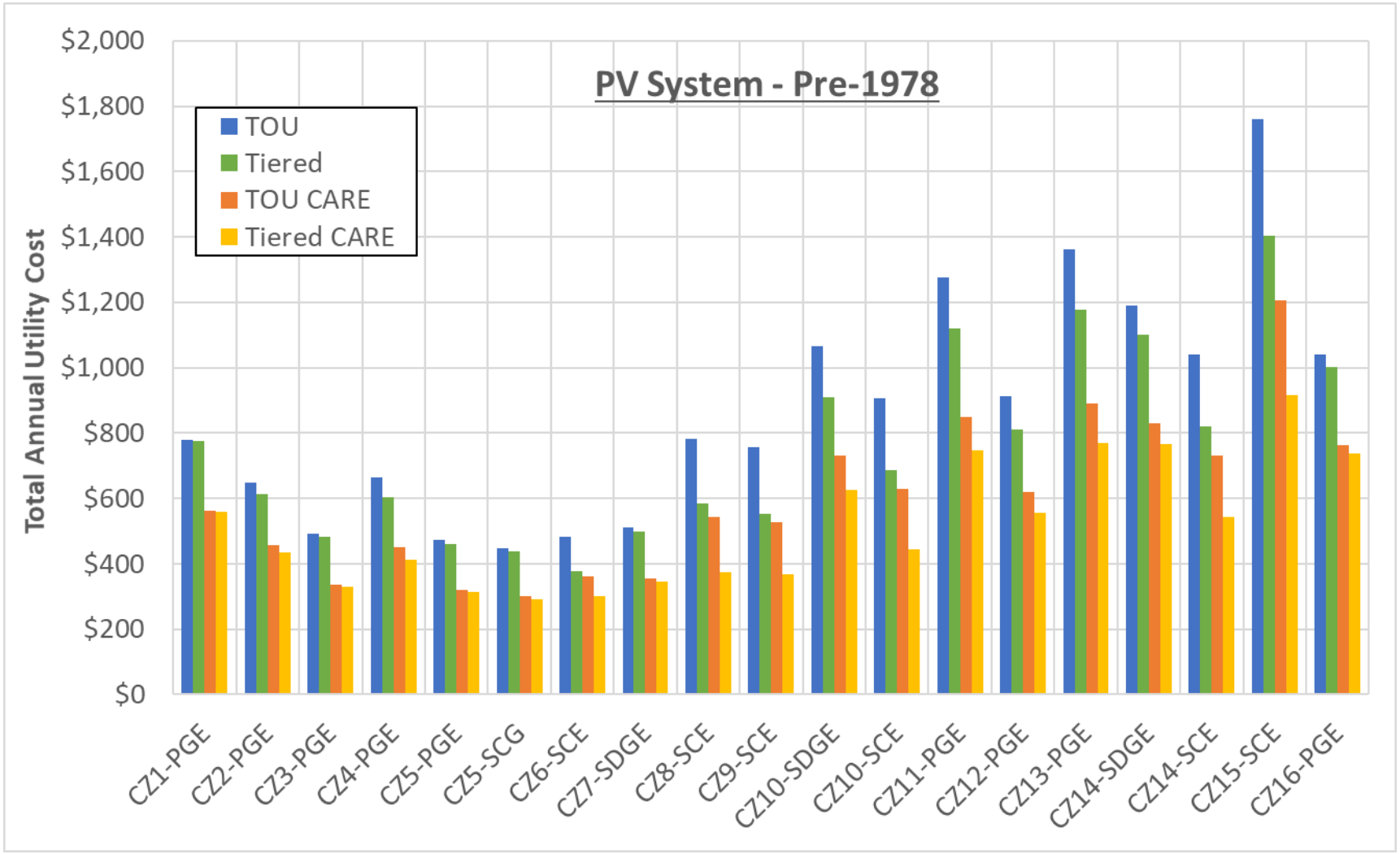

Figure 19: First year annual utility cost after installation of a PV system.

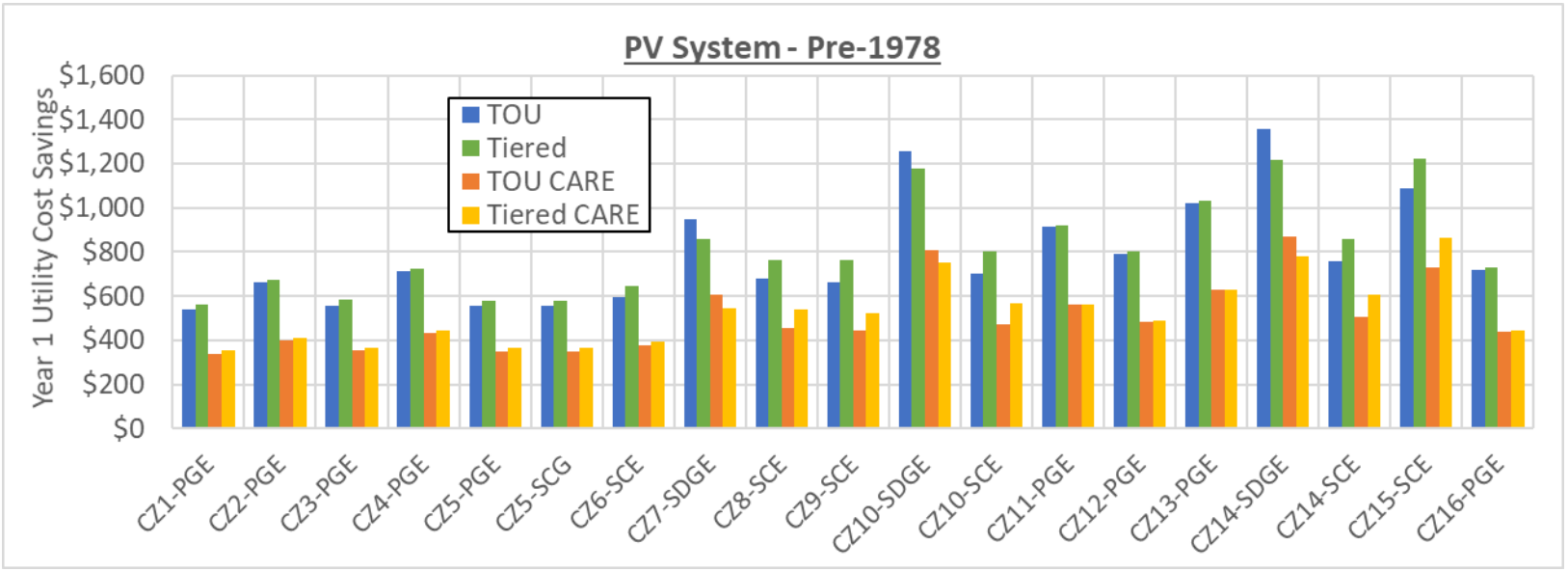

Figure 20: First year utility cost savings for a PV system.

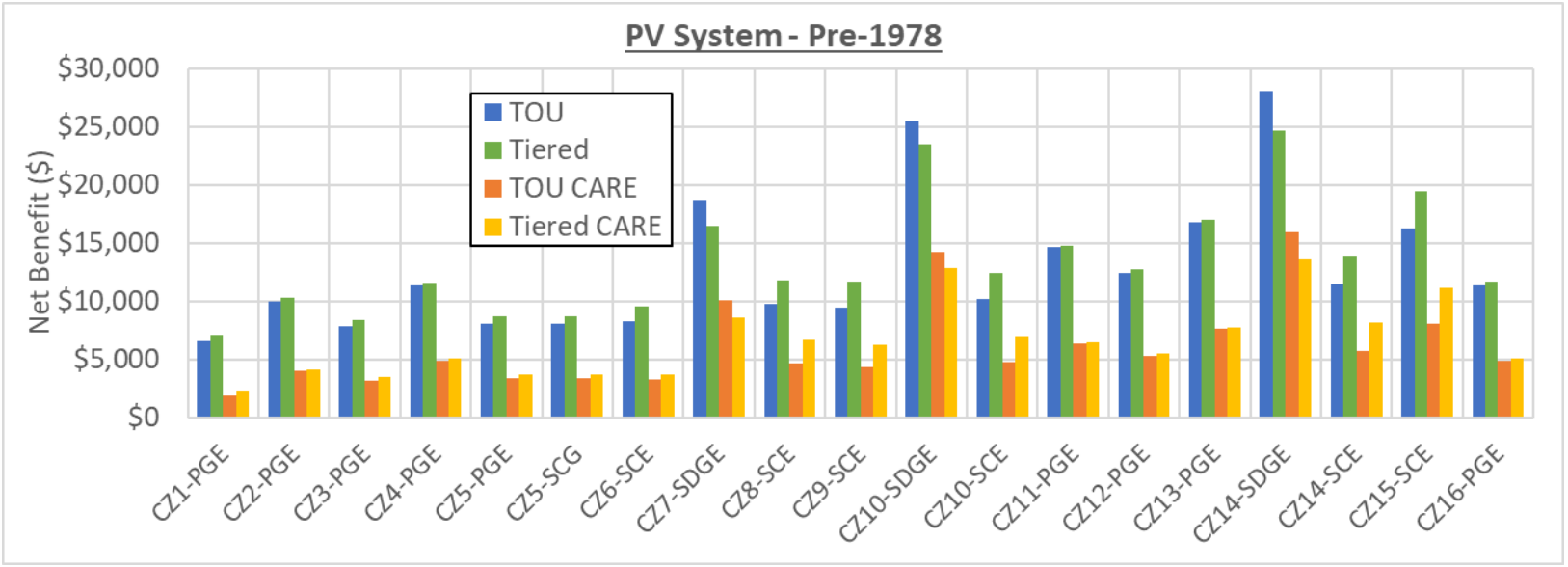

Figure 21: 30-year net present value for a PV system.

4 Recommendations and Discussions

This analysis evaluated the feasibility and cost effectiveness of retrofit measures in California existing multifamily buildings built before 2010. The Statewide Reach Code Team used both On-Bill- and TDV-based LCC approaches to evaluate cost effectiveness and quantify the energy cost savings associated with energy efficiency measures compared to the incremental costs associated with the measures.

4.1 Recommended Efficiency Measures

Based on the analysis, the following cost-effective measures or packages of measures are recommended where they are found to be cost-effective in Section 3. Descriptions of each measure or package and the relevant recommended requirements are provided below. In most cases, exceptions are defined which would exempt a particular project from a measure under certain conditions. These exceptions are based on existing on-site conditions and cost effectiveness.

Attic Insulation: In vented attics, insulation shall be installed to achieve a weighted U-factor of 0.020 or insulation installed at the ceiling level shall result in an installed thermal resistance of R-49 or greater for the insulation alone. This measure applies to buildings according to vintage and climate zone as defined in Table 13.

> Exception 1: Buildings with at least R-38 existing insulation installed at the ceiling level.
>
> Exception 2: Buildings where the alteration would directly cause the disturbance of asbestos unless the alteration is made in conjunction with asbestos abatement.
>
> Exception 3: Buildings with knob and tube wiring located in the vented attic.
>
> Exception 4: Where the accessible space in the attic is not large enough to accommodate the required R-value, the entire accessible space shall be filled with insulation provided such installation does not violate roof ventilation clearance requirements in Section 806.3 of Title 24, Part 2.5.
>
> Exception 5: Where the attic space above the altered dwelling unit is shared with other dwelling units and the attic insulation requirement is not triggered for the other dwelling units.

Air Sealing: Seal all accessible cracks, holes, and gaps in the building envelope at walls, floors, and ceilings. Pay special attention to penetrations including plumbing, electrical, and mechanical vents, and windows. Weather-strip doors if not already present. Verification shall be conducted following a prescriptive checklist[8] that outlines which building aspects need to be addressed by the permit applicant and verified by an inspector. Compliance can also be demonstrated with blower door testing showing at least a 30 percent reduction from pre-retrofit conditions. This measure applies to buildings according to vintage, building type and climate zone as defined in Table 13.

> Exception 1: Buildings that can demonstrate blower door test results showing five ACH50 or lower or can otherwise demonstrate that air sealing meeting the requirements of this ordinance was conducted within the last 12 months.

Duct Sealing: Air seal all space conditioning ductwork to meet the requirements of the 2019 Title 24, Part 6 Section 150.2(b)1E (15 percent maximum leakage). See Appendix C: Standards Sections for additional details on the requirements per Title 24, Part 6. The duct system must be tested to confirm that the requirements have been met. Cost effectiveness included costs for a third-party HERS Rater to verify the duct sealing. This measure applies to buildings according to vintage, building type and climate zone as defined in Table 13.

> Exception 1: All exceptions as stated in the 2019 Title 24, Part 6 Section 150.2(b)1E are allowed.

[8] This checklist was not developed as part of this analysis.

Exception 2: Buildings without ductwork or where the ducts are in conditioned space.

New Ducts: Replace existing space conditioning ductwork with new R-8 ducts that meet the requirements of 2019 Title 24, Part 6 Section 150.0(m)11, with the exception that the maximum duct leakage be reduced from the current code requirement of 12 percent to five percent in alignment with the requirement for single family homes. This measure applies to buildings according to vintage and climate zone as defined in Table 13.

Exception 1: Buildings without ductwork or where the ducts are in conditioned space.

Windows: Replace existing windows with high performance windows with an area weighted average U-factor no greater than 0.32.

Exception 1: All exceptions as stated in the 2019 Title 24, Part 6 Section 150.1©3A are allowed.

Exception 2: Buildings where it is not feasible to meet the performance requirements as a result of historic preservation design guidelines or other reasons as determined by the jurisdiction.

Window upgrades were only found to be cost-effective in Climate Zones 10 through 15 for certain scenarios and in Climate Zones 9 through 16 as part of the Advanced Envelope Package in pre-1978 vintage buildings (see Table 13 and Table 14). Because the cost requirement for window replacement is significant and the margin for cost effectiveness is lower than many other measures, it is recommended that jurisdictions consider whether a window replacement requirement is appropriate and only require it for large projects where the additional cost is small relative to total cost.

Wall Insulation: Older vintage buildings with no insulation in exterior walls shall be insulated to achieve a weighted U-factor of 0.102 or insulation installed in the exterior wall cavity shall result in an installed thermal resistance of R-13 or greater for the insulation alone. This measure applies to buildings according to vintage and climate zone as defined in Table 13.

Floor Insulation: Older vintage buildings with no insulation in exterior raised floors shall be insulated to achieve a weighted U-factor of 0.037 or insulation installed in the floor cavity shall result in an installed thermal resistance of R-19 or greater for the insulation alone. This measure applies to buildings according to vintage and climate zone as defined in Table 13.

Cool Roof: When replacing a roof, install a roofing product rated by the Cool Roof Rating Council to have an aged solar reflectance equal to or greater than 0.25, and a thermal emittance equal to or greater than 0.75, regardless of the compliance approach (prescriptive or performance). This measure only applies to steep slope roofs (ratio of rise to run greater than 2:12) and to buildings that are installing a new roof as part of the scope of the remodel and where more than 50 percent of the roof is being replaced. This applies only to certain buildings according to vintage, building type, and climate zone as defined in Table 13. Low slope roofs (ratio of rise to run of 2:12 or less) shall meet the requirements of Section 150.2(b)1Iii of 2019 Title 24, Part 6. See Appendix C: Standards Sections for additional details on the requirements per Title 24, Part 6.

Exception 1: Projects that are not installing a new roof as part of the scope. Only areas of roof that are to be re-roofed are subject to the cool roof upgrade.

Exception 2: All exceptions as stated in the 2019 Title 24, Part 6 Section 150.2(b)1Ii for steep slope roofs and 150.2(b)1Iii for low slope roofs are allowed.

Envelope and Duct Packages: Air sealing of the boundary between the attic and living space should be addressed any time there is significant work in the attic, such as adding attic insulation and sealing or replacing ductwork. At time of building shell improvement, air sealing is an important component to be addressed. The boundary between the living space and vented attics is where a significant amount of building air leakage can occur and sealing these areas prior to covering the attic floor with insulation is both practical and effective. For this reason, several envelope and duct

packages were evaluated and are recommended when cost-effective. Detailed requirements and relevant exceptions are listed above for the individual measures.

> **Attic Insulation, Air Sealing, and Duct Packages:** Jurisdictions may consider applying these package requirements when an entirely new or complete replacement duct system is installed in a vented attic space, in alignment with the 2022 Title 24, Part 6 code requirements. Addressing air sealing and attic insulation when attic ductwork is being replaced avoids lost opportunities to improve the building shell. While replacing ductwork the contractor accesses most areas of the ceiling and there are efficiencies to be gained with performing air sealing at the same time. Addressing air sealing and ceiling insulation when HVAC systems and ductwork are being replaced provides the potential ability to downsize equipment by reducing heating and cooling loads.
>
> **Advanced Envelope Package:** This package only applies to older vintage buildings with single-pane windows and no exterior wall insulation where cost-effective as defined in Table 14. Because the incremental cost of this package is significantly higher than other packages, jurisdictions may wish to consider placing a limit on the incremental cost relative to the total project cost, limiting the requirement to large projects.

Water Heating Package: Add exterior insulation meeting a minimum of R-6 to existing storage water heaters. Insulate all accessible hot water pipes with pipe insulation a minimum of ¾ inch thick. This includes insulating the supply pipe leaving the water heater, piping to faucets underneath sinks, and accessible pipes in attic spaces or crawlspaces. Upgrade fittings in sinks and showers to meet current CALGreen (Title 24, Part 11) requirements.

> Exception 1: Water heater blanket is not required on water heaters less than 20 gallons.
>
> Exception 2: Water heater blanket not required if application of a water heater blanket voids the warranty on the water heater.
>
> Exception 3: Fixtures with rated or measured flow rates no more than ten percent greater than current CALGreen requirements.

Lighting Measures – LED Lamps and Exterior Photocell Sensors: Replace all interior and exterior screw-in incandescent, halogen, and compact fluorescent lamps with screw-in LED lamps. Install photocell controls on all exterior lighting luminaires.

Installation of PV: Install a PV system that meets the requirements of 2019 Title 24, Part 6 Section 150.1(c)14. Alternatively, a smaller PV system can be required as analysis found that cost-effectiveness results do not change appreciably with a PV system as small as one kW_{DC}.

> Exception 1: All exceptions as stated in the 2019 Title 24, Part 6 Section 150.1(c)14 are allowed.
>
> Exception 2: A smaller PV system may be installed if the proposed system capacity is larger than the maximum size allowed by the electric utility based on NEM requirements.

Installation of PV and Battery: Install a PV system that meets the requirements of 2019 Title 24, Part 6 Section 150.1(c)14 and a battery system that meets the requirements of 2019 Title 24, Part 6 Joint Appendix 12. Combining PV with a battery system is cost-effective both On-Bill and TDV as shown in Table 15; however, battery systems are not cost-effective on their own without the energy savings from the PV system.

Alternatively, instead of requiring a battery system battery-ready measures could be required with a PV installation including locating and reserving a zone for installation of a battery storage system, running conduit for a future battery storage system, and possibly panel upgrades if the main service panel is replaced as part of the scope of work.

> Exception 1: All exceptions as stated in the 2019 Title 24, Part 6 Section 150.1(c)14 are allowed.

4.2 Fuel Substitution Measures

HVAC Heat Pump: Replace an existing ducted natural gas furnace/AC with a ducted heat pump at time of equipment replacement. This measure applies to buildings according to climate zone as defined in Table 16 and Table 17, and summarized in Figure 4, Figure 5, Figure 6, and Figure 7. While it is cost-effective based on 2022 TDV in some conditions, replacement of the HVAC equipment with a minimum efficiency heat pump results in higher utility costs in most cases, resulting in negative impact on customer's ability to recover costs. Operating costs are sensitive to utility rate structures and changes in natural gas and electricity rates. As shown in Climate Zone 12 with SMUD rates, installing a heat pump can result in lower utility costs. Installing high-efficiency heat pumps can improve cost-effectiveness and lower operating costs but cannot be used for the basis of a reach code.

Installation of PV in addition to replacing a gas furnace/AC with a heat pump increases first cost but results in reduced utility costs and positive On-Bill cost effectiveness in most cases.

Exception 1: Non-ducted space conditioning systems and systems without central air conditioning.

Exception 2: Ducted space conditioning systems where only the gas furnace is replaced.

Exception 3: The main service panel does not have the capacity or space to accommodate an additional 240 V, 30 A circuit, and the cost to upgrade the main service panel and run required electrical service to the heat pump air handler is prohibitive as determined by the jurisdiction.

HPWH: Replace an existing natural gas storage water heater with a heat pump at time of equipment replacement. This measure applies to buildings according to climate zone as defined in Table 16 and Table 17, and summarized in Figure 8, Figure 9, Figure 10, and Figure 11. This measure is cost-effective based on 2022 TDV in all climate zones except 1 and 16, but installation of a HPWH to replace an existing storage tank water heater can result in higher utility costs. Like the space conditioning heat pump, operating costs are sensitive to utility rate structures and future changes in natural gas and electricity rates. Installing a HPWH in Climate Zone 12 with SMUD rates results in lower utility costs. Like space conditioning heat pumps, installing higher efficiency equipment lowers operating costs but cannot be used for the basis of a reach code.

While replacing an electric resistance water heater wasn't directly evaluated, cost effectiveness will only improve relative to a gas water heater baseline as incremental costs will be similar and utility cost savings will be greater. This was evaluated in the Residential Energy Savings and Process Improvements for Additions and Alterations 2022 CASE analysis and was found to be cost effective for multifamily buildings using the 8-unit prototype in all climate zones except 16 (Statewide CASE Team, 2020b).

Installation of PV in addition to replacing an existing water heater with a HPWH significantly increases first cost but results in reduced utility costs and positive On-Bill cost effectiveness in all cases. While not evaluated in this report, 120V HPWHs are starting to enter the market and may be considered in future evaluations by the Statewide Reach Code Team.

This requirement applies when replacing an existing water heater under the following conditions:

1. Natural gas, propane, or electric resistance water heater located in a vented closet with adequate space and ventilation or a garage, and
2. There is adequate space in the main service panel for a 240 V, 30 A dedicated breaker.

   Exception 1: The proposed location of the new water heater is within conditioned space.

   Exception 2: The proposed location of the replacement water heater is not large enough to accommodate a HPWH equivalent in size and one-hour capacity rating to the existing water heater or the next nominal size available.

Exception 3: The main service panel does not have the capacity or space to accommodate an additional 240 V, 30 A circuit, or the cost to upgrade the main service panel and run required electrical service to the water heater is prohibitive as determined by the jurisdiction.

Exception 4: A solar water heating system is installed meeting the installation criteria specified in Reference Residential Appendix RA4.4.20 and with a minimum solar savings fraction of 60 percent.

PV and Electric Readiness Measures: Install a PV system and wiring for 240 V power to the furnace location and the water heater location and upgrade the main service panel to allow for installation of electric appliances at a future date. The requirements include the following:

1. Heat Pump Space Heater Ready

    a. Install a dedicated 240 volt branch circuit wiring within 3 feet from the existing furnace and accessible to the furnace with no obstructions. The branch circuit conductors shall be rated at 30 amps minimum. The blank cover shall be identified as “240V ready”. All electrical components shall be installed in accordance with the California Electrical Code.

    b. The main electrical service panel shall have a reserved space to allow for the installation of a double pole circuit breaker for a future heat pump space heater installation. The reserved space shall be permanently marked as “For Future 240V use”.

    Exception 1: The building does not have existing central ducted heating or cooling system.

    Exception 2: The building already has a heat pump for space heating.

2. Heat Pump Water Heater Ready

    a. Install a dedicated 240 volt branch circuit wiring within three feet from the existing water heater and accessible to the water heater with no obstructions. The branch circuit conductors shall be rated at 30 amps minimum. The blank cover shall be identified as “240V ready”. All electrical components shall be installed in accordance with the California Electrical Code.

    b. The main electrical service panel shall have a reserved space to allow for the installation of a double pole circuit breaker for a future heat pump space heater installation. The reserved space shall be permanently marked as “For Future 240V use”.

    Exception 1: The proposed location of the new water heater is located within conditioned space.

    Exception 2: The proposed location of the replacement water heater is not large enough to accommodate a heat pump water heater equivalent in size and one-hour capacity rating to the existing water heater or the next larger nominal size available.

    Exception 3: The building already has a heat pump water heater.

3. Upgrade existing main service panel to a minimum 200 A panel to accommodate future connection of electric appliances.

    Exception 1: The existing main service panel can be documented by an electrician or engineer to have sufficient capacity for the following electrical appliances: space heating, water heating, cooking, clothes drying, and Level 2 electric vehicle service equipment.

    Exception 2: The building already uses electric appliances for space heating, water heating, cooking, and clothes drying.

4.3 Other Considerations

Measure Tradeoffs for Energy Performance Equivalency: Jurisdictions that wish to provide more flexibility than a prescriptive approach that requires the installation of specific measures or packages, may specify a target performance level based upon the potential savings from the cost-effective measures. This flexible approach expands the menu of available measure options beyond only cost-effective measures. It allows (but does not require) owners to select measures that are not cost-effective based on the analysis but that may be more appropriate for the specific project scope. The combination of measures must achieve equivalent site energy savings as the target performance level or score.

A jurisdiction may quickly develop an ordinance using this flexible approach in the Cost-Effectiveness Explorer[9] tool developed by the Statewide Reach Code Team. The tool walks the user through the process and allows the user to test various scenarios. Once complete, draft policy options (including weighted measure menu tables and draft model ordinance language) can be downloaded and shared with colleagues to gather feedback and refine requirements.

Tiered and CARE Tariffs: Whether a customer is on a TOU or tiered rate generally won't impact the results of this analysis as total utility costs under these two rate options were found to be within 10 percent of one another. Homes with PV systems are the exception where there are larger differences in total utility costs. Even so, this didn't impact cost effectiveness in the scenarios evaluated by the Reach Code Team because PV is so cost effective.

CARE tariffs can have a substantial impact on total utility costs and can change whether a measure is cost effective depending on how beneficial the measure is. For efficiency measures the CARE tariff decreases how cost-effective a measure is and in some cases an efficiency measure may be cost-effective under a non-CARE tariff but not under a CARE tariff. The opposite is true for fuel substitution measures. There is a larger reduction in electricity rates relative to natural gas rates in the CARE tariffs, and as a result utility savings for fuel substitution measures increase. In some cases, a fuel substitution measure may not be cost-effective under a non-CARE tariff but is under a CARE tariff.

It's important to consider these impacts carefully when developing a local ordinance. Complete results for all measures presented in this report for tiered and CARE rates will be available on the Cost-Effectiveness Explorer.[9]

HERS Rater Field Verification: HERS Rater field verification applies to duct sealing and new duct measures. It also may be required for other measures depending on the project work scope.

Combustion Appliance Safety and Indoor Air Quality: Implementation of some of the recommended measures will affect the pressure balance of the home which can subsequently impact the safe operation of existing combustion appliances as well as indoor air quality. Buildings with older gas appliances can present serious health and safety problems which may not be addressed in a remodel if the appliances are not being replaced. It is recommended that the building department require inspection and testing of all combustion appliances after completion of the retrofit work. It is also recommended that jurisdictions require combustion safety testing by a certified professional whenever air sealing and insulation measures are applied, and existing combustion appliances are located within the pressure boundary of the building.

Jurisdictions may also want to consider requiring mechanical ventilation in buildings where air sealing has been conducted. In older buildings, outdoor air is typically introduced through leaks in the building envelope. After air sealing a building, it may be necessary to forcefully bring in fresh outdoor air using supply and/or exhaust fans to minimize potential issues associated with poor indoor air quality.

Required Measures Included in Title 24, Part 6 Performance Simulation: If any of the measures above are included in a performance Title 24, Part 6 compliance report, it's suggested that trade-offs be allowed as long as all minimum code requirements are met. For example, if a project is installing new windows, a new roof, and insulating the

[9] https://explorer.localenergycodes.com/

attic and is demonstrating Title 24, Part 6 compliance with a performance simulation run, it would be acceptable if the installed roof did not meet the requirements listed above as long as this was traded off with either an increase in attic insulation or better performing windows. This would also allow trade-offs for projects that are installing high impact measures, such as solar water heating or whole house fans.

This would require two simulation runs; however, it's not expected this approach would be utilized often.

- Run number one would evaluate the proposed building upgrades. This would also be the report submitted to the building department for the permit application demonstrating compliance with Title 24, Part 6.
- Run number two would also be completed with the minimum ordinance requirements modeled for each of the affected building components.

To show compliance with the ordinance the applicant would need to demonstrate that the proposed upgrades in run one would result in annual TDV energy use equal to or less than the annual TDV energy use of the case based on the ordinance requirements in run two.

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6 Appendices

6.1 Appendix A: Map of California Climate Zones

Climate zone geographical boundaries are depicted in Figure 22. The map in Figure 22 along with a zip-code search directory is available at: https://ww2.energy.ca.gov/maps/renewable/building_climate_zones.html

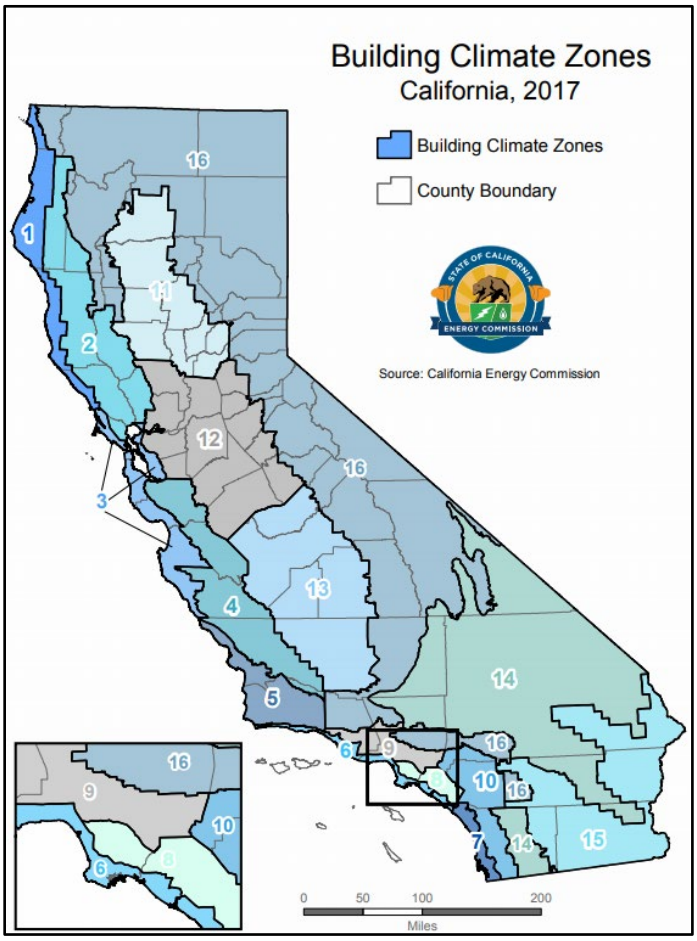

Figure 22: Map of California Climate Zones.
Source: California Energy Commission

6.2 Appendix B: Utility Rate Schedules

6.2.1 PG&E

The following pages provide details on the PG&E electricity and natural gas tariffs applied in this study. Table 19 describes the baseline territories that were assumed for each climate zone.

Table 19: 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 August 2021 according to the rates shown in Table 20. The corresponding CARE rates are shown in Table 21.

Table 20: PG&E Monthly Gas Rate ($/therm)

Month	Procurement Charge	Transportation Charge		Total Charge	
		Baseline	Excess	Baseline	Excess
Jan 2021	$0.49332	$1.09586	$1.53752	$1.58918	$2.03084
Feb 2021	$0.49073	$1.09586	$1.53752	$1.58659	$2.02825
Mar 2021	$0.42316	$1.19868	$1.68034	$1.62184	$2.10350
Apr 2021	$0.22304	$1.19868	$1.68034	$1.42172	$1.90338
May 2021	$0.21063	$1.19868	$1.68034	$1.40931	$1.89097
June 2021	$0.21778	$1.20019	$1.68243	$1.41797	$1.90021
July 2021	$0.19109	$1.20019	$1.68243	$1.39128	$1.87352
Aug 2021	$0.22551	$1.20019	$1.68243	$1.42570	$1.90794
Sept 2020	$0.41891	$1.13126	$1.64861	$1.55017	$2.06752
Oct 2020	$0.38068	$1.13416	$1.65280	$1.51484	$2.03348
Nov 2020	$0.46046	$1.13416	$1.65280	$1.59462	$2.11326
Dec 2020	$0.48474	$1.13416	$1.65280	$1.6189	$2.13754

Table 21: PG&E Monthly CARE (GL-1) Gas Rate ($/therm)

Month	CARE Discount		Total CARE Charge	
	Baseline	Excess	Baseline	Excess
Jan 2021	-$0.31722	-$0.40555	$1.26886	$1.62219
Feb 2021	-$0.31670	-$0.40503	$1.26679	$1.62012
Mar 2021	-$0.32375	-$0.42008	$1.29499	$1.68032
Apr 2021	-$0.28372	-$0.38006	$1.13490	$1.52022
May 2021	-$0.28124	-$0.37757	$1.12497	$1.51030
June 2021	-$0.28297	-$0.37942	$1.13190	$1.51769
July 2021	-$0.27764	-$0.37408	$1.11054	$1.49634
Aug 2021	-$0.28452	-$0.38097	$1.13808	$1.52387
Sept 2020	-$0.30964	-$0.41311	$1.23858	$1.65246
Oct 2020	-$0.30258	-$0.40631	$1.21031	$1.62522
Nov 2020	-$0.31853	-$0.42226	$1.27414	$1.68905
Dec 2020	-$0.32339	-$0.42712	$1.29356	$1.70847

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Revised *Cal. P.U.C. Sheet No.* 34288-G

GAS SCHEDULE G-1
RESIDENTIAL SERVICE

Sheet 2

BASELINE QUANTITIES:

The delivered quantities of gas shown below are billed at the rates for baseline use.

BASELINE QUANTITIES (Therms Per Day Per Dwelling Unit)

Baseline Territories ***	Summer (April-October) Effective Apr. 1, 2020		Winter Off-Peak (Nov,Feb,Mar) Effective Nov. 1, 2019		Winter On-Peak (Dec, Jan) Effective Dec. 1, 2019		(T) | (T)
P	0.39	(R)	1.88	(R)	2.16	(I)	
Q	0.59	(R)	1.55	(R)	2.16	(I)	
R	0.36	(R)	1.28	(R)	1.97	(I)	
S	0.39	(R)	1.38	(R)	2.06	(I)	
T	0.59	(R)	1.38	(R)	1.81	(I)	
V	0.62	(R)	1.51	(R)	1.84	(I)	
W	0.39	(R)	1.18	(R)	1.84	(I)	
X	0.49	(R)	1.55	(R)	2.16	(I)	
Y	0.69	(R)	2.15	(R)	2.65	(I)	

SEASONAL CHANGES:

The summer season is April-October, the winter off-peak season is November, February and March, and the winter on-peak season is December and January. Baseline quantities for bills that include the April 1, November 1 and December 1 seasonal changeover dates will be calculated by multiplying the applicable daily baseline quantity for each season by the number of days in each season for the billing period.

BASELINE QUANTITIES:

The delivered quantities of gas shown below are billed at the rates for baseline use.

BASELINE QUANTITIES (Therms Per Day Per Dwelling Unit)

Baseline Territories **	Summer (April-October) Effective Apr. 1, 2020		Winter Off-Peak (Nov,Feb,Mar) Effective Nov. 1, 2019		Winter On-Peak (Dec, Jan) Effective Dec. 1, 2019		(T) | (T)
P	0.39	(R)	1.88	(R)	2.16	(I)	
Q	0.59	(R)	1.55	(R)	2.16	(I)	
R	0.36	(R)	1.28	(R)	1.97	(I)	
S	0.39	(R)	1.38	(R)	2.06	(I)	
T	0.59	(R)	1.38	(R)	1.81	(I)	
V	0.62	(R)	1.51	(R)	1.84	(I)	
W	0.39	(R)	1.18	(R)	1.84	(I)	
X	0.49	(R)	1.55	(R)	2.16	(I)	
Y	0.69	(R)	2.15	(R)	2.65	(I)	

SEASONAL CHANGES:

The summer season is April-October, the winter off-peak season is November, February and March, and the winter on-peak season is December and January. Baseline quantities for bills that include the April 1, November 1 and December 1 seasonal changeover dates will be calculated by multiplying the applicable daily baseline quantity for each season by the number of days in each season for the billing period.

ELECTRIC SCHEDULE E-TOU-C Sheet 2
RESIDENTIAL TIME-OF-USE (PEAK PRICING 4 - 9 p.m. EVERY DAY)

RATES: (Cont'd.)

E-TOU-C TOTAL RATES

Total Energy Rates ($ per kWh)	PEAK		OFF-PEAK	
Summer				
Total Usage	$0.41972	(I)	$0.35628	(I)
Baseline Credit (Applied to Baseline Usage Only)	($0.07575)	(I)	($0.07575)	(I)
Winter				
Total Usage	$0.32264	(I)	$0.30531	(I)
Baseline Credit (Applied to Baseline Usage Only)	($0.07575)	(I)	($0.07575)	(I)
Delivery Minimum Bill Amount ($ per meter per day)	$0.33260	(I)		
California Climate Credit (per household, per semi-annual payment occurring in the April and October bill cycles)	($17.20)			

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, Wildfire Fund Charge, and New System Generation Charges based on kWh usage times the corresponding unbundled rate component per kWh, with any residual revenue assigned to Distribution.

(Continued)

ELECTRIC SCHEDULE E-TOU-C Sheet 4 (T)
RESIDENTIAL TIME-OF-USE (PEAK PRICING 4 - 9 p.m. EVERY DAY)

SPECIAL CONDITIONS:

1. BASELINE (TIER 1) QUANTITIES: The following quantities of electricity are to be used to define usage eligible for the baseline credit (also see Rule 19 for additional allowances for medical needs):

BASELINE QUANTITIES (kWh PER DAY)

Baseline Territory*	Code B - Basic Quantities		Code H - All-Electric Quantities	
	Summer Tier I	Winter Tier I	Summer Tier I	Winter Tier I
P	14.2	12.0	16.0	27.4
Q	10.3	12.0	8.9	27.4
R	18.6	11.3	20.9	28.1
S	15.8	11.1	18.7	24.9
T	6.8	8.2	7.5	13.6
V	7.5	8.8	10.9	16.9
W	20.2	10.7	23.6	20.0
X	10.3	10.5	8.9	15.4
Y	11.0	12.1	12.6	25.3
Z	6.2	8.1	7.0	16.5

2. TIME PERIODS FOR **E-TOU-C**: Times of the year and times of the day are defined as follows: (T)

Summer (service from June 1 through September 30):

Peak: 4:00 p.m. to 9:00 p.m. All days

Off-Peak: All other times

Winter (service from October 1 through May 31):

Peak: 4:00 p.m. to 9:00 p.m. All days

Off-Peak: All other times

* The applicable baseline territory is described in Part A of the Preliminary Statement

(Continued)

ELECTRIC SCHEDULE E-1 Sheet 1
RESIDENTIAL SERVICES

APPLICABILITY: This schedule is applicable to single-phase and polyphase residential service in single-family dwellings and in flats and apartments separately metered by PG&E; to single-phase and polyphase service in common areas in a multifamily complex (see Special Condition 8); and to all single-phase and polyphase farm service on the premises operated by the person whose residence is supplied through the same meter.

The provisions of Schedule S—Standby Service Special Conditions 1 through 6 shall also apply to customers whose premises are regularly supplied in part (but not in whole) by electric energy from a nonutility source of supply. These customers will pay monthly reservation charges as specified under Section 1 of Schedule S, in addition to all applicable Schedule E-1 charges. See Special Conditions 11 and 12 of this rate schedule for exemptions to standby charges.

TERRITORY: This rate schedule applies everywhere PG&E provides electric service.

RATES: Total bundled service charges are calculated using the total rates below. Customers on this schedule are subject to the delivery minimum bill amount shown below applied to the delivery portion of the bill (i.e. to all rate components other than the generation rate). In addition, total bundled charges will include applicable generation charges per kWh for all kWh usage.

Customers receiving a medical baseline allowance shall pay for all usage in excess of 200 percent of baseline at a rate $0.04000 per kWh less than the applicable rate for usage in excess of 200 percent of baseline. No portion of the rates paid by customers that receive a Medical Baseline allowance shall be used to pay the Wildfire Fund Charge. For these customers, the Conservation Incentive Adjustment is calculated residually based on the total rate less the sum of: Transmission, Transmission Rate Adjustments, Reliability Services, Distribution, Generation, Public Purpose Programs, Nuclear Decommissioning, Competition Transition Charges (CTC), New System Generation Charges, and Energy Cost Recovery Amount. Customers receiving a medical baseline allowance shall also receive a 50 percent discount on the delivery minimum bill amount shown below.

Direct Access (DA) and Community Choice Aggregation (CCA) charges shall be calculated in accordance with the paragraph in this rate schedule titled Billing.

TOTAL RATES

Total Energy Rates ($ per kWh)	
Baseline Usage	$0.26071 (I)
101% - 400% of Baseline	$0.32751 (I)
High Usage Over 400% of Baseline	$0.40939 (I)
Delivery Minimum Bill Amount ($ per meter per day)	$0.33260 (I)
California Climate Credit (per household, per semi-annual payment occurring in the April and October bill cycles)	($17.20)

(Continued)

ELECTRIC SCHEDULE D-CARE Sheet 1
LINE-ITEM DISCOUNT FOR CALIFORNIA ALTERNATE RATES FOR ENERGY (CARE) CUSTOMERS

APPLICABILITY: This schedule is applicable to single-phase and polyphase residential service in single-family dwellings and in flats and apartments separately metered by PG&E and domestic submetered tenants residing in multifamily accommodations, mobilehome parks and to qualifying recreational vehicle parks and marinas and to farm service on the premises operated by the person whose residence is supplied through the same meter, where the applicant qualifies for California Alternate Rates for Energy (CARE) under the eligibility and certification criteria set forth in Electric Rule 19.1. CARE service is available on Schedules E-1, E-6, E-TOU-B, E-TOU-C, E-TOU-D, EV2, EM, ES, ESR, ET and EM-TOU.

TERRITORY: This rate schedule applies everywhere PG&E provides electric service.

RATES: Customers taking service on this rate schedule will receive a percentage discount ("A" below) on their total bundled charges on their otherwise applicable rate schedule (except for the California Climate Credit, which will not be discounted). In addition, customers will receive a percentage discount ("B" below) on the delivery minimum bill amount, if applicable. The CARE discount will be calculated for direct access and community choice aggregation customers based on the total charges as if they were subject to bundled service rates. Discounts will be applied as a residual reduction to distribution charges, after D-CARE customers are exempted from the Wildfire Fund Charge and the CARE surcharge portion of the public purpose program charge used to fund the CARE discount. These conditions also apply to master-metered customers and to qualified sub-metered tenants where the master-meter customer is jointly served under PG&E's Rate Schedule D-CARE and either Schedule EM, ES, ESR, ET, or EM-TOU.

For master-metered customers where one or more of the submetered tenants qualifies for CARE rates under the eligibility and certification criteria set forth in Rule 19.1, 19.2, or 19.3, the CARE discount is equal to a percentage ("C" below) of the total bundled charges, multiplied by the number of CARE units divided by the total number of units. In addition, master-metered customers eligible for D-CARE will receive a percentage discount ("D" below) on the delivery minimum bill amount, if applicable.

It is the responsibility of the master-metered customer to advise PG&E within 15 days following any change in the number of dwelling units and/or any decrease in the number of qualifying CARE applicants that results when such applicants move out of their submetered or non-submetered dwelling unit, or submetered permanent-residence RV or permanent-residence boat.

A.	D-CARE Discount:	34.950 % (Percent)	(R)
B.	Delivery Minimum Bill Discount:	50.000 % (Percent)	
C.	Master-Meter D-CARE Discount:	34.950 % (Percent)	(R)
D.	Master-Meter Delivery Minimum Bill Discount:	50.000 % (Percent)	

SPECIAL CONDITIONS: 1. OTHERWISE APPLICABLE SCHEDULE: The Special Conditions of the Customer's otherwise applicable rate schedule will apply to this schedule.

(Continued)

6.2.2 SCE

The following pages provide details on are the SCE electricity tariffs applied in this study. Table 22 describes the baseline territories that were assumed for each climate zone.

Table 22: SCE Baseline Territory by Climate Zone

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

Summer Daily Allocations (June through September)

Baseline Region Number	Daily kWh Allocation	All-Electric Allocation
5	17.2	17.9
6	11.4	8.8
8	12.6	9.8
9	16.5	12.4
10	18.9	15.8
13	22.0	24.6
14	18.7	18.3
15	46.4	24.1
16	14.4	13.5

Winter Daily Allocations (October through May)

Baseline Region Number	Daily kWh Allocation	All-Electric Allocation
5	18.7	29.1
6	11.3	13.0
8	10.6	12.7
9	12.3	14.3
10	12.5	17.0
13	12.6	24.3
14	12.0	21.3
15	9.9	18.2
16	12.6	23.1

Schedule TOU-D
TIME-OF-USE
DOMESTIC
(Continued)

Sheet 12 (T)

SPECIAL CONDITIONS

1. Applicable rate time periods are defined as follows:

Option 4-9 PM, Option 4-9 PM-CPP, Option PRIME, Option PRIME-CPP : (T)

TOU Period	Weekdays		Weekends and Holidays	
	Summer	Winter	Summer	Winter
On-Peak	4 p.m. - 9 p.m.	N/A	N/A	N/A
Mid-Peak	N/A	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	N/A	8 a.m. - 4 p.m.	N/A	8 a.m. - 4 p.m.
CPP Event Period	4 p.m. - 9 p.m.	4 p.m. - 9 p.m.	N/A	N/A

Schedule TOU-D
TIME-OF-USE
DOMESTIC
(Continued)

Sheet 2

RATES

Customers receiving service under this Schedule will be charged the applicable rates under Option 4-9 PM, Option 4-9 PM-CPP, Option 5-8 PM, Option 5-8 PM-CPP, Option PRIME, Option PRIME-CPP Option A, Option A-CPP, Option B, or Option B-CPP, as listed below. CPP Event Charges will apply to all energy usage during CPP Event Energy Charge periods and CPP Non-Event Energy Credits will apply as a reduction on CPP Non-Event Energy Credit Periods during Summer Season weekdays, 4:00 p.m. to 9:00 p.m., as described in Special Conditions 1 and 3, below:

		Delivery Service	Generation[2]	
Option 4-9 PM / Option 4-9 PM-CPP		Total[1]	UG***	DWREC[3]
Energy Charge - $/kWh				
	Summer Season - On-Peak	0.25131 (I)	0.18267 (I)	0.00000
	Mid-Peak	0.25131 (I)	0.10084 (I)	0.00000
	Off-Peak	0.19777 (I)	0.07377 (R)	0.00000
	Winter Season - Mid-Peak	0.25131 (I)	0.12676 (I)	0.00000
	Off-Peak	0.19777 (I)	0.08891 (R)	0.00000
	Super-Off-Peak	0.19141 (I)	0.06899 (R)	0.00000
Baseline Credit**** - $/kWh		(0.07299) (I)	0.00000	
Basic Charge - $/day				
	Single-Family Residence	0.031		
	Multi-Family Residence	0.024		
Minimum Charge** - $/day				
	Single Family Residence	0.346		
	Multi-Family Residence	0.346		
Minimum Charge (Medical Baseline)** - $/day				
	Single Family Residence	0.173		
	Multi-Family Residence	0.173		
California Climate Credit[10]		(29.00)		
California Alternate Rates for Energy Discount - %		100.00*		
Family Electric Rate Assistance Discount - %		100.00		
Option 4-9 PM-CPP				
CPP Event Energy Charge - $/kWh			0.80000	
Summer CPP Non-Event Credit On-Peak Energy Credit - $/kWh			(0.15170)	
Maximum Available Credit - $/kWh*****				
	Summer Season		(0.58195) (R)	

* Represents 100% of the discount percentage as shown in the applicable Special Condition of this Schedule.
** The Minimum Charge is applicable when the Delivery Service Energy Charge, plus the applicable Basic Charge is less than the Minimum Charge.
*** The ongoing Competition Transition Charge CTC of ($0.00002) per kWh is recovered in the UG component of Generation.
**** The Baseline Credit applies up to 100% of the Baseline Allocation, regardless of Time of Use. The Baseline Allocation is set forth in Preliminary Statement, Part H.
***** The Maximum Available Credit is the capped credit amount for CPP Customers dual participating in other demand response programs.
1 Total = Total Delivery Service rates are applicable to Bundled Service, Direct Access (DA) and Community Choice Aggregation Service (CCA Service) Customers, except DA and CCA Service Customers are not subject to the DWREC rate component of this Schedule but instead pay the DWREC as provided by Schedule DA-CRS or Schedule CCA-CRS.
2 Generation = The Gen rates are applicable only to Bundled Service Customers.
3 DWREC = Department of Water Resources (DWR) Energy Credit – For more information on the DWR Energy Credit, see the Billing Calculation Special Condition of this Schedule.
4 Applied on an equal basis, per household, semi-annually. See the Special Conditions of this Schedule for more information.

(Continued)

Schedule D
DOMESTIC SERVICE

Sheet 2

(Continued)

RATES

	Delivery Service Total[1]	Generation[2] UG***	Generation[2] DWREC[3]
Energy Charge- $/kWh/Meter/Day			
Baseline Service			
Summer	0.13890 (I)	0.09558 (I)	0.00000
Winter	0.13890 (I)	0.09558 (I)	0.00000
Nonbaseline Service*			
101% - 400% of Baseline - Summer	0.20573 (I)	0.09558 (I)	0.00000
Winter	0.20573 (I)	0.09558 (I)	0.00000
High Usage Charge			
(Over 400% of Baseline) - Summer	0.28105 (I)	0.09558 (I)	0.00000
- Winter	0.28105 (I)	0.09558 (I)	0.00000
Basic Charge - $/Meter/Day			
Single-Family Accommodation	0.031		
Multi-Family Accommodation	0.024		
Minimum Charge** - $/Meter/Day			
Single-Family Accommodation	0.346		
Multi-Family Accommodation	0.346		
Minimum Charge (Medical Baseline)** - $/Meter/Day			
Single-Family Accommodation	0.173		
Multi-Family Accommodation	0.173		
California Climate Credit[10]	(29.00)		

* Nonbaseline Service includes all kWh in excess of applicable Baseline allocations as described in Preliminary Statement, Part H, Baseline Service.
** The Minimum Charge is applicable when the Delivery Service Energy Charge, minus the DWRBC, plus the applicable Basic Charge is less than the Minimum Charge. The difference between these two amounts is the Balance of Minimum Charge and is included on a Customer's bill.
*** The ongoing Competition Transition Charge (CTC) of ($0.00002) per kWh is recovered in the UG component of Generation.
1 Total = Total Delivery Service rates are applicable to Bundled Service, Direct Access (DA) and Community Choice Aggregation Service (CCA Service) Customers, except DA and CCA Service Customers are not subject to the DWRBC rate component of this Schedule but instead pay the DWRBC as provided by Schedule DA-CRS or Schedule CCA-CRS.
2 Generation = The Generation rates are applicable only to Bundled Service Customers.
3 DWREC = Department of Water Resources (DWR) Energy Credit - For more information on the DWR Energy Credit, see the Billing Calculation Special Condition of this Schedule.
4 Applied on an equal basis, per household, semi-annually. See the Special Conditions of this Schedule for more information.

(Continued)

Schedule D-CARE Sheet 1
CALIFORNIA ALTERNATE RATES FOR ENERGY
DOMESTIC SERVICE

APPLICABILITY

Applicable to domestic service to CARE households residing in a permanent Single-Family Accommodation or Multifamily Accommodation where the customer meets all the Special Conditions of this Schedule. Customers enrolled in the CARE program are not eligible for the Family Electric Rate Assistance (FERA) program.

Pursuant to Special Condition 12 herein, customers receiving service under this Schedule are eligible to receive the California Climate Credit as shown in the Rates section below.

TERRITORY

Within the entire territory served.

RATES

The applicable charges set forth in Schedule D shall apply to Customers served under this Schedule.

CARE Discount:

A 28.3 percent discount is applied to a CARE Customer's bill prior to the application of the Public Utilities Commission Reimbursement Fee (PUCRF) and any applicable user fees, taxes, and late payment charges. CARE Customers are required to pay the PUCRF and any applicable user fees, taxes, and late payment charges in full. In addition, CARE Customers are exempt from paying the CARE Surcharge of $0.00907 per kWh and the Department of Water Resources Bond Charge of $0.00580 per kWh. The 28.3 percent discount (which includes the exemption of the Fixed Recovery Charge of $0.00053 per kWh) in addition to these exemptions result in an average effective CARE Discount of 32.5 percent. (I) (N) (N)

(Continued)

6.2.3 SoCalGas

Following are the SoCalGas natural gas tariffs applied in this study. Table 23 describes the baseline territories that were assumed for each climate zone.

Table 23: SoCalGas Baseline Territory by Climate Zone

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

The SoCalGas monthly gas rate in $/therm was applied on a monthly basis for the 12-month period ending August 2021 according to the rates shown in Table 24. Historical natural gas rate data was only available for SoCalGas' procurement charges.[10] To estimate total costs by month, the baseline and excess transmission charges were assumed to be relatively consistence and applied for the entire year based on January 2021 and April 2021 costs. CARE rates reflect the 20 percent discount per the GR tariff.

Table 24: SoCalGas Monthly Gas Rate ($/therm)

Month	Procurement Charge	Transportation Charge		Total Charge	
		Baseline	Excess	Baseline	Excess
Jan 2021	$0.39764	$0.82358	$1.21382	$1.22122	$1.61146
Feb 2021	$0.36766	$0.82358	$1.21382	$1.19124	$1.58148
Mar 2021	$0.36982	$0.82358	$1.21382	$1.1934	$1.58364
Apr 2021	$0.31373	$0.80599	$1.20562	$1.11972	$1.51935
May 2021	$0.35684	$0.80599	$1.20562	$1.16283	$1.56246
June 2021	$0.3946	$0.80599	$1.20562	$1.20059	$1.60022
July 2021	$0.42622	$0.80599	$1.20562	$1.23221	$1.63184
Aug 2021	$0.44599	$0.80599	$1.20562	$1.25198	$1.65161
Sept 2020	$0.25498	$0.82358	$1.21382	$1.07856	$1.4688
Oct 2020	$0.25268	$0.82358	$1.21382	$1.07626	$1.4665
Nov 2020	$0.3432	$0.82358	$1.21382	$1.16678	$1.55702
Dec 2020	$0.36159	$0.82358	$1.21382	$1.18517	$1.57541

[10] The SoCalGas procurement and transmission charges were obtained from the following site: https://www.socalgas.com/for-your-business/energy-market-services/gas-prices

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¢

6.2.4 SDG&E

Following are the SDG&E electricity and natural gas tariffs applied in this study. Table 25 describes the baseline territories that were assumed for each climate zone.

Table 25: SDG&E Baseline Territory by Climate Zone

	Baseline Territory
CZ07	Coastal
CZ10	Inland
CZ14	Mountain

The SDG&E monthly gas rate in $/therm was applied on a monthly basis for the 12-month period ending August 2021 according to the rates shown in Table 26. CARE rates reflect the 20 percent discount per the G-CARE tariff.

Table 26: SDG&E Monthly Gas Rate ($/therm)

Month	Procurement Charge	Transportation Charge		Total Charge	
		Baseline	Excess	Baseline	Excess
Jan 2021	$0.39803	$1.44464	$1.70732	$1.84267	$2.10535
Feb 2021	$0.36802	$1.44464	$1.70732	$1.81266	$2.07534
Mar 2021	$0.37018	$1.44464	$1.70732	$1.81482	$2.07750
Apr 2021	$0.31401	$1.44464	$1.70732	$1.75865	$2.02133
May 2021	$0.35719	$1.44464	$1.70732	$1.80183	$2.06451
June 2021	$0.39498	$1.44464	$1.70732	$1.83962	$2.10230
July 2021	$0.42663	$1.44464	$1.70732	$1.87127	$2.13395
Aug 2021	$0.44642	$1.44464	$1.70732	$1.89106	$2.15374
Sept 2020	$0.25521	$1.39202	$1.62888	$1.64723	$1.88409
Oct 2020	$0.2529	$1.42577	$1.67181	$1.67867	$1.92471
Nov 2020	$0.34351	$1.42577	$1.67181	$1.76928	$2.01532
Dec 2020	$0.36192	$1.42577	$1.67181	$1.78769	$2.03373

Baseline Usage: The following quantities of gas used in individually metered residences are to be billed at the baseline rates:

All Customers:	Daily Therm Allowance
Summer (May 1 to October 31, inclusive)	0.493
Winter (November 1 to April 30, inclusive)	1.546

SCHEDULE G-CARE

CALIFORNIA ALTERNATE RATES FOR ENERGY (CARE) PROGRAM

APPLICABILITY

This schedule provides a California Alternate Rates for Energy (CARE) discount to each of the following types of customers listed below that meet the requirements for CARE eligibility as defined in Rule 1, Definitions, and herein, and is taken in conjunction with the customer's otherwise applicable service schedule.

1) Customers residing in a permanent single-family accommodation, separately metered by the Utility.

2) Multi-family dwelling units and mobile home parks supplied through one meter on a single premises where the individual unit is submetered.

3) Non-profit group living facilities.

4) Agricultural employee housing facilities.

TERRITORY

Within the entire territory served natural gas by the Utility.

DISCOUNT

The qualified customer will receive a 20% CARE discount on all customer, commodity, and transportation charges on their otherwise applicable service schedule. In addition, the customer will not pay the CARE portion of the Public Purpose Programs Surcharge as specified in Schedule G-PPPS.

SPECIAL CONDITIONS

ALL CUSTOMERS

1. Applicable Conditions. All special conditions contained in the customer's otherwise applicable schedule are applicable to service under this schedule.

2. Application and Eligibility Declaration.* An application and eligibility declaration, on a form authorized by the Commission, is required for service under the CARE program unless otherwise authorized by the Commission. Renewal of a customer's eligibility declaration, also referred to as recertification, will be required at the request of the Utility. N

3. Commencement of CARE Discount. Eligible customers shall begin receiving the CARE discount no later than one billing period after receipt of a completed and approved application by the Utility or as may otherwise be authorized by the Commission.

*Per SDG&E Advice Letter 3516-E-C/2854-G-C, submitted pursuant to Resolution M-4842, certain customer protections will be offered to eligible customers effective March 4, 2020 through April 16, 2021, or as otherwise extended. N N N

(Continued)

SCHEDULE TOU-DR1

RESIDENTIAL TIME-OF-USE

RATES

Total Rates:

Description – TOU DR1	UDC Total Rate		DWR-BC Rate		EECC Rate + DWR Credit	Total Rate	
Summer:							
On-Peak	0.23911	I	0.00580		0.36416	0.60907	I
Off-Peak	0.23911	I	0.00580		0.11685	0.36176	I
Super Off-Peak	0.23911	I	0.00580		0.05970	0.30461	I
Winter:							
On-Peak	0.32216	I	0.00580		0.09855	0.42651	I
Off-Peak	0.32216	I	0.00580		0.08748	0.41544	I
Super Off-Peak	0.32216	I	0.00580		0.07520	0.40316	I
Summer Baseline Adjustment Credit up to 130% of Baseline	(0.08531)	R				(0.08531)	R
Winter Baseline Adjustment Credit up to 130% of Baseline	(0.08531)	R				(0.08531)	R
Minimum Bill ($/day)	0.345					0.345	

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.

Time Periods

All time periods listed are applicable to local time. The definition of time will be based upon the date service is rendered.

TOU Periods – Weekdays	Summer	Winter
On-Peak	4:00 p.m. – 9:00 p.m.	4:00 p.m. – 9:00 p.m.
Off-Peak	6:00 a.m. – 4:00 p.m.; 9:00 p.m. - midnight	6:00 a.m. – 4:00 p.m. Excluding 10:00 a.m. – 2:00 p.m. in March and April; 9:00 p.m. - midnight
Super Off-Peak	Midnight – 6:00 a.m.	Midnight – 6:00 a.m. 10:00 a.m. – 2:00 p.m. in March and April
TOU Period – Weekends and Holidays	Summer	Winter
On-Peak	4:00 p.m. – 9:00 p.m.	4:00 p.m. – 9:00 p.m.
Off-Peak	2:00 p.m. – 4:00 p.m.; 9:00 p.m. - midnight	2:00 p.m. – 4:00 p.m.; 9:00 p.m. - midnight
Super Off-Peak	Midnight – 2:00 p.m.	Midnight – 2:00 p.m.

Seasons: Summer June 1 – October 31
Winter November 1 – May 31

15. Baseline Usage: The following quantities of electricity are used to calculate the baseline adjustment credit.

	Baseline Allowance For Climatic Zones*			
	Coastal	Inland	Mountain	Desert
Basic Allowance				
Summer (June 1 to October 31)	9.0	10.4	13.6	15.9
Winter (November 1 to May 31)	9.2	9.6	12.9	10.9
All Electric**				
Summer (June 1 to October 31)	6.0	8.7	15,2	17.0
Winter (November 1 to May 31)	8.8	12.2	22.1	17.1

* Climatic Zones are shown on the Territory Served, Map No. 1.
** All Electric allowances are available upon application to those customers who have permanently installed space heating or who have electric water heating and receive no energy from another source.

SCHEDULE DR

RESIDENTIAL SERVICE
(Includes Rates for DR-LI)

APPLICABILITY

This Schedule is optionally available to domestic service for lighting, heating, cooking, water heating, and power, or combination thereof, in single family dwellings, flats, and apartments, separately metered by the utility; to service used in common for residential purposes by tenants in multi-family dwellings under Special Condition 8; to any approved combination of residential and nonresidential service on the same meter; and to incidental farm service under Special Condition 7.

This schedule is also applicable to customers qualifying for the California Alternate Rates for Energy (CARE) Program and/or Medical Baseline, residing in single-family accommodations, separately metered by the Utility, and may include Non-profit Group Living Facilities and Qualified Agricultural Employee Housing Facilities, if such facilities qualify to receive service under the terms and conditions of Schedule E-CARE. The rates for CARE and Medical Baseline customers are identified in the rates tables below as DR-LI and DR-MB rates, respectively.

Customers on this schedule may also qualify for a semi-annual California Climate Credit $\$_{(34.60)}$ per Schedule GHG-ARR.

TERRITORY

Within the entire territory served by the Utility.

RATES

Total Rates:

Description - DR Rates	UDC Total Rate		DWR-BC Rate	EECC Rate + DWR Credit	Total Rate	
Summer:						
Up to 130% of Baseline Energy ($/kWh)	0.15380	I	0.00580	0.16964	0.32924	I
131% - 400% of Baseline ($/kWh)	0.23911	I	0.00580	0.16964	0.41455	I
Above 400% of Baseline ($/kWh)	0.23911	R	0.00580	0.16964	0.41455	R
Winter:						
Up to 130% of Baseline Energy ($/kWh)	0.23685	I	0.00580	0.08659	0.32924	I
131% - 400% of Baseline ($/kWh)	0.32216	I	0.00580	0.08659	0.41455	I
Above 400% of Baseline ($/kWh)	0.32216	R	0.00580	0.08659	0.41455	R
Minimum Bill ($/day)	0.345				0.345	

(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 of $0.00000 that customers receive on their monthly bills.

(2) Total Rates presented are for customers that receive commodity supply and delivery service from Utility. Differences in total rates paid by Direct Access (DA) and Community Choice Aggregation (CCA) customers are identified in Schedule DA-CRS and CCA-CRS, respectively.

(3) DWR-BC charges do not apply to CARE or Medical Baseline customers.

(4) Total Effective CARE Rate is presented for illustrative purposes only, and reflects the average effective CARE discount CARE customers receive which consists of (a) exemptions from paying the CARE Surcharge, DWR-BC, California Solar Initiative (CSI) and Vehicle-Grid Integration (VGI) Costs; (b) a 50% minimum bill relative to Non-CARE; and (c) a separate line-item bill discount for all qualified residential CARE customers.

(5) Current DWR-BC as presented is now used for collecting the California Wildfire Fund Charge effective Oct 1, 2020 (See Schedule WF – NBC). DWR BC will be renamed at implementation of SDG&E's new customer information system.

Sheet 1

SCHEDULE E-CARE

CALIFORNIA ALTERNATE RATES FOR ENERGY

APPLICABILITY

This schedule provides a California Alternate Rates for Energy (CARE) discount to each of the following types of customers listed below that meet the requirements for CARE eligibility as defined in Rule 1, Definitions, and herein, and is taken in conjunction with the customer's otherwise applicable service schedule.

1) Customers residing in a permanent single-family accommodation, separately metered by the Utility.

2) Multi-family dwelling units and mobile home parks supplied through one meter on a single premises where the individual unit is submetered.

3) Non-profit group living facilities.

4) Agricultural employee housing facilities.

TERRITORY

Within the entire territory served by the Utility.

DISCOUNT

1) **Residential CARE**: Qualified residential CARE customers will receive a total effective discount according to the following:

	2015	2016	2017	2018	2019	2020 and beyond
Effective Discount	40%	39%	38%	38%	36% R	35%

Pursuant to Commission Decision (D.) 15-07-001, the average effective CARE discount for residential customers will decrease 1% each year until an average effective discount of 35% is reached in 2020.

The average effective CARE discount consists of: (a) exemptions from paying the CARE Surcharge, Department of Water Resources Bond Charge (DWR-BC), Vehicle-Grid Integration (VGI) costs, and California Solar Initiative (CSI); (b) a 50% minimum bill relative to Non-CARE; and (c) a separate line-item bill discount for all qualified residential CARE customers with the exclusion of CARE Medical Baseline customers taking service on tiered rates schedules. D.15-07-001 retained the rate subsidies in Non-CARE Medical Baseline tiered rates and thereby a separate line-item discount is provided for these CARE Medical Baseline customers

6.2.5 SMUD

Following are the SMUD electricity tariffs applied in this study.

II. Firm Service Rates

A. Time-of-Day (5-8 p.m.) Rate — **Rate Category RT02**

Effective January 1, 2021	
Non-Summer Prices*	
System Infrastructure Fixed Charge per month	$22.25
Electricity Usage Charge	
Peak $/kWh	$0.1465
Off-Peak $/kWh	$0.1061
Summer Prices	
System Infrastructure Fixed Charge per month	$22.25
Electricity Usage Charge	
Peak $/kWh	$0.3105
Mid-Peak $/kWh	$0.1765
Off-Peak $/kWh	$0.1277
Effective October 1, 2021	
Non-Summer Prices*	
System Infrastructure Fixed Charge per month	$22.70
Electricity Usage Charge	
Peak $/kWh	$0.1494
Off-Peak $/kWh	$0.1082
Summer Prices	
System Infrastructure Fixed Charge per month	$22.70
Electricity Usage Charge	
Peak $/kWh	$0.3167
Mid-Peak $/kWh	$0.1800
Off-Peak $/kWh	$0.1303

* Non-Summer Season includes Fall (Oct 1 – Nov 30), Winter (Dec 1 – Mar 31) and Spring (Apr 1 – May 31) periods.

Summer (Jun 1 - Sept 30)	**Peak**	Weekdays between 5:00 p.m. and 8:00 p.m.
	Mid-Peak	Weekdays between noon and midnight except during the Peak hours.
	Off-Peak	All other hours, including weekends and holidays[1].
Non-Summer (Oct 1 - May 31)	**Peak**	Weekdays between 5:00 p.m. and 8:00 p.m.
	Off-Peak	All other hours, including weekends and holidays[1].

6.2.6 CPAU

Following are the CPAU electricity and natural gas tariffs applied in this study. The CPAU monthly gas rate in $/therm was applied on a monthly basis for the 12-month period ending August 2021 according to the rates shown in Table 27. The distribution charge was $0.4835/therm for Tier 1 and $1.0426/therm for Tier 2. The monthly service charge applied was $10.94 per month per the G-1 tariff in effect at the time of the analysis.

Table 27: CPAU Monthly Gas Rate ($/therm)

Effective Date	Commodity Rate	Cap and Trade Compliance Charge	Transportation Charge	Carbon Offset Charge	G1 Tier 1 Volumetric Totals	G1 Tier 2 Volumetric Totals
Jan 2021	$0.3436	$0.0486	$0.11104	$0.040	$1.04704	$1.83144
Feb 2021	$0.3309	$0.0486	$0.11104	$0.040	$1.03434	$1.81874
Mar 2021	$0.3577	$0.0486	$0.12200	$0.040	$1.0721	$1.8565
Apr 2021	$0.3375	$0.0486	$0.12200	$0.040	$1.0519	$1.8363
May 2021	$0.3901	$0.0486	$0.12200	$0.040	$1.1045	$1.8889
June 2021	$0.3982	$0.0486	$0.12214	$0.040	$1.11274	$1.89714
July 2021	$0.4800	$0.0486	$0.12274	$0.040	$1.22034	$2.04394
Aug 2021	$0.5492	$0.0486	$0.12274	$0.040	$1.28954	$2.11314
Sept 2020	$0.3203	$0.033	$0.09862	$0.040	$0.99572	$1.78012
Oct 2020	$0.3724	$0.033	$0.09862	$0.040	$1.04782	$1.83222
Nov 2020	$0.3749	$0.033	$0.09862	$0.040	$1.05032	$1.83472
Dec 2020	$0.3446	$0.033	$0.09862	$0.040	$1.02002	$1.80442

RESIDENTIAL ELECTRIC SERVICE

UTILITY RATE SCHEDULE E-1

A. APPLICABILITY:

This Rate Schedule applies to separately metered single-family residential dwellings receiving Electric Service from the City of Palo Alto Utilities.

B. TERRITORY:

This rate schedule applies everywhere the City of Palo Alto provides Electric Service.

C. UNBUNDLED RATES:

Per kilowatt-hour (kWh)	Commodity	Distribution	Public Benefits	Total
Tier 1 usage	$0.08339	$0.04971	$0.00447	$0.13757
Tier 2 usage Any usage over Tier 1	0.11569	0.07351	0.00447	0.19367
Minimum Bill ($/day)				0.3283

EXPORT ELECTRICITY COMPENSATION

UTILITY RATE SCHEDULE E-EEC-1

A. APPLICABILITY:

This Rate Schedule applies in conjunction with the otherwise applicable Rate Schedules for each Customer class. This Rate Schedule may not apply in conjunction with any time-of-use Rate Schedule. This Rate Schedule applies to Customer-Generators as defined in Rule and Regulation 2 who are either not eligible for Net Energy Metering or who are eligible for Net Energy metering but elect to take Service under this Rate Schedule.

B. TERRITORY:

This Rate Schedule applies anywhere the City of Palo Alto provides Electric Service.

C. RATE:

The following buyback rate shall apply to all electricity exported to the grid.

	Per kWh
Export electricity compensation rate	$0.1078

6.2.7 Escalation Assumptions

The average annual escalation rates in Table 28 were used in this study. These are based on assumptions from the CPUC 2021 En Banc hearings on utility costs through 2030 (California Public Utilities Commission, 2021b). Escalation rates through the remainder of the 30-year evaluation period are based on the escalation rate assumptions within the 2022 TDV factors.

Table 28: Real Utility Rate Escalation Rate Assumptions

	Statewide Natural Gas Residential Average Rate (%/year, real)	Electric Residential Average Rate (%/year escalation, real)		
		PG&E	SCE	SDG&E
2022	4.6%	1.80%	1.60%	2.80%
2023	4.6%	1.80%	1.60%	2.80%
2024	4.6%	1.80%	1.60%	2.80%
2025	4.6%	1.80%	1.60%	2.80%
2026	4.6%	1.80%	1.60%	2.80%
2027	4.6%	1.80%	1.60%	2.80%
2028	4.6%	1.80%	1.60%	2.80%
2029	4.6%	1.80%	1.60%	2.80%
2030	4.6%	1.80%	1.60%	2.80%
2031	2.0%	0.57%	0.57%	0.57%
2032	2.4%	0.57%	0.57%	0.57%
2033	2.1%	0.57%	0.57%	0.57%
2034	1.9%	0.57%	0.57%	0.57%
2035	1.9%	0.57%	0.57%	0.57%
2036	1.8%	0.57%	0.57%	0.57%
2037	1.7%	0.57%	0.57%	0.57%
2038	1.6%	0.57%	0.57%	0.57%
2039	2.1%	0.57%	0.57%	0.57%
2040	1.6%	0.57%	0.57%	0.57%
2041	2.2%	0.57%	0.57%	0.57%
2042	2.2%	0.57%	0.57%	0.57%
2043	2.3%	0.57%	0.57%	0.57%
2044	2.4%	0.57%	0.57%	0.57%
2045	2.5%	0.57%	0.57%	0.57%
2046	1.5%	0.57%	0.57%	0.57%
2047	1.3%	0.57%	0.57%	0.57%
2048	1.6%	0.57%	0.57%	0.57%
2049	1.3%	0.57%	0.57%	0.57%
2050	1.5%	0.57%	0.57%	0.57%
2051	1.8%	0.57%	0.57%	0.57%

6.3 Appendix C: Standards Sections

2019 Building Energy Efficiency Standards Section 150.2(b)1I

Roofs. Replacements of the exterior surface of existing roofs, including adding a new surface layer on top of the existing exterior surface, shall meet the requirements of Section 110.8 and the applicable requirements of Subsections i and ii where more than 50 percent of the roof is being replaced.

i. Low-rise residential buildings with steep-sloped roofs, in Climate Zones 10 through 15 shall have a minimum aged solar reflectance of 0.20 and a minimum thermal emittance of 0.75, or a minimum SRI of 16.

EXCEPTION TO 150.2(b)1Ii: The following shall be considered equivalent to Subsection i:

a. Air-space of 1.0 inch (25 mm) is provided between the top of the roof deck to the bottom of the roofing product; or
b. The installed roofing product has a profile ratio of rise to width of 1 to 5 for 50 percent or greater of the width of the roofing product; or
c. Existing ducts in the attic are insulated and sealed according to Section 150.1(c)9; or
d. Buildings with at least R-38 ceiling insulation; or
e. Buildings with a radiant barrier in the attic meeting the requirements of Section 150.1(c)2; or
f. Buildings that have no ducts in the attic; or
g. In Climate Zones 10-15, R-2or greater insulation above the roof deck.

ii. Low-sloped roofs in Climate Zones 13 and 15 shall have a 3-year aged solar reflectance equal or greater than 0.63 and a thermal emittance equal or greater than 0.75, or a minimum SRI of 75.

EXCEPTION 1 to Section 150.2(b)1Iii: Buildings with no ducts in the attic.

EXCEPTION 2 to Section 150.2(b)1Iii: The aged solar reflectance can be met by using insulation at the roof deck specified in TABLE 150.2-B.

2019 Building Energy Efficiency Standards Section 150.2(b)1E

Altered Space-Conditioning System - Duct Sealing: In all climate zones, when a space-conditioning system serving a single family or multifamily dwelling is altered by the installation or replacement of space-conditioning system equipment, including replacement of the air handler, outdoor condensing unit of a split system air conditioner or heat pump, or cooling or heating coil; the duct system that is connected to the altered space-conditioning system equipment shall be sealed, as confirmed through field verification and diagnostic testing in accordance with the applicable procedures for duct sealing of altered existing duct systems as specified in Reference Residential Appendix RA3.1 and the leakage compliance criteria specified in subsection i, ii, or iii below. Additionally, when altered ducts, air-handling units, cooling or heating coils, or plenums are located in garage spaces, the system shall comply with Section 150.2(b)1Diic regardless of the length of any new or replacement space-conditioning ducts installed in the garage space.

i. The measured duct leakage shall be equal to or less than 15 percent of system air handler airflow as determined utilizing the procedures in Reference Residential Appendix Section RA3.1.4.3.1; or
ii. The measured duct leakage to outside shall be equal to or less than 10 percent of system air handler airflow as determined utilizing the procedures in Reference Residential Appendix Section RA3.1.4.3.4; or
iii. If it is not possible to meet the duct sealing requirements of either Section 150.2(b)1Ei or Section 150.2(b)1Eii, then, all accessible leaks shall be sealed and verified through a visual inspection and a smoke test by a certified HERS Rater utilizing the methods specified in Reference Residential Appendix RA3.1.4.3.5.

EXCEPTION 1 to Section 150.2(b)1E: Duct Sealing. Duct systems that are documented to have been previously sealed as confirmed through field verification and diagnostic testing in accordance with procedures in the Reference Residential Appendix RA3.1.

EXCEPTION 2 to Section 150.2(b)1E: Duct Sealing. Duct systems with less than 40 linear feet as determined by visual inspection.

EXCEPTION 3 to Section 150.2(b)1E: Duct Sealing. Existing duct systems constructed, insulated or sealed with asbestos.

6.4 Appendix D: Cost-Effectiveness Detail by Climate Zone

Detailed cost-effectiveness analysis results are summarized by vintage and climate zone in Table 29 through Table 112. Site energy savings, cost savings, measure cost, and cost effectiveness including lifecycle B/C ratio and NPV of savings are provided. For climate zones that are served by multiple utilities, where cost effectiveness may differ based on applicable utility rates, cost-effectiveness results are reported for both applicable utility territories.

Shaded cells in the tables and values in red indicate that the measure is not cost-effective with B/C ratios less than one. Cells with “n/a” reflect lighting and water heating efficiency measures and packages that did not look at TDV cost effectiveness.

6.4.1 Climate Zone 1:

Note: Values in red and grey rows indicate option is not cost-effective with B/C ratio less than 1. Cells with "n/a" reflect lighting and water heating efficiency measures and packages that did not look at TDV cost effectiveness or GHG impacts.

Table 29: CZ 1 - Multifamily Efficiency Upgrade Cost-Effectiveness Results

Measure	Vintage	Measure Cost ($)	Electricity Savings (kWh)	Gas Savings (therm)	GHG Savings (lb CO_2e)	Utility Cost Savings		Customer On-Bill		2019 TDV		2022 TDV	
						Year 1	Avg Annual	B/C Ratio	NPV	B/C Ratio	NPV	B/C Ratio	NPV
R-49 Attic Insulation	Pre-1978	$745	17	20	202	$41	$41	1.49	$407	1.22	$167	1.67	$503
	1978-1991	$745	8	10	101	$19	$20	0.71	-$245	0.62	-$286	0.84	-$120
	1992-2010	$625	3	4	38	$7	$7	0.31	-$485	0.28	-$452	0.38	-$389
Reduced Infiltration	Pre-1978	$448	11	14	143	$29	$30	1.78	$391	1.33	$150	1.95	$423
	1978-1991		7	10	100	$19	$20	1.17	$85	1.05	$22	1.36	$162
	1992-2010		4	7	74	$14	$14	0.83	-$86	0.81	-$85	1.00	$2
Duct Sealing	Pre-1978	$130	7	8	84	$17	$17	3.58	$377	3.08	$270	3.99	$389
	1978-1991	$130	3	3	36	$7	$7	1.46	$67	1.31	$40	1.71	$93
New Ducts	Pre-1978	$1,353	17	19	198	$40	$41	0.80	-$303	0.70	-$404	0.91	-$124
	1978-1991		10	11	117	$22	$23	0.45	-$837	0.43	-$777	0.54	-$619
	1992-2010		3	4	38	$7	$7	0.14	-$1,307	0.14	-$1,162	0.17	-$1,120
Cool Roof	Pre-1978	$225	-2	-3	-27	-$5	-$6	0.00	-$413	0.00	-$333	0.00	-$380
	1978-1991		-1	-2	-16	-$3	-$3	0.00	-$340	0.00	-$293	0.00	-$315
	1992-2010		0	-1	-10	-$2	-$2	0.00	-$301	0.00	-$270	0.00	-$284
R-13 Wall Insulation	Pre-1978	$1,006	36	45	460	$92	$93	2.48	$1,674	2.15	$1,155	2.79	$1,800
Floor Insulation	Pre-1978	$822	33	43	436	$87	$88	2.88	$1,731	2.29	$1,059	3.22	$1,822
Windows	Pre-1978	$5,873	43	50	512	$102	$103	0.47	-$3,495	0.28	-$4,206	0.54	-$2,697
	1978-1991		36	43	444	$84	$85	0.39	-$4,040	0.24	-$4,438	0.47	-$3,118
LED lamp vs CFL	All	$2.26	1.2	0	n/a	$0.29	$0.22	2.97	$4.45	n/a	n/a	n/a	n/a
Exterior Photosensor	All	$42.58	12.1	0	n/a	$3.09	$2.38	1.68	$28.96	n/a	n/a	n/a	n/a

Table 30: CZ 1 - Multifamily Efficiency Packages Cost-Effectiveness Results

Measure	Vintage	Measure Cost ($)	Electricity Savings (kWh)	Gas Savings (therm)	GHG Savings (lb CO_2e)	Utility Cost Savings		Customer On-Bill		2019 TDV		2022 TDV	
						Year 1	Avg Annual	B/C Ratio	NPV	B/C Ratio	NPV	B/C Ratio	NPV
R49 Attic & Air Sealing Package	Pre-1978	$1,193	28	34	347	$70	$71	1.59	$787	1.28	$339	1.79	$937
	1978-1991	$1,193	16	20	202	$39	$39	0.88	-$162	0.79	-$252	1.04	$50
	1992-2010	$1,073	8	11	112	$21	$21	0.53	-$570	0.50	-$534	0.64	-$384
R49 Attic & Duct Sealing Package	Pre-1978	$875	23	27	275	$55	$56	1.72	$703	1.44	$385	1.95	$830
	1978-1991	$875	11	13	131	$25	$26	0.78	-$216	0.69	-$267	0.93	-$59
R49 Attic, Air Sealing & Duct Sealing Package	Pre-1978	$1,323	34	41	416	$83	$85	1.71	$1,056	1.41	$537	1.94	$1,239
	1978-1991	$1,323	18	23	232	$44	$45	0.90	-$141	0.82	-$241	1.08	$104
	1992-2010	$1,203	8	11	112	$21	$21	0.47	-$716	0.45	-$664	0.57	-$514
R49 Attic, Air Sealing & New Ducts Package	Pre-1978	$2,546	42	50	513	$102	$104	1.09	$265	0.92	-$209	1.24	$618
	1978-1991	$2,546	24	29	301	$57	$58	0.61	-$1,117	0.56	-$1,113	0.73	-$684
	1992-2010	$2,427	10	14	145	$27	$27	0.30	-$1,903	0.29	-$1,716	0.37	-$1,531
Advanced Envelope Package	Pre-1978	$8,201	106	129	1,323	$256	$261	0.85	-$1,378	0.66	-$2,762	0.99	-$48
Water Heating Package	All Vintages	$168	0	12	0	$23	$17	1.37	$70	n/a	n/a	n/a	n/a

Table 31: CZ 1 - Multifamily PV & Battery Cost-Effectiveness Results

Measure	Vintage	Measure Cost ($)	Electricity Savings (kWh)	Gas Savings (therm)	GHG Savings (lb CO_2e)	Utility Cost Savings		Customer On-Bill		2019 TDV		2022 TDV	
						Year 1	Avg Annual	B/C Ratio	NPV	B/C Ratio	NPV	B/C Ratio	NPV
Prescriptive PV System	Pre-1978	$5,362	2,569	0	158	$538	$416	2.11	$6,563	1.92	$4,941	1.49	$2,638
	1978-1991		2,569		158	$531	$410	2.08	$6,392	1.92	$4,936	1.49	$2,635
	1992-2010		2,557		157	$522	$403	2.05	$6,189	1.90	$4,834	1.48	$2,596
PV + Battery	Pre-1978	$7,636	2,516	0	325	$543	$420	1.51	$4,263	1.53	$4,050	1.22	$1,717
	1978-1991		2,516		325	$536	$414	1.49	$4,091	1.53	$4,050	1.22	$1,715
	1992-2010		2,516		325	$528	$408	1.47	$3,907	1.53	$4,050	1.22	$1,717

Table 32: CZ 1 - Multifamily Equipment Fuel Substitution Cost-Effectiveness Results

Measure	Vintage	Measure Cost ($)	Electricity Savings (kWh)	Gas Savings (therm)	GHG Savings (lb CO_2e)	Utility Cost Savings		Customer On-Bill		2019 TDV		2022 TDV	
						Year 1	Avg Annual	B/C Ratio	NPV	B/C Ratio	NPV	B/C Ratio	NPV
Heat Pump at HVAC Replacement	Pre-1978	$227	-2,352	213	1,166	-$215	-$65	0.00	-$2,200	0.00	-$3,941	1.00	-$1
	1978-1991		-1,729	150	791	-$156	-$50	0.00	-$1,764	0.00	-$3,172	0.00	-$398
	1992-2010		-1,020	84	418	-$95	-$35	0.00	-$1,289	0.00	-$2,132	0.00	-$535
High-Effic. Heat Pump at HVAC Replacement	Pre-1978	$3,245	-2,020	213	1,295	-$122	$7	0.06	-$3,307	0.00	-$5,215	0.60	-$1,301
	1978-1991		-1,497	150	882	-$95	-$4	0.00	-$3,628	0.00	-$4,957	0.32	-$2,210
	1992-2010		-895	84	467	-$66	-$12	0.00	-$3,878	0.00	-$4,470	0.10	-$2,908
Heat Pump at HVAC Replacement + PV	Pre-1978	$5,588	217	213	1,324	$438	$439	2.14	$7,015	1.20	$1,091	1.48	$2,681
	1978-1991		839	150	949	$475	$437	2.13	$6,950	1.33	$1,841	1.41	$2,270
	1992-2010		1,548	84	575	$526	$445	2.17	$7,184	1.51	$2,848	1.38	$2,121
HVAC HP Replacement, PV, + Panel Upgrade	Pre-1978	$8,769	217	213	1,324	$438	$439	1.35	$3,443	0.76	-$2,090	0.94	-$500
	1978-1991		839	150	949	$475	$437	1.35	$3,378	0.85	-$1,340	0.90	-$911
	1992-2010		1,548	84	575	$526	$445	1.37	$3,612	0.96	-$333	0.88	-$1,060
HPWH at Water Heater Replacement	Pre-1978	$2,594	-1,504	151	1,090	-$199	-$83	0.00	-$5,379	0.00	-$4,985	0.55	-$1,161
	1978-1991		-1,504	151	1,090	-$205	-$91	0.00	-$5,615	0.00	-$4,985	0.55	-$1,161
	1992-2010		-1,504	151	1,090	-$208	-$95	0.00	-$5,727	0.00	-$4,985	0.55	-$1,161
NEEA Tier 3 HPWH at Replacement	Pre-1978	$2,775	-1,088	151	1,224	-$64	$21	0.21	-$2,445	0.00	-$3,266	1.30	$840
	1978-1991		-1,088	151	1,224	-$70	$14	0.13	-$2,681	0.00	-$3,266	1.30	$840
	1992-2010		-1,088	151	1,224	-$73	$10	0.10	-$2,792	0.00	-$3,266	1.30	$840
HPWH at Water Heater Replacement + PV	Pre-1978	$7,955	1,064	151	1,248	$510	$465	1.58	$5,143	1.02	$189	1.21	$1,709
	1978-1991		1,064	151	1,248	$501	$455	1.55	$4,837	1.02	$186	1.21	$1,707
	1992-2010		1,064	151	1,248	$495	$449	1.53	$4,658	1.02	$181	1.21	$1,706
HPWH Replacement, PV, + Panel Upgrade	Pre-1978	$11,136	1,064	151	1,248	$510	$465	1.13	$1,571	0.73	-$2,992	0.87	-$1,472
	1978-1991		1,064	151	1,248	$501	$455	1.10	$1,265	0.73	-$2,995	0.87	-$1,474
	1992-2010		1,064	151	1,248	$495	$449	1.09	$1,086	0.73	-$3,000	0.87	-$1,475
PV + Electric Ready Pre-Wire	Pre-1978	$9,453	2,569	0	868	$538	$416	1.19	$1,970	1.09	$850	0.85	-$1,453
	1978-1991		2,569	0	910	$531	$410	1.17	$1,798	0.75	-$2,318	0.85	-$1,456
	1992-2010		2,557	0	971	$522	$403	1.15	$1,595	0.41	-$5,610	0.84	-$1,495

6.4.2 Climate Zone 2:

Note: Values in red and grey rows indicate option is not cost-effective with B/C ratio less than 1. Cells with "n/a" reflect lighting and water heating efficiency measures and packages that did not look at TDV cost effectiveness or GHG impacts.

Table 33: CZ 2 - Multifamily Efficiency Upgrade Cost-Effectiveness Results

Measure	Vintage	Measure Cost ($)	Electricity Savings (kWh)	Gas Savings (therm)	GHG Savings (lb CO_2e)	Utility Cost Savings		Customer On-Bill		2019 TDV		2022 TDV	
						Year 1	Avg Annual	B/C Ratio	NPV	B/C Ratio	NPV	B/C Ratio	NPV
R-49 Attic Insulation	Pre-1978	$745	141	12	142	$70	$60	2.14	$956	1.96	$712	2.24	$921
	1978-1991	$745	72	6	70	$34	$29	1.04	$32	1.01	$8	1.19	$142
	1992-2010	$625	20	2	26	$10	$9	0.37	-$442	0.46	-$336	0.58	-$266
Reduced Infiltration	Pre-1978	$448	1	9	94	$16	$16	0.97	-$13	0.97	-$11	1.42	$190
	1978-1991		-3	7	66	$10	$11	0.63	-$188	0.63	-$167	0.91	-$39
	1992-2010		1	5	50	$9	$9	0.53	-$237	0.58	-$188	0.81	-$85
Duct Sealing	Pre-1978	$130	75	5	62	$35	$29	6.05	$736	7.00	$781	9.39	$1,091
	1978-1991	$130	41	2	29	$18	$15	3.02	$295	4.01	$391	5.06	$528
New Ducts	Pre-1978	$1,353	168	11	144	$80	$67	1.32	$485	1.55	$746	2.10	$1,482
	1978-1991		125	6	92	$53	$44	0.87	-$197	1.16	$220	1.58	$779
	1992-2010		30	2	30	$13	$11	0.22	-$1,187	0.38	-$833	0.53	-$638
Cool Roof	Pre-1978	$225	69	-1	-1	$23	$17	2.13	$276	1.93	$210	2.24	$279
	1978-1991		50	-1	1	$16	$12	1.51	$124	1.55	$124	1.87	$196
	1992-2010		21	-1	-1	$6	$4	0.49	-$125	0.85	-$34	0.96	-$10
R-13 Wall Insulation	Pre-1978	$1,006	38	25	265	$55	$54	1.43	$487	1.81	$811	2.15	$1,158
Floor Insulation	Pre-1978	$822	-70	18	162	$4	$11	0.37	-$581	0.21	-$652	0.68	-$264
Windows	Pre-1978	$5,873	351	18	262	$151	$125	0.57	-$2,853	0.52	-$2,847	0.81	-$1,134
	1978-1991		284	16	224	$117	$98	0.44	-$3,660	0.42	-$3,380	0.68	-$1,895
LED lamp vs CFL	All	$2.26	1.2	0	n/a	$0.29	$0.22	2.97	$4.45	n/a	n/a	n/a	n/a
Exterior Photosensor	All	$42.58	12.1	0	n/a	$3.09	$2.38	1.68	$28.96	n/a	n/a	n/a	n/a

Table 34: CZ 2 - Multifamily Efficiency Packages Cost-Effectiveness Results

Measure	Vintage	Measure Cost ($)	Electricity Savings (kWh)	Gas Savings (therm)	GHG Savings (lb CO_2e)	Utility Cost Savings		Customer On-Bill		2019 TDV		2022 TDV	
						Year 1	Avg Annual	B/C Ratio	NPV	B/C Ratio	NPV	B/C Ratio	NPV
R49 Attic & Air Sealing Package	Pre-1978	$1,193	142	21	236	$86	$76	1.70	$938	1.60	$713	1.97	$1,154
	1978-1991	$1,193	69	12	136	$44	$40	0.89	-$148	0.87	-$151	1.08	$98
	1992-2010	$1,073	22	7	77	$19	$18	0.44	-$674	0.50	-$536	0.64	-$390
R49 Attic & Duct Sealing Package	Pre-1978	$875	204	16	196	$99	$84	2.56	$1,536	2.65	$1,440	3.22	$1,943
	1978-1991	$875	108	7	95	$49	$41	1.26	$254	1.38	$335	1.71	$623
R49 Attic, Air Sealing & Duct Sealing Package	Pre-1978	$1,323	204	25	288	$114	$100	2.01	$1,503	2.11	$1,469	2.63	$2,160
	1978-1991	$1,323	104	14	159	$58	$51	1.04	$57	1.17	$221	1.47	$620
	1992-2010	$1,203	22	7	77	$19	$18	0.39	-$820	0.45	-$666	0.57	-$520
R49 Attic, Air Sealing & New Ducts Package	Pre-1978	$2,546	289	30	361	$152	$131	1.37	$1,071	1.55	$1,399	1.98	$2,500
	1978-1991	$2,546	182	18	215	$90	$77	0.81	-$542	1.02	$47	1.31	$791
	1992-2010	$2,427	49	9	103	$31	$28	0.31	-$1,892	0.43	-$1,374	0.55	-$1,092
Advanced Envelope Package	Pre-1978	$8,201	455	73	834	$274	$245	0.80	-$1,858	0.85	-$1,198	1.16	$1,303
Water Heating Package	All Vintages	$168	0	12	0	$38	$19	1.52	$98	n/a	n/a	n/a	n/a

Table 35: CZ 2 - Multifamily PV & Battery Cost-Effectiveness Results

Measure	Vintage	Measure Cost ($)	Electricity Savings (kWh)	Gas Savings (therm)	GHG Savings (lb CO_2e)	Utility Cost Savings		Customer On-Bill		2019 TDV		2022 TDV	
						Year 1	Avg Annual	B/C Ratio	NPV	B/C Ratio	NPV	B/C Ratio	NPV
Prescriptive PV System	Pre-1978	$4,815	2,693	0	169	$661	$511	2.89	$10,016	2.31	$6,309	1.80	$3,867
	1978-1991		2,693		169	$632	$489	2.76	$9,350	2.31	$6,298	1.80	$3,858
	1992-2010		2,693		169	$571	$442	2.49	$7,934	2.26	$6,078	1.80	$3,837
PV + Battery	Pre-1978	$7,090	2,637	0	307	$675	$521	2.03	$7,916	1.66	$4,648	1.31	$2,206
	1978-1991		2,637		313	$639	$494	1.92	$7,096	1.67	$4,758	1.32	$2,239
	1992-2010		2,637		330	$578	$447	1.74	$5,680	1.73	$5,193	1.36	$2,535

Table 36: CZ 2 - Multifamily Equipment Fuel Substitution Cost-Effectiveness Results

Measure	Vintage	Measure Cost ($)	Electricity Savings (kWh)	Gas Savings (therm)	GHG Savings (lb CO_2e)	Utility Cost Savings		Customer On-Bill		2019 TDV		2022 TDV	
						Year 1	Avg Annual	B/C Ratio	NPV	B/C Ratio	NPV	B/C Ratio	NPV
Heat Pump at HVAC Replacement	Pre-1978	$227	-1,182	105	504	-$119	-$44	0.00	-$1,560	0.00	-$3,941	1.71	$162
	1978-1991		-788	69	323	-$68	-$21	0.00	-$877	0.00	-$3,172	1.01	$2
	1992-2010		-608	53	247	-$52	-$16	0.00	-$726	0.00	-$2,132	0.38	-$141
High-Effic. Heat Pump at HVAC Replacement	Pre-1978	$3,245	-925	105	606	-$38	$19	0.16	-$2,953	0.00	-$5,215	0.75	-$804
	1978-1991		-611	69	393	-$19	$17	0.14	-$3,014	0.00	-$4,957	0.55	-$1,462
	1992-2010		-490	53	296	-$21	$8	0.06	-$3,286	0.00	-$4,470	0.36	-$2,073
Heat Pump at HVAC Replacement + PV	Pre-1978	$5,042	1,510	105	673	$554	$476	2.57	$8,733	1.20	$1,091	1.80	$4,044
	1978-1991		1,905	69	492	$584	$483	2.60	$8,925	1.33	$1,841	1.77	$3,871
	1992-2010		2,085	53	416	$594	$483	2.61	$8,927	1.51	$2,848	1.74	$3,711
HVAC HP Replacement, PV, + Panel Upgrade	Pre-1978	$8,223	1,510	105	673	$554	$476	1.57	$5,161	0.76	-$2,090	1.10	$863
	1978-1991		1,905	69	492	$584	$483	1.59	$5,353	0.85	-$1,340	1.08	$690
	1992-2010		2,085	53	416	$594	$483	1.59	$5,355	0.96	-$333	1.06	$530
HPWH at Water Heater Replacement	Pre-1978	$2,594	-1,171	141	1,057	-$100	-$16	0.00	-$3,361	0.00	-$4,985	1.06	$163
	1978-1991		-1,171	141	1,057	-$96	-$13	0.00	-$3,285	0.00	-$4,985	1.06	$163
	1992-2010		-1,171	141	1,057	-$78	$1	0.01	-$2,870	0.00	-$4,985	1.06	$163
NEEA Tier 3 HPWH at Replacement	Pre-1978	$2,775	-937	141	1,149	-$27	$40	0.39	-$1,880	0.00	-$3,266	1.41	$1,144
	1978-1991		-937	141	1,149	-$25	$42	0.41	-$1,826	0.00	-$3,266	1.41	$1,144
	1992-2010		-937	141	1,149	-$11	$52	0.51	-$1,523	0.00	-$3,266	1.41	$1,144
HPWH at Water Heater Replacement + PV	Pre-1978	$7,409	1,522	141	1,226	$606	$530	1.94	$7,695	1.02	$189	1.57	$4,216
	1978-1991		1,522	141	1,226	$596	$522	1.91	$7,455	1.02	$186	1.57	$4,209
	1992-2010		1,522	141	1,226	$592	$519	1.90	$7,355	1.02	$181	1.57	$4,189
HPWH Replacement, PV, + Panel Upgrade	Pre-1978	$10,590	1,522	141	1,226	$606	$530	1.35	$4,123	0.73	-$2,992	1.10	$1,035
	1978-1991		1,522	141	1,226	$596	$522	1.33	$3,883	0.73	-$2,995	1.10	$1,028
	1992-2010		1,522	141	1,226	$592	$519	1.32	$3,783	0.73	-$3,000	1.10	$1,008
PV + Electric Ready Pre-Wire	Pre-1978	$8,906	2,693	0	1,049	$661	$511	1.55	$5,422	1.09	$850	0.97	-$224
	1978-1991		2,693	0	1,080	$632	$489	1.48	$4,756	0.75	-$2,318	0.97	-$233
	1992-2010		2,693	0	1,072	$571	$442	1.34	$3,340	0.41	-$5,610	0.97	-$254

6.4.3 Climate Zone 3:

Note: Values in red and grey rows indicate option is not cost-effective with B/C ratio less than 1. Cells with "n/a" reflect lighting and water heating efficiency measures and packages that did not look at TDV cost effectiveness or GHG impacts.

Table 37: CZ 3 - Multifamily Efficiency Upgrade Cost-Effectiveness Results

Measure	Vintage	Measure Cost ($)	Electricity Savings (kWh)	Gas Savings (therm)	GHG Savings (lb CO_2e)	Utility Cost Savings		Customer On-Bill		2019 TDV		2022 TDV	
						Year 1	Avg Annual	B/C Ratio	NPV	B/C Ratio	NPV	B/C Ratio	NPV
R-49 Attic Insulation	Pre-1978	$745	42	10	106	$30	$28	1.00	-$2	1.15	$113	1.25	$187
	1978-1991	$745	19	4	48	$13	$12	0.44	-$469	0.62	-$281	0.62	-$280
	1992-2010	$625	6	2	18	$5	$4	0.18	-$575	0.26	-$460	0.29	-$442
Reduced Infiltration	Pre-1978	$448	-1	7	74	$12	$12	0.73	-$134	0.92	-$36	0.98	-$10
	1978-1991		-2	5	45	$6	$7	0.42	-$293	0.62	-$171	0.57	-$191
	1992-2010		0	3	34	$5	$6	0.34	-$331	0.48	-$233	0.47	-$236
Duct Sealing	Pre-1978	$130	16	3	37	$11	$10	2.00	$146	2.45	$189	3.64	$343
	1978-1991	$130	8	1	14	$5	$4	0.85	-$22	1.10	$13	1.82	$106
New Ducts	Pre-1978	$1,353	41	8	89	$26	$24	0.47	-$798	0.62	-$513	0.89	-$146
	1978-1991		29	4	49	$16	$14	0.29	-$1,086	0.40	-$810	0.64	-$494
	1992-2010		6	1	15	$4	$4	0.07	-$1,408	0.11	-$1,201	0.19	-$1,094
Cool Roof	Pre-1978	$225	20	-1	-6	$5	$4	0.44	-$137	0.37	-$142	0.59	-$93
	1978-1991		13	-1	-3	$3	$2	0.29	-$173	0.41	-$132	0.59	-$93
	1992-2010		5	0	-3	$1	$1	0.07	-$229	0.17	-$186	0.30	-$157
R-13 Wall Insulation	Pre-1978	$1,006	13	19	198	$35	$36	0.96	-$43	1.23	$234	1.37	$373
Floor Insulation	Pre-1978	$822	-22	18	177	$22	$25	0.82	-$162	0.95	-$39	0.79	-$173
Windows	Pre-1978	$5,873	82	20	223	$60	$55	0.25	-$4,934	0.22	-$4,571	0.44	-$3,279
	1978-1991		57	16	175	$44	$41	0.19	-$5,362	0.19	-$4,771	0.35	-$3,811
LED lamp vs CFL	All	$2.26	1.2	0	n/a	$0.29	$0.22	2.97	$4.45	n/a	n/a	n/a	n/a
Exterior Photosensor	All	$42.58	12.1	0	n/a	$3.09	$2.38	1.68	$28.96	n/a	n/a	n/a	n/a

Table 38: CZ 3 - Multifamily Efficiency Packages Cost-Effectiveness Results

Measure	Vintage	Measure Cost ($)	Electricity Savings (kWh)	Gas Savings (therm)	GHG Savings (lb CO_2e)	Utility Cost Savings		Customer On-Bill		2019 TDV		2022 TDV	
						Year 1	Avg Annual	B/C Ratio	NPV	B/C Ratio	NPV	B/C Ratio	NPV
R49 Attic & Air Sealing Package	Pre-1978	$1,193	42	17	180	$42	$40	0.91	-$127	1.07	$85	1.15	$178
	1978-1991	$1,193	17	9	93	$20	$19	0.43	-$760	0.62	-$448	0.61	-$470
	1992-2010	$1,073	6	5	52	$10	$10	0.25	-$905	0.36	-$691	0.37	-$677
R49 Attic & Duct Sealing Package	Pre-1978	$875	55	12	137	$39	$36	1.09	$84	1.29	$257	1.56	$492
	1978-1991	$875	26	5	60	$17	$16	0.48	-$511	0.67	-$285	0.78	-$189
R49 Attic, Air Sealing & Duct Sealing Package	Pre-1978	$1,323	55	19	208	$50	$48	0.96	-$55	1.16	$214	1.35	$468
	1978-1991	$1,323	24	10	104	$24	$23	0.46	-$805	0.65	-$459	0.71	-$384
	1992-2010	$1,203	6	5	52	$10	$10	0.22	-$1,051	0.32	-$821	0.33	-$807
R49 Attic, Air Sealing & New Ducts Package	Pre-1978	$2,546	76	23	249	$63	$59	0.62	-$1,085	0.78	-$559	0.98	-$61
	1978-1991	$2,546	44	12	132	$34	$31	0.33	-$1,917	0.47	-$1,339	0.60	-$1,017
	1992-2010	$2,427	12	6	65	$13	$13	0.14	-$2,330	0.21	-$1,909	0.26	-$1,794
Advanced Envelope Package	Pre-1978	$8,201	131	53	568	$129	$124	0.40	-$5,504	0.48	-$4,262	0.66	-$2,798
Water Heating Package	All Vintages	$168	0	12	0	$36	$19	1.49	$92	n/a	n/a	n/a	n/a

Table 39: CZ 3 - Multifamily PV & Battery Cost-Effectiveness Results

Measure	Vintage	Measure Cost ($)	Electricity Savings (kWh)	Gas Savings (therm)	GHG Savings (lb CO_2e)	Utility Cost Savings		Customer On-Bill		2019 TDV		2022 TDV	
						Year 1	Avg Annual	B/C Ratio	NPV	B/C Ratio	NPV	B/C Ratio	NPV
Prescriptive PV System	Pre-1978	$4,559	2,660	0	173	$559	$432	2.58	$7,923	2.27	$5,784	1.84	$3,847
	1978-1991		2,649		173	$548	$424	2.53	$7,678	2.25	$5,690	1.84	$3,811
	1992-2010		2,559		167	$522	$404	2.41	$7,077	2.21	$5,497	1.78	$3,534
PV + Battery	Pre-1978	$6,833	2,602	0	348	$564	$436	1.76	$5,647	1.67	$4,606	1.35	$2,408
	1978-1991		2,602		350	$555	$429	1.73	$5,427	1.69	$4,713	1.36	$2,481
	1992-2010		2,602		357	$532	$411	1.66	$4,893	1.75	$5,108	1.44	$2,989

Table 40: CZ 3 - Multifamily Equipment Fuel Substitution Cost-Effectiveness Results

Measure	Vintage	Measure Cost ($)	Electricity Savings (kWh)	Gas Savings (therm)	GHG Savings (lb CO_2e)	Utility Cost Savings		Customer On-Bill		2019 TDV		2022 TDV	
						Year 1	Avg Annual	B/C Ratio	NPV	B/C Ratio	NPV	B/C Ratio	NPV
Heat Pump at HVAC Replacement	Pre-1978	$227	-714	70	350	-$53	-$9	0.00	-$525	0.00	-$933	2.67	$380
	1978-1991		-438	42	205	-$30	-$4	0.00	-$365	0.00	-$708	1.41	$94
	1992-2010		-327	32	154	-$23	-$3	0.00	-$352	0.00	-$591	1.08	$17
High-Effic. Heat Pump at HVAC Replacement	Pre-1978	$3,245	-583	70	410	-$16	$19	0.16	-$2,937	0.08	-$3,000	0.52	-$1,557
	1978-1991		-355	42	243	-$9	$12	0.10	-$3,160	0.04	-$3,102	0.34	-$2,141
	1992-2010		-274	32	180	-$10	$7	0.06	-$3,317	0.02	-$3,193	0.23	-$2,511
Heat Pump at HVAC Replacement + PV	Pre-1978	$4,785	1,945	70	523	$592	$489	2.78	$9,396	2.02	$4,876	1.88	$4,235
	1978-1991		2,221	42	378	$568	$458	2.60	$8,467	2.06	$5,088	1.82	$3,941
	1992-2010		2,332	32	328	$552	$441	2.51	$7,949	2.09	$5,204	1.81	$3,860
HVAC HP Replacement, PV, + Panel Upgrade	Pre-1978	$7,966	1,945	70	523	$592	$489	1.66	$5,824	1.21	$1,695	1.13	$1,054
	1978-1991		2,221	42	378	$568	$458	1.55	$4,895	1.24	$1,907	1.10	$760
	1992-2010		2,332	32	328	$552	$441	1.49	$4,377	1.25	$2,023	1.09	$679
HPWH at Water Heater Replacement	Pre-1978	$2,594	-1,037	141	1,108	-$101	-$18	0.00	-$3,425	0.00	-$3,053	1.29	$753
	1978-1991		-1,037	141	1,108	-$100	-$16	0.00	-$3,385	0.00	-$3,053	1.29	$753
	1992-2010		-1,037	141	1,108	-$95	-$13	0.00	-$3,275	0.00	-$3,053	1.29	$753
NEEA Tier 3 HPWH at Replacement	Pre-1978	$2,775	-842	141	1,195	-$37	$32	0.31	-$2,140	0.26	-$2,055	1.57	$1,591
	1978-1991		-842	141	1,195	-$36	$33	0.32	-$2,100	0.26	-$2,055	1.57	$1,591
	1992-2010		-842	141	1,195	-$31	$37	0.36	-$1,991	0.26	-$2,055	1.57	$1,591
HPWH at Water Heater Replacement + PV	Pre-1978	$7,152	1,623	141	1,282	$614	$535	2.03	$8,123	1.41	$2,936	1.67	$4,801
	1978-1991		1,623	141	1,282	$611	$533	2.02	$8,068	1.41	$2,935	1.67	$4,798
	1992-2010		1,623	141	1,282	$609	$531	2.01	$8,014	1.41	$2,932	1.67	$4,792
HPWH Replacement, PV, + Panel Upgrade	Pre-1978	$10,333	1,623	141	1,282	$614	$535	1.40	$4,551	0.98	-$245	1.16	$1,620
	1978-1991		1,623	141	1,282	$611	$533	1.39	$4,496	0.98	-$246	1.16	$1,617
	1992-2010		1,623	141	1,282	$609	$531	1.39	$4,442	0.98	-$249	1.16	$1,611
PV + Electric Ready Pre-Wire	Pre-1978	$8,650	2,660	0	1,059	$559	$432	1.35	$3,330	1.20	$1,693	0.97	-$244
	1978-1991		2,649	0	1,093	$548	$424	1.32	$3,084	0.95	-$454	0.97	-$280
	1992-2010		2,559	0	1,091	$522	$404	1.26	$2,483	0.77	-$1,970	0.94	-$557

Climate Zone 4 PG&E:

Note: Values in red and grey rows indicate option is not cost-effective with B/C ratio less than 1. Cells with "n/a" reflect lighting and water heating efficiency measures and packages that did not look at TDV cost effectiveness or GHG impacts.

Table 41: CZ 4 (PG&E) - Multifamily Efficiency Upgrade Cost-Effectiveness Results

Measure	Vintage	Measure Cost ($)	Electricity Savings (kWh)	Gas Savings (therm)	GHG Savings (lb CO_2e)	Utility Cost Savings		Customer On-Bill		2019 TDV		2022 TDV	
						Year 1	Avg Annual	B/C Ratio	NPV	B/C Ratio	NPV	B/C Ratio	NPV
R-49 Attic Insulation	Pre-1978	$745	148	8	107	$68	$56	2.02	$850	1.98	$729	2.07	$801
	1978-1991	$745	75	4	50	$35	$28	1.02	$18	1.05	$41	1.20	$152
	1992-2010	$625	23	1	20	$10	$8	0.36	-$448	0.43	-$357	0.42	-$360
Reduced Infiltration	Pre-1978	$448	-1	6	61	$9	$10	0.60	-$199	0.73	-$123	1.07	$31
	1978-1991		-4	4	39	$5	$6	0.35	-$325	0.50	-$222	0.78	-$100
	1992-2010		-1	3	30	$5	$5	0.30	-$354	0.37	-$282	0.45	-$248
Duct Sealing	Pre-1978	$130	97	3	47	$41	$33	6.72	$835	8.25	$943	9.44	$1,097
	1978-1991	$130	54	1	22	$22	$18	3.61	$382	5.13	$537	5.15	$540
New Ducts	Pre-1978	$1,353	235	7	116	$98	$79	1.56	$857	2.04	$1,410	$929	$349
	1978-1991		185	4	79	$75	$60	1.18	$267	1.62	$835	$874	$311
	1992-2010		50	1	25	$19	$15	0.30	-$1,069	0.48	-$706	$742	$297
Cool Roof	Pre-1978	$225	83	-1	6	$29	$22	2.72	$422	2.98	$446	$985	$362
	1978-1991		62	0	7	$22	$17	2.07	$262	2.23	$278	$920	$318
	1992-2010		27	0	3	$8	$6	0.77	-$56	1.02	$4	$750	$300
R-13 Wall Insulation	Pre-1978	$1,006	40	16	171	$41	$39	1.04	$43	1.40	$400	$1,002	$333
Floor Insulation	Pre-1978	$822	-81	12	106	-$10	-$2	0.00	-$980	0.00	-$876	$1,077	$349
Windows	Pre-1978	$5,873	475	10	191	$189	$150	0.68	-$2,084	0.62	-$2,224	$843	$345
	1978-1991		394	8	166	$157	$125	0.57	-$2,854	0.53	-$2,777	$800	$304
LED lamp vs CFL	All	$2.26	1.2	0	n/a	$0.29	$0.22	2.97	$4.45	n/a	n/a	n/a	n/a
Exterior Photosensor	All	$42.58	12.1	0	n/a	$3.09	$2.38	1.68	$28.96	n/a	n/a	n/a	n/a

Table 42: CZ 4 (PG&E) - Multifamily Efficiency Packages Cost-Effectiveness Results

Measure	Vintage	Measure Cost ($)	Electricity Savings (kWh)	Gas Savings (therm)	GHG Savings (lb CO_2e)	Utility Cost Savings		Customer On-Bill		2019 TDV		2022 TDV	
						Year 1	Avg Annual	B/C Ratio	NPV	B/C Ratio	NPV	B/C Ratio	NPV
R49 Attic & Air Sealing Package	Pre-1978	$1,193	148	14	167	$78	$67	1.49	$658	1.54	$648	1.75	$892
	1978-1991	$1,193	70	8	91	$39	$34	0.76	-$323	0.85	-$184	0.94	-$73
	1992-2010	$1,073	22	4	49	$15	$13	0.33	-$804	0.40	-$644	0.43	-$608
R49 Attic & Duct Sealing Package	Pre-1978	$875	234	11	149	$104	$85	2.60	$1,568	2.83	$1,598	3.02	$1,771
	1978-1991	$875	124	5	71	$54	$44	1.34	$336	1.59	$514	1.60	$526
R49 Attic, Air Sealing & Duct Sealing Package	Pre-1978	$1,323	232	17	207	$113	$95	1.91	$1,353	2.13	$1,495	2.38	$1,823
	1978-1991	$1,323	119	9	109	$59	$50	1.00	$1	1.19	$257	1.31	$409
	1992-2010	$1,203	22	4	49	$15	$13	0.30	-$950	0.36	-$774	0.39	-$738
R49 Attic, Air Sealing & New Ducts Package	Pre-1978	$2,546	364	20	270	$167	$138	1.45	$1,276	1.75	$1,909	1.83	$2,120
	1978-1991	$2,546	246	11	162	$109	$89	0.93	-$197	1.21	$524	1.19	$482
	1992-2010	$2,427	70	5	72	$32	$27	0.30	-$1,901	0.44	-$1,353	0.44	-$1,365
Advanced Envelope Package	Pre-1978	$8,201	560	46	566	$279	$237	0.77	-$2,107	0.84	-$1,287	0.99	-$117
Water Heating Package	All Vintages	$168	0	13	0	$41	$20	1.56	$106	n/a	n/a	n/a	n/a

Table 43: CZ 4 (PG&E) - Multifamily PV & Battery Cost-Effectiveness Results

Measure	Vintage	Measure Cost ($)	Electricity Savings (kWh)	Gas Savings (therm)	GHG Savings (lb CO_2e)	Utility Cost Savings		Customer On-Bill		2019 TDV		2022 TDV	
						Year 1	Avg Annual	B/C Ratio	NPV	B/C Ratio	NPV	B/C Ratio	NPV
Prescriptive PV System	Pre-1978	$4,705	2,798	0	182	$713	$551	3.18	$11,337	2.38	$6,481	1.99	$4,663
	1978-1991		2,798		182	$701	$542	3.13	$11,060	2.38	$6,472	1.99	$4,649
	1992-2010		2,798		182	$626	$484	2.80	$9,322	2.36	$6,418	1.98	$4,618
PV + Battery	Pre-1978	$6,979	2,738	0	306	$726	$561	2.21	$9,229	1.65	$4,521	1.43	$2,971
	1978-1991		2,738		310	$715	$552	2.18	$8,964	1.65	$4,565	1.43	$3,000
	1992-2010		2,738		334	$634	$490	1.93	$7,096	1.80	$5,597	1.49	$3,424

Table 44: CZ 4 (PG&E) - Multifamily Equipment Fuel Substitution Cost-Effectiveness Results

Measure	Vintage	Measure Cost ($)	Electricity Savings (kWh)	Gas Savings (therm)	GHG Savings (lb CO_2e)	Utility Cost Savings		Customer On-Bill		2019 TDV		2022 TDV	
						Year 1	Avg Annual	B/C Ratio	NPV	B/C Ratio	NPV	B/C Ratio	NPV
Heat Pump at HVAC Replacement	Pre-1978	$227	-620	58	278	-$57	-$18	0.00	-$785	0.00	-$1,855	1.53	$121
	1978-1991		-382	35	160	-$41	-$16	0.00	-$724	0.00	-$1,285	0.62	-$87
	1992-2010		-280	25	116	-$27	-$9	0.00	-$518	0.00	-$1,080	0.43	-$129
High-Effic. Heat Pump at HVAC Replacement	Pre-1978	$3,245	-374	58	366	$21	$43	0.37	-$2,228	0.09	-$2,949	0.70	-$977
	1978-1991		-195	35	225	$21	$32	0.27	-$2,553	0.13	-$2,812	0.52	-$1,573
	1992-2010		-158	25	163	$12	$21	0.18	-$2,888	0.07	-$3,033	0.36	-$2,085
Heat Pump at HVAC Replacement + PV	Pre-1978	$4,932	2,177	58	460	$645	$525	2.90	$10,315	1.94	$4,647	1.97	$4,787
	1978-1991		2,416	35	342	$655	$522	2.88	$10,211	2.05	$5,202	1.93	$4,564
	1992-2010		2,518	25	299	$635	$502	2.77	$9,619	2.09	$5,390	1.91	$4,493
HVAC HP Replacement, PV, + Panel Upgrade	Pre-1978	$8,113	2,177	58	460	$645	$525	1.75	$6,743	1.18	$1,466	1.20	$1,606
	1978-1991		2,416	35	342	$655	$522	1.74	$6,639	1.25	$2,021	1.17	$1,383
	1992-2010		2,518	25	299	$635	$502	1.67	$6,047	1.27	$2,209	1.16	$1,312
HPWH at Water Heater Replacement	Pre-1978	$2,594	-924	134	1,068	-$44	$24	0.25	-$2,171	0.00	-$2,609	1.34	$887
	1978-1991		-924	134	1,068	-$41	$26	0.27	-$2,110	0.00	-$2,609	1.34	$887
	1992-2010		-924	134	1,068	-$28	$36	0.37	-$1,810	0.00	-$2,609	1.34	$887
NEEA Tier 3 HPWH at Replacement	Pre-1978	$2,775	-764	134	1,143	$4	$61	0.59	-$1,260	0.27	-$2,024	1.55	$1,530
	1978-1991		-764	134	1,143	$6	$63	0.61	-$1,207	0.27	-$2,024	1.55	$1,530
	1992-2010		-764	134	1,143	$17	$71	0.69	-$948	0.27	-$2,024	1.55	$1,530
HPWH at Water Heater Replacement + PV	Pre-1978	$7,299	1,874	134	1,250	$705	$603	2.24	$10,015	1.56	$4,057	1.78	$5,722
	1978-1991		1,874	134	1,250	$693	$593	2.20	$9,716	1.56	$4,051	1.78	$5,710
	1992-2010		1,874	134	1,250	$668	$574	2.13	$9,138	1.55	$4,033	1.78	$5,681
HPWH Replacement, PV, + Panel Upgrade	Pre-1978	$10,480	1,874	134	1,250	$705	$603	1.55	$6,443	1.08	$876	1.24	$2,541
	1978-1991		1,874	134	1,250	$693	$593	1.53	$6,144	1.08	$870	1.24	$2,529
	1992-2010		1,874	134	1,250	$668	$574	1.48	$5,566	1.08	$852	1.24	$2,500
PV + Electric Ready Pre-Wire	Pre-1978	$8,796	2,798	0	1,086	$713	$551	1.69	$6,743	1.27	$2,390	1.07	$572
	1978-1991		2,798	0	1,115	$701	$542	1.66	$6,467	0.92	-$704	1.06	$558
	1992-2010		2,798	0	1,108	$626	$484	1.48	$4,728	0.38	-$5,457	1.06	$527

6.4.4 Climate Zone 4 CPAU:

Note: Values in red and grey rows indicate option is not cost-effective with B/C ratio less than 1. Cells with "n/a" reflect lighting and water heating efficiency measures and packages that did not look at TDV cost effectiveness or GHG impacts.

Table 45: CZ 4 (CPAU) - Multifamily Efficiency Upgrade Cost-Effectiveness Results

Measure	Vintage	Measure Cost ($)	Electricity Savings (kWh)	Gas Savings (therm)	GHG Savings (lb CO_2e)	Utility Cost Savings		Customer On-Bill		2019 TDV		2022 TDV	
						Year 1	Avg Annual	B/C Ratio	NPV	B/C Ratio	NPV	B/C Ratio	NPV
R-49 Attic Insulation	Pre-1978	$745	148	8	107	$68	$56	1.07	$57	1.98	$729	2.07	$801
	1978-1991	$745	75	4	50	$35	$28	0.52	-$401	1.05	$41	1.20	$152
	1992-2010	$625	23	1	20	$10	$8	0.18	-$573	0.43	-$357	0.42	-$360
Reduced Infiltration	Pre-1978	$448	-1	6	61	$9	$10	0.38	-$312	0.73	-$123	1.07	$31
	1978-1991		-4	4	39	$5	$6	0.23	-$388	0.50	-$222	0.78	-$100
	1992-2010		-1	3	30	$5	$5	0.19	-$408	0.37	-$282	0.45	-$248
Duct Sealing	Pre-1978	$130	97	3	47	$41	$33	3.43	$354	8.25	$943	9.44	$1,097
	1978-1991	$130	54	1	22	$22	$18	1.75	$110	5.13	$537	5.15	$540
New Ducts	Pre-1978	$1,353	235	7	116	$98	$79	0.79	-$317	2.04	$1,410	2.13	$1,526
	1978-1991		185	4	79	$75	$60	0.57	-$647	1.62	$835	1.57	$767
	1992-2010		50	1	25	$19	$15	0.14	-$1,303	0.48	-$706	0.46	-$727
Cool Roof	Pre-1978	$225	83	-1	6	$29	$22	1.33	$81	2.98	$446	2.75	$395
	1978-1991		62	0	7	$22	$17	0.96	-$10	2.23	$278	2.24	$279
	1992-2010		27	0	3	$8	$6	0.35	-$161	1.02	$4	0.85	-$34
R-13 Wall Insulation	Pre-1978	$1,006	40	16	171	$41	$39	0.61	-$444	1.40	$400	1.58	$581
Floor Insulation	Pre-1978	$822	-81	12	106	-$10	-$2	0.06	-$865	0.00	-$876	0.42	-$474
Windows	Pre-1978	$5,873	475	10	191	$189	$150	0.34	-$4,355	0.62	-$2,224	0.81	-$1,107
	1978-1991		394	8	166	$157	$125	0.27	-$4,807	0.53	-$2,777	0.66	-$1,982
LED lamp vs CFL	All	$2.26	1.2	0	n/a	$0.17	$0.13	1.75	$1.70	n/a	n/a	n/a	n/a
Exterior Photosensor	All	$42.58	12.1	0	n/a	$1.66	$1.29	0.91	-$3.99	n/a	n/a	n/a	n/a

Table 46: CZ 4 (CPAU) - Multifamily Efficiency Packages Cost-Effectiveness Results

Measure	Vintage	Measure Cost ($)	Electricity Savings (kWh)	Gas Savings (therm)	GHG Savings (lb CO_2e)	Utility Cost Savings		Customer On-Bill		2019 TDV		2022 TDV	
						Year 1	Avg Annual	B/C Ratio	NPV	B/C Ratio	NPV	B/C Ratio	NPV
R49 Attic & Air Sealing Package	Pre-1978	$1,193	148	14	167	$78	$67	0.81	-$252	1.54	$648	1.75	$892
	1978-1991	$1,193	70	8	91	$39	$34	0.41	-$793	0.85	-$184	0.94	-$73
	1992-2010	$1,073	22	4	49	$15	$13	0.19	-$981	0.40	-$644	0.43	-$608
R49 Attic & Duct Sealing Package	Pre-1978	$875	234	11	149	$104	$85	1.34	$338	2.83	$1,598	3.02	$1,771
	1978-1991	$875	124	5	71	$54	$44	0.67	-$321	1.59	$514	1.60	$526
R49 Attic, Air Sealing & Duct Sealing Package	Pre-1978	$1,323	232	17	207	$113	$95	1.01	$20	2.13	$1,495	2.38	$1,823
	1978-1991	$1,323	119	9	109	$59	$50	0.52	-$713	1.19	$257	1.31	$409
	1992-2010	$1,203	22	4	49	$15	$13	0.17	-$1,127	0.36	-$774	0.39	-$738
R49 Attic, Air Sealing & New Ducts Package	Pre-1978	$2,546	364	20	270	$167	$138	0.75	-$715	1.75	$1,909	1.83	$2,120
	1978-1991	$2,546	246	11	162	$109	$89	0.47	-$1,513	1.21	$524	1.19	$482
	1992-2010	$2,427	70	5	72	$32	$27	0.15	-$2,305	0.44	-$1,353	0.44	-$1,365
Advanced Envelope Package	Pre-1978	$8,201	560	46	566	$279	$237	0.40	-$5,494	0.84	-$1,287	0.99	-$117
Water Heating Package	All Vintages	$168	0	13	0	$30	$16	1.24	$45	n/a	n/a	n/a	n/a

Table 47: CZ 4 (CPAU) - Multifamily PV & Battery Cost-Effectiveness Results

Measure	Vintage	Measure Cost ($)	Electricity Savings (kWh)	Gas Savings (therm)	GHG Savings (lb CO_2e)	Utility Cost Savings		Customer On-Bill		2019 TDV		2022 TDV	
						Year 1	Avg Annual	B/C Ratio	NPV	B/C Ratio	NPV	B/C Ratio	NPV
Prescriptive PV System	Pre-1978	$4,705	2,798	0	182	$713	$551	1.58	$3,024	2.38	$6,481	1.99	$4,663
	1978-1991		2,798		182	$701	$542	1.55	$2,870	2.38	$6,472	1.99	$4,649
	1992-2010		2,798		182	$626	$484	1.49	$2,542	2.36	$6,418	1.98	$4,618
PV + Battery	Pre-1978	$6,979	2,738	0	306	$726	$561	1.12	$905	1.65	$4,521	1.43	$2,971
	1978-1991		2,738		310	$715	$552	1.09	$709	1.65	$4,565	1.43	$3,000
	1992-2010		2,738		334	$634	$490	1.04	$342	1.80	$5,597	1.49	$3,424

Table 48: CZ 4 (CPAU) - Multifamily Equipment Fuel Substitution Cost-Effectiveness Results

Measure	Vintage	Measure Cost ($)	Electricity Savings (kWh)	Gas Savings (therm)	GHG Savings (lb CO_2e)	Utility Cost Savings		Customer On-Bill		2019 TDV		2022 TDV	
						Year 1	Avg Annual	B/C Ratio	NPV	B/C Ratio	NPV	B/C Ratio	NPV
Heat Pump at HVAC Replacement	Pre-1978	$227	-620	58	278	-$57	-$18	0.00	-$642	0.00	-$1,855	1.53	$121
	1978-1991		-382	35	160	-$41	-$16	0.00	-$390	0.00	-$1,285	0.62	-$87
	1992-2010		-280	25	116	-$27	-$9	0.00	-$312	0.00	-$1,080	0.43	-$129
High-Effic. Heat Pump at HVAC Replacement	Pre-1978	$3,245	-374	58	366	$21	$43	0.17	-$2,907	0.09	-$2,949	0.70	-$977
	1978-1991		-195	35	225	$21	$32	0.16	-$2,958	0.13	-$2,812	0.52	-$1,573
	1992-2010		-158	25	163	$12	$21	0.10	-$3,178	0.07	-$3,033	0.36	-$2,085
Heat Pump at HVAC Replacement + PV	Pre-1978	$4,932	2,177	58	460	$645	$525	1.43	$2,345	1.94	$4,647	1.97	$4,787
	1978-1991		2,416	35	342	$655	$522	1.43	$2,324	2.05	$5,202	1.93	$4,564
	1992-2010		2,518	25	299	$635	$502	1.41	$2,224	2.09	$5,390	1.91	$4,493
HVAC HP Replacement, PV, + Panel Upgrade	Pre-1978	$8,113	2,177	58	460	$645	$525	0.86	-$1,227	1.18	$1,466	1.20	$1,606
	1978-1991		2,416	35	342	$655	$522	0.86	-$1,248	1.25	$2,021	1.17	$1,383
	1992-2010		2,518	25	299	$635	$502	0.85	-$1,348	1.27	$2,209	1.16	$1,312
HPWH at Water Heater Replacement	Pre-1978	$2,594	-924	134	1,068	-$44	$24	0.41	-$1,698	0.00	-$2,609	1.34	$887
	1978-1991		-924	134	1,068	-$41	$26	0.43	-$1,639	0.00	-$2,609	1.34	$887
	1992-2010		-924	134	1,068	-$28	$36	0.52	-$1,388	0.00	-$2,609	1.34	$887
NEEA Tier 3 HPWH at Replacement	Pre-1978	$2,775	-764	134	1,143	$4	$61	0.59	-$1,270	0.27	-$2,024	1.55	$1,530
	1978-1991		-764	134	1,143	$6	$63	0.60	-$1,228	0.27	-$2,024	1.55	$1,530
	1992-2010		-764	134	1,143	$17	$71	0.67	-$1,025	0.27	-$2,024	1.55	$1,530
HPWH at Water Heater Replacement + PV	Pre-1978	$7,299	1,874	134	1,250	$705	$603	1.23	$1,889	1.56	$4,057	1.78	$5,722
	1978-1991		1,874	134	1,250	$693	$593	1.22	$1,756	1.56	$4,051	1.78	$5,710
	1992-2010		1,874	134	1,250	$668	$574	1.18	$1,474	1.55	$4,033	1.78	$5,681
HPWH Replacement, PV, + Panel Upgrade	Pre-1978	$10,480	1,874	134	1,250	$705	$603	0.86	-$1,683	1.08	$876	1.24	$2,541
	1978-1991		1,874	134	1,250	$693	$593	0.84	-$1,816	1.08	$870	1.24	$2,529
	1992-2010		1,874	134	1,250	$668	$574	0.82	-$2,098	1.08	$852	1.24	$2,500
PV + Electric Ready Pre-Wire	Pre-1978	$8,796	2,798	0	1,086	$713	$551	1.69	$6,743	1.27	$2,390	1.07	$572
	1978-1991		2,798	0	1,115	$701	$542	1.66	$6,467	0.92	-$704	1.06	$558
	1992-2010		2,798	0	1,108	$626	$484	1.48	$4,728	0.38	-$5,457	1.06	$527

6.4.5 Climate Zone 5 (PG&E):

Note: Values in red and grey rows indicate option is not cost-effective with B/C ratio less than 1. Cells with "n/a" reflect lighting and water heating efficiency measures and packages that did not look at TDV cost effectiveness or GHG impacts.

Table 49: CZ 5 (PG&E) - Multifamily Efficiency Upgrade Cost-Effectiveness Results

Measure	Vintage	Measure Cost ($)	Electricity Savings (kWh)	Gas Savings (therm)	GHG Savings (lb CO_2e)	Utility Cost Savings		Customer On-Bill		2019 TDV		2022 TDV	
						Year 1	Avg Annual	B/C Ratio	NPV	B/C Ratio	NPV	B/C Ratio	NPV
R-49 Attic Insulation	Pre-1978	$745	45	9	102	$30	$28	0.99	-$8	1.13	$96	1.05	$35
	1978-1991	$745	23	4	46	$14	$13	0.46	-$450	0.56	-$328	0.49	-$382
	1992-2010	$625	5	2	17	$4	$4	0.17	-$585	0.25	-$472	0.22	-$488
Reduced Infiltration	Pre-1978	$448	-3	7	73	$11	$12	0.70	-$149	0.99	-$5	0.93	-$33
	1978-1991		-5	5	45	$6	$6	0.39	-$309	0.63	-$165	0.55	-$201
	1992-2010		0	3	34	$5	$6	0.34	-$331	0.51	-$221	0.44	-$251
Duct Sealing	Pre-1978	$130	13	3	33	$9	$9	1.78	$114	2.03	$133	2.10	$142
	1978-1991	$130	6	1	12	$4	$3	0.71	-$42	0.86	-$19	0.86	-$19
New Ducts	Pre-1978	$1,353	36	7	80	$24	$22	0.43	-$862	0.52	-$655	0.53	-$638
	1978-1991		26	3	41	$14	$12	0.25	-$1,147	0.31	-$927	0.34	-$896
	1992-2010		5	1	13	$3	$3	0.06	-$1,430	0.08	-$1,243	0.10	-$1,222
Cool Roof	Pre-1978	$225	19	-1	-6	$5	$4	0.43	-$141	0.34	-$148	0.23	-$174
	1978-1991		16	-1	-2	$4	$3	0.39	-$149	0.33	-$150	0.28	-$162
	1992-2010		5	0	-3	$1	$0	0.05	-$232	0.13	-$195	0.11	-$201
R-13 Wall Insulation	Pre-1978	$1,006	7	19	189	$32	$33	0.89	-$125	1.23	$227	1.16	$156
Floor Insulation	Pre-1978	$822	-24	15	148	$16	$20	0.64	-$336	1.09	$75	0.79	-$173
Windows	Pre-1978	$5,873	74	17	186	$51	$47	0.21	-$5,177	0.19	-$4,732	0.26	-$4,325
	1978-1991		52	13	146	$38	$35	0.16	-$5,542	0.15	-$4,969	0.21	-$4,668
LED lamp vs CFL	All	$2.26	1.2	0	n/a	$0.29	$0.22	2.97	$4.45	n/a	n/a	n/a	n/a
Exterior Photosensor	All	$42.58	12.1	0	n/a	$3.09	$2.38	1.68	$28.96	n/a	n/a	n/a	n/a

Table 50: CZ 5 (PG&E) - Multifamily Efficiency Packages Cost-Effectiveness Results

Measure	Vintage	Measure Cost ($)	Electricity Savings (kWh)	Gas Savings (therm)	GHG Savings (lb CO_2e)	Utility Cost Savings		Customer On-Bill		2019 TDV		2022 TDV	
						Year 1	Avg Annual	B/C Ratio	NPV	B/C Ratio	NPV	B/C Ratio	NPV
R49 Attic & Air Sealing Package	Pre-1978	$1,193	43	16	175	$42	$40	0.89	-$147	1.09	$103	1.01	$10
	1978-1991	$1,193	18	9	90	$20	$19	0.44	-$757	0.59	-$490	0.51	-$585
	1992-2010	$1,073	5	5	51	$10	$10	0.24	-$914	0.35	-$697	0.31	-$738
R49 Attic & Duct Sealing Package	Pre-1978	$875	54	11	128	$37	$34	1.04	$39	1.20	$179	1.16	$141
	1978-1991	$875	28	5	55	$17	$16	0.47	-$517	0.58	-$366	0.54	-$402
R49 Attic, Air Sealing & Duct Sealing Package	Pre-1978	$1,323	52	18	198	$48	$46	0.92	-$114	1.13	$175	1.07	$93
	1978-1991	$1,323	23	9	99	$23	$22	0.44	-$827	0.60	-$531	0.53	-$616
	1992-2010	$1,203	5	5	51	$10	$10	0.22	-$1,060	0.31	-$827	0.28	-$868
R49 Attic, Air Sealing & New Ducts Package	Pre-1978	$2,546	71	21	234	$59	$55	0.58	-$1,197	0.72	-$705	0.71	-$742
	1978-1991	$2,546	41	11	122	$31	$29	0.31	-$1,986	0.41	-$1,496	0.40	-$1,538
	1992-2010	$2,427	10	6	61	$12	$12	0.13	-$2,359	0.19	-$1,961	0.19	-$1,975
Advanced Envelope Package	Pre-1978	$8,201	115	48	515	$116	$111	0.36	-$5,872	0.44	-$4,597	0.46	-$4,429
Water Heating Package	All Vintages	$168	0	13	0	$37	$19	1.50	$94	n/a	n/a	n/a	n/a

Table 51: CZ 5 (PG&E) - Multifamily PV & Battery Cost-Effectiveness Results

Measure	Vintage	Measure Cost ($)	Electricity Savings (kWh)	Gas Savings (therm)	GHG Savings (lb CO_2e)	Utility Cost Savings		Customer On-Bill		2019 TDV		2022 TDV	
						Year 1	Avg Annual	B/C Ratio	NPV	B/C Ratio	NPV	B/C Ratio	NPV
Prescriptive PV System	Pre-1978	$4,292	2,676	0	200	$555	$429	2.72	$8,134	2.41	$6,049	1.99	$4,255
	1978-1991		2,632		197	$542	$419	2.66	$7,840	2.37	$5,879	1.96	$4,120
	1992-2010		2,548		191	$519	$401	2.54	$7,298	2.34	$5,750	1.90	$3,863
PV + Battery	Pre-1978	$6,567	2,616	0	380	$561	$434	1.82	$5,864	1.82	$5,381	1.47	$3,096
	1978-1991		2,616		382	$553	$427	1.79	$5,679	1.83	$5,464	1.48	$3,138
	1992-2010		2,616		391	$530	$409	1.72	$5,137	1.85	$5,593	1.52	$3,442

Table 52: CZ 5 (PG&E) - Multifamily Equipment Fuel Substitution Cost-Effectiveness Results

Measure	Vintage	Measure Cost ($)	Electricity Savings (kWh)	Gas Savings (therm)	GHG Savings (lb CO_2e)	Utility Cost Savings		Customer On-Bill		2019 TDV		2022 TDV	
						Year 1	Avg Annual	B/C Ratio	NPV	B/C Ratio	NPV	B/C Ratio	NPV
Heat Pump at HVAC Replacement	Pre-1978	$227	-752	61	247	-$77	-$32	0.00	-$1,209	0.00	-$1,950	0.00	-$415
	1978-1991		-447	35	129	-$44	-$18	0.00	-$798	0.00	-$1,303	0.00	-$439
	1992-2010		-337	27	102	-$33	-$14	0.00	-$656	0.00	-$1,100	0.00	-$353
High-Effic. Heat Pump at HVAC Replacement	Pre-1978	$3,245	-634	61	301	-$44	-$6	0.00	-$3,707	0.00	-$4,091	0.17	-$2,699
	1978-1991		-376	35	161	-$27	-$5	0.00	-$3,659	0.00	-$3,768	0.09	-$2,968
	1992-2010		-291	27	125	-$22	-$5	0.00	-$3,663	0.00	-$3,751	0.06	-$3,056
Heat Pump at HVAC Replacement + PV	Pre-1978	$4,519	1,923	61	447	$570	$468	2.82	$9,064	1.94	$4,241	1.85	$3,847
	1978-1991	$4,446	2,228	35	329	$554	$444	2.72	$8,417	2.08	$4,877	1.87	$3,890
	1992-2010	$4,245	2,338	27	303	$543	$431	2.77	$8,265	2.12	$5,081	1.98	$4,173
HVAC HP Replacement, PV, + Panel Upgrade	Pre-1978	$7,700	1,923	61	447	$570	$468	1.64	$5,492	1.14	$1,060	1.09	$666
	1978-1991	$7,627	2,228	35	329	$554	$444	1.57	$4,845	1.22	$1,696	1.09	$709
	1992-2010	$7,426	2,338	27	303	$543	$431	1.57	$4,693	1.25	$1,900	1.13	$992
HPWH at Water Heater Replacement	Pre-1978	$2,594	-1,066	141	1,090	-$109	-$23	0.00	-$3,584	0.00	-$3,479	1.16	$407
	1978-1991		-1,066	141	1,090	-$108	-$23	0.00	-$3,580	0.00	-$3,479	1.16	$407
	1992-2010		-1,066	141	1,090	-$103	-$19	0.00	-$3,467	0.00	-$3,479	1.16	$407
NEEA Tier 3 HPWH at Replacement	Pre-1978	$2,775	-861	141	1,175	-$41	$29	0.28	-$2,225	0.14	-$2,376	1.47	$1,315
	1978-1991		-861	141	1,175	-$41	$29	0.28	-$2,221	0.14	-$2,376	1.47	$1,315
	1992-2010		-861	141	1,175	-$36	$33	0.32	-$2,107	0.14	-$2,376	1.47	$1,315
HPWH at Water Heater Replacement + PV	Pre-1978	$6,886	1,610	141	1,290	$608	$531	2.09	$8,295	1.42	$2,905	1.71	$4,861
	1978-1991	$6,814	1,610	141	1,290	$605	$528	2.10	$8,300	1.42	$2,903	1.72	$4,931
	1992-2010	$6,612	1,610	141	1,290	$604	$527	2.16	$8,490	1.42	$2,902	1.78	$5,128
HPWH Replacement, PV, + Panel Upgrade	Pre-1978	$10,067	1,610	141	1,290	$608	$531	1.42	$4,723	0.97	-$276	1.17	$1,680
	1978-1991	$9,995	1,610	141	1,290	$605	$528	1.43	$4,728	0.97	-$278	1.18	$1,750
	1992-2010	$9,973	1,610	141	1,290	$604	$527	1.45	$4,918	0.97	-$279	1.20	$1,947
PV + Electric Ready Pre-Wire	Pre-1978	$8,383	2,676	0	1,074	$555	$429	1.38	$3,540	1.23	$1,958	1.02	$164
	1978-1991	$8,311	2,632	0	1,111	$542	$419	1.36	$3,326	0.98	-$138	1.01	$101
	1992-2010	$8,109	2,548	0	1,101	$519	$401	1.33	$3,007	0.84	-$1,353	1.01	$46

6.4.6 Climate Zone 5 (PG&E/SoCalGas):

Note: Values in red and grey rows indicate option is not cost-effective with B/C ratio less than 1. Cells with "n/a" reflect lighting and water heating efficiency measures and packages that did not look at TDV cost effectiveness or GHG impacts.

Table 53: CZ 5 (PG&E/SoCalGas) - Multifamily Efficiency Upgrade Cost-Effectiveness Results

Measure	Vintage	Measure Cost ($)	Electricity Savings (kWh)	Gas Savings (therm)	GHG Savings (lb CO_2e)	Utility Cost Savings		Customer On-Bill		2019 TDV		2022 TDV	
						Year 1	Avg Annual	B/C Ratio	NPV	B/C Ratio	NPV	B/C Ratio	NPV
R-49 Attic Insulation	Pre-1978	$745	45	9	102	$27	$24	0.85	-$128	1.13	$96	1.05	$35
	1978-1991	$745	23	4	46	$13	$11	0.40	-$503	0.56	-$328	0.49	-$382
	1992-2010	$625	5	2	17	$4	$3	0.14	-$604	0.25	-$472	0.22	-$488
Reduced Infiltration	Pre-1978	$448	-3	7	73	$8	$9	0.51	-$247	0.99	-$5	0.93	-$33
	1978-1991		-5	5	45	$4	$4	0.27	-$369	0.63	-$165	0.55	-$201
	1992-2010		0	3	34	$4	$4	0.26	-$372	0.51	-$221	0.44	-$251
Duct Sealing	Pre-1978	$130	13	3	33	$8	$7	1.51	$75	2.03	$133	2.10	$142
	1978-1991	$130	6	1	12	$3	$3	0.63	-$55	0.86	-$19	0.86	-$19
New Ducts	Pre-1978	$1,353	36	7	80	$21	$19	0.37	-$955	0.52	-$655	0.53	-$638
	1978-1991		26	3	41	$13	$11	0.22	-$1,191	0.31	-$927	0.34	-$896
	1992-2010		5	1	13	$3	$3	0.05	-$1,443	0.08	-$1,243	0.10	-$1,222
Cool Roof	Pre-1978	$225	19	-1	-6	$6	$4	0.49	-$126	0.34	-$148	0.23	-$174
	1978-1991		16	-1	-2	$5	$3	0.43	-$141	0.33	-$150	0.28	-$162
	1992-2010		5	0	-3	$1	$1	0.07	-$227	0.13	-$195	0.11	-$201
R-13 Wall Insulation	Pre-1978	$1,006	7	19	189	$24	$25	0.67	-$373	1.23	$227	1.16	$156
Floor Insulation	Pre-1978	$822	-24	15	148	$10	$13	0.42	-$539	1.09	$75	0.79	-$173
Windows	Pre-1978	$5,873	74	17	186	$44	$40	0.18	-$5,396	0.19	-$4,732	0.26	-$4,325
	1978-1991		52	13	146	$32	$30	0.13	-$5,706	0.15	-$4,969	0.21	-$4,668
LED lamp vs CFL	All	$2.26	1.2	0	n/a	$0.29	$0.22	2.97	$4.45	n/a	n/a	n/a	n/a
Exterior Photosensor	All	$42.58	12.1	0	n/a	$3.09	$2.38	1.68	$28.96	n/a	n/a	n/a	n/a

Table 54: CZ 5 (PG&E/SoCalGas) - Multifamily Efficiency Packages Cost-Effectiveness Results

Measure	Vintage	Measure Cost ($)	Electricity Savings (kWh)	Gas Savings (therm)	GHG Savings (lb CO_2e)	Utility Cost Savings		Customer On-Bill		2019 TDV		2022 TDV	
						Year 1	Avg Annual	B/C Ratio	NPV	B/C Ratio	NPV	B/C Ratio	NPV
R49 Attic & Air Sealing Package	Pre-1978	$1,193	43	16	175	$35	$32	0.73	-$365	1.09	$103	1.01	$10
	1978-1991	$1,193	18	9	90	$17	$16	0.35	-$866	0.59	-$490	0.51	-$585
	1992-2010	$1,073	5	5	51	$8	$8	0.19	-$973	0.35	-$697	0.31	-$738
R49 Attic & Duct Sealing Package	Pre-1978	$875	54	11	128	$32	$29	0.89	-$112	1.20	$179	1.16	$141
	1978-1991	$875	28	5	55	$15	$13	0.41	-$580	0.58	-$366	0.54	-$402
R49 Attic, Air Sealing & Duct Sealing Package	Pre-1978	$1,323	5	2	17	$4	$3	0.12	-$750	1.13	$175	1.07	$93
	1978-1991	$1,323	52	18	198	$40	$38	0.76	-$359	0.60	-$531	0.53	-$616
	1992-2010	$1,203	23	9	99	$19	$18	0.36	-$944	0.31	-$827	0.28	-$868
R49 Attic, Air Sealing & New Ducts Package	Pre-1978	$2,546	5	5	51	$8	$8	0.17	-$1,119	0.72	-$705	0.71	-$742
	1978-1991	$2,546	71	21	234	$50	$46	0.48	-$1,481	0.41	-$1,496	0.40	-$1,538
	1992-2010	$2,427	41	11	122	$27	$24	0.26	-$2,125	0.19	-$1,961	0.19	-$1,975
Advanced Envelope Package	Pre-1978	$8,201	10	6	61	$10	$10	0.11	-$2,429	0.44	-$4,597	0.46	-$4,429
Water Heating Package	All Vintages	$168	0	13	0	$31	$15	1.22	$42	n/a	n/a	n/a	n/a

Table 55: CZ 5 (PG&E/SoCalGas) - Multifamily PV & Battery Cost-Effectiveness Results

Measure	Vintage	Measure Cost ($)	Electricity Savings (kWh)	Gas Savings (therm)	GHG Savings (lb CO_2e)	Utility Cost Savings		Customer On-Bill		2019 TDV		2022 TDV	
						Year 1	Avg Annual	B/C Ratio	NPV	B/C Ratio	NPV	B/C Ratio	NPV
Prescriptive PV System	Pre-1978	$4,292	2,676	0	200	$555	$429	2.72	$8,134	2.41	$6,049	1.99	$4,255
	1978-1991		2,632		197	$542	$419	2.66	$7,840	2.37	$5,879	1.96	$4,120
	1992-2010		2,548		191	$519	$401	2.54	$7,298	2.34	$5,750	1.90	$3,863
PV + Battery	Pre-1978	$6,567	2,616	0	380	$561	$434	1.82	$5,864	1.82	$5,381	1.47	$3,096
	1978-1991		2,616		382	$553	$427	1.79	$5,679	1.83	$5,464	1.48	$3,138
	1992-2010		2,616		391	$530	$409	1.72	$5,137	1.85	$5,593	1.52	$3,442

Table 56: CZ 5 (PG&E/SoCalGas) - Multifamily Equipment Fuel Substitution Cost-Effectiveness Results

Measure	Vintage	Measure Cost ($)	Electricity Savings (kWh)	Gas Savings (therm)	GHG Savings (lb CO_2e)	Utility Cost Savings		Customer On-Bill		2019 TDV		2022 TDV	
						Year 1	Avg Annual	B/C Ratio	NPV	B/C Ratio	NPV	B/C Ratio	NPV
Heat Pump at HVAC Replacement	Pre-1978	$227	-752	61	247	-$102	-$57	0.00	-$1,967	0.00	-$1,950	0.00	-$415
	1978-1991		-447	35	129	-$57	-$32	0.00	-$1,207	0.00	-$1,303	0.00	-$439
	1992-2010		-337	27	102	-$43	-$24	0.00	-$960	0.00	-$1,100	0.00	-$353
High-Effic. Heat Pump at HVAC Replacement	Pre-1978	$3,245	-634	61	301	-$69	-$32	0.00	-$4,465	0.00	-$4,091	0.17	-$2,699
	1978-1991		-376	35	161	-$40	-$18	0.00	-$4,067	0.00	-$3,768	0.09	-$2,968
	1992-2010		-291	27	125	-$32	-$15	0.00	-$3,967	0.00	-$3,751	0.06	-$3,056
Heat Pump at HVAC Replacement + PV	Pre-1978	$4,519	1,923	61	447	$546	$443	2.67	$8,306	1.94	$4,241	1.85	$3,847
	1978-1991	$4,446	2,228	35	329	$541	$430	2.63	$8,009	2.08	$4,877	1.87	$3,890
	1992-2010	$4,245	2,338	27	303	$533	$421	2.70	$7,961	2.12	$5,081	1.98	$4,173
HVAC HP Replacement, PV, + Panel Upgrade	Pre-1978	$7,700	1,923	61	447	$546	$443	1.55	$4,734	1.14	$1,060	1.09	$666
	1978-1991	$7,627	2,228	35	329	$541	$430	1.52	$4,437	1.22	$1,696	1.09	$709
	1992-2010	$7,426	2,338	27	303	$533	$421	1.53	$4,389	1.25	$1,900	1.13	$992
HPWH at Water Heater Replacement	Pre-1978	$2,594	-1,066	141	1,090	-$157	-$73	0.00	-$5,086	0.00	-$3,479	1.16	$407
	1978-1991		-1,066	141	1,090	-$155	-$72	0.00	-$5,053	0.00	-$3,479	1.16	$407
	1992-2010		-1,066	141	1,090	-$150	-$68	0.00	-$4,941	0.00	-$3,479	1.16	$407
NEEA Tier 3 HPWH at Replacement	Pre-1978	$2,775	-861	141	1,175	-$89	-$21	0.00	-$3,727	0.14	-$2,376	1.47	$1,315
	1978-1991		-861	141	1,175	-$88	-$20	0.00	-$3,693	0.14	-$2,376	1.47	$1,315
	1992-2010		-861	141	1,175	-$83	-$16	0.00	-$3,581	0.14	-$2,376	1.47	$1,315
HPWH at Water Heater Replacement + PV	Pre-1978	$6,886	1,610	141	1,290	$560	$481	1.89	$6,793	1.42	$2,905	1.71	$4,861
	1978-1991	$6,814	1,610	141	1,290	$558	$479	1.91	$6,828	1.42	$2,903	1.72	$4,931
	1992-2010	$6,612	1,610	141	1,290	$557	$478	1.96	$7,016	1.42	$2,902	1.78	$5,128
HPWH Replacement, PV, + Panel Upgrade	Pre-1978	$10,067	1,610	141	1,290	$560	$481	1.29	$3,221	0.97	-$276	1.17	$1,680
	1978-1991	$9,995	1,610	141	1,290	$558	$479	1.29	$3,256	0.97	-$278	1.18	$1,750
	1992-2010	$9,973	1,610	141	1,290	$557	$478	1.32	$3,444	0.97	-$279	1.20	$1,947
PV + Electric Ready Pre-Wire	Pre-1978	$8,383	2,676	0	1,074	$555	$429	1.38	$3,540	1.23	$1,958	1.02	$164
	1978-1991	$8,311	2,632	0	1,111	$542	$419	1.36	$3,326	0.98	-$138	1.01	$101
	1992-2010	$8,109	2,548	0	1,101	$519	$401	1.33	$3,007	0.84	-$1,353	1.01	$46

6.4.7 Climate Zone 6:

Note: Values in red and grey rows indicate option is not cost-effective with B/C ratio less than 1. Cells with "n/a" reflect lighting and water heating efficiency measures and packages that did not look at TDV cost effectiveness or GHG impacts.

Table 57: CZ 6 - Multifamily Efficiency Upgrade Cost-Effectiveness Results

Measure	Vintage	Measure Cost ($)	Electricity Savings (kWh)	Gas Savings (therm)	GHG Savings (lb CO_2e)	Utility Cost Savings		Customer On-Bill		2019 TDV		2022 TDV	
						Year 1	Avg Annual	B/C Ratio	NPV	B/C Ratio	NPV	B/C Ratio	NPV
R-49 Attic Insulation	Pre-1978	$745	143	4	64	$52	$41	1.48	$398	1.61	$455	1.31	$233
	1978-1991	$745	58	1	20	$20	$16	0.57	-$361	0.63	-$272	0.50	-$375
	1992-2010	$625	18	0	7	$6	$5	0.21	-$556	0.29	-$445	0.21	-$491
Reduced Infiltration	Pre-1978	$448	-17	2	20	-$3	-$2	0.00	-$549	0.24	-$343	0.23	-$347
	1978-1991		-15	1	9	-$3	-$2	0.00	-$566	0.06	-$422	0.06	-$422
	1992-2010		-8	1	5	-$1	-$1	0.00	-$527	0.05	-$424	0.02	-$437
Duct Sealing	Pre-1978	$130	63	1	19	$23	$18	3.71	$396	4.30	$428	4.06	$398
	1978-1991	$130	38	0	10	$13	$10	2.04	$152	2.43	$186	2.58	$206
New Ducts	Pre-1978	$1,353	146	2	46	$52	$41	0.80	-$297	0.99	-$11	0.94	-$78
	1978-1991		116	1	29	$39	$30	0.59	-$620	0.78	-$301	0.76	-$321
	1992-2010		28	0	8	$9	$7	0.14	-$1,312	0.24	-$1,025	0.23	-$1,045
Cool Roof	Pre-1978	$225	89	0	19	$30	$23	2.83	$450	2.67	$377	2.29	$291
	1978-1991		51	0	8	$16	$12	1.49	$121	1.36	$82	1.33	$74
	1992-2010		22	0	4	$7	$5	0.60	-$97	0.78	-$51	0.63	-$84
R-13 Wall Insulation	Pre-1978	$1,006	-1	7	64	$8	$8	0.22	-$883	0.64	-$360	0.52	-$485
Floor Insulation	Pre-1978	$822	-101	5	28	-$29	-$20	0.00	-$1,523	0.00	-$1,141	0.00	-$1,159
Windows	Pre-1978	$5,873	397	2	87	$128	$98	0.45	-$3,646	0.33	-$3,922	0.47	-$3,099
	1978-1991		340	2	79	$108	$83	0.38	-$4,113	0.29	-$4,158	0.42	-$3,394
LED lamp vs CFL	All	$2.26	1.2	0	n/a	$0.28	$0.22	2.86	$4.19	n/a	n/a	n/a	n/a
Exterior Photosensor	All	$42.58	12.1	0	n/a	$2.34	$1.78	1.25	$10.76	n/a	n/a	n/a	n/a

Table 58: CZ 6 - Multifamily Efficiency Packages Cost-Effectiveness Results

Measure	Vintage	Measure Cost ($)	Electricity Savings (kWh)	Gas Savings (therm)	GHG Savings (lb CO_2e)	Utility Cost Savings		Customer On-Bill		2019 TDV		2022 TDV	
						Year 1	Avg Annual	B/C Ratio	NPV	B/C Ratio	NPV	B/C Ratio	NPV
R49 Attic & Air Sealing Package	Pre-1978	$1,193	125	7	83	$49	$39	0.88	-$155	1.09	$109	0.89	-$129
	1978-1991	$1,193	43	2	28	$17	$14	0.30	-$932	0.42	-$698	0.33	-$803
	1992-2010	$1,073	9	1	12	$5	$4	0.10	-$1,090	0.19	-$867	0.13	-$935
R49 Attic & Duct Sealing Package	Pre-1978	$875	198	5	80	$71	$56	1.70	$688	1.95	$833	1.68	$593
	1978-1991	$875	93	1	29	$32	$25	0.75	-$243	0.88	-$109	0.78	-$196
R49 Attic, Air Sealing & Duct Sealing Package	Pre-1978	$1,323	181	7	98	$68	$54	1.10	$144	1.36	$482	1.18	$233
	1978-1991	$1,323	78	3	36	$28	$23	0.46	-$810	0.60	-$536	0.52	-$632
	1992-2010	$1,203	9	1	12	$5	$4	0.08	-$1,236	0.17	-$997	0.12	-$1,065
R49 Attic, Air Sealing & New Ducts Package	Pre-1978	$2,546	258	8	120	$94	$74	0.78	-$637	1.01	$31	0.90	-$266
	1978-1991	$2,546	154	3	54	$53	$41	0.43	-$1,621	0.60	-$1,022	0.55	-$1,155
	1992-2010	$2,427	37	1	19	$13	$10	0.12	-$2,410	0.22	-$1,903	0.18	-$1,986
Advanced Envelope Package	Pre-1978	$8,201	399	15	207	$146	$117	0.38	-$5,709	0.45	-$4,550	0.46	-$4,452
Water Heating Package	All Vintages	$168	0	13	0	$33	$15	1.20	$38	n/a	n/a	n/a	n/a

Table 59: CZ 6 - Multifamily PV & Battery Cost-Effectiveness Results

Measure	Vintage	Measure Cost ($)	Electricity Savings (kWh)	Gas Savings (therm)	GHG Savings (lb CO_2e)	Utility Cost Savings		Customer On-Bill		2019 TDV		2022 TDV	
						Year 1	Avg Annual	B/C Ratio	NPV	B/C Ratio	NPV	B/C Ratio	NPV
Prescriptive PV System	Pre-1978	$4,779	3,035	0	241	$595	$453	2.58	$8,315	2.25	$5,950	2.10	$5,265
	1978-1991		3,035		241	$589	$448	2.55	$8,175	2.24	$5,939	2.10	$5,248
	1992-2010		2,845		226	$510	$388	2.21	$6,372	2.18	$5,652	1.97	$4,622
PV + Battery	Pre-1978	$7,053	2,973	0	367	$649	$494	1.93	$7,141	1.66	$4,622	1.54	$3,796
	1978-1991		2,973		373	$623	$474	1.85	$6,545	1.67	$4,742	1.55	$3,853
	1992-2010		2,973		401	$558	$425	1.66	$5,072	1.74	$5,201	1.58	$4,118

Table 60: CZ 6 - Multifamily Equipment Fuel Substitution Cost-Effectiveness Results

Measure	Vintage	Measure Cost ($)	Electricity Savings (kWh)	Gas Savings (therm)	GHG Savings (lb CO_2e)	Utility Cost Savings		Customer On-Bill		2019 TDV		2022 TDV	
						Year 1	Avg Annual	B/C Ratio	NPV	B/C Ratio	NPV	B/C Ratio	NPV
Heat Pump at HVAC Replacement	Pre-1978	$227	-178	17	80	-$28	-$15	0.00	-$695	0.00	-$508	0.46	-$123
	1978-1991		-79	8	35	-$15	-$9	0.00	-$515	0.00	-$412	0.15	-$194
	1992-2010		-52	5	25	-$5	-$2	0.00	-$316	0.00	-$367	0.14	-$195
High-Effic. Heat Pump at HVAC Replacement	Pre-1978	$3,245	-34	17	121	$19	$20	0.17	-$2,899	0.24	-$2,458	0.41	-$1,921
	1978-1991		31	8	66	$22	$20	0.17	-$2,925	0.20	-$2,606	0.32	-$2,196
	1992-2010		15	5	46	$16	$14	0.12	-$3,103	0.14	-$2,801	0.23	-$2,488
Heat Pump at HVAC Replacement + PV	Pre-1978	$5,005	2,857	17	321	$570	$440	2.39	$7,673	2.09	$5,445	2.03	$5,135
	1978-1991		2,955	8	276	$556	$426	2.31	$7,256	2.10	$5,527	2.01	$5,049
	1992-2010		2,824	5	254	$510	$390	2.12	$6,192	2.11	$5,557	1.90	$4,522
HVAC HP Replacement, PV, + Panel Upgrade	Pre-1978	$8,186	2,857	17	321	$570	$440	1.45	$4,101	1.28	$2,264	1.24	$1,954
	1978-1991		2,955	8	276	$556	$426	1.41	$3,684	1.29	$2,346	1.23	$1,868
	1992-2010		2,824	5	254	$510	$390	1.29	$2,620	1.29	$2,376	1.16	$1,341
HPWH at Water Heater Replacement	Pre-1978	$2,594	-793	130	1,072	-$32	$22	0.22	-$2,246	0.25	-$1,957	1.49	$1,265
	1978-1991		-793	130	1,072	-$31	$23	0.23	-$2,214	0.25	-$1,957	1.49	$1,265
	1992-2010		-793	130	1,072	-$16	$33	0.35	-$1,888	0.25	-$1,957	1.49	$1,265
NEEA Tier 3 HPWH at Replacement	Pre-1978	$2,775	-681	130	1,133	$0	$46	0.45	-$1,708	0.46	-$1,502	1.61	$1,682
	1978-1991		-681	130	1,133	$1	$47	0.46	-$1,677	0.46	-$1,502	1.61	$1,682
	1992-2010		-681	130	1,133	$14	$57	0.55	-$1,392	0.46	-$1,502	1.61	$1,682
HPWH at Water Heater Replacement + PV	Pre-1978	$7,372	2,241	130	1,313	$584	$491	1.80	$6,561	1.57	$4,175	1.91	$6,696
	1978-1991		2,241	130	1,313	$578	$486	1.79	$6,423	1.57	$4,167	1.91	$6,679
	1992-2010		2,241	130	1,313	$574	$483	1.78	$6,334	1.56	$4,151	1.90	$6,651
HPWH Replacement, PV, + Panel Upgrade	Pre-1978	$10,553	2,241	130	1,313	$584	$491	1.25	$2,990	1.09	$994	1.33	$3,515
	1978-1991		2,241	130	1,313	$578	$486	1.24	$2,851	1.09	$986	1.33	$3,498
	1992-2010		2,241	130	1,313	$574	$483	1.24	$2,762	1.09	$970	1.33	$3,470
PV + Electric Ready Pre-Wire	Pre-1978	$8,870	3,035	0	1,153	$595	$453	1.38	$3,721	1.21	$1,859	1.13	$1,174
	1978-1991		3,035	0	1,182	$589	$448	1.36	$3,582	1.01	$62	1.13	$1,157
	1992-2010		2,845	0	1,176	$510	$388	1.18	$1,779	0.70	-$2,638	1.06	$531

6.4.8 Climate Zone 7:

Note: Values in red and grey rows indicate option is not cost-effective with B/C ratio less than 1. Cells with "n/a" reflect lighting and water heating efficiency measures and packages that did not look at TDV cost effectiveness or GHG impacts.

Table 61: CZ 7 - Multifamily Efficiency Upgrade Cost-Effectiveness Results

Measure	Vintage	Measure Cost ($)	Electricity Savings (kWh)	Gas Savings (therm)	GHG Savings (lb CO_2e)	Utility Cost Savings		Customer On-Bill		2019 TDV		2022 TDV	
						Year 1	Avg Annual	B/C Ratio	NPV	B/C Ratio	NPV	B/C Ratio	NPV
R-49 Attic Insulation	Pre-1978	$745	129	3	42	$63	$54	1.93	$775	1.10	$74	0.90	-$74
	1978-1991	$745	55	1	13	$27	$22	0.80	-$166	0.40	-$445	0.37	-$466
	1992-2010	$625	15	0	4	$8	$6	0.27	-$509	0.20	-$502	0.13	-$543
Reduced Infiltration	Pre-1978	$448	-19	1	9	-$5	-$4	0.00	-$620	0.00	-$466	0.00	-$466
	1978-1991		-16	1	1	-$5	-$4	0.00	-$631	0.00	-$516	0.00	-$504
	1992-2010		-8	0	0	-$3	-$2	0.00	-$565	0.00	-$498	0.00	-$478
Duct Sealing	Pre-1978	$130	55	0	13	$27	$23	4.69	$538	2.77	$230	2.47	$191
	1978-1991	$130	33	0	9	$16	$13	2.73	$253	1.69	$90	1.83	$108
New Ducts	Pre-1978	$1,353	140	1	36	$69	$58	1.15	$227	0.65	-$476	0.65	-$479
	1978-1991		115	0	27	$57	$47	0.94	-$99	0.53	-$629	0.56	-$598
	1992-2010		28	0	8	$14	$12	0.23	-$1,165	0.17	-$1,124	0.17	-$1,128
Cool Roof	Pre-1978	$225	87	0	18	$40	$33	4.05	$748	2.09	$246	1.93	$208
	1978-1991		50	0	10	$22	$19	2.26	$310	1.06	$13	1.20	$44
	1992-2010		21	0	5	$9	$8	0.94	-$16	0.64	-$82	0.53	-$105
R-13 Wall Insulation	Pre-1978	$1,006	-16	4	29	$2	$3	0.08	-$1,040	0.19	-$812	0.11	-$893
Floor Insulation	Pre-1978	$822	-101	3	1	-$40	-$32	0.00	-$1,895	0.00	-$1,314	0.00	-$1,289
Windows	Pre-1978	$5,873	343	1	69	$158	$132	0.60	-$2,633	0.25	-$4,416	0.32	-$3,978
	1978-1991		295	1	67	$139	$116	0.53	-$3,126	0.23	-$4,507	0.30	-$4,096
LED lamp vs CFL	All	$2.26	1.2	0	n/a	$0.41	$0.34	4.49	$7.87	n/a	n/a	n/a	n/a
Exterior Photosensor	All	$42.58	12.1	0	n/a	$3.39	$2.82	1.99	$42.01	n/a	n/a	n/a	n/a

Table 62: CZ 7 - Multifamily Efficiency Packages Cost-Effectiveness Results

Measure	Vintage	Measure Cost ($)	Electricity Savings (kWh)	Gas Savings (therm)	GHG Savings (lb CO_2e)	Utility Cost Savings		Customer On-Bill		2019 TDV		2022 TDV	
						Year 1	Avg Annual	B/C Ratio	NPV	B/C Ratio	NPV	B/C Ratio	NPV
R49 Attic & Air Sealing Package	Pre-1978	$1,193	110	4	50	$58	$50	1.11	$146	0.66	-$403	0.55	-$535
	1978-1991	$1,193	38	1	12	$21	$18	0.39	-$813	0.19	-$966	0.18	-$982
	1992-2010	$1,073	7	0	4	$5	$4	0.11	-$1,075	0.07	-$1,001	0.05	-$1,021
R49 Attic & Duct Sealing Package	Pre-1978	$875	177	3	57	$87	$74	2.25	$1,227	1.29	$257	1.17	$150
	1978-1991	$875	84	1	20	$41	$34	1.05	$47	0.59	-$359	0.54	-$399
R49 Attic, Air Sealing & Duct Sealing Package	Pre-1978	$1,323	159	4	63	$82	$70	1.41	$604	0.84	-$218	0.75	-$333
	1978-1991	$1,323	67	1	20	$35	$30	0.60	-$594	0.33	-$886	0.31	-$911
	1992-2010	$1,203	7	0	4	$5	$4	0.10	-$1,221	0.06	-$1,131	0.04	-$1,151
R49 Attic, Air Sealing & New Ducts Package	Pre-1978	$2,546	240	5	83	$122	$104	1.09	$250	0.64	-$913	0.60	-$1,008
	1978-1991	$2,546	149	1	39	$76	$63	0.66	-$959	0.37	-$1,593	0.38	-$1,580
	1992-2010	$2,427	35	0	12	$19	$16	0.18	-$2,245	0.12	-$2,132	0.12	-$2,138
Advanced Envelope Package	Pre-1978	$8,201	332	8	117	$174	$148	0.48	-$4,766	0.26	-$6,103	0.26	-$6,043
Water Heating Package	All Vintages	$168	0	13	0	$44	$20	1.61	$116	n/a	n/a	n/a	n/a

Table 63: CZ 7 - Multifamily PV & Battery Cost-Effectiveness Results

Measure	Vintage	Measure Cost ($)	Electricity Savings (kWh)	Gas Savings (therm)	GHG Savings (lb CO_2e)	Utility Cost Savings		Customer On-Bill		2019 TDV		2022 TDV	
						Year 1	Avg Annual	B/C Ratio	NPV	B/C Ratio	NPV	B/C Ratio	NPV
Prescriptive PV System	Pre-1978	$4,507	2,687	0	226	$948	$788	4.76	$18,682	2.35	$6,093	1.94	$4,258
	1978-1991		2,687		226	$947	$788	4.75	$18,669	2.35	$6,086	1.94	$4,248
	1992-2010		2,687		226	$857	$713	4.30	$16,410	2.28	$5,777	1.94	$4,219
PV + Battery	Pre-1978	$6,782	2,626	0	351	$935	$778	3.16	$15,944	1.72	$4,854	1.40	$2,739
	1978-1991		2,626		357	$999	$831	3.38	$17,541	1.73	$4,956	1.41	$2,770
	1992-2010		2,626		388	$857	$713	2.90	$14,000	1.79	$5,391	1.44	$2,997

Table 64: CZ 7 - Multifamily Equipment Fuel Substitution Cost-Effectiveness Results

Measure	Vintage	Measure Cost ($)	Electricity Savings (kWh)	Gas Savings (therm)	GHG Savings (lb CO_2e)	Utility Cost Savings		Customer On-Bill		2019 TDV		2022 TDV	
						Year 1	Avg Annual	B/C Ratio	NPV	B/C Ratio	NPV	B/C Ratio	NPV
Heat Pump at HVAC Replacement	Pre-1978	$227	-84	10	55	-$36	-$26	0.00	-$1,033	0.12	-$200	0.74	-$58
	1978-1991		-32	4	27	-$26	-$20	0.00	-$841	0.17	-$188	0.40	-$135
	1992-2010		-19	3	22	-$13	-$9	0.00	-$528	0.21	-$179	0.38	-$139
High-Effic. Heat Pump at HVAC Replacement	Pre-1978	$3,245	41	10	92	$27	$26	0.22	-$2,725	0.24	-$2,481	0.33	-$2,175
	1978-1991		70	4	58	$27	$24	0.21	-$2,781	0.20	-$2,601	0.27	-$2,363
	1992-2010		45	3	45	$21	$19	0.16	-$2,952	0.15	-$2,767	0.20	-$2,583
Heat Pump at HVAC Replacement + PV	Pre-1978	$4,734	2,603	10	281	$922	$771	4.43	$17,903	2.24	$5,893	1.89	$4,196
	1978-1991		2,656	4	253	$929	$775	4.45	$18,024	2.25	$5,898	1.87	$4,108
	1992-2010		2,669	3	249	$853	$711	4.08	$16,101	2.19	$5,636	1.86	$4,080
HVAC HP Replacement, PV, + Panel Upgrade	Pre-1978	$7,915	2,603	10	281	$922	$771	2.63	$14,331	1.34	$2,712	1.13	$1,015
	1978-1991		2,656	4	253	$929	$775	2.64	$14,452	1.34	$2,717	1.12	$927
	1992-2010		2,669	3	249	$853	$711	2.42	$12,529	1.31	$2,455	1.11	$899
HPWH at Water Heater Replacement	Pre-1978	$2,594	-782	130	1,078	-$29	$27	0.28	-$2,075	0.25	-$1,944	1.49	$1,276
	1978-1991		-782	130	1,078	-$25	$31	0.32	-$1,971	0.25	-$1,944	1.49	$1,276
	1992-2010		-782	130	1,078	-$13	$40	0.42	-$1,688	0.25	-$1,944	1.49	$1,276
NEEA Tier 3 HPWH at Replacement	Pre-1978	$2,775	-675	130	1,140	$10	$60	0.58	-$1,292	0.44	-$1,544	1.63	$1,736
	1978-1991		-675	130	1,140	$15	$63	0.62	-$1,187	0.44	-$1,544	1.63	$1,736
	1992-2010		-675	130	1,140	$24	$71	0.69	-$950	0.44	-$1,544	1.63	$1,736
HPWH at Water Heater Replacement + PV	Pre-1978	$7,101	1,905	130	1,304	$814	$728	2.78	$13,991	1.61	$4,333	1.80	$5,695
	1978-1991		1,905	130	1,304	$811	$726	2.77	$13,915	1.61	$4,327	1.80	$5,686
	1992-2010		1,905	130	1,304	$806	$722	2.75	$13,788	1.61	$4,319	1.80	$5,662
HPWH Replacement, PV, + Panel Upgrade	Pre-1978	$10,282	1,905	130	1,304	$814	$728	1.91	$10,419	1.11	$1,152	1.24	$2,514
	1978-1991		1,905	130	1,304	$811	$726	1.90	$10,343	1.11	$1,146	1.24	$2,505
	1992-2010		1,905	130	1,304	$806	$722	1.89	$10,216	1.11	$1,138	1.24	$2,481
PV + Electric Ready Pre-Wire	Pre-1978	$8,598	2,687	0	1,185	$948	$788	2.47	$14,089	1.23	$2,002	1.02	$167
	1978-1991		2,687	0	1,215	$947	$788	2.47	$14,075	1.13	$1,084	1.02	$157
	1992-2010		2,687	0	1,208	$857	$713	2.24	$11,816	0.89	-$925	1.01	$128

6.4.9 Climate Zone 8:

Note: Values in red and grey rows indicate option is not cost-effective with B/C ratio less than 1. Cells with "n/a" reflect lighting and water heating efficiency measures and packages that did not look at TDV cost effectiveness or GHG impacts.

Table 65: CZ 8 - Multifamily Efficiency Upgrade Cost-Effectiveness Results

Measure	Vintage	Measure Cost ($)	Electricity Savings (kWh)	Gas Savings (therm)	GHG Savings (lb CO_2e)	Utility Cost Savings		Customer On-Bill		2019 TDV		2022 TDV	
						Year 1	Avg Annual	B/C Ratio	NPV	B/C Ratio	NPV	B/C Ratio	NPV
R-49 Attic Insulation	Pre-1978	$745	211	3	47	$71	$55	1.97	$809	1.80	$598	2.09	$814
	1978-1991	$745	108	1	18	$36	$28	1.01	$4	0.98	-$16	1.09	$66
	1992-2010	$625	33	0	6	$11	$8	0.35	-$454	0.45	-$342	0.48	-$323
Reduced Infiltration	Pre-1978	$448	-7	2	15	$0	$1	0.04	-$481	0.39	-$272	0.45	-$245
	1978-1991		-8	1	8	-$1	-$1	0.00	-$519	0.18	-$365	0.12	-$392
	1992-2010		-6	1	3	-$1	-$1	0.00	-$519	0.15	-$380	0.15	-$379
Duct Sealing	Pre-1978	$130	167	1	27	$58	$44	9.12	$1,185	9.02	$1,042	11.11	$1,315
	1978-1991	$130	100	0	17	$35	$27	5.50	$657	5.48	$582	6.11	$665
New Ducts	Pre-1978	$1,353	375	2	64	$131	$100	1.98	$1,491	2.00	$1,351	2.44	$1,947
	1978-1991		303	1	49	$107	$82	1.61	$929	1.66	$889	1.96	$1,300
	1992-2010		87	0	17	$29	$22	0.44	-$856	0.55	-$613	0.64	-$482
Cool Roof	Pre-1978	$225	128	0	11	$41	$31	3.80	$688	3.07	$466	3.81	$633
	1978-1991		96	0	11	$32	$24	2.94	$478	2.67	$377	3.03	$457
	1992-2010		44	0	6	$14	$10	1.27	$65	1.32	$73	1.58	$132
R-13 Wall Insulation	Pre-1978	$1,006	40	6	58	$22	$19	0.51	-$556	1.04	$37	0.98	-$25
Floor Insulation	Pre-1978	$822	-102	3	7	-$30	-$21	0.00	-$1,568	0.00	-$1,105	0.00	-$1,089
Windows	Pre-1978	$5,873	634	2	98	$213	$163	0.74	-$1,699	0.51	-$2,897	0.76	-$1,407
	1978-1991		515	2	83	$177	$135	0.62	-$2,536	0.42	-$3,389	0.63	-$2,149
LED lamp vs CFL	All	$2.26	1.2	0	n/a	$0.28	$0.22	2.86	$4.19	n/a	n/a	n/a	n/a
Exterior Photosensor	All	$42.58	12.1	0	n/a	$2.34	$1.78	1.25	$10.76	n/a	n/a	n/a	n/a

Table 66: CZ 8 - Multifamily Efficiency Packages Cost-Effectiveness Results

Measure	Vintage	Measure Cost ($)	Electricity Savings (kWh)	Gas Savings (therm)	GHG Savings (lb CO_2e)	Utility Cost Savings		Customer On-Bill		2019 TDV		2022 TDV	
						Year 1	Avg Annual	B/C Ratio	NPV	B/C Ratio	NPV	B/C Ratio	NPV
R49 Attic & Air Sealing Package	Pre-1978	$1,193	200	5	60	$69	$55	1.22	$296	1.27	$320	1.50	$592
	1978-1991	$1,193	98	2	24	$34	$27	0.60	-$533	0.67	-$398	0.72	-$330
	1992-2010	$1,073	26	1	8	$10	$8	0.19	-$976	0.31	-$745	0.34	-$703
R49 Attic & Duct Sealing Package	Pre-1978	$875	366	4	75	$125	$97	2.95	$1,921	2.86	$1,624	3.33	$2,040
	1978-1991	$875	200	1	34	$69	$53	1.62	$608	1.60	$526	1.82	$717
R49 Attic, Air Sealing & Duct Sealing Package	Pre-1978	$1,323	353	5	87	$123	$96	1.94	$1,392	2.00	$1,320	2.33	$1,763
	1978-1991	$1,323	185	2	35	$65	$51	1.02	$33	1.11	$142	1.31	$414
	1992-2010	$1,203	26	1	8	$10	$8	0.17	-$1,122	0.27	-$875	0.31	-$833
R49 Attic, Air Sealing & New Ducts Package	Pre-1978	$2,546	559	6	122	$197	$152	1.60	$1,706	1.65	$1,662	2.00	$2,537
	1978-1991	$2,546	387	2	70	$138	$106	1.11	$314	1.17	$432	1.38	$980
	1992-2010	$2,427	111	1	25	$38	$29	0.32	-$1,846	0.42	-$1,397	0.49	-$1,227
Advanced Envelope Package	Pre-1978	$8,201	755	12	186	$272	$211	0.69	-$2,873	0.69	-$2,524	0.86	-$1,172
Water Heating Package	All Vintages	$168	0	13	0	$34	$15	1.21	$39	n/a	n/a	n/a	n/a

Table 67: CZ 8 - Multifamily PV & Battery Cost-Effectiveness Results

Measure	Vintage	Measure Cost ($)	Electricity Savings (kWh)	Gas Savings (therm)	GHG Savings (lb CO_2e)	Utility Cost Savings		Customer On-Bill		2019 TDV		2022 TDV	
						Year 1	Avg Annual	B/C Ratio	NPV	B/C Ratio	NPV	B/C Ratio	NPV
Prescriptive PV System	Pre-1978	$5,142	3,143	0	250	$678	$516	2.73	$9,817	2.31	$6,751	2.17	$6,037
	1978-1991		3,143		250	$660	$502	2.66	$9,401	2.31	$6,737	2.17	$6,013
	1992-2010		3,143		250	$614	$468	2.47	$8,354	2.30	$6,703	2.16	$5,952
PV + Battery	Pre-1978	$7,417	3,081	0	339	$731	$557	2.07	$8,618	1.70	$5,167	1.61	$4,497
	1978-1991		3,081		343	$716	$546	2.02	$8,283	1.71	$5,288	1.62	$4,609
	1992-2010		3,081		367	$670	$510	1.89	$7,221	1.79	$5,863	1.67	$4,937

Table 68: CZ 8 - Multifamily Equipment Fuel Substitution Cost-Effectiveness Results

Measure	Vintage	Measure Cost ($)	Electricity Savings (kWh)	Gas Savings (therm)	GHG Savings (lb CO_2e)	Utility Cost Savings		Customer On-Bill		2019 TDV		2022 TDV	
						Year 1	Avg Annual	B/C Ratio	NPV	B/C Ratio	NPV	B/C Ratio	NPV
Heat Pump at HVAC Replacement	Pre-1978	$227	-148	14	67	-$34	-$20	0.00	-$864	0.00	-$285	0.48	-$118
	1978-1991		-73	7	33	-$26	-$17	0.00	-$758	0.00	-$278	0.21	-$179
	1992-2010		-49	5	24	-$17	-$11	0.00	-$585	0.00	-$263	0.17	-$189
High-Effic. Heat Pump at HVAC Replacement	Pre-1978	$3,245	123	14	133	$59	$50	0.43	-$2,018	0.51	-$1,588	0.66	-$1,093
	1978-1991		156	7	89	$53	$43	0.37	-$2,220	0.42	-$1,871	0.56	-$1,444
	1992-2010		116	5	70	$40	$32	0.28	-$2,545	0.33	-$2,187	0.41	-$1,910
Heat Pump at HVAC Replacement + PV	Pre-1978	$5,369	2,995	14	317	$616	$474	2.40	$8,311	2.20	$6,462	2.10	$5,902
	1978-1991		3,070	7	283	$615	$470	2.38	$8,192	2.20	$6,453	2.08	$5,818
	1992-2010		3,094	5	273	$606	$463	2.35	$7,976	2.20	$6,440	2.07	$5,759
HVAC HP Replacement, PV, + Panel Upgrade	Pre-1978	$8,550	2,995	14	317	$616	$474	1.50	$4,739	1.38	$3,281	1.32	$2,721
	1978-1991		3,070	7	283	$615	$470	1.49	$4,620	1.38	$3,272	1.31	$2,637
	1992-2010		3,094	5	273	$606	$463	1.46	$4,404	1.38	$3,259	1.30	$2,578
HPWH at Water Heater Replacement	Pre-1978	$2,594	-750	127	1,048	-$31	$21	0.22	-$2,265	0.35	-$1,680	1.51	$1,313
	1978-1991		-750	127	1,048	-$29	$22	0.23	-$2,222	0.35	-$1,680	1.51	$1,313
	1992-2010		-750	127	1,048	-$22	$28	0.29	-$2,047	0.35	-$1,680	1.51	$1,313
NEEA Tier 3 HPWH at Replacement	Pre-1978	$2,775	-637	127	1,106	$1	$45	0.44	-$1,726	0.50	-$1,383	1.63	$1,757
	1978-1991		-637	127	1,106	$2	$47	0.45	-$1,691	0.50	-$1,383	1.63	$1,757
	1992-2010		-637	127	1,106	$9	$52	0.50	-$1,535	0.50	-$1,383	1.63	$1,757
HPWH at Water Heater Replacement + PV	Pre-1978	$7,736	2,393	127	1,298	$673	$557	1.95	$8,160	1.68	$5,244	1.97	$7,500
	1978-1991		2,393	127	1,298	$656	$544	1.91	$7,760	1.68	$5,230	1.97	$7,479
	1992-2010		2,393	127	1,298	$610	$509	1.78	$6,716	1.67	$5,198	1.96	$7,420
HPWH Replacement, PV, + Panel Upgrade	Pre-1978	$10,917	2,393	127	1,298	$673	$557	1.38	$4,588	1.19	$2,063	1.40	$4,319
	1978-1991		2,393	127	1,298	$656	$544	1.35	$4,188	1.19	$2,049	1.39	$4,298
	1992-2010		2,393	127	1,298	$610	$509	1.26	$3,144	1.18	$2,017	1.39	$4,239
PV + Electric Ready Pre-Wire	Pre-1978	$9,233	3,143	0	1,155	$678	$516	1.51	$5,223	1.29	$2,660	1.21	$1,946
	1978-1991		3,143	0	1,186	$660	$502	1.47	$4,807	1.01	$109	1.21	$1,922
	1992-2010		3,143	0	1,178	$614	$468	1.37	$3,760	0.47	-$4,867	1.20	$1,861

6.4.10 Climate Zone 9:

Note: Values in red and grey rows indicate option is not cost-effective with B/C ratio less than 1. Cells with "n/a" reflect lighting and water heating efficiency measures and packages that did not look at TDV cost effectiveness or GHG impacts.

Table 69: CZ 9 - Multifamily Efficiency Upgrade Cost-Effectiveness Results

Measure	Vintage	Measure Cost ($)	Electricity Savings (kWh)	Gas Savings (therm)	GHG Savings (lb CO_2e)	Utility Cost Savings		Customer On-Bill		2019 TDV		2022 TDV	
						Year 1	Avg Annual	B/C Ratio	NPV	B/C Ratio	NPV	B/C Ratio	NPV
R-49 Attic Insulation	Pre-1978	$745	192	5	70	$66	$52	1.88	$734	2.19	$885	1.93	$695
	1978-1991	$745	98	2	30	$33	$26	0.92	-$63	1.18	$133	1.02	$18
	1992-2010	$625	32	1	12	$10	$8	0.35	-$457	0.53	-$293	0.46	-$339
Reduced Infiltration	Pre-1978	$448	-2	3	28	$3	$3	0.19	-$406	0.95	-$21	0.52	-$216
	1978-1991		-6	2	16	$0	$1	0.06	-$473	0.61	-$173	0.37	-$284
	1992-2010		-3	1	11	$1	$1	0.06	-$472	0.47	-$237	0.27	-$329
Duct Sealing	Pre-1978	$130	158	1	41	$56	$43	8.79	$1,138	12.71	$1,523	9.84	$1,149
	1978-1991	$130	92	0	20	$31	$24	4.89	$568	7.61	$859	6.03	$654
New Ducts	Pre-1978	$1,353	363	3	94	$126	$97	1.92	$1,403	2.77	$2,391	2.27	$1,725
	1978-1991		292	2	67	$95	$73	1.44	$671	2.21	$1,639	1.86	$1,163
	1992-2010		84	0	23	$26	$20	0.39	-$923	0.75	-$339	0.61	-$533
Cool Roof	Pre-1978	$225	121	0	14	$39	$29	3.60	$639	3.92	$657	3.08	$467
	1978-1991		91	0	10	$28	$22	2.64	$403	3.32	$523	2.77	$398
	1992-2010		43	0	6	$12	$9	1.14	$34	1.64	$144	1.44	$98
R-13 Wall Insulation	Pre-1978	$1,006	52	9	96	$30	$26	0.69	-$347	1.61	$615	1.23	$230
Floor Insulation	Pre-1978	$822	-99	5	27	-$26	-$18	0.00	-$1,465	0.00	-$858	0.00	-$938
Windows	Pre-1978	$5,873	653	4	131	$211	$162	0.74	-$1,738	0.67	-$1,943	0.82	-$1,085
	1978-1991		538	3	112	$169	$130	0.59	-$2,703	0.56	-$2,578	0.70	-$1,753
LED lamp vs CFL	All	$2.26	1.2	0	n/a	$0.28	$0.22	2.86	$4.19	n/a	n/a	n/a	n/a
Exterior Photosensor	All	$42.58	12.1	0	n/a	$2.34	$1.78	1.25	$10.76	n/a	n/a	n/a	n/a

Table 70: CZ 9 - Multifamily Efficiency Packages Cost-Effectiveness Results

Measure	Vintage	Measure Cost ($)	Electricity Savings (kWh)	Gas Savings (therm)	GHG Savings (lb CO_2e)	Utility Cost Savings		Customer On-Bill		2019 TDV		2022 TDV	
						Year 1	Avg Annual	B/C Ratio	NPV	B/C Ratio	NPV	B/C Ratio	NPV
R49 Attic & Air Sealing Package	Pre-1978	$1,193	188	8	98	$69	$55	1.23	$314	1.72	$860	1.39	$466
	1978-1991	$1,193	91	4	45	$33	$26	0.59	-$546	0.94	-$70	0.76	-$287
	1992-2010	$1,073	29	2	22	$11	$9	0.23	-$932	0.51	-$527	0.37	-$679
R49 Attic & Duct Sealing Package	Pre-1978	$875	339	6	106	$118	$92	2.80	$1,769	3.70	$2,366	3.12	$1,855
	1978-1991	$875	185	3	50	$61	$47	1.44	$431	2.09	$951	1.72	$629
R49 Attic, Air Sealing & Duct Sealing Package	Pre-1978	$1,323	333	9	133	$119	$94	1.90	$1,330	2.74	$2,307	2.22	$1,615
	1978-1991	$1,323	175	4	61	$60	$47	0.95	-$70	1.56	$735	1.29	$379
	1992-2010	$1,203	29	2	22	$11	$9	0.20	-$1,078	0.45	-$657	0.33	-$809
R49 Attic, Air Sealing & New Ducts Package	Pre-1978	$2,546	536	10	184	$186	$145	1.52	$1,488	2.25	$3,182	1.87	$2,217
	1978-1991	$2,546	372	5	108	$123	$96	1.01	$15	1.61	$1,555	1.33	$836
	1992-2010	$2,427	110	2	44	$36	$28	0.31	-$1,878	0.63	-$902	0.49	-$1,244
Advanced Envelope Package	Pre-1978	$8,201	772	22	317	$273	$216	0.70	-$2,740	0.99	-$110	0.94	-$491
Water Heating Package	All Vintages	$168	0	13	0	$33	$15	1.20	$37	n/a	n/a	n/a	n/a

Table 71: CZ 9 - Multifamily PV & Battery Cost-Effectiveness Results

Measure	Vintage	Measure Cost ($)	Electricity Savings (kWh)	Gas Savings (therm)	GHG Savings (lb CO_2e)	Utility Cost Savings		Customer On-Bill		2019 TDV		2022 TDV	
						Year 1	Avg Annual	B/C Ratio	NPV	B/C Ratio	NPV	B/C Ratio	NPV
Prescriptive PV System	Pre-1978	$5,179	3,306	0	260	$665	$506	2.66	$9,471	2.36	$7,044	2.18	$6,104
	1978-1991		3,306	0	260	$649	$494	2.59	$9,106	2.36	$7,022	2.17	$6,080
	1992-2010		3,306	0	260	$636	$484	2.54	$8,807	2.35	$6,985	2.16	$6,020
PV + Battery	Pre-1978	$7,454	3,244	0	354	$719	$547	2.02	$8,293	1.70	$5,202	1.60	$4,491
	1978-1991		3,244	0	358	$705	$537	1.98	$7,989	1.71	$5,255	1.62	$4,600
	1992-2010		3,244	0	381	$666	$507	1.87	$7,095	1.76	$5,674	1.65	$4,877

Table 72: CZ 9 - Multifamily Equipment Fuel Substitution Cost-Effectiveness Results

Measure	Vintage	Measure Cost ($)	Electricity Savings (kWh)	Gas Savings (therm)	GHG Savings (lb CO_2e)	Utility Cost Savings		Customer On-Bill		2019 TDV		2022 TDV	
						Year 1	Avg Annual	B/C Ratio	NPV	B/C Ratio	NPV	B/C Ratio	NPV
Heat Pump at HVAC Replacement	Pre-1978	$227	-283	26	121	-$45	-$25	0.00	-$992	0.00	-$356	0.70	-$67
	1978-1991		-158	14	65	-$26	-$14	0.00	-$679	0.00	-$329	0.27	-$167
	1992-2010		-111	10	47	-$12	-$5	0.00	-$411	0.00	-$311	0.22	-$177
High-Effic. Heat Pump at HVAC Replacement	Pre-1978	$3,245	-4	26	198	$45	$44	0.37	-$2,204	0.66	-$1,113	0.68	-$1,042
	1978-1991		72	14	128	$48	$42	0.36	-$2,264	0.54	-$1,492	0.55	-$1,468
	1992-2010		50	10	97	$36	$31	0.27	-$2,577	0.42	-$1,894	0.40	-$1,933
Heat Pump at HVAC Replacement + PV	Pre-1978	$5,406	3,023	26	380	$611	$475	2.39	$8,277	2.24	$6,687	2.11	$6,022
	1978-1991		3,148	14	324	$622	$479	2.41	$8,393	2.24	$6,692	2.09	$5,900
	1992-2010		3,195	10	307	$620	$476	2.40	$8,322	2.24	$6,678	2.08	$5,841
HVAC HP Replacement, PV, + Panel Upgrade	Pre-1978	$8,587	3,023	26	380	$611	$475	1.49	$4,705	1.41	$3,506	1.33	$2,841
	1978-1991		3,148	14	324	$622	$479	1.51	$4,822	1.41	$3,511	1.32	$2,719
	1992-2010		3,195	10	307	$620	$476	1.50	$4,750	1.41	$3,497	1.31	$2,660
HPWH at Water Heater Replacement	Pre-1978	$2,594	-778	128	1,049	-$32	$21	0.21	-$2,270	0.32	-$1,756	1.49	$1,277
	1978-1991		-778	128	1,049	-$29	$23	0.24	-$2,211	0.32	-$1,756	1.49	$1,277
	1992-2010		-778	128	1,049	-$14	$35	0.36	-$1,848	0.32	-$1,756	1.49	$1,277
NEEA Tier 3 HPWH at Replacement	Pre-1978	$2,775	-662	128	1,108	$0	$45	0.44	-$1,741	0.51	-$1,368	1.61	$1,700
	1978-1991		-662	128	1,108	$2	$47	0.46	-$1,682	0.51	-$1,368	1.61	$1,700
	1992-2010		-662	128	1,108	$15	$57	0.55	-$1,384	0.51	-$1,368	1.61	$1,700
HPWH at Water Heater Replacement + PV	Pre-1978	$7,773	2,528	128	1,309	$657	$545	1.90	$7,749	1.70	$5,467	1.97	$7,546
	1978-1991		2,528	128	1,308	$641	$533	1.86	$7,385	1.70	$5,449	1.97	$7,523
	1992-2010		2,528	128	1,308	$628	$523	1.82	$7,089	1.70	$5,413	1.96	$7,467
HPWH Replacement, PV, + Panel Upgrade	Pre-1978	$10,954	2,528	128	1,309	$657	$545	1.34	$4,177	1.21	$2,286	1.40	$4,365
	1978-1991		2,528	128	1,308	$641	$533	1.31	$3,813	1.21	$2,268	1.40	$4,342
	1992-2010		2,528	128	1,308	$628	$523	1.29	$3,517	1.20	$2,232	1.39	$4,286
PV + Electric Ready Pre-Wire	Pre-1978	$9,270	3,306	0	1,141	$665	$506	1.47	$4,877	1.32	$2,953	1.22	$2,013
	1978-1991		3,306	0	1,157	$649	$494	1.44	$4,512	0.92	-$771	1.21	$1,989
	1992-2010		3,306	0	1,151	$636	$484	1.41	$4,213	0.20	-$7,428	1.21	$1,929

6.4.11 Climate Zone 10 (SCE/SoCalGas):

Note: Values in red and grey rows indicate option is not cost-effective with B/C ratio less than 1. Cells with "n/a" reflect lighting and water heating efficiency measures and packages that did not look at TDV cost effectiveness or GHG impacts.

Table 73: CZ 10 (SCE/SoCalGas) - Multifamily Efficiency Upgrade Cost-Effectiveness Results

Measure	Vintage	Measure Cost ($)	Electricity Savings (kWh)	Gas Savings (therm)	GHG Savings (lb CO_2e)	Utility Cost Savings		Customer On-Bill		2019 TDV		2022 TDV	
						Year 1	Avg Annual	B/C Ratio	NPV	B/C Ratio	NPV	B/C Ratio	NPV
R-49 Attic Insulation	Pre-1978	$745	235	6	79	$78	$62	2.21	$1,010	2.28	$954	2.04	$772
	1978-1991	$745	121	3	31	$39	$31	1.11	$89	1.24	$181	1.11	$81
	1992-2010	$625	39	1	12	$12	$10	0.42	-$411	0.55	-$281	0.49	-$321
Reduced Infiltration	Pre-1978	$448	16	4	42	$10	$9	0.56	-$220	1.01	$4	0.96	-$16
	1978-1991		7	3	25	$5	$5	0.31	-$347	0.69	-$141	0.65	-$156
	1992-2010		4	2	17	$4	$4	0.21	-$396	0.39	-$275	0.50	-$225
Duct Sealing	Pre-1978	$130	218	2	45	$73	$56	11.58	$1,544	14.01	$1,691	11.62	$1,381
	1978-1991	$130	125	1	22	$41	$31	6.44	$795	8.38	$960	6.94	$772
New Ducts	Pre-1978	$1,353	476	5	103	$159	$123	2.43	$2,168	3.03	$2,750	2.55	$2,096
	1978-1991		374	2	71	$123	$95	1.87	$1,324	2.41	$1,905	2.06	$1,433
	1992-2010		110	1	26	$33	$26	0.51	-$747	0.79	-$283	0.69	-$426
Cool Roof	Pre-1978	$225	144	-1	8	$44	$33	4.04	$748	4.08	$693	3.14	$481
	1978-1991		107	0	4	$32	$24	2.96	$483	3.10	$472	2.67	$377
	1992-2010		50	0	4	$14	$11	1.28	$69	1.75	$168	1.36	$80
R-13 Wall Insulation	Pre-1978	$1,006	99	12	133	$48	$41	1.08	$92	1.94	$948	1.57	$578
Floor Insulation	Pre-1978	$822	-65	8	65	-$11	-$5	0.00	-$1,085	0.22	-$643	0.32	-$556
Windows	Pre-1978	$5,873	806	6	153	$259	$199	0.91	-$618	0.78	-$1,282	0.87	-$782
	1978-1991		655	5	130	$208	$160	0.73	-$1,787	0.64	-$2,114	0.73	-$1,613
LED lamp vs CFL	All	$2.26	1.2	0	n/a	$0.28	$0.22	2.86	$4.19	n/a	n/a	n/a	n/a
Exterior Photosensor	All	$42.58	12.1	0	n/a	$2.34	$1.78	1.25	$10.76	n/a	n/a	n/a	n/a

Table 74: CZ 10 (SCE/SoCalGas) - Multifamily Efficiency Packages Cost-Effectiveness Results

Measure	Vintage	Measure Cost ($)	Electricity Savings (kWh)	Gas Savings (therm)	GHG Savings (lb CO_2e)	Utility Cost Savings		Customer On-Bill		2019 TDV		2022 TDV	
						Year 1	Avg Annual	B/C Ratio	NPV	B/C Ratio	NPV	B/C Ratio	NPV
R49 Attic & Air Sealing Package	Pre-1978	$1,193	250	10	121	$88	$71	1.58	$780	1.81	$971	1.65	$774
	1978-1991	$1,193	127	5	57	$44	$36	0.80	-$265	1.04	$47	0.93	-$88
	1992-2010	$1,073	43	3	31	$16	$13	0.33	-$809	0.53	-$503	0.48	-$562
R49 Attic & Duct Sealing Package	Pre-1978	$875	438	8	120	$146	$114	3.48	$2,434	3.96	$2,590	3.44	$2,132
	1978-1991	$875	238	3	53	$78	$60	1.85	$832	2.22	$1,070	1.93	$811
R49 Attic, Air Sealing & Duct Sealing Package	Pre-1978	$1,323	448	12	161	$154	$122	2.46	$2,165	2.97	$2,601	2.59	$2,106
	1978-1991	$1,323	241	6	78	$82	$65	1.31	$458	1.68	$897	1.48	$629
	1992-2010	$1,203	43	3	31	$16	$13	0.29	-$955	0.47	-$633	0.43	-$692
R49 Attic, Air Sealing & New Ducts Package	Pre-1978	$2,546	705	14	217	$240	$188	1.97	$2,776	2.43	$3,637	2.13	$2,884
	1978-1991	$2,546	485	7	124	$162	$126	1.33	$930	1.73	$1,861	1.51	$1,295
	1992-2010	$2,427	149	4	56	$48	$38	0.42	-$1,579	0.66	-$813	0.58	-$1,010
Advanced Envelope Package	Pre-1978	$8,201	1,054	31	420	$368	$292	0.95	-$461	1.13	$1,042	1.08	$688
Water Heating Package	All Vintages	$168	0	13	0	$34	$15	1.22	$41	n/a	n/a	n/a	n/a

Table 75: CZ 10 (SCE/SoCalGas) - Multifamily PV & Battery Cost-Effectiveness Results

Measure	Vintage	Measure Cost ($)	Electricity Savings (kWh)	Gas Savings (therm)	GHG Savings (lb CO_2e)	Utility Cost Savings		Customer On-Bill		2019 TDV		2022 TDV	
						Year 1	Avg Annual	B/C Ratio	NPV	B/C Ratio	NPV	B/C Ratio	NPV
Prescriptive PV System	Pre-1978	$5,350	3,409	0	271	$704	$536	2.73	$10,182	2.28	$6,830	2.14	$6,097
	1978-1991		3,409		271	$683	$520	2.65	$9,707	2.27	$6,809	2.13	$6,067
	1992-2010		3,409		271	$657	$500	2.54	$9,102	2.26	$6,765	2.12	$5,996
PV + Battery	Pre-1978	$7,624	3,347	0	362	$755	$575	2.07	$8,933	1.65	$4,948	1.57	$4,358
	1978-1991		3,347		365	$737	$561	2.03	$8,520	1.65	$4,954	1.58	$4,430
	1992-2010		3,347		383	$715	$544	1.96	$8,019	1.69	$5,233	1.60	$4,582

Table 76: CZ 10 (SCE/SoCalGas) - Multifamily Equipment Fuel Substitution Cost-Effectiveness Results

Measure	Vintage	Measure Cost ($)	Electricity Savings (kWh)	Gas Savings (therm)	GHG Savings (lb CO_2e)	Utility Cost Savings		Customer On-Bill		2019 TDV		2022 TDV	
						Year 1	Avg Annual	B/C Ratio	NPV	B/C Ratio	NPV	B/C Ratio	NPV
Heat Pump at HVAC Replacement	Pre-1978	$227	-458	39	155	-$60	-$32	0.00	-$1,203	0.00	-$547	0.33	-$152
	1978-1991		-272	22	86	-$37	-$20	0.00	-$858	0.00	-$456	0.00	-$240
	1992-2010		-202	17	62	-$22	-$11	0.00	-$585	0.00	-$416	0.00	-$246
High-Effic. Heat Pump at HVAC Replacement	Pre-1978	$3,245	-100	39	254	$48	$50	0.43	-$2,004	0.67	-$1,064	0.76	-$765
	1978-1991		17	22	164	$50	$46	0.39	-$2,136	0.56	-$1,432	0.61	-$1,257
	1992-2010		7	17	126	$37	$34	0.29	-$2,497	0.43	-$1,856	0.46	-$1,739
Heat Pump at HVAC Replacement + PV	Pre-1978	$5,576	2,951	39	426	$614	$482	2.35	$8,298	2.13	$6,285	2.06	$5,930
	1978-1991		3,136	22	357	$628	$487	2.37	$8,447	2.14	$6,353	2.04	$5,813
	1992-2010		3,207	17	333	$634	$489	2.38	$8,516	2.14	$6,356	2.03	$5,748
HVAC HP Replacement, PV, + Panel Upgrade	Pre-1978	$8,757	2,951	39	426	$614	$482	1.49	$4,726	1.35	$3,104	1.31	$2,749
	1978-1991		3,136	22	357	$628	$487	1.50	$4,875	1.36	$3,172	1.30	$2,632
	1992-2010		3,207	17	333	$634	$489	1.51	$4,944	1.36	$3,175	1.29	$2,567
HPWH at Water Heater Replacement	Pre-1978	$2,594	-825	128	1,018	-$44	$11	0.12	-$2,558	0.28	-$1,865	1.39	$1,009
	1978-1991		-825	128	1,018	-$38	$16	0.17	-$2,401	0.28	-$1,865	1.39	$1,009
	1992-2010		-825	128	1,018	-$26	$25	0.26	-$2,141	0.28	-$1,865	1.39	$1,009
NEEA Tier 3 HPWH at Replacement	Pre-1978	$2,775	-686	128	1,082	-$7	$40	0.39	-$1,889	0.51	-$1,371	1.54	$1,504
	1978-1991		-686	128	1,082	-$1	$44	0.43	-$1,763	0.51	-$1,371	1.54	$1,504
	1992-2010		-686	128	1,082	$9	$52	0.50	-$1,541	0.51	-$1,371	1.54	$1,504
HPWH at Water Heater Replacement + PV	Pre-1978	$7,943	2,584	128	1,289	$684	$566	1.93	$8,187	1.65	$5,137	1.91	$7,266
	1978-1991		2,584	128	1,289	$664	$550	1.88	$7,714	1.64	$5,118	1.91	$7,237
	1992-2010		2,584	128	1,289	$637	$530	1.81	$7,113	1.64	$5,076	1.90	$7,171
HPWH Replacement, PV, + Panel Upgrade	Pre-1978	$11,124	2,584	128	1,289	$684	$566	1.37	$4,615	1.18	$1,956	1.37	$4,085
	1978-1991		2,584	128	1,289	$664	$550	1.34	$4,142	1.17	$1,937	1.36	$4,056
	1992-2010		2,584	128	1,289	$637	$530	1.29	$3,541	1.17	$1,895	1.36	$3,990
PV + Electric Ready Pre-Wire	Pre-1978	$9,441	3,409	0	1,110	$704	$536	1.53	$5,588	1.29	$2,739	1.21	$2,006
	1978-1991		3,409	0	1,129	$683	$520	1.49	$5,113	0.84	-$1,530	1.21	$1,976
	1992-2010		3,409	0	1,121	$657	$500	1.43	$4,508	0.05	-$8,962	1.20	$1,905

6.4.12 Climate Zone 10 (SDG&E):

Note: Values in red and grey rows indicate option is not cost-effective with B/C ratio less than 1. Cells with "n/a" reflect lighting and water heating efficiency measures and packages that did not look at TDV cost effectiveness or GHG impacts.

Table 77: CZ 10 (SDG&E) - Multifamily Efficiency Upgrade Cost-Effectiveness Results

Measure	Vintage	Measure Cost ($)	Electricity Savings (kWh)	Gas Savings (therm)	GHG Savings (lb CO_2e)	Utility Cost Savings		Customer On-Bill		2019 TDV		2022 TDV	
						Year 1	Avg Annual	B/C Ratio	NPV	B/C Ratio	NPV	B/C Ratio	NPV
R-49 Attic Insulation	Pre-1978	$745	235	6	79	$113	$97	3.46	$2,060	2.28	$954	2.04	$772
	1978-1991	$745	121	3	31	$59	$50	1.79	$658	1.24	$181	1.11	$81
	1992-2010	$625	39	1	12	$20	$17	0.71	-$202	0.55	-$281	0.49	-$321
Reduced Infiltration	Pre-1978	$448	16	4	42	$16	$15	0.87	-$65	1.01	$4	0.96	-$16
	1978-1991		7	3	25	$9	$8	0.49	-$255	0.69	-$141	0.65	-$156
	1992-2010		4	2	17	$6	$6	0.36	-$322	0.39	-$275	0.50	-$225
Duct Sealing	Pre-1978	$130	218	2	45	$107	$90	18.48	$2,551	14.01	$1,691	11.62	$1,381
	1978-1991	$130	125	1	22	$62	$52	10.69	$1,414	8.38	$960	6.94	$772
New Ducts	Pre-1978	$1,353	476	5	103	$237	$199	3.92	$4,443	3.03	$2,750	2.55	$2,096
	1978-1991		374	2	71	$188	$157	3.11	$3,205	2.41	$1,905	2.06	$1,433
	1992-2010		110	1	26	$55	$46	0.91	-$131	0.79	-$283	0.69	-$426
Cool Roof	Pre-1978	$225	144	-1	8	$63	$52	6.39	$1,324	4.08	$693	3.14	$481
	1978-1991		107	0	4	$48	$40	4.87	$950	3.10	$472	2.67	$377
	1992-2010		50	0	4	$22	$19	2.26	$310	1.75	$168	1.36	$80
R-13 Wall Insulation	Pre-1978	$1,006	99	12	133	$71	$64	1.70	$792	1.94	$948	1.57	$578
Floor Insulation	Pre-1978	$822	-65	8	65	-$13	-$7	0.00	-$1,145	0.22	-$643	0.32	-$556
Windows	Pre-1978	$5,873	806	6	153	$383	$321	1.46	$3,033	0.78	-$1,282	0.87	-$782
	1978-1991		655	5	130	$316	$265	1.20	$1,342	0.64	-$2,114	0.73	-$1,613
LED lamp vs CFL	All	$2.26	1.2	0	n/a	$0.41	$0.34	4.49	$7.87	n/a	n/a	n/a	n/a
Exterior Photosensor	All	$42.58	12.1	0	n/a	$3.39	$2.82	1.99	$42.01	n/a	n/a	n/a	n/a

Table 78: CZ 10 (SDG&E) - Multifamily Efficiency Packages Cost-Effectiveness Results

Measure	Vintage	Measure Cost ($)	Electricity Savings (kWh)	Gas Savings (therm)	GHG Savings (lb CO_2e)	Utility Cost Savings		Customer On-Bill		2019 TDV		2022 TDV	
						Year 1	Avg Annual	B/C Ratio	NPV	B/C Ratio	NPV	B/C Ratio	NPV
R49 Attic & Air Sealing Package	Pre-1978	$1,193	250	10	121	$128	$111	2.48	$1,982	1.81	$971	1.65	$774
	1978-1991	$1,193	127	5	57	$67	$58	1.29	$391	1.04	$47	0.93	-$88
	1992-2010	$1,073	43	3	31	$26	$23	0.56	-$528	0.53	-$503	0.48	-$562
R49 Attic & Duct Sealing Package	Pre-1978	$875	438	8	120	$215	$182	5.55	$4,466	3.96	$2,590	3.44	$2,132
	1978-1991	$875	238	3	53	$118	$99	3.03	$1,990	2.22	$1,070	1.93	$811
R49 Attic, Air Sealing & Duct Sealing Package	Pre-1978	$1,323	448	12	161	$227	$194	3.92	$4,331	2.97	$2,601	2.59	$2,106
	1978-1991	$1,323	241	6	78	$124	$106	2.14	$1,691	1.68	$897	1.48	$629
	1992-2010	$1,203	43	3	31	$26	$23	0.50	-$674	0.47	-$633	0.43	-$692
R49 Attic, Air Sealing & New Ducts Package	Pre-1978	$2,546	705	14	217	$358	$304	3.19	$6,252	2.43	$3,637	2.13	$2,884
	1978-1991	$2,546	485	7	124	$250	$211	2.21	$3,469	1.73	$1,861	1.51	$1,295
	1992-2010	$2,427	149	4	56	$80	$68	0.74	-$696	0.66	-$813	0.58	-$1,010
Advanced Envelope Package	Pre-1978	$8,201	1,054	31	420	$555	$474	1.54	$5,016	1.13	$1,042	1.08	$688
Water Heating Package	All Vintages	$168	0	13	0	$46	$21	1.63	$120	n/a	n/a	n/a	n/a

Table 79: CZ 10 (SDG&E) - Multifamily PV & Battery Cost-Effectiveness Results

Measure	Vintage	Measure Cost ($)	Electricity Savings (kWh)	Gas Savings (therm)	GHG Savings (lb CO_2e)	Utility Cost Savings		Customer On-Bill		2019 TDV		2022 TDV	
						Year 1	Avg Annual	B/C Ratio	NPV	B/C Ratio	NPV	B/C Ratio	NPV
Prescriptive PV System	Pre-1978	$5,350	3,409	0	271	$1,259	$1,047	5.32	$25,513	2.28	$6,830	2.14	$6,097
	1978-1991		3,409		271	$1,240	$1,032	5.24	$25,047	2.27	$6,809	2.13	$6,067
	1992-2010		3,409		271	$1,225	$1,019	5.18	$24,678	2.26	$6,765	2.12	$5,996
PV + Battery	Pre-1978	$7,624	3,347	0	362	$1,254	$1,043	3.77	$22,982	1.65	$4,948	1.57	$4,358
	1978-1991		3,347		365	$1,273	$1,059	3.82	$23,458	1.65	$4,954	1.58	$4,430
	1992-2010		3,347		383	$1,225	$1,019	3.68	$22,268	1.69	$5,233	1.60	$4,582

Table 80: CZ 10 (SDG&E) - Multifamily Equipment Fuel Substitution Cost-Effectiveness Results

Measure	Vintage	Measure Cost ($)	Electricity Savings (kWh)	Gas Savings (therm)	GHG Savings (lb CO_2e)	Utility Cost Savings		Customer On-Bill		2019 TDV		2022 TDV	
						Year 1	Avg Annual	B/C Ratio	NPV	B/C Ratio	NPV	B/C Ratio	NPV
Heat Pump at HVAC Replacement	Pre-1978	$227	-458	39	155	-$101	-$69	0.00	-$2,307	0.00	-$547	0.33	-$152
	1978-1991		-272	22	86	-$70	-$49	0.00	-$1,724	0.00	-$456	0.00	-$240
	1992-2010		-202	17	62	-$49	-$34	0.00	-$1,269	0.00	-$416	0.00	-$246
High-Effic. Heat Pump at HVAC Replacement	Pre-1978	$3,245	-100	39	254	$67	$71	0.61	-$1,373	0.67	-$1,064	0.76	-$765
	1978-1991		17	22	164	$71	$68	0.58	-$1,478	0.56	-$1,432	0.61	-$1,257
	1992-2010		7	17	126	$51	$49	0.42	-$2,046	0.43	-$1,856	0.46	-$1,739
Heat Pump at HVAC Replacement + PV	Pre-1978	$5,576	2,951	39	426	$1,124	$951	4.64	$22,377	2.13	$6,285	2.06	$5,930
	1978-1991		3,136	22	357	$1,142	$959	4.68	$22,608	2.14	$6,353	2.04	$5,813
	1992-2010		3,207	17	333	$1,140	$955	4.66	$22,499	2.14	$6,356	2.03	$5,748
HVAC HP Replacement, PV, + Panel Upgrade	Pre-1978	$8,757	2,951	39	426	$1,124	$951	2.93	$18,805	1.35	$3,104	1.31	$2,749
	1978-1991		3,136	22	357	$1,142	$959	2.96	$19,036	1.36	$3,172	1.30	$2,632
	1992-2010		3,207	17	333	$1,140	$955	2.95	$18,927	1.36	$3,175	1.29	$2,567
HPWH at Water Heater Replacement	Pre-1978	$2,594	-825	128	1,018	-$52	$7	0.07	-$2,680	0.28	-$1,865	1.39	$1,009
	1978-1991		-825	128	1,018	-$50	$9	0.09	-$2,623	0.28	-$1,865	1.39	$1,009
	1992-2010		-825	128	1,018	-$40	$17	0.18	-$2,384	0.28	-$1,865	1.39	$1,009
NEEA Tier 3 HPWH at Replacement	Pre-1978	$2,775	-686	128	1,082	-$3	$48	0.47	-$1,650	0.51	-$1,371	1.54	$1,504
	1978-1991		-686	128	1,082	-$1	$49	0.48	-$1,614	0.51	-$1,371	1.54	$1,504
	1992-2010		-686	128	1,082	$7	$56	0.54	-$1,411	0.51	-$1,371	1.54	$1,504
HPWH at Water Heater Replacement + PV	Pre-1978	$7,943	2,584	128	1,289	$1,091	$958	3.27	$19,934	1.65	$5,137	1.91	$7,266
	1978-1991		2,584	128	1,289	$1,073	$943	3.22	$19,503	1.64	$5,118	1.91	$7,237
	1992-2010		2,584	128	1,289	$1,047	$921	3.14	$18,837	1.64	$5,076	1.90	$7,171
HPWH Replacement, PV, + Panel Upgrade	Pre-1978	$11,124	2,584	128	1,289	$1,091	$958	2.32	$16,362	1.18	$1,956	1.37	$4,085
	1978-1991		2,584	128	1,289	$1,073	$943	2.29	$15,931	1.17	$1,937	1.36	$4,056
	1992-2010		2,584	128	1,289	$1,047	$921	2.23	$15,265	1.17	$1,895	1.36	$3,990
PV + Electric Ready Pre-Wire	Pre-1978	$9,441	3,409	0	1,110	$1,259	$1,047	2.99	$20,920	1.29	$2,739	1.21	$2,006
	1978-1991		3,409	0	1,129	$1,240	$1,032	2.95	$20,453	0.84	-$1,530	1.21	$1,976
	1992-2010		3,409	0	1,121	$1,225	$1,019	2.91	$20,084	0.05	-$8,962	1.20	$1,905

6.4.13 Climate Zone 11:

Note: Values in red and grey rows indicate option is not cost-effective with B/C ratio less than 1. Cells with "n/a" reflect lighting and water heating efficiency measures and packages that did not look at TDV cost effectiveness or GHG impacts.

Table 81: CZ 11 - Multifamily Efficiency Upgrade Cost-Effectiveness Results

Measure	Vintage	Measure Cost ($)	Electricity Savings (kWh)	Gas Savings (therm)	GHG Savings (lb CO_2e)	Utility Cost Savings		Customer On-Bill		2019 TDV		2022 TDV	
						Year 1	Avg Annual	B/C Ratio	NPV	B/C Ratio	NPV	B/C Ratio	NPV
R-49 Attic Insulation	Pre-1978	$745	226	13	158	$105	$87	3.13	$1,778	3.21	$1,644	2.81	$1,349
	1978-1991	$745	120	6	75	$53	$44	1.58	$489	1.66	$495	1.46	$340
	1992-2010	$625	40	2	29	$17	$14	0.61	-$275	0.77	-$147	0.66	-$211
Reduced Infiltration	Pre-1978	$448	39	10	103	$31	$29	1.72	$363	1.80	$359	2.02	$457
	1978-1991		25	7	69	$20	$19	1.11	$54	1.28	$127	1.35	$159
	1992-2010		16	5	53	$13	$13	0.75	-$127	0.76	-$106	0.94	-$27
Duct Sealing	Pre-1978	$130	265	6	97	$110	$88	18.10	$2,496	20.79	$2,573	17.31	$2,120
	1978-1991	$130	156	3	51	$62	$49	10.09	$1,327	11.94	$1,422	9.93	$1,161
New Ducts	Pre-1978	$1,353	563	14	222	$236	$189	3.73	$4,146	4.43	$4,643	3.66	$3,606
	1978-1991		439	8	154	$177	$140	2.77	$2,691	3.46	$3,328	2.83	$2,483
	1992-2010		137	3	57	$50	$40	0.79	-$317	1.14	$188	0.96	-$53
Cool Roof	Pre-1978	$225	135	-1	7	$49	$37	4.56	$874	4.62	$815	3.25	$506
	1978-1991		101	0	5	$36	$28	3.41	$592	4.15	$708	2.59	$359
	1992-2010		50	0	4	$16	$12	1.46	$112	1.83	$186	1.44	$98
R-13 Wall Insulation	Pre-1978	$1,006	194	25	294	$116	$102	2.71	$1,930	3.32	$2,337	3.15	$2,162
Floor Insulation	Pre-1978	$822	-21	20	206	$29	$33	1.07	$62	1.24	$194	1.54	$445
Windows	Pre-1978	$5,873	974	25	405	$398	$319	1.45	$2,973	1.12	$699	1.37	$2,145
	1978-1991		798	19	322	$320	$256	1.17	$1,098	0.91	-$513	1.11	$642
LED lamp vs CFL	All	$2.26	1.2	0	n/a	$0.29	$0.22	2.97	$4.45	n/a	n/a	n/a	n/a
Exterior Photosensor	All	$42.58	12.1	0	n/a	$3.09	$2.38	1.68	$28.96	n/a	n/a	n/a	n/a

Table 82: CZ 11 - Multifamily Efficiency Packages Cost-Effectiveness Results

Measure	Vintage	Measure Cost ($)	Electricity Savings (kWh)	Gas Savings (therm)	GHG Savings (lb CO_2e)	Utility Cost Savings		Customer On-Bill		2019 TDV		2022 TDV	
						Year 1	Avg Annual	B/C Ratio	NPV	B/C Ratio	NPV	B/C Ratio	NPV
R49 Attic & Air Sealing Package	Pre-1978	$1,193	265	23	263	$136	$116	2.60	$2,139	2.76	$2,105	2.53	$1,825
	1978-1991	$1,193	145	13	146	$74	$63	1.41	$548	1.55	$657	1.42	$506
	1992-2010	$1,073	56	7	81	$30	$27	0.66	-$404	0.78	-$232	0.79	-$224
R49 Attic & Duct Sealing Package	Pre-1978	$875	481	18	248	$210	$171	5.22	$4,144	5.80	$4,196	4.90	$3,415
	1978-1991	$875	268	8	122	$112	$90	2.76	$1,731	3.25	$1,965	2.67	$1,459
R49 Attic, Air Sealing & Duct Sealing Package	Pre-1978	$1,323	516	28	354	$239	$198	3.99	$4,445	4.46	$4,573	3.90	$3,831
	1978-1991	$1,323	291	15	193	$132	$108	2.19	$1,769	2.62	$2,143	2.22	$1,609
	1992-2010	$1,203	56	7	81	$30	$27	0.59	-$550	0.70	-$362	0.71	-$354
R49 Attic, Air Sealing & New Ducts Package	Pre-1978	$2,546	816	34	474	$362	$296	3.10	$6,016	3.65	$6,737	3.11	$5,375
	1978-1991	$2,546	571	20	292	$244	$198	2.07	$3,067	2.56	$3,969	2.14	$2,911
	1992-2010	$2,427	188	10	133	$78	$65	0.71	-$777	0.98	-$36	0.88	-$289
Advanced Envelope Package	Pre-1978	$8,201	1,390	81	1,039	$647	$537	1.75	$6,905	1.76	$6,233	1.82	$6,720
Water Heating Package	All Vintages	$168	0	13	0	$42	$20	1.57	$107	n/a	n/a	n/a	n/a

Table 83: CZ 11 - Multifamily PV & Battery Cost-Effectiveness Results

Measure	Vintage	Measure Cost ($)	Electricity Savings (kWh)	Gas Savings (therm)	GHG Savings (lb CO_2e)	Utility Cost Savings		Customer On-Bill		2019 TDV		2022 TDV	
						Year 1	Avg Annual	B/C Ratio	NPV	B/C Ratio	NPV	B/C Ratio	NPV
Prescriptive PV System	Pre-1978	$5,929	3,376	0	217	$915	$707	3.24	$14,664	2.44	$8,518	1.84	$4,986
	1978-1991		3,376		217	$887	$686	3.14	$14,025	2.43	$8,488	1.84	$4,954
	1992-2010		3,376		217	$818	$632	2.90	$12,427	2.42	$8,424	1.82	$4,887
PV + Battery	Pre-1978	$8,203	3,319	0	304	$922	$712	2.39	$12,422	1.79	$6,467	1.38	$3,127
	1978-1991		3,319		305	$896	$693	2.32	$11,827	1.79	$6,446	1.38	$3,101
	1992-2010		3,318		319	$831	$642	2.15	$10,316	1.79	$6,465	1.38	$3,079

Table 84: CZ 11 - Multifamily Equipment Fuel Substitution Cost-Effectiveness Results

Measure	Vintage	Measure Cost ($)	Electricity Savings (kWh)	Gas Savings (therm)	GHG Savings (lb CO_2e)	Utility Cost Savings		Customer On-Bill		2019 TDV		2022 TDV	
						Year 1	Avg Annual	B/C Ratio	NPV	B/C Ratio	NPV	B/C Ratio	NPV
Heat Pump at HVAC Replacement	Pre-1978	$227	-1,291	116	534	-$84	-$12	0.00	-$615	0.00	-$1,748	2.63	$369
	1978-1991		-865	76	343	-$60	-$12	0.00	-$599	0.00	-$1,198	1.41	$94
	1992-2010		-649	57	252	-$55	-$16	0.00	-$743	0.00	-$994	0.87	-$30
High-Effic. Heat Pump at HVAC Replacement	Pre-1978	$3,245	-746	116	710	$80	$115	0.98	-$75	0.79	-$694	1.31	$1,013
	1978-1991		-438	76	478	$64	$85	0.72	-$977	0.67	-$1,063	1.01	$34
	1992-2010		-336	57	357	$35	$53	0.45	-$1,917	0.51	-$1,587	0.76	-$789
Heat Pump at HVAC Replacement + PV	Pre-1978	$6,156	2,085	116	751	$747	$631	2.79	$12,128	2.10	$6,791	1.87	$5,358
	1978-1991		2,511	76	560	$759	$622	2.75	$11,864	2.19	$7,303	1.82	$5,048
	1992-2010		2,727	57	468	$760	$613	2.71	$11,609	2.21	$7,458	1.79	$4,869
HVAC HP Replacement, PV, + Panel Upgrade	Pre-1978	$9,337	2,085	116	751	$747	$631	1.83	$8,556	1.39	$3,610	1.23	$2,177
	1978-1991		2,511	76	560	$759	$622	1.80	$8,292	1.44	$4,122	1.20	$1,867
	1992-2010		2,727	57	468	$760	$613	1.78	$8,037	1.46	$4,277	1.18	$1,688
HPWH at Water Heater Replacement	Pre-1978	$2,594	-994	130	982	-$60	$12	0.13	-$2,526	0.00	-$2,815	1.14	$353
	1978-1991		-994	130	982	-$59	$12	0.13	-$2,518	0.00	-$2,815	1.14	$353
	1992-2010		-994	130	982	-$46	$23	0.23	-$2,216	0.00	-$2,815	1.14	$353
NEEA Tier 3 HPWH at Replacement	Pre-1978	$2,775	-808	130	1,057	-$5	$55	0.53	-$1,453	0.24	-$2,101	1.37	$1,032
	1978-1991		-808	130	1,057	-$4	$54	0.53	-$1,458	0.24	-$2,101	1.37	$1,032
	1992-2010		-808	130	1,057	$7	$63	0.61	-$1,202	0.24	-$2,101	1.37	$1,032
HPWH at Water Heater Replacement + PV	Pre-1978	$8,523	2,382	130	1,199	$888	$745	2.37	$12,913	1.69	$5,881	1.65	$5,500
	1978-1991		2,382	130	1,199	$863	$725	2.31	$12,321	1.69	$5,855	1.64	$5,470
	1992-2010		2,382	130	1,199	$796	$673	2.14	$10,755	1.68	$5,795	1.63	$5,407
HPWH Replacement, PV, + Panel Upgrade	Pre-1978	$11,704	2,382	130	1,199	$888	$745	1.72	$9,341	1.23	$2,700	1.20	$2,319
	1978-1991		2,382	130	1,199	$863	$725	1.67	$8,749	1.23	$2,674	1.20	$2,289
	1992-2010		2,382	130	1,199	$796	$673	1.55	$7,183	1.22	$2,614	1.19	$2,226
PV + Electric Ready Pre-Wire	Pre-1978	$10,020	3,376	0	1,008	$915	$707	1.90	$10,070	1.44	$4,427	1.09	$895
	1978-1991		3,376	0	1,036	$887	$686	1.85	$9,431	0.75	-$2,467	1.09	$863
	1992-2010		3,376	0	1,036	$818	$632	1.70	$7,833	0.00	-$13,027	1.08	$796

6.4.14 Climate Zone 12 (PG&E):

Note: Values in red and grey rows indicate option is not cost-effective with B/C ratio less than 1. Cells with "n/a" reflect lighting and water heating efficiency measures and packages that did not look at TDV cost effectiveness or GHG impacts.

Table 85: CZ 12 (PG&E) - Multifamily Efficiency Upgrade Cost-Effectiveness Results

Measure	Vintage	Measure Cost ($)	Electricity Savings (kWh)	Gas Savings (therm)	GHG Savings (lb CO_2e)	Utility Cost Savings		Customer On-Bill		2019 TDV		2022 TDV	
						Year 1	Avg Annual	B/C Ratio	NPV	B/C Ratio	NPV	B/C Ratio	NPV
R-49 Attic Insulation	Pre-1978	$745	200	11	142	$91	$75	2.70	$1,420	2.83	$1,367	2.60	$1,195
	1978-1991	$745	105	6	71	$46	$38	1.37	$312	1.64	$474	1.39	$289
	1992-2010	$625	34	2	29	$14	$12	0.51	-$345	0.68	-$202	0.59	-$257
Reduced Infiltration	Pre-1978	$448	13	8	84	$18	$18	1.06	$29	1.39	$175	1.51	$229
	1978-1991		6	6	59	$12	$12	0.69	-$158	1.03	$16	0.99	-$4
	1992-2010		6	4	45	$9	$9	0.52	-$243	0.78	-$100	0.70	-$135
Duct Sealing	Pre-1978	$130	173	5	77	$72	$58	11.93	$1,596	16.58	$2,025	13.43	$1,616
	1978-1991	$130	99	2	40	$40	$32	6.51	$805	9.32	$1,082	7.70	$871
New Ducts	Pre-1978	$1,353	380	11	182	$160	$129	2.54	$2,338	3.45	$3,320	2.96	$2,652
	1978-1991		296	7	129	$118	$94	1.86	$1,299	2.71	$2,316	2.31	$1,774
	1992-2010		86	2	46	$31	$25	0.50	-$761	0.87	-$172	0.76	-$327
Cool Roof	Pre-1978	$225	119	-1	7	$42	$32	3.92	$718	4.67	$827	3.42	$545
	1978-1991		88	0	9	$31	$24	2.89	$463	3.86	$643	2.71	$386
	1992-2010		42	0	6	$12	$9	1.14	$35	1.81	$183	1.29	$65
R-13 Wall Insulation	Pre-1978	$1,006	97	22	249	$73	$67	1.77	$869	2.64	$1,648	2.41	$1,414
Floor Insulation	Pre-1978	$822	-87	15	138	-$5	$3	0.11	-$819	0.44	-$459	0.65	-$288
Windows	Pre-1978	$5,873	684	20	321	$276	$222	1.01	$59	0.91	-$534	1.06	$354
	1978-1991		565	16	273	$221	$178	0.81	-$1,245	0.74	-$1,506	0.88	-$681
LED lamp vs CFL	All	$2.26	1.2	0	n/a	$0.29	$0.22	2.97	$4.45	n/a	n/a	n/a	n/a
Exterior Photosensor	All	$42.58	12.1	0	n/a	$3.09	$2.38	1.68	$28.96	n/a	n/a	n/a	n/a

Table 86: CZ 12 (PG&E) - Multifamily Efficiency Packages Cost-Effectiveness Results

Measure	Vintage	Measure Cost ($)	Electricity Savings (kWh)	Gas Savings (therm)	GHG Savings (lb CO_2e)	Utility Cost Savings		Customer On-Bill		2019 TDV		2022 TDV	
						Year 1	Avg Annual	B/C Ratio	NPV	B/C Ratio	NPV	B/C Ratio	NPV
R49 Attic & Air Sealing Package	Pre-1978	$1,193	212	20	225	$109	$93	2.08	$1,452	2.31	$1,566	2.22	$1,450
	1978-1991	$1,193	111	11	129	$58	$50	1.12	$160	1.35	$418	1.26	$308
	1992-2010	$1,073	40	6	72	$23	$21	0.52	-$582	0.69	-$336	0.70	-$318
R49 Attic & Duct Sealing Package	Pre-1978	$875	360	16	214	$157	$128	3.92	$2,871	4.78	$3,305	4.18	$2,784
	1978-1991	$875	197	7	107	$82	$67	2.04	$1,024	2.72	$1,503	2.31	$1,146
R49 Attic, Air Sealing & Duct Sealing Package	Pre-1978	$1,323	370	24	296	$173	$145	2.92	$2,858	3.58	$3,420	3.26	$2,983
	1978-1991	$1,323	202	13	165	$93	$78	1.57	$852	2.07	$1,415	1.86	$1,138
	1992-2010	$1,203	40	6	72	$23	$21	0.46	-$728	0.61	-$466	0.63	-$448
R49 Attic, Air Sealing & New Ducts Package	Pre-1978	$2,546	574	29	395	$256	$211	2.22	$3,478	2.88	$4,799	2.59	$4,052
	1978-1991	$2,546	394	17	248	$168	$137	1.44	$1,265	2.02	$2,588	1.79	$1,999
	1992-2010	$2,427	123	9	114	$53	$45	0.49	-$1,383	0.78	-$533	0.73	-$652
Advanced Envelope Package	Pre-1978	$8,201	908	69	858	$434	$367	1.20	$1,802	1.40	$3,257	1.43	$3,557
Water Heating Package	All Vintages	$168	0	13	0	$41	$20	1.57	$108	n/a	n/a	n/a	n/a

Table 87: CZ 12 (PG&E) - Multifamily PV & Battery Cost-Effectiveness Results

Measure	Vintage	Measure Cost ($)	Electricity Savings (kWh)	Gas Savings (therm)	GHG Savings (lb CO_2e)	Utility Cost Savings		Customer On-Bill		2019 TDV		2022 TDV	
						Year 1	Avg Annual	B/C Ratio	NPV	B/C Ratio	NPV	B/C Ratio	NPV
Prescriptive PV System	Pre-1978	$5,289	3,097	0	190	$789	$610	3.14	$12,456	2.38	$7,307	1.88	$4,637
	1978-1991		3,097		190	$768	$594	3.05	$11,975	2.38	$7,292	1.87	$4,619
	1992-2010		3,097		190	$715	$552	2.84	$10,739	2.37	$7,255	1.87	$4,577
PV + Battery	Pre-1978	$7,563	3,041	0	295	$801	$619	2.25	$10,318	1.70	$5,271	1.38	$2,841
	1978-1991		3,041		298	$781	$603	2.20	$9,858	1.70	$5,268	1.37	$2,834
	1992-2010		3,041		318	$722	$558	2.03	$8,502	1.72	$5,412	1.38	$2,858

Table 88: CZ 12 (PG&E) - Multifamily Equipment Fuel Substitution Cost-Effectiveness Results

Measure	Vintage	Measure Cost ($)	Electricity Savings (kWh)	Gas Savings (therm)	GHG Savings (lb CO_2e)	Utility Cost Savings		Customer On-Bill		2019 TDV		2022 TDV	
						Year 1	Avg Annual	B/C Ratio	NPV	B/C Ratio	NPV	B/C Ratio	NPV
Heat Pump at HVAC Replacement	Pre-1978	$227	-1,095	101	468	-$80	-$16	0.00	-$720	0.00	-$1,067	2.34	$305
	1978-1991		-743	67	308	-$58	-$14	0.00	-$661	0.00	-$841	1.35	$80
	1992-2010		-566	51	233	-$45	-$11	0.00	-$585	0.00	-$742	0.92	-$18
High-Effic. Heat Pump at HVAC Replacement	Pre-1978	$3,245	-717	101	604	$25	$65	0.56	-$1,557	0.67	-$1,067	1.02	$66
	1978-1991		-452	67	411	$25	$50	0.43	-$2,019	0.55	-$1,465	0.78	-$699
	1992-2010		-362	51	310	$13	$33	0.28	-$2,517	0.40	-$1,940	0.57	-$1,386
Heat Pump at HVAC Replacement + PV	Pre-1978	$5,516	2,003	101	658	$669	$563	2.78	$10,804	2.14	$6,271	1.90	$4,948
	1978-1991		2,355	67	498	$690	$564	2.78	$10,844	2.17	$6,473	1.85	$4,701
	1992-2010		2,532	51	422	$702	$566	2.79	$10,890	2.19	$6,542	1.83	$4,570
HVAC HP Replacement, PV, + Panel Upgrade	Pre-1978	$8,697	2,003	101	658	$669	$563	1.75	$7,232	1.36	$3,090	1.20	$1,767
	1978-1991		2,355	67	498	$690	$564	1.75	$7,272	1.38	$3,292	1.17	$1,520
	1992-2010		2,532	51	422	$702	$566	1.76	$7,318	1.39	$3,361	1.16	$1,389
HPWH at Water Heater Replacement	Pre-1978	$2,594	-1,010	134	1,030	-$60	$13	0.14	-$2,488	0.00	-$2,741	1.19	$493
	1978-1991		-1,010	134	1,030	-$56	$16	0.17	-$2,404	0.00	-$2,741	1.19	$493
	1992-2010		-1,010	134	1,030	-$37	$31	0.32	-$1,962	0.00	-$2,741	1.19	$493
NEEA Tier 3 HPWH at Replacement	Pre-1978	$2,775	-822	134	1,110	-$3	$57	0.55	-$1,376	0.25	-$2,084	1.44	$1,229
	1978-1991		-822	134	1,110	$0	$59	0.57	-$1,317	0.25	-$2,084	1.44	$1,229
	1992-2010		-822	134	1,110	$15	$71	0.69	-$963	0.25	-$2,084	1.44	$1,229
HPWH at Water Heater Replacement + PV	Pre-1978	$7,883	2,087	134	1,220	$768	$653	2.24	$10,855	1.60	$4,750	1.67	$5,306
	1978-1991		2,087	134	1,220	$746	$636	2.19	$10,350	1.60	$4,736	1.67	$5,288
	1992-2010		2,087	134	1,220	$724	$619	2.13	$9,838	1.60	$4,703	1.67	$5,251
HPWH Replacement, PV, + Panel Upgrade	Pre-1978	$11,064	2,087	134	1,220	$768	$653	1.59	$7,283	1.14	$1,569	1.19	$2,125
	1978-1991		2,087	134	1,220	$746	$636	1.55	$6,778	1.14	$1,555	1.19	$2,107
	1992-2010		2,087	134	1,220	$724	$619	1.51	$6,266	1.14	$1,522	1.19	$2,070
PV + Electric Ready Pre-Wire	Pre-1978	$9,380	3,097	0	1,068	$789	$610	1.75	$7,862	1.34	$3,216	1.06	$546
	1978-1991		3,097	0	1,089	$768	$594	1.71	$7,381	0.77	-$2,172	1.06	$528
	1992-2010		3,097	0	1,085	$715	$552	1.59	$6,145	0.00	-$10,311	1.05	$486

6.4.15 Climate Zone 12 (SMUD):

Note: Values in red and grey rows indicate option is not cost-effective with B/C ratio less than 1. Cells with "n/a" reflect lighting and water heating efficiency measures and packages that did not look at TDV cost effectiveness or GHG impacts.

Table 89: CZ 12 (SMUD) - Multifamily Efficiency Upgrade Cost-Effectiveness Results

Measure	Vintage	Measure Cost ($)	Electricity Savings (kWh)	Gas Savings (therm)	GHG Savings (lb CO_2e)	Utility Cost Savings		Customer On-Bill		2019 TDV		2022 TDV	
						Year 1	Avg Annual	B/C Ratio	NPV	B/C Ratio	NPV	B/C Ratio	NPV
R-49 Attic Insulation	Pre-1978	$745	200	11	142	$54	$47	1.69	$577	2.83	$1,367	2.60	$1,195
	1978-1991	$745	105	6	71	$28	$24	0.87	-$108	1.64	$474	1.39	$289
	1992-2010	$625	34	2	29	$10	$9	0.37	-$441	0.68	-$202	0.59	-$257
Reduced Infiltration	Pre-1978	$448	13	8	84	$16	$16	0.95	-$27	1.39	$175	1.51	$229
	1978-1991		6	6	59	$10	$11	0.63	-$186	1.03	$16	0.99	-$4
	1992-2010		6	4	45	$8	$8	0.48	-$261	0.78	-$100	0.70	-$135
Duct Sealing	Pre-1978	$130	173	5	77	$40	$33	6.88	$858	16.58	$2,025	13.43	$1,616
	1978-1991	$130	99	2	40	$22	$18	3.74	$400	9.32	$1,082	7.70	$871
New Ducts	Pre-1978	$1,353	380	11	182	$90	$75	1.48	$735	3.45	$3,320	2.96	$2,652
	1978-1991		296	7	129	$68	$56	1.10	$151	2.71	$2,316	2.31	$1,774
	1992-2010		86	2	46	$21	$17	0.34	-$1,007	0.87	-$172	0.76	-$327
Cool Roof	Pre-1978	$225	119	-1	7	$20	$15	1.86	$211	4.67	$827	3.42	$545
	1978-1991		88	0	9	$15	$12	1.43	$106	3.86	$643	2.71	$386
	1992-2010		42	0	6	$7	$5	0.66	-$83	1.81	$183	1.29	$65
R-13 Wall Insulation	Pre-1978	$1,006	97	22	249	$56	$53	1.41	$467	2.64	$1,648	2.41	$1,414
Floor Insulation	Pre-1978	$822	-87	15	138	$11	$16	0.51	-$453	0.44	-$459	0.65	-$288
Windows	Pre-1978	$5,873	684	20	321	$160	$133	0.60	-$2,612	0.91	-$534	1.06	$354
	1978-1991		565	16	273	$134	$111	0.50	-$3,274	0.74	-$1,506	0.88	-$681
LED lamp vs CFL	All	$2.26	1.2	0	n/a	$0.26	$0.20	2.70	$3.83	n/a	n/a	n/a	n/a
Exterior Photosensor	All	$42.58	12.1	0	n/a	$1.53	$1.18	0.83	-$7.16	n/a	n/a	n/a	n/a

Table 90: CZ 12 (SMUD) - Multifamily Efficiency Packages Cost-Effectiveness Results

Measure	Vintage	Measure Cost ($)	Electricity Savings (kWh)	Gas Savings (therm)	GHG Savings (lb CO_2e)	Utility Cost Savings		Customer On-Bill		2019 TDV		2022 TDV	
						Year 1	Avg Annual	B/C Ratio	NPV	B/C Ratio	NPV	B/C Ratio	NPV
R49 Attic & Air Sealing Package	Pre-1978	$1,193	212	20	225	$70	$63	1.41	$554	2.31	$1,566	2.22	$1,450
	1978-1991	$1,193	111	11	129	$39	$35	0.78	-$288	1.35	$418	1.26	$308
	1992-2010	$1,073	40	6	72	$18	$17	0.42	-$694	0.69	-$336	0.70	-$318
R49 Attic & Duct Sealing Package	Pre-1978	$875	360	16	214	$92	$78	2.39	$1,363	4.78	$3,305	4.18	$2,784
	1978-1991	$875	197	7	107	$49	$41	1.26	$256	2.72	$1,503	2.31	$1,146
R49 Attic, Air Sealing & Duct Sealing Package	Pre-1978	$1,323	370	24	296	$107	$93	1.88	$1,310	3.58	$3,420	3.26	$2,983
	1978-1991	$1,323	202	13	165	$59	$52	1.04	$62	2.07	$1,415	1.86	$1,138
	1992-2010	$1,203	40	6	72	$18	$17	0.38	-$840	0.61	-$466	0.63	-$448
R49 Attic, Air Sealing & New Ducts Package	Pre-1978	$2,546	574	29	395	$155	$133	1.40	$1,135	2.88	$4,799	2.59	$4,052
	1978-1991	$2,546	394	17	248	$103	$87	0.92	-$242	2.02	$2,588	1.79	$1,999
	1992-2010	$2,427	123	9	114	$38	$33	0.37	-$1,729	0.78	-$533	0.73	-$652
Advanced Envelope Package	Pre-1978	$8,201	908	69	858	$284	$251	0.82	-$1,674	1.40	$3,257	1.43	$3,557
Water Heating Package	All Vintages	$168	0	13	0	$37	$20	1.57	$108	n/a	n/a	n/a	n/a

Table 91: CZ 12 (SMUD) - Multifamily PV & Battery Cost-Effectiveness Results

Measure	Vintage	Measure Cost ($)	Electricity Savings (kWh)	Gas Savings (therm)	GHG Savings (lb CO_2e)	Utility Cost Savings		Customer On-Bill		2019 TDV		2022 TDV	
						Year 1	Avg Annual	B/C Ratio	NPV	B/C Ratio	NPV	B/C Ratio	NPV
Prescriptive PV System	Pre-1978	$5,289	3,097	0	190	$394	$304	1.56	$3,295	2.38	$7,307	1.88	$4,637
	1978-1991		3,097		190	$394	$304	1.56	$3,295	2.38	$7,292	1.87	$4,619
	1992-2010		3,097		190	$394	$304	1.56	$3,295	2.37	$7,255	1.87	$4,577
PV + Battery	Pre-1978	$7,563	3,041	0	295	$408	$315	1.15	$1,210	1.70	$5,271	1.38	$2,841
	1978-1991		3,041		298	$409	$316	1.15	$1,227	1.70	$5,268	1.37	$2,834
	1992-2010		3,041		318	$412	$318	1.16	$1,296	1.72	$5,412	1.38	$2,858

Table 92: CZ 12 (SMUD) - Multifamily Equipment Fuel Substitution Cost-Effectiveness Results

Measure	Vintage	Measure Cost ($)	Electricity Savings (kWh)	Gas Savings (therm)	GHG Savings (lb CO_2e)	Utility Cost Savings		Customer On-Bill		2019 TDV		2022 TDV	
						Year 1	Avg Annual	B/C Ratio	NPV	B/C Ratio	NPV	B/C Ratio	NPV
Heat Pump at HVAC Replacement	Pre-1978	$227	-1,095	101	468	$51	$85	10.25	$2,309	0.00	-$1,067	2.34	$305
	1978-1991		-743	67	308	$33	$57	6.81	$1,450	0.00	-$841	1.35	$80
	1992-2010		-566	51	233	$25	$42	5.10	$1,024	0.00	-$742	0.92	-$18
High-Effic. Heat Pump at HVAC Replacement	Pre-1978	$3,245	-717	101	604	$109	$130	1.11	$401	0.67	-$1,067	1.02	$66
	1978-1991		-452	67	411	$80	$93	0.79	-$731	0.55	-$1,465	0.78	-$699
	1992-2010		-362	51	310	$57	$68	0.58	-$1,486	0.40	-$1,940	0.57	-$1,386
Heat Pump at HVAC Replacement + PV	Pre-1978	$5,516	2,003	101	658	$445	$390	1.92	$5,603	2.14	$6,271	1.90	$4,948
	1978-1991		2,355	67	498	$427	$361	1.78	$4,745	2.17	$6,473	1.85	$4,701
	1992-2010		2,532	51	422	$419	$347	1.71	$4,319	2.19	$6,542	1.83	$4,570
HVAC HP Replacement, PV, + Panel Upgrade	Pre-1978	$8,697	2,003	101	658	$445	$390	1.21	$2,031	1.36	$3,090	1.20	$1,767
	1978-1991		2,355	67	498	$427	$361	1.12	$1,173	1.38	$3,292	1.17	$1,520
	1992-2010		2,532	51	422	$419	$347	1.08	$747	1.39	$3,361	1.16	$1,389
HPWH at Water Heater Replacement	Pre-1978	$2,594	-1,010	134	1,030	$99	$136	1.41	$1,198	0.00	-$2,741	1.19	$493
	1978-1991		-1,010	134	1,030	$99	$135	1.41	$1,173	0.00	-$2,741	1.19	$493
	1992-2010		-1,010	134	1,030	$98	$135	1.40	$1,167	0.00	-$2,741	1.19	$493
NEEA Tier 3 HPWH at Replacement	Pre-1978	$2,775	-822	134	1,110	$122	$154	1.49	$1,521	0.25	-$2,084	1.44	$1,229
	1978-1991		-822	134	1,110	$121	$153	1.48	$1,496	0.25	-$2,084	1.44	$1,229
	1992-2010		-822	134	1,110	$121	$153	1.48	$1,490	0.25	-$2,084	1.44	$1,229
HPWH at Water Heater Replacement + PV	Pre-1978	$7,883	2,087	134	1,220	$493	$441	1.51	$4,493	1.60	$4,750	1.67	$5,306
	1978-1991		2,087	134	1,220	$492	$440	1.51	$4,468	1.60	$4,736	1.67	$5,288
	1992-2010		2,087	134	1,220	$492	$440	1.51	$4,462	1.60	$4,703	1.67	$5,251
HPWH Replacement, PV, + Panel Upgrade	Pre-1978	$11,064	2,087	134	1,220	$493	$441	1.07	$921	1.14	$1,569	1.19	$2,125
	1978-1991		2,087	134	1,220	$492	$440	1.07	$896	1.14	$1,555	1.19	$2,107
	1992-2010		2,087	134	1,220	$492	$440	1.07	$890	1.14	$1,522	1.19	$2,070
PV + Electric Ready Pre-Wire	Pre-1978	$9,380	3,097	0	1,068	$394	$304	0.88	-$1,299	1.34	$3,216	1.06	$546
	1978-1991		3,097	0	1,089	$394	$304	0.88	-$1,299	0.77	-$2,172	1.06	$528
	1992-2010		3,097	0	1,085	$394	$304	0.88	-$1,299	0.00	-$10,311	1.05	$486

6.4.16 Climate Zone 13:

Note: Values in red and grey rows indicate option is not cost-effective with B/C ratio less than 1. Cells with "n/a" reflect lighting and water heating efficiency measures and packages that did not look at TDV cost effectiveness or GHG impacts.

Table 93: CZ 13 - Multifamily Efficiency Upgrade Cost-Effectiveness Results

Measure	Vintage	Measure Cost ($)	Electricity Savings (kWh)	Gas Savings (therm)	GHG Savings (lb CO_2e)	Utility Cost Savings		Customer On-Bill		2019 TDV		2022 TDV	
						Year 1	Avg Annual	B/C Ratio	NPV	B/C Ratio	NPV	B/C Ratio	NPV
R-49 Attic Insulation	Pre-1978	$745	310	8	119	$124	$100	3.57	$2,153	2.95	$1,453	3.10	$1,567
	1978-1991	$745	166	4	60	$67	$53	1.91	$764	1.67	$497	1.69	$513
	1992-2010	$625	55	2	23	$22	$17	0.74	-$180	0.83	-$108	0.75	-$157
Reduced Infiltration	Pre-1978	$448	41	6	72	$26	$23	1.39	$194	1.79	$354	1.67	$300
	1978-1991		28	5	49	$19	$17	0.99	-$3	1.18	$79	1.35	$159
	1992-2010		19	4	39	$13	$12	0.69	-$154	1.00	$2	0.85	-$69
Duct Sealing	Pre-1978	$130	334	4	84	$131	$103	21.08	$2,932	19.38	$2,390	19.98	$2,468
	1978-1991	$130	197	2	45	$77	$60	12.32	$1,653	11.83	$1,408	12.26	$1,464
New Ducts	Pre-1978	$1,353	718	9	190	$283	$223	4.40	$5,167	4.18	$4,304	4.33	$4,511
	1978-1991		564	5	144	$222	$174	3.43	$3,691	3.41	$3,264	3.38	$3,215
	1992-2010		176	2	53	$65	$51	1.01	$9	1.27	$372	1.11	$155
Cool Roof	Pre-1978	$225	180	-1	14	$64	$49	6.03	$1,235	4.53	$794	4.68	$828
	1978-1991		137	-1	13	$50	$38	4.65	$897	3.86	$643	3.78	$625
	1992-2010		66	0	5	$23	$17	2.10	$271	2.35	$305	2.17	$263
R-13 Wall Insulation	Pre-1978	$1,006	235	17	220	$117	$99	2.62	$1,831	3.26	$2,271	2.87	$1,879
Floor Insulation	Pre-1978	$822	-31	11	111	$10	$13	0.42	-$534	0.85	-$121	0.85	-$119
Windows	Pre-1978	$5,873	1,113	16	312	$436	$344	1.56	$3,716	1.04	$262	1.44	$2,558
	1978-1991		913	13	266	$358	$282	1.28	$1,878	0.87	-$745	1.17	$988
LED lamp vs CFL	All	$2.26	1.2	0	n/a	$0.29	$0.22	2.97	$4.45	n/a	n/a	n/a	n/a
Exterior Photosensor	All	$42.58	12.1	0	n/a	$3.09	$2.38	1.68	$28.96	n/a	n/a	n/a	n/a

Table 94: CZ 13 - Multifamily Efficiency Packages Cost-Effectiveness Results

Measure	Vintage	Measure Cost ($)	Electricity Savings (kWh)	Gas Savings (therm)	GHG Savings (lb CO_2e)	Utility Cost Savings		Customer On-Bill		2019 TDV		2022 TDV	
						Year 1	Avg Annual	B/C Ratio	NPV	B/C Ratio	NPV	B/C Ratio	NPV
R49 Attic & Air Sealing Package	Pre-1978	$1,193	353	15	189	$152	$124	2.78	$2,378	2.49	$1,777	2.69	$2,019
	1978-1991	$1,193	194	9	114	$85	$70	1.57	$764	1.47	$564	1.49	$582
	1992-2010	$1,073	73	5	62	$34	$29	0.72	-$343	0.87	-$137	0.81	-$205
R49 Attic & Duct Sealing Package	Pre-1978	$875	630	11	202	$250	$198	6.06	$4,968	5.37	$3,819	5.59	$4,020
	1978-1991	$875	354	6	106	$140	$111	3.38	$2,334	3.11	$1,842	3.12	$1,857
R49 Attic, Air Sealing & Duct Sealing Package	Pre-1978	$1,323	668	18	275	$275	$221	4.46	$5,136	4.13	$4,145	4.23	$4,272
	1978-1991	$1,323	378	10	155	$157	$126	2.55	$2,301	2.47	$1,943	2.51	$1,996
	1992-2010	$1,203	73	5	62	$34	$29	0.64	-$489	0.78	-$267	0.72	-$335
R49 Attic, Air Sealing & New Ducts Package	Pre-1978	$2,546	1,051	22	382	$427	$340	3.57	$7,351	3.43	$6,194	3.47	$6,301
	1978-1991	$2,546	739	13	252	$299	$237	2.49	$4,264	2.51	$3,835	2.46	$3,711
	1992-2010	$2,427	243	7	113	$96	$77	0.85	-$405	1.06	$143	0.97	-$77
Advanced Envelope Package	Pre-1978	$8,201	1,686	54	799	$715	$577	1.88	$8,112	1.68	$5,557	1.86	$7,029
Water Heating Package	All Vintages	$168	0	13	0	$44	$20	1.61	$116	n/a	n/a	n/a	n/a

Table 95: CZ 13 - Multifamily PV & Battery Cost-Effectiveness Results

Measure	Vintage	Measure Cost ($)	Electricity Savings (kWh)	Gas Savings (therm)	GHG Savings (lb CO_2e)	Utility Cost Savings		Customer On-Bill		2019 TDV		2022 TDV	
						Year 1	Avg Annual	B/C Ratio	NPV	B/C Ratio	NPV	B/C Ratio	NPV
Prescriptive PV System	Pre-1978	$6,259	3,702	0	236	$1,024	$791	3.44	$16,826	2.30	$8,145	1.93	$5,848
	1978-1991		3,702		236	$1,002	$775	3.37	$16,337	2.30	$8,109	1.93	$5,806
	1992-2010		3,702		236	$907	$701	3.04	$14,118	2.28	$8,037	1.91	$5,719
PV + Battery	Pre-1978	$8,533	3,643	0	313	$1,029	$795	2.56	$14,547	1.71	$6,075	1.46	$3,953
	1978-1991		3,643		316	$1,010	$780	2.51	$14,091	1.71	$6,045	1.46	$3,923
	1992-2010		3,643		331	$919	$710	2.29	$11,991	1.71	$6,020	1.46	$3,895

Table 96: CZ 13 - Multifamily Equipment Fuel Substitution Cost-Effectiveness Results

Measure	Vintage	Measure Cost ($)	Electricity Savings (kWh)	Gas Savings (therm)	GHG Savings (lb CO_2e)	Utility Cost Savings		Customer On-Bill		2019 TDV		2022 TDV	
						Year 1	Avg Annual	B/C Ratio	NPV	B/C Ratio	NPV	B/C Ratio	NPV
Heat Pump at HVAC Replacement	Pre-1978	$227	-859	77	339	-$45	$0	0.00	-$250	0.00	-$1,169	1.31	$70
	1978-1991		-580	51	220	-$28	$2	0.20	-$201	0.00	-$924	0.60	-$90
	1992-2010		-436	38	161	-$31	-$7	0.00	-$458	0.00	-$800	0.30	-$159
High-Effic. Heat Pump at HVAC Replacement	Pre-1978	$3,245	-297	77	505	$137	$141	1.20	$715	0.90	-$327	1.26	$834
	1978-1991		-125	51	352	$116	$113	0.96	-$131	0.75	-$802	1.01	$16
	1992-2010		-98	38	267	$68	$70	0.59	-$1,425	0.58	-$1,350	0.76	-$787
Heat Pump at HVAC Replacement + PV	Pre-1978	$6,485	2,843	77	575	$884	$718	3.01	$14,383	2.08	$6,990	1.91	$5,908
	1978-1991		3,123	51	455	$880	$703	2.95	$13,941	2.11	$7,193	1.88	$5,705
	1992-2010		3,266	38	397	$860	$682	2.86	$13,305	2.12	$7,261	1.86	$5,568
HVAC HP Replacement, PV, + Panel Upgrade	Pre-1978	$9,666	2,843	77	575	$884	$718	2.01	$10,811	1.39	$3,809	1.28	$2,727
	1978-1991		3,123	51	455	$880	$703	1.97	$10,369	1.42	$4,012	1.26	$2,524
	1992-2010		3,266	38	397	$860	$682	1.91	$9,733	1.42	$4,080	1.25	$2,387
HPWH at Water Heater Replacement	Pre-1978	$2,594	-901	127	986	-$40	$25	0.26	-$2,130	0.00	-$2,675	1.25	$645
	1978-1991		-901	127	986	-$39	$26	0.27	-$2,104	0.00	-$2,675	1.25	$645
	1992-2010		-901	127	986	-$34	$30	0.31	-$1,992	0.00	-$2,675	1.25	$645
NEEA Tier 3 HPWH at Replacement	Pre-1978	$2,775	-728	127	1,061	$10	$64	0.62	-$1,161	0.28	-$1,992	1.45	$1,241
	1978-1991		-728	127	1,061	$11	$65	0.63	-$1,137	0.28	-$1,992	1.45	$1,241
	1992-2010		-728	127	1,061	$16	$68	0.66	-$1,036	0.28	-$1,992	1.45	$1,241
HPWH at Water Heater Replacement + PV	Pre-1978	$8,852	2,801	127	1,221	$1,009	$836	2.56	$15,288	1.64	$5,646	1.75	$6,656
	1978-1991		2,801	127	1,221	$991	$822	2.52	$14,870	1.63	$5,613	1.75	$6,617
	1992-2010		2,801	127	1,221	$901	$753	2.31	$12,784	1.63	$5,545	1.74	$6,534
HPWH Replacement, PV, + Panel Upgrade	Pre-1978	$12,033	2,801	127	1,221	$1,009	$836	1.88	$11,717	1.20	$2,465	1.29	$3,475
	1978-1991		2,801	127	1,221	$991	$822	1.85	$11,298	1.20	$2,432	1.29	$3,436
	1992-2010		2,801	127	1,221	$901	$753	1.69	$9,212	1.20	$2,364	1.28	$3,353
PV + Electric Ready Pre-Wire	Pre-1978	$10,350	3,702	0	1,060	$1,024	$791	2.06	$12,232	1.39	$4,054	1.17	$1,757
	1978-1991		3,702	0	1,078	$1,002	$775	2.02	$11,743	0.77	-$2,341	1.17	$1,715
	1992-2010		3,702	0	1,071	$907	$701	1.83	$9,524	0.00	-$12,863	1.16	$1,628

6.4.17 Climate Zone 14 (SCE/SoCalGas):

Note: Values in red and grey rows indicate option is not cost-effective with B/C ratio less than 1. Cells with "n/a" reflect lighting and water heating efficiency measures and packages that did not look at TDV cost effectiveness or GHG impacts.

Table 97: CZ 14 (SCE/SoCalGas) - Multifamily Efficiency Upgrade Cost-Effectiveness Results

Measure	Vintage	Measure Cost ($)	Electricity Savings (kWh)	Gas Savings (therm)	GHG Savings (lb CO_2e)	Utility Cost Savings		Customer On-Bill		2019 TDV		2022 TDV	
						Year 1	Avg Annual	B/C Ratio	NPV	B/C Ratio	NPV	B/C Ratio	NPV
R-49 Attic Insulation	Pre-1978	$745	211	13	154	$82	$67	2.40	$1,173	2.84	$1,373	2.92	$1,427
	1978-1991	$745	111	6	71	$41	$34	1.21	$171	1.56	$414	1.54	$399
	1992-2010	$625	36	2	27	$13	$11	0.48	-$368	0.70	-$187	0.70	-$187
Reduced Infiltration	Pre-1978	$448	40	10	109	$25	$23	1.35	$176	2.19	$535	1.98	$440
	1978-1991		24	7	69	$16	$14	0.85	-$73	1.53	$235	1.46	$207
	1992-2010		14	5	51	$10	$9	0.55	-$226	0.96	-$19	0.98	-$10
Duct Sealing	Pre-1978	$130	241	6	88	$86	$68	13.94	$1,889	18.61	$2,289	17.02	$2,082
	1978-1991	$130	138	2	41	$48	$37	7.60	$964	11.32	$1,342	9.54	$1,110
New Ducts	Pre-1978	$1,353	523	13	196	$186	$147	2.89	$2,878	3.95	$3,996	3.63	$3,553
	1978-1991		404	7	128	$141	$110	2.18	$1,787	3.13	$2,882	2.78	$2,409
	1992-2010		121	3	47	$39	$31	0.61	-$598	1.02	$28	0.92	-$103
Cool Roof	Pre-1978	$225	124	-1	-3	$39	$29	3.55	$626	3.76	$622	3.62	$589
	1978-1991		92	-1	-1	$28	$21	2.57	$385	3.28	$512	2.92	$431
	1992-2010		43	-1	-1	$12	$9	1.12	$29	1.72	$162	1.54	$123
R-13 Wall Insulation	Pre-1978	$1,006	166	26	293	$89	$77	2.04	$1,179	3.12	$2,131	2.87	$1,884
Floor Insulation	Pre-1978	$822	-11	21	215	$20	$22	0.73	-$251	1.58	$475	1.48	$395
Windows	Pre-1978	$5,873	855	15	277	$293	$229	1.04	$272	0.99	-$36	1.10	$563
	1978-1991		701	11	211	$234	$182	0.83	-$1,120	0.81	-$1,110	0.90	-$572
LED lamp vs CFL	All	$2.26	1.2	0	n/a	$0.28	$0.22	2.86	$4.19	n/a	n/a	n/a	n/a
Exterior Photosensor	All	$42.58	12.1	0	n/a	$2.34	$1.78	1.25	$10.76	n/a	n/a	n/a	n/a

Table 98: CZ 14 (SCE/SoCalGas) - Multifamily Efficiency Packages Cost-Effectiveness Results

Measure	Vintage	Measure Cost ($)	Electricity Savings (kWh)	Gas Savings (therm)	GHG Savings (lb CO_2e)	Utility Cost Savings		Customer On-Bill		2019 TDV		2022 TDV	
						Year 1	Avg Annual	B/C Ratio	NPV	B/C Ratio	NPV	B/C Ratio	NPV
R49 Attic & Air Sealing Package	Pre-1978	$1,193	252	24	264	$107	$90	2.01	$1,357	2.59	$1,900	2.60	$1,905
	1978-1991	$1,193	134	13	138	$57	$48	1.08	$102	1.54	$648	1.54	$642
	1992-2010	$1,073	50	7	79	$23	$20	0.51	-$592	0.85	-$166	0.80	-$214
R49 Attic & Duct Sealing Package	Pre-1978	$875	440	18	233	$162	$130	3.96	$2,912	5.12	$3,609	4.91	$3,421
	1978-1991	$875	241	8	108	$86	$69	2.10	$1,079	2.92	$1,684	2.68	$1,469
R49 Attic, Air Sealing & Duct Sealing Package	Pre-1978	$1,323	474	28	338	$184	$150	3.04	$3,027	4.15	$4,174	3.87	$3,797
	1978-1991	$1,323	261	15	178	$101	$82	1.66	$978	2.45	$1,916	2.21	$1,595
	1992-2010	$1,203	50	7	79	$23	$20	0.45	-$738	0.75	-$296	0.71	-$344
R49 Attic, Air Sealing & New Ducts Package	Pre-1978	$2,546	756	34	439	$285	$229	2.40	$4,014	3.29	$5,839	3.08	$5,307
	1978-1991	$2,546	524	19	255	$192	$153	1.61	$1,737	2.32	$3,367	2.15	$2,926
	1992-2010	$2,427	165	10	122	$60	$49	0.54	-$1,257	0.92	-$196	0.85	-$363
Advanced Envelope Package	Pre-1978	$8,201	1,228	76	932	$485	$396	1.29	$2,678	1.63	$5,164	1.64	$5,238
Water Heating Package	All Vintages	$168	0	13	0	$34	$16	1.24	$45	n/a	n/a	n/a	n/a

Table 99: CZ 14 (SCE/SoCalGas) - Multifamily PV & Battery Cost-Effectiveness Results

Measure	Vintage	Measure Cost ($)	Electricity Savings (kWh)	Gas Savings (therm)	GHG Savings (lb CO_2e)	Utility Cost Savings		Customer On-Bill		2019 TDV		2022 TDV	
						Year 1	Avg Annual	B/C Ratio	NPV	B/C Ratio	NPV	B/C Ratio	NPV
Prescriptive PV System	Pre-1978	$5,210	3,593	0	289	$756	$575	3.00	$11,516	2.64	$8,561	2.32	$6,889
	1978-1991		3,593		289	$736	$560	2.92	$11,058	2.64	$8,530	2.32	$6,854
	1992-2010		3,593		289	$690	$526	2.74	$10,019	2.63	$8,471	2.30	$6,787
PV + Battery	Pre-1978	$7,485	3,530	0	392	$802	$611	2.25	$10,171	1.90	$6,746	1.69	$5,147
	1978-1991		3,530		393	$785	$598	2.20	$9,785	1.91	$6,815	1.70	$5,265
	1992-2010		3,530		406	$746	$568	2.09	$8,878	1.96	$7,223	1.72	$5,405

Table 100: CZ 14 (SCE/SoCalGas) - Multifamily Equipment Fuel Substitution Cost-Effectiveness Results

Measure	Vintage	Measure Cost ($)	Electricity Savings (kWh)	Gas Savings (therm)	GHG Savings (lb CO_2e)	Utility Cost Savings		Customer On-Bill		2019 TDV		2022 TDV	
						Year 1	Avg Annual	B/C Ratio	NPV	B/C Ratio	NPV	B/C Ratio	NPV
Heat Pump at HVAC Replacement	Pre-1978	$227	-1,361	105	359	-$166	-$89	0.00	-$2,921	0.00	-$1,920	0.00	-$696
	1978-1991		-872	66	211	-$107	-$57	0.00	-$1,972	0.00	-$1,405	0.00	-$594
	1992-2010		-685	52	166	-$83	-$45	0.00	-$1,600	0.00	-$1,158	0.00	-$574
High-Effic. Heat Pump at HVAC Replacement	Pre-1978	$3,245	-858	105	527	-$24	$19	0.17	-$2,933	0.60	-$1,284	0.87	-$411
	1978-1991		-485	66	339	$1	$25	0.21	-$2,776	0.53	-$1,522	0.68	-$1,036
	1992-2010		-396	52	267	-$7	$13	0.11	-$3,128	0.41	-$1,907	0.51	-$1,584
Heat Pump at HVAC Replacement + PV	Pre-1978	$5,437	2,232	105	648	$546	$454	2.27	$7,609	2.23	$6,686	2.14	$6,196
	1978-1991		2,721	66	500	$593	$475	2.38	$8,260	2.32	$7,154	2.15	$6,260
	1992-2010		2,909	52	455	$606	$480	2.40	$8,403	2.35	$7,356	2.14	$6,224
HVAC HP Replacement, PV, + Panel Upgrade	Pre-1978	$8,618	2,232	105	648	$546	$454	1.42	$4,037	1.41	$3,505	1.35	$3,015
	1978-1991		2,721	66	500	$593	$475	1.49	$4,688	1.46	$3,973	1.36	$3,079
	1992-2010		2,909	52	455	$606	$480	1.50	$4,831	1.48	$4,175	1.35	$3,043
HPWH at Water Heater Replacement	Pre-1978	$2,594	-1,037	131	963	-$97	-$28	0.00	-$3,731	0.00	-$2,896	1.10	$249
	1978-1991		-1,037	131	963	-$89	-$22	0.00	-$3,550	0.00	-$2,896	1.10	$249
	1992-2010		-1,037	131	963	-$76	-$12	0.00	-$3,252	0.00	-$2,896	1.10	$249
NEEA Tier 3 HPWH at Replacement	Pre-1978	$2,775	-849	131	1,034	-$43	$13	0.13	-$2,690	0.17	-$2,307	1.32	$892
	1978-1991		-849	131	1,034	-$36	$19	0.18	-$2,522	0.17	-$2,307	1.32	$892
	1992-2010		-849	131	1,034	-$26	$26	0.25	-$2,306	0.17	-$2,307	1.32	$892
HPWH at Water Heater Replacement + PV	Pre-1978	$7,804	2,556	131	1,252	$689	$570	1.98	$8,473	1.75	$5,879	1.94	$7,334
	1978-1991		2,556	131	1,252	$673	$559	1.94	$8,124	1.75	$5,851	1.94	$7,302
	1992-2010		2,556	131	1,252	$629	$525	1.82	$7,109	1.74	$5,797	1.93	$7,238
HPWH Replacement, PV, + Panel Upgrade	Pre-1978	$10,985	2,556	131	1,252	$689	$570	1.40	$4,901	1.25	$2,698	1.38	$4,153
	1978-1991		2,556	131	1,252	$673	$559	1.37	$4,552	1.24	$2,670	1.38	$4,121
	1992-2010		2,556	131	1,252	$629	$525	1.29	$3,537	1.24	$2,616	1.37	$4,057
PV + Electric Ready Pre-Wire	Pre-1978	$9,301	3,593	0	1,022	$756	$575	1.67	$6,922	1.48	$4,470	1.30	$2,798
	1978-1991		3,593	0	1,049	$736	$560	1.63	$6,464	0.79	-$1,996	1.30	$2,763
	1992-2010		3,593	0	1,046	$690	$526	1.52	$5,425	0.00	-$11,567	1.29	$2,696

6.4.18 Climate Zone 14 (SDG&E):

Note: Values in red and grey rows indicate option is not cost-effective with B/C ratio less than 1. Cells with "n/a" reflect lighting and water heating efficiency measures and packages that did not look at TDV cost effectiveness or GHG impacts.

Table 101: CZ 14 (SDG&E) - Multifamily Efficiency Upgrade Cost-Effectiveness Results

Measure	Vintage	Measure Cost ($)	Electricity Savings (kWh)	Gas Savings (therm)	GHG Savings (lb CO_2e)	Utility Cost Savings		Customer On-Bill		2019 TDV		2022 TDV	
						Year 1	Avg Annual	B/C Ratio	NPV	B/C Ratio	NPV	B/C Ratio	NPV
R-49 Attic Insulation	Pre-1978	$745	211	13	154	$115	$102	3.64	$2,210	2.84	$1,373	2.92	$1,427
	1978-1991	$745	111	6	71	$58	$51	1.83	$692	1.56	$414	1.54	$399
	1992-2010	$625	36	2	27	$20	$17	0.75	-$179	0.70	-$187	0.70	-$187
Reduced Infiltration	Pre-1978	$448	40	10	109	$37	$35	2.09	$550	2.19	$535	1.98	$440
	1978-1991		24	7	69	$23	$22	1.29	$144	1.53	$235	1.46	$207
	1992-2010		14	5	51	$14	$14	0.83	-$88	0.96	-$19	0.98	-$10
Duct Sealing	Pre-1978	$130	241	6	88	$124	$105	21.64	$3,012	18.61	$2,289	17.02	$2,082
	1978-1991	$130	138	2	41	$68	$58	11.84	$1,582	11.32	$1,342	9.54	$1,110
New Ducts	Pre-1978	$1,353	523	13	196	$269	$230	4.53	$5,366	3.95	$3,996	3.63	$3,553
	1978-1991		404	7	128	$203	$172	3.40	$3,640	3.13	$2,882	2.78	$2,409
	1992-2010		121	3	47	$60	$51	1.01	$13	1.02	$28	0.92	-$103
Cool Roof	Pre-1978	$225	124	-1	-3	$53	$43	5.28	$1,052	3.76	$622	3.62	$589
	1978-1991		92	-1	-1	$39	$32	3.96	$727	3.28	$512	2.92	$431
	1992-2010		43	-1	-1	$18	$15	1.80	$197	1.72	$162	1.54	$123
R-13 Wall Insulation	Pre-1978	$1,006	166	26	293	$130	$119	3.15	$2,429	3.12	$2,131	2.87	$1,884
Floor Insulation	Pre-1978	$822	-11	21	215	$34	$37	1.22	$199	1.58	$475	1.48	$395
Windows	Pre-1978	$5,873	855	15	277	$422	$358	1.63	$4,134	0.99	-$36	1.10	$563
	1978-1991		701	11	211	$340	$287	1.31	$2,022	0.81	-$1,110	0.90	-$572
LED lamp vs CFL	All	$2.26	1.2	0	n/a	$0.41	$0.34	4.49	$7.87	n/a	n/a	n/a	n/a
Exterior Photosensor	All	$42.58	12.1	0	n/a	$3.39	$2.82	1.99	$42.01	n/a	n/a	n/a	n/a

Table 102: CZ 14 (SDG&E) - Multifamily Efficiency Packages Cost-Effectiveness Results

Measure	Vintage	Measure Cost ($)	Electricity Savings (kWh)	Gas Savings (therm)	GHG Savings (lb CO_2e)	Utility Cost Savings		Customer On-Bill		2019 TDV		2022 TDV	
						Year 1	Avg Annual	B/C Ratio	NPV	B/C Ratio	NPV	B/C Ratio	NPV
R49 Attic & Air Sealing Package	Pre-1978	$1,193	252	24	264	$152	$137	3.06	$2,757	2.59	$1,900	2.60	$1,905
	1978-1991	$1,193	134	13	138	$81	$73	1.63	$843	1.54	$648	1.54	$642
	1992-2010	$1,073	50	7	79	$34	$31	0.78	-$263	0.85	-$166	0.80	-$214
R49 Attic & Duct Sealing Package	Pre-1978	$875	440	18	233	$233	$201	6.15	$5,062	5.12	$3,609	4.91	$3,421
	1978-1991	$875	241	8	108	$123	$106	3.23	$2,192	2.92	$1,684	2.68	$1,469
R49 Attic, Air Sealing & Duct Sealing Package	Pre-1978	$1,323	474	28	338	$266	$232	4.70	$5,489	4.15	$4,174	3.87	$3,797
	1978-1991	$1,323	261	15	178	$144	$126	2.54	$2,294	2.45	$1,916	2.21	$1,595
	1992-2010	$1,203	50	7	79	$34	$31	0.70	-$409	0.75	-$296	0.71	-$344
R49 Attic, Air Sealing & New Ducts Package	Pre-1978	$2,546	756	34	439	$410	$355	3.73	$7,801	3.29	$5,839	3.08	$5,307
	1978-1991	$2,546	524	19	255	$279	$240	2.52	$4,337	2.32	$3,367	2.15	$2,926
	1992-2010	$2,427	165	10	122	$92	$80	0.88	-$322	0.92	-$196	0.85	-$363
Advanced Envelope Package	Pre-1978	$8,201	1,228	76	932	$704	$616	2.01	$9,280	1.63	$5,164	1.64	$5,238
Water Heating Package	All Vintages	$168	0	13	0	$44	$20	1.61	$114	n/a	n/a	n/a	n/a

Table 103: CZ 14 (SDG&E) - Multifamily PV & Battery Cost-Effectiveness Results

Measure	Vintage	Measure Cost ($)	Electricity Savings (kWh)	Gas Savings (therm)	GHG Savings (lb CO_2e)	Utility Cost Savings		Customer On-Bill		2019 TDV		2022 TDV	
						Year 1	Avg Annual	B/C Ratio	NPV	B/C Ratio	NPV	B/C Ratio	NPV
Prescriptive PV System	Pre-1978	$5,210	3,593	0	289	$1,356	$1,128	5.89	$28,082	2.64	$8,561	2.32	$6,889
	1978-1991		3,593		289	$1,382	$1,149	6.00	$28,737	2.64	$8,530	2.32	$6,854
	1992-2010		3,593		289	$1,260	$1,048	5.47	$25,687	2.63	$8,471	2.30	$6,787
PV + Battery	Pre-1978	$7,485	3,530	0	392	$1,377	$1,146	4.21	$26,207	1.90	$6,746	1.69	$5,147
	1978-1991		3,530		393	$1,407	$1,170	4.30	$26,956	1.91	$6,815	1.70	$5,265
	1992-2010		3,530		406	$1,260	$1,048	3.85	$23,276	1.96	$7,223	1.72	$5,405

Table 104: CZ 14 (SDG&E) - Multifamily Equipment Fuel Substitution Cost-Effectiveness Results

Measure	Vintage	Measure Cost ($)	Electricity Savings (kWh)	Gas Savings (therm)	GHG Savings (lb CO_2e)	Utility Cost Savings		Customer On-Bill		2019 TDV		2022 TDV	
						Year 1	Avg Annual	B/C Ratio	NPV	B/C Ratio	NPV	B/C Ratio	NPV
Heat Pump at HVAC Replacement	Pre-1978	$227	-1,361	105	359	-$232	-$151	0.00	-$4,770	0.00	-$1,920	0.00	-$696
	1978-1991		-872	66	211	-$147	-$96	0.00	-$3,142	0.00	-$1,405	0.00	-$594
	1992-2010		-685	52	166	-$126	-$84	0.00	-$2,770	0.00	-$1,158	0.00	-$574
High-Effic. Heat Pump at HVAC Replacement	Pre-1978	$3,245	-858	105	527	-$28	$18	0.16	-$2,959	0.60	-$1,284	0.87	-$411
	1978-1991		-485	66	339	$5	$31	0.26	-$2,592	0.53	-$1,522	0.68	-$1,036
	1992-2010		-396	52	267	-$12	$11	0.09	-$3,192	0.41	-$1,907	0.51	-$1,584
Heat Pump at HVAC Replacement + PV	Pre-1978	$5,437	2,232	105	648	$1,104	$961	4.81	$22,822	2.23	$6,686	2.14	$6,196
	1978-1991		2,721	66	500	$1,183	$1,011	5.06	$24,320	2.32	$7,154	2.15	$6,260
	1992-2010		2,909	52	455	$1,258	$1,067	5.34	$26,004	2.35	$7,356	2.14	$6,224
HVAC HP Replacement, PV, + Panel Upgrade	Pre-1978	$8,618	2,232	105	648	$1,104	$961	3.01	$19,250	1.41	$3,505	1.35	$3,015
	1978-1991		2,721	66	500	$1,183	$1,011	3.17	$20,748	1.46	$3,973	1.36	$3,079
	1992-2010		2,909	52	455	$1,258	$1,067	3.34	$22,432	1.48	$4,175	1.35	$3,043
HPWH at Water Heater Replacement	Pre-1978	$2,594	-1,037	131	963	-$106	-$37	0.00	-$3,987	0.00	-$2,896	1.10	$249
	1978-1991		-1,037	131	963	-$107	-$38	0.00	-$4,021	0.00	-$2,896	1.10	$249
	1992-2010		-1,037	131	963	-$99	-$31	0.00	-$3,825	0.00	-$2,896	1.10	$249
NEEA Tier 3 HPWH at Replacement	Pre-1978	$2,775	-849	131	1,034	-$42	$17	0.16	-$2,591	0.17	-$2,307	1.32	$892
	1978-1991		-849	131	1,034	-$43	$15	0.15	-$2,625	0.17	-$2,307	1.32	$892
	1992-2010		-849	131	1,034	-$37	$21	0.20	-$2,461	0.17	-$2,307	1.32	$892
HPWH at Water Heater Replacement + PV	Pre-1978	$7,804	2,556	131	1,252	$1,116	$980	3.40	$20,758	1.75	$5,879	1.94	$7,334
	1978-1991		2,556	131	1,252	$1,098	$965	3.35	$20,307	1.75	$5,851	1.94	$7,302
	1992-2010		2,556	131	1,252	$1,135	$995	3.46	$21,221	1.74	$5,797	1.93	$7,238
HPWH Replacement, PV, + Panel Upgrade	Pre-1978	$10,985	2,556	131	1,252	$1,116	$980	2.41	$17,186	1.25	$2,698	1.38	$4,153
	1978-1991		2,556	131	1,252	$1,098	$965	2.37	$16,735	1.24	$2,670	1.38	$4,121
	1992-2010		2,556	131	1,252	$1,135	$995	2.45	$17,649	1.24	$2,616	1.37	$4,057
PV + Electric Ready Pre-Wire	Pre-1978	$9,301	3,593	0	1,022	$1,356	$1,128	3.27	$23,488	1.48	$4,470	1.30	$2,798
	1978-1991		3,593	0	1,049	$1,382	$1,149	3.33	$24,144	0.79	-$1,996	1.30	$2,763
	1992-2010		3,593	0	1,046	$1,260	$1,048	3.04	$21,093	0.00	-$11,567	1.29	$2,696

6.4.19 Climate Zone 15:

Note: Values in red and grey rows indicate option is not cost-effective with B/C ratio less than 1. Cells with "n/a" reflect lighting and water heating efficiency measures and packages that did not look at TDV cost effectiveness or GHG impacts.

Table 105: CZ 15 - Multifamily Efficiency Upgrade Cost-Effectiveness Results

Measure	Vintage	Measure Cost ($)	Electricity Savings (kWh)	Gas Savings (therm)	GHG Savings (lb CO_2e)	Utility Cost Savings		Customer On-Bill		2019 TDV		2022 TDV	
						Year 1	Avg Annual	B/C Ratio	NPV	B/C Ratio	NPV	B/C Ratio	NPV
R-49 Attic Insulation	Pre-1978	$745	410	2	60	$127	$97	3.49	$2,086	3.30	$1,713	3.13	$1,586
	1978-1991	$745	224	1	30	$60	$46	1.64	$536	1.80	$596	1.61	$455
	1992-2010	$625	75	0	8	$21	$16	0.68	-$226	0.76	-$150	0.75	-$156
Reduced Infiltration	Pre-1978	$448	101	1	27	$33	$25	1.50	$254	2.06	$475	1.54	$241
	1978-1991		70	1	18	$18	$14	0.83	-$86	1.35	$159	0.96	-$18
	1992-2010		40	0	10	$10	$8	0.48	-$261	0.76	-$109	0.56	-$195
Duct Sealing	Pre-1978	$130	572	1	66	$181	$138	28.35	$3,992	29.07	$3,649	26.17	$3,272
	1978-1991	$130	338	0	41	$94	$71	14.65	$1,993	17.62	$2,161	16.04	$1,955
New Ducts	Pre-1978	$1,353	1,179	2	144	$367	$280	5.53	$6,880	5.81	$6,505	5.35	$5,889
	1978-1991		921	1	121	$257	$196	3.87	$4,361	4.66	$4,952	4.27	$4,420
	1992-2010		294	0	46	$84	$64	1.27	$403	1.64	$873	1.47	$632
Cool Roof	Pre-1978	$225	246	0	15	$76	$58	7.03	$1,480	5.88	$1,098	5.86	$1,095
	1978-1991		190	0	19	$52	$39	4.81	$935	4.76	$847	4.45	$776
	1992-2010		93	0	12	$26	$20	2.40	$344	2.53	$345	2.35	$305
R-13 Wall Insulation	Pre-1978	$1,006	452	4	101	$148	$114	3.03	$2,288	4.20	$3,214	3.10	$2,117
Floor Insulation	Pre-1978	$822	159	1	58	$49	$38	1.22	$207	1.92	$757	1.35	$286
Windows	Pre-1978	$5,873	1,869	2	229	$557	$425	1.93	$6,142	1.57	$3,321	1.81	$4,773
	1978-1991		1,521	2	184	$421	$321	1.46	$3,051	1.25	$1,442	1.47	$2,785
LED lamp vs CFL	All	$2.26	1.2	0	n/a	$0.29	$0.22	2.97	$4.45	n/a	n/a	n/a	n/a
Exterior Photosensor	All	$42.58	12.1	0	n/a	$3.09	$2.38	1.68	$28.96	n/a	n/a	n/a	n/a

Table 106: CZ 15 - Multifamily Efficiency Packages Cost-Effectiveness Results

Measure	Vintage	Measure Cost ($)	Electricity Savings (kWh)	Gas Savings (therm)	GHG Savings (lb CO_2e)	Utility Cost Savings		Customer On-Bill		2019 TDV		2022 TDV	
						Year 1	Avg Annual	B/C Ratio	NPV	B/C Ratio	NPV	B/C Ratio	NPV
R49 Attic & Air Sealing Package	Pre-1978	$1,193	512	4	85	$159	$123	2.75	$2,341	2.79	$2,138	2.55	$1,850
	1978-1991	$1,193	291	1	39	$76	$59	1.31	$417	1.56	$663	1.44	$523
	1992-2010	$1,073	115	1	17	$31	$24	0.59	-$489	0.77	-$245	0.67	-$352
R49 Attic & Duct Sealing Package	Pre-1978	$875	969	3	132	$300	$230	7.01	$5,903	7.08	$5,320	6.50	$4,808
	1978-1991	$875	550	1	72	$151	$115	3.51	$2,466	4.07	$2,686	3.68	$2,349
R49 Attic, Air Sealing & Duct Sealing Package	Pre-1978	$1,323	1,063	4	157	$330	$252	5.10	$6,084	5.35	$5,751	4.83	$5,062
	1978-1991	$1,323	608	1	79	$165	$126	2.55	$2,302	3.08	$2,748	2.82	$2,404
	1992-2010	$1,203	115	1	17	$31	$24	0.53	-$634	0.69	-$375	0.60	-$482
R49 Attic, Air Sealing & New Ducts Package	Pre-1978	$2,546	1,679	4	239	$505	$386	4.05	$8,720	4.47	$8,829	4.09	$7,872
	1978-1991	$2,546	1,185	2	158	$328	$251	2.63	$4,661	3.22	$5,645	2.95	$4,960
	1992-2010	$2,427	399	1	62	$113	$86	0.95	-$139	1.26	$623	1.11	$266
Advanced Envelope Package	Pre-1978	$8,201	2,873	9	415	$831	$636	2.07	$9,875	2.24	$10,152	2.15	$9,410
Water Heating Package	All Vintages	$168	0	13	0	$36	$16	1.25	$47	n/a	n/a	n/a	n/a

Table 107: CZ 15 - Multifamily PV & Battery Cost-Effectiveness Results

Measure	Vintage	Measure Cost ($)	Electricity Savings (kWh)	Gas Savings (therm)	GHG Savings (lb CO_2e)	Utility Cost Savings		Customer On-Bill		2019 TDV		2022 TDV	
						Year 1	Avg Annual	B/C Ratio	NPV	B/C Ratio	NPV	B/C Ratio	NPV
Prescriptive PV System	Pre-1978	$7,734	4,911	0	404	$1,086	$827	2.91	$16,277	2.42	$10,967	2.14	$8,801
	1978-1991		4,911		404	$1,034	$787	2.77	$15,092	2.41	$10,885	2.13	$8,702
	1992-2010		4,911		404	$982	$748	2.63	$13,897	2.39	$10,730	2.10	$8,512
PV + Battery	Pre-1978	$10,009	4,848	0	447	$1,120	$853	2.34	$14,636	1.89	$8,957	1.68	$6,842
	1978-1991		4,848		449	$1,070	$815	2.23	$13,500	1.89	$8,894	1.67	$6,751
	1992-2010		4,848		467	$1,030	$784	2.15	$12,586	1.89	$8,886	1.67	$6,731

Table 108: CZ 15 - Multifamily Equipment Fuel Substitution Cost-Effectiveness Results

Measure	Vintage	Measure Cost ($)	Electricity Savings (kWh)	Gas Savings (therm)	GHG Savings (lb CO_2e)	Utility Cost Savings		Customer On-Bill		2019 TDV		2022 TDV	
						Year 1	Avg Annual	B/C Ratio	NPV	B/C Ratio	NPV	B/C Ratio	NPV
Heat Pump at HVAC Replacement	Pre-1978	$227	-104	10	43	-$55	-$39	0.00	-$1,410	0.00	-$299	0.19	-$185
	1978-1991		-49	5	20	-$15	-$10	0.00	-$544	0.00	-$269	0.11	-$203
	1992-2010		-32	3	14	$14	$12	1.41	$103	0.00	-$254	0.09	-$206
High-Effic. Heat Pump at HVAC Replacement	Pre-1978	$3,245	677	10	206	$199	$155	1.32	$1,141	1.57	$1,850	1.48	$1,567
	1978-1991		616	5	164	$196	$151	1.29	$1,010	1.33	$1,071	1.26	$856
	1992-2010		485	3	139	$167	$128	1.09	$332	1.09	$293	1.00	-$3
Heat Pump at HVAC Replacement + PV	Pre-1978	$7,961	4,807	10	446	$999	$764	2.61	$14,138	2.33	$10,594	2.07	$8,535
	1978-1991		4,862	5	424	$991	$756	2.58	$13,898	2.33	$10,553	2.06	$8,436
	1992-2010		4,880	3	418	$971	$740	2.53	$13,429	2.31	$10,463	2.04	$8,291
HVAC HP Replacement, PV, + Panel Upgrade	Pre-1978	$11,142	4,807	10	446	$999	$764	1.86	$10,566	1.67	$7,413	1.48	$5,354
	1978-1991		4,862	5	424	$991	$756	1.84	$10,326	1.66	$7,372	1.47	$5,255
	1992-2010		4,880	3	418	$971	$740	1.80	$9,857	1.65	$7,282	1.46	$5,110
HPWH at Water Heater Replacement	Pre-1978	$2,594	-539	109	923	-$8	$32	0.34	-$1,922	0.54	-$1,188	1.50	$1,307
	1978-1991		-539	109	923	-$3	$36	0.37	-$1,811	0.54	-$1,188	1.50	$1,307
	1992-2010		-539	109	923	$1	$39	0.40	-$1,722	0.54	-$1,188	1.50	$1,307
NEEA Tier 3 HPWH at Replacement	Pre-1978	$2,775	-457	109	963	$17	$52	0.50	-$1,534	0.63	-$1,015	1.56	$1,563
	1978-1991		-457	109	963	$22	$55	0.53	-$1,442	0.63	-$1,015	1.56	$1,563
	1992-2010		-457	109	963	$24	$57	0.55	-$1,384	0.63	-$1,015	1.56	$1,563
HPWH at Water Heater Replacement + PV	Pre-1978	$10,328	4,372	109	1,327	$1,100	$876	2.30	$14,866	1.96	$9,911	1.99	$10,221
	1978-1991		4,372	109	1,327	$1,048	$837	2.20	$13,683	1.95	$9,831	1.98	$10,123
	1992-2010		4,372	109	1,327	$1,002	$801	2.10	$12,619	1.94	$9,681	1.96	$9,938
HPWH Replacement, PV, + Panel Upgrade	Pre-1978	$13,509	4,372	109	1,327	$1,100	$876	1.75	$11,294	1.50	$6,730	1.52	$7,040
	1978-1991		4,372	109	1,327	$1,048	$837	1.67	$10,112	1.49	$6,650	1.51	$6,942
	1992-2010		4,372	109	1,327	$1,002	$801	1.60	$9,047	1.48	$6,500	1.50	$6,757
PV + Electric Ready Pre-Wire	Pre-1978	$11,825	4,911	0	1,047	$1,086	$827	1.89	$11,683	1.58	$6,876	1.40	$4,710
	1978-1991		4,911	0	1,067	$1,034	$787	1.80	$10,499	0.86	-$1,685	1.39	$4,611
	1992-2010		4,911	0	1,062	$982	$748	1.71	$9,303	0.00	-$17,301	1.37	$4,421

6.4.20 Climate Zone 16:

Note: Values in red and grey rows indicate option is not cost-effective with B/C ratio less than 1. Cells with "n/a" reflect lighting and water heating efficiency measures and packages that did not look at TDV cost effectiveness or GHG impacts.

Table 109: CZ 16 - Multifamily Efficiency Upgrade Cost-Effectiveness Results

Measure	Vintage	Measure Cost ($)	Electricity Savings (kWh)	Gas Savings (therm)	GHG Savings (lb CO_2e)	Utility Cost Savings		Customer On-Bill		2019 TDV		2022 TDV	
						Year 1	Avg Annual	B/C Ratio	NPV	B/C Ratio	NPV	B/C Ratio	NPV
R-49 Attic Insulation	Pre-1978	$745	111	25	268	$84	$77	2.77	$1,484	2.18	$882	2.62	$1,204
	1978-1991	$745	56	12	131	$40	$37	1.31	$259	1.10	$72	1.28	$209
	1992-2010	$625	18	5	50	$13	$13	0.54	-$326	0.49	-$317	0.57	-$269
Reduced Infiltration	Pre-1978	$448	7	15	155	$30	$31	1.85	$426	1.37	$166	2.14	$509
	1978-1991		4	11	107	$19	$20	1.17	$83	1.09	$38	1.46	$207
	1992-2010		3	9	87	$15	$16	0.94	-$31	0.89	-$48	1.19	$86
Duct Sealing	Pre-1978	$130	71	14	154	$51	$47	9.62	$1,258	7.63	$862	8.82	$1,017
	1978-1991	$130	39	6	72	$25	$22	4.51	$512	3.80	$364	4.24	$421
New Ducts	Pre-1978	$1,353	173	31	343	$118	$106	2.10	$1,675	1.70	$948	1.92	$1,246
	1978-1991		136	20	228	$81	$72	1.41	$630	1.24	$323	1.32	$433
	1992-2010		39	7	82	$24	$22	0.44	-$854	0.43	-$768	0.45	-$738
Cool Roof	Pre-1978	$225	57	-2	-12	$17	$12	1.46	$112	0.90	-$23	0.43	-$129
	1978-1991		42	-2	-8	$12	$9	1.08	$20	0.76	-$54	0.30	-$157
	1992-2010		19	-1	-7	$4	$3	0.35	-$161	0.33	-$151	0.06	-$212
R-13 Wall Insulation	Pre-1978	$1,006	49	52	537	$109	$111	2.94	$2,188	2.62	$1,628	3.36	$2,375
Floor Insulation	Pre-1978	$822	-48	44	427	$59	$68	2.21	$1,116	1.73	$603	2.94	$1,594
Windows	Pre-1978	$5,873	234	69	739	$202	$190	0.86	-$905	0.51	-$2,877	0.88	-$677
	1978-1991		265	41	472	$159	$142	0.64	-$2,344	0.40	-$3,494	0.63	-$2,190
LED lamp vs CFL	All	$2.26	1.2	0	n/a	$0.29	$0.22	2.97	$4.45	n/a	n/a	n/a	n/a
Exterior Photosensor	All	$42.58	12.1	0	n/a	$3.09	$2.38	1.68	$28.96	n/a	n/a	n/a	n/a

Table 110: CZ 16 - Multifamily Efficiency Packages Cost-Effectiveness Results

Measure	Vintage	Measure Cost ($)	Electricity Savings (kWh)	Gas Savings (therm)	GHG Savings (lb CO_2e)	Utility Cost Savings		Customer On-Bill		2019 TDV		2022 TDV	
						Year 1	Avg Annual	B/C Ratio	NPV	B/C Ratio	NPV	B/C Ratio	NPV
R49 Attic & Air Sealing Package	Pre-1978	$1,193	118	40	422	$112	$107	2.39	$1,866	1.90	$1,069	2.43	$1,707
	1978-1991	$1,193	60	23	239	$59	$56	1.26	$351	1.08	$98	1.36	$428
	1992-2010	$1,073	21	13	137	$29	$28	0.71	-$352	0.66	-$360	0.83	-$178
R49 Attic & Duct Sealing Package	Pre-1978	$875	175	37	403	$128	$117	3.58	$2,531	2.89	$1,654	3.38	$2,086
	1978-1991	$875	91	18	196	$62	$56	1.71	$700	1.46	$401	1.66	$579
R49 Attic, Air Sealing & Duct Sealing Package	Pre-1978	$1,323	179	52	552	$155	$145	2.94	$2,875	2.34	$1,779	2.92	$2,545
	1978-1991	$1,323	95	29	304	$80	$76	1.53	$783	1.32	$423	1.60	$793
	1992-2010	$1,203	21	13	137	$29	$28	0.63	-$498	0.59	-$490	0.74	-$308
R49 Attic, Air Sealing & New Ducts Package	Pre-1978	$2,546	279	67	729	$215	$199	2.09	$3,118	1.72	$1,844	2.06	$2,693
	1978-1991	$2,546	188	41	449	$133	$122	1.28	$810	1.13	$338	1.29	$732
	1992-2010	$2,427	59	20	215	$52	$49	0.54	-$1,242	0.53	-$1,143	0.61	-$947
Advanced Envelope Package	Pre-1978	$8,201	435	165	1,741	$428	$410	1.33	$3,081	1.02	$202	1.45	$3,653
Water Heating Package	All Vintages	$168	0	12	0	$35	$18	1.40	$76	n/a	n/a	n/a	n/a

Table 111: CZ 16 - Multifamily PV & Battery Cost-Effectiveness Results

Measure	Vintage	Measure Cost ($)	Electricity Savings (kWh)	Gas Savings (therm)	GHG Savings (lb CO_2e)	Utility Cost Savings		Customer On-Bill		2019 TDV		2022 TDV	
						Year 1	Avg Annual	B/C Ratio	NPV	B/C Ratio	NPV	B/C Ratio	NPV
Prescriptive PV System	Pre-1978	$4,742	2,911	0	205	$717	$554	3.18	$11,388	2.38	$6,553	1.99	$4,677
	1978-1991		2,911		205	$696	$538	3.09	$10,914	2.38	$6,538	1.98	$4,662
	1992-2010		2,911		205	$633	$489	2.81	$9,450	2.37	$6,510	1.98	$4,635
PV + Battery	Pre-1978	$7,016	2,855	0	333	$729	$564	2.21	$9,270	1.74	$5,196	1.51	$3,556
	1978-1991		2,855		336	$703	$543	2.13	$8,647	1.75	$5,234	1.51	$3,574
	1992-2010		2,855		352	$640	$495	1.94	$7,207	1.76	$5,357	1.52	$3,628

Table 112: CZ 16 - Multifamily Equipment Fuel Substitution Cost-Effectiveness Results

Measure	Vintage	Measure Cost ($)	Electricity Savings (kWh)	Gas Savings (therm)	GHG Savings (lb CO_2e)	Utility Cost Savings		Customer On-Bill		2019 TDV		2022 TDV	
						Year 1	Avg Annual	B/C Ratio	NPV	B/C Ratio	NPV	B/C Ratio	NPV
Heat Pump at HVAC Replacement	Pre-1978	$227	-3,740	303	1,517	-$394	-$163	0.00	-$5,139	0.00	-$8,687	0.00	-$4,424
	1978-1991		-2,835	228	1,131	-$278	-$109	0.00	-$3,524	0.00	-$6,679	0.00	-$3,466
	1992-2010		-1,865	148	722	-$184	-$74	0.00	-$2,480	0.00	-$4,712	0.00	-$2,420
High-Effic. Heat Pump at HVAC Replacement	Pre-1978	$3,245	-3,101	303	1,759	-$213	-$23	0.00	-$4,217	0.00	-$8,144	0.00	-$3,742
	1978-1991		-2,331	228	1,323	-$145	-$6	0.00	-$3,708	0.00	-$6,931	0.00	-$3,543
	1992-2010		-1,543	148	845	-$103	-$11	0.00	-$3,858	0.00	-$5,732	0.00	-$3,567
Heat Pump at HVAC Replacement + PV	Pre-1978	$4,968	-828	303	1,722	$348	$410	2.25	$6,827	0.60	-$1,984	1.07	$333
	1978-1991		77	228	1,336	$436	$442	2.42	$7,787	1.00	-$8	1.25	$1,264
	1992-2010		1,047	148	926	$521	$470	2.57	$8,622	1.38	$1,907	1.46	$2,277
HVAC HP Replacement, PV, + Panel Upgrade	Pre-1978	$8,149	-828	303	1,722	$348	$410	1.36	$3,255	0.37	-$5,165	0.65	-$2,848
	1978-1991		77	228	1,336	$436	$442	1.47	$4,216	0.61	-$3,189	0.76	-$1,917
	1992-2010		1,047	148	926	$521	$470	1.56	$5,050	0.84	-$1,274	0.89	-$904
HPWH at Water Heater Replacement	Pre-1978	$2,594	-1,745	149	998	-$233	-$112	0.00	-$6,246	0.00	-$6,850	0.00	-$2,663
	1978-1991		-1,745	149	998	-$234	-$115	0.00	-$6,335	0.00	-$6,850	0.00	-$2,663
	1992-2010		-1,745	149	998	-$220	-$104	0.00	-$6,011	0.00	-$6,850	0.00	-$2,663
NEEA Tier 3 HPWH at Replacement	Pre-1978	$2,775	-1,525	149	1,061	-$166	-$60	0.00	-$4,881	0.00	-$6,235	0.29	-$1,964
	1978-1991		-1,525	149	1,061	-$167	-$63	0.00	-$4,969	0.00	-$6,235	0.29	-$1,964
	1992-2010		-1,525	149	1,061	-$154	-$53	0.00	-$4,676	0.00	-$6,235	0.29	-$1,964
HPWH at Water Heater Replacement + PV	Pre-1978	$7,336	1,166	149	1,202	$556	$498	1.84	$6,828	1.00	-$16	1.31	$2,284
	1978-1991		1,166	149	1,202	$542	$485	1.79	$6,440	1.00	-$25	1.31	$2,272
	1992-2010		1,166	149	1,202	$533	$478	1.76	$6,211	0.99	-$46	1.31	$2,250
HPWH Replacement, PV, + Panel Upgrade	Pre-1978	$10,517	1,166	149	1,202	$556	$498	1.28	$3,256	0.70	-$3,197	0.91	-$897
	1978-1991		1,166	149	1,202	$542	$485	1.25	$2,868	0.70	-$3,206	0.91	-$909
	1992-2010		1,166	149	1,202	$533	$478	1.23	$2,639	0.69	-$3,227	0.91	-$931
PV + Electric Ready Pre-Wire	Pre-1978	$8,833	2,911	0	1,008	$717	$554	1.69	$6,794	1.28	$2,462	1.07	$586
	1978-1991		2,911	0	1,035	$696	$538	1.64	$6,320	0.77	-$2,003	1.06	$571
	1992-2010		2,911	0	1,057	$633	$489	1.49	$4,856	0.17	-$7,302	1.06	$544

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