

DOCKETED	
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Project Title:	Applications for Local Ordinances Exceeding the 2025 Energy Code
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Document Title:	2025 City of Ojai Application Submission to the CEC
Description:	Plain text of 2025 City of Ojai Application Submission to the CEC
Filer:	Anushka Raut
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CITY OF OJAI
Community Development Department
- Building Division -

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www.ojai.ca.gov

December 19, 2025

To: LocalOrdinances@energy.ca.gov

Cc: Mvega@trccompanies.com

TITLE 24 PART 6 AMENDMENTS

RE: APPLICATION FOR LOCALLY ADOPTED ENERGY STANDARDS BY THE CITY OF OJAI'S CITY COUNCIL IN ACCORDANCE WITH THE 2025 CALIFORNIA ENERGY CODE, TITLE 24, PART 6 OF THE CALIFORNIA CODE OF REGULATIONS

Dear Drew Bohan,

Please be advised that the City of Ojai – City Council has adopted amendments to the 2025 Edition of the California's 2025 Energy Code, Title 24, Part 6– via Ordinance No. 969, enclosed.

In accordance with California Health and Safety Code Sections 17958.5, 17958.7 and 18941.5, Public Resources Code Section 25402.1 (h)(2), and California Code of Regulations, Title 24, Part 1, §10-106, the package of materials demonstrates the City of Ojai's City Council determined the local ordinance:

- Contains standards that are cost effective, and these standards were adopted at a public City Council meeting on December 9, 2025; and
- Will result in buildings designed to consume less energy than permitted by the 2025 California Energy Code.

The ordinance and cost-effectiveness studies were presented to the City of Ojai City Council on October 28, 2025. The ordinance will become effective following approval by the California Energy Commission and filing by the California Building Standards Commission.

Please find the following materials enclosed:

- **Attachment 1:** Staff reports to the City of Ojai's City Council, outlining the goals of the updated building standards. The report clearly identifies the City of Ojai – City Council made an express finding that amendments to the building standards in the 2025 California Energy Code are reasonably necessary because of local climatic, geological, topographical or environmental conditions.
- **Attachment 2:** Signed Ordinance No. 969, which adopts local amendments to the 2025 California Energy Code and Green Building Standards Code baseline for single-family residential buildings (Section 13).
- **Attachment 3:** Cost effectiveness studies demonstrating the expected energy savings and the cost effectiveness of the ordinance in the City of Ojai, Climate Zone No. 9.
- **Attachment 4:** Demonstration of cost effectiveness summarizing how cost effectiveness study results informed the ordinance parameters.
- **Attachment 5:** Evidence of California Environmental Quality Act (CEQA) compliance through the attached Notice of Exemption. The City of Ojai's City Council found that under CEQA pursuant to Sections 15301, 15307, 15308 and Section 15061(b)(3) of the CEQA Guidelines, there is no possibility the implementation of this ordinance will have a significant negative impact on the environment, and this is exempt from the requirements of CEQA.

Please consider and accept enclosed Ordinance No. 969 pursuant to California Code of Regulations, Title 24 Part 1, Section 10-106. If you have any questions, please contact Mayra Vega via email at Mvega@trccompanies.com, Farhad Farahmand via email at ffarahmand@trccompanies.com and Lucas Seibert, Community Development Director at (805) 646-5581 x113 or via email at Lucas.Seibert@ojai.ca.gov.

Sincerely,
Lucas Seibert
Community Development Director
City of Ojai

Attachments:

Attachment 1 – October 28 & December 9, 2025 City of Ojai's City Council Staff Reports
Attachment 2 – City Council Adopted Ordinance No. 969
Attachment 3 – Cost Effective Studies Within Climate Zone No. 9
Attachment 4 – Cost Effective Study Demonstration
Attachment 5 – CEQA Notice of Exemption



Administrative Report

TO: Honorable City Council

FROM: Lucas Seibert, Community Development Director
Eric Simonson, Building Official

MEETING DATE: October 28, 2025

SUBJECT: Introduction and First Reading of Ordinance of the 2025 California Building Codes

RECOMMENDATION

That the City Council introduce Ordinance No. 25-__ to adopt 2025 California Building Codes with amendments to Chapter 15.08 of the Municipal Code.

DISCUSSION

The State's Health and Safety Code, Section 17950, mandates the California Building Standards Commission adopt and publish the California Codes, Title 24, known as the California Code of Regulations.

Every three years, the codes are published to incorporate all code changes accepted by a majority vote of members at the annual code development meetings. As a result, the new codes will become effective statewide on January 1, 2026. (See attached Bulletin 25-01 from the Building Standards Commission), (Exhibit "A"). Each jurisdiction in the State is mandated to adopt the California Code of Regulations, Title 24, and make amendments to the codes that are reasonably necessary because of local climatic, geological, or topographical conditions.

With the adoption of Assembly Bill 130 this year, the City's ability to modify Residential building standards in the California Building Code is now limited. From October 1, 2025, through June 1, 2031, cities and counties may not change residential building standards—including green building requirements—unless the changes are substantially equivalent to standards in effect before September 30, 2025, are deemed necessary for emergency health or safety, relate to home hardening, are proposed by a local fire prevention district, or are needed to implement an approved general plan that permits mixed-fuel construction while promoting all-electric construction to reduce greenhouse gas emissions.

ANALYSIS

The following codes are mandated by the State of California Building Standards, Commission Information Bulletin 25-01, for local adoption by January 1, 2026. The codes include:

- 2025 California Building Code, Volumes 1 and 2

- 2025 California Fire Code
- 2025 California Existing Building Code
- 2025 California Historical Code
- 2025 California Energy Code, including the amendments for Single Family Residential Flex-Path provisions
- 2025 Administrative Code
- 2025 California Referenced Standards Code
- 2025 California Residential Code
- 2025 California Green Building Standards Code
- 2025 California Mechanical Code
- 2025 California Electrical Code
- 2025 California Plumbing Code
- 2025 California Wildland-Urban Interface Code
- 2024 International Property Maintenance Code
- 1997 Uniform Code for Abatement of Dangerous Buildings

The 2025 California Fire Code and 2025 California Wildland-Urban Interface Code listed above will be introduced by the Fire Department in a separate staff report.

The State has established the 2024 Editions of the International Codes as the basis for the 2025 California Codes. Likewise, the 2024 Editions of the Uniform Mechanical and Plumbing Codes developed by the International Association of Plumbing and Mechanical Officials as the basis for the 2025 California Plumbing and Mechanical Codes. The 2023 Edition of the National Electrical Code developed by the National Fire Protection Association are the basis of the corresponding 2025 Edition of the California Electrical Code.

The California Residential Code (CRC) will address the structural and life safety aspects of one- and two-family dwellings and townhouses not more than three stories. Electrical, plumbing, and mechanical conditions will still be addressed by the appropriate California Code Books. Amendments proposed were adopted prior to the September 30, 2025 deadline in AB 130, so they are permissible under Ca. Health and Safety Code section 17985(b)(1).

The California Green Building Standards Code addresses such conditions as site development, water savings, recycling, and material selection. In addition, issues such as moisture control, interior and exterior air quality and compliance with California Title 24 requirements as addressed. Environmental quality issues of concern involve the use of materials that produce volatile organic compounds such as composite wood products, paints, adhesives, and carpets.

The proposed amendments are added to the existing chapters of the Ojai Municipal Code Title 9, by adding the 2025, California Code of Regulations.

The California Wildland-Urban Interface Code is required to be adopted by all jurisdictions within the State of California and will only be enforced for areas that are in fire hazard severity zones as identified by the state fire marshal severity hazard zone maps. The intent

of the California Wildland-Urban Interface Code is to be able to construct new buildings and additions that are located in fire zones with fire resistant materials such as noncombustible siding and overhangs, tempered or 20-minute rated glazing (windows), ember resistive attic and crawl space vents as well as provide defensible spaces around the structure. Majority of the code requirements that are set forth in the California Wildland-Urban Interface Code are carried over from Chapter 7A of the California Building Code and Section R337 of the California Residential Code, which had previously been adopted.

Single-Family Residential “FlexPath” Program

The City of Ojai’s Single-Family Residential “FlexPath” program is a local energy-efficiency ordinance that applies to remodels and additions of existing single-family homes. Instead of mandating one rigid set of upgrades, it provides a flexible compliance path allowing homeowners to choose from various energy-saving and electrification measures—such as improved insulation, efficient HVAC systems, and electric appliances—to meet performance goals. The program aims to reduce greenhouse gas emissions, improve home energy performance, and support the city’s sustainability objectives while accommodating different project types and budgets. Certain projects, such as small additions or affordable housing units, may qualify for exemptions. Flexpath amendments to the California Residential Code were adopted prior to the September 30, 2025 deadline in AB 130, so they are allowed under state law, and have been submitted to the appropriate state commissions for approval.

CITY COUNCIL GOALS ALIGNMENT

Goal No. 2 - Wildfire Safety and Risk Mitigation

Goal No. 5 - Public Safety

Goal No. 7 - Climate Resiliency

OPTIONS

1. Take no action;
2. Provide alternative direction to staff.

FISCAL IMPACT

Willdan Engineering will be purchasing a new set of the 2025 code books for the City of Ojai’s Building & Safety Division at a cost of approximately \$1,600, and the enforcement of these codes is covered under the existing Willdan Engineering, Inc. contract services; therefore, there is no additional fiscal impact on the City of Ojai.

Prepared by: Lucas Seibert, Community Development Director

ATTACHMENT(S)

- A. Building Standards Commission Bulletin 25-01
- B. Draft City Council Ordinance



Administrative Report

TO: Honorable City Council

FROM: Lucas Seibert, Community Development Director
Stephanie Spieler, Building Official

MEETING DATE: December 9, 2025

SUBJECT: SECOND READING | Adoption of Ordinance Adopting the 2025 California Building Codes

RECOMMENDATION

Conduct second reading, waiving the reading of the full text, and adopt Ordinance No. 969 adopting the 2025 California Building Codes, by reading of the title as stated in the agenda.

DISCUSSION

The State's Health and Safety Code, Section 17950, mandates the California Building Standards Commission adopt and publish the California Codes, Title 24, known as the California Code of Regulations.

Every three years, the codes are published to incorporate all code changes accepted by a majority vote of members at the annual code development meetings. As a result, the new codes will become effective statewide on January 1, 2026. (See attached Bulletin 25-01 from the Building Standards Commission), (Exhibit "A"). Each jurisdiction in the State is mandated to adopt the California Code of Regulations, Title 24, and make amendments to the codes that are reasonably necessary because of local climatic, geological, or topographical conditions.

ANALYSIS

The following codes are mandated by the State of California Building Standards, Commission Information Bulletin 25-01, for local adoption by January 1, 2026. The codes include:

- 2025 California Building Code, Volumes 1 and 2
- 2025 California Fire Code
- 2025 California Existing Building Code
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- 2025 California Energy Code, including the amendments for Single Family Residential Flex-Path provisions
- 2025 Administrative Code
- 2025 California Referenced Standards Code
- 2025 California Residential Code

- 2025 California Green Building Standards Code
- 2025 California Mechanical Code
- 2025 California Electrical Code
- 2025 California Plumbing Code
- 2025 California Wildland-Urban Interface Code
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The California Residential Code (CRC) will address the structural and life safety aspects of one- and two-family dwellings and townhouses not more than three stories. Electrical, plumbing, and mechanical conditions will still be addressed by the appropriate California Code Books.

The California Green Building Standards Code addresses such conditions as site development, water savings, recycling, and material selection. In addition, issues such as moisture control, interior and exterior air quality and compliance with California Title 24 requirements as addressed. Environmental quality issues of concern involve the use of materials that produce volatile organic compounds such as composite wood products, paints, adhesives, and carpets.

The proposed amendments are added to the existing chapters of the Ojai Municipal Code Title 9, by adding the 2025, California Code of Regulations.

The California Wildland-Urban Interface Code is required to be adopted by all jurisdictions within the State of California and will only be enforced for areas that are in fire hazard severity zones as identified by the state fire marshal severity hazard zone maps. The intent of the California Wildland-Urban Interface Code is to be able to construct new buildings and additions that are located in fire zones with fire resistant materials such as noncombustible siding and overhangs, tempered or 20-minute rated glazing (windows), ember resistive attic and crawl space vents as well as provide defensible spaces around the structure. Majority of the code requirements that are set forth in the California Wildland-Urban Interface Code are carried over from Chapter 7A of the California Building Code and Section R337 of the California Residential Code, which had previously been adopted.

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The City of Ojai’s Single-Family Residential “FlexPath” program is a local energy-efficiency ordinance that applies to remodels and additions of existing single-family homes. Instead

of mandating one rigid set of upgrades, it provides a flexible compliance path allowing homeowners to choose from various energy-saving and electrification measures—such as improved insulation, efficient HVAC systems, and electric appliances—to meet performance goals. The program aims to reduce greenhouse gas emissions, improve home energy performance, and support the city’s sustainability objectives while accommodating different project types and budgets. Certain projects, such as small additions or affordable housing units, may qualify for exemptions.

CITY COUNCIL GOALS ALIGNMENT

Goal No. 2 - Wildfire Safety and Risk Mitigation

Goal No. 5 - Public Safety

OPTIONS

1. Take no action;
2. Provide alternative direction to staff.

FISCAL IMPACT

Willdan Engineering could purchase a new set of the 2025 code books for the City of Ojai’s Building & Safety Division at a cost of approximately \$1,600. Alternatively, these codes are transposed online at no charge via <https://www.dgs.ca.gov/bsc/codes>. The cost for these updated code books is covered under the existing Willdan contract services; therefore there is no additional fiscal impact on the City of Ojai either way.

Prepared by: Lucas Seibert, Community Development Director

ATTACHMENT

- A. Ordinance No. 969

**CITY OF OJAI
ORDINANCE NO. 969**

AN ORDINANCE OF THE CITY COUNCIL OF THE CITY OF OJAI ADOPTING BY REFERENCE, PURSUANT TO GOVERNMENT CODE SECTION 50022.2, CALIFORNIA CODE OF REGULATIONS – TITLE 24, THE 2025 CALIFORNIA BUILDING STANDARDS CODE, INCLUDING (1) CALIFORNIA BUILDING CODE, VOLUMES 1 & 2, 2025 EDITION; WITH APPENDICES I AND J; (2) CALIFORNIA ELECTRICAL CODE, 2025 EDITION; (3) CALIFORNIA PLUMBING CODE, 2025 EDITION, WITH APPENDICES H AND L; (4) CALIFORNIA MECHANICAL CODE, 2025 EDITION; (5) CALIFORNIA ADMINISTRATIVE CODE, 2025 EDITION; (6) CALIFORNIA ENERGY CODE, 2025 EDITION; (7) CALIFORNIA REFERENCE STANDARDS, 2025 EDITION; (8) CALIFORNIA EXISTING BUILDING CODE, 2022 EDITION; (9) CALIFORNIA RESIDENTIAL CODE, 2022 EDITION, WITH APPENDIX AH; (10) CALIFORNIA GREEN BUILDING STANDARDS CODE, 2025 EDITION; (11) CALIFORNIA FIRE CODE, 2025 EDITION; (12) CALIFORNIA WILD LAND INTERFACE CODE 2025 AND ADOPTING LOCAL AMENDMENTS THERETO IN ACCORDANCE WITH CALIFORNIA HEALTH AND SAFETY CODE SECTIONS 17922, 17958, 17958.5, 17958.7, AND 18941.5 AND FINDING THAT THE ADOPTION OF THIS AMENDMENT IS EXEMPT FROM THE CALIFORNIA ENVIRONMENTAL QUALITY ACT

WHEREAS, the City Council of the City of Ojai does hereby find that there is a need to enforce the 2025 edition of the California Building Standards Code (“CBSC”), (1) California Building Code, Volumes 1 & 2, 2025 Edition; with Appendices I and J; (2) California Electrical Code, 2025 Edition; (3) California Plumbing Code, 2025 Edition, with Appendices H and L; (4) California Mechanical Code, 2025 Edition; (5) California Administrative Code, 2025 Edition; (6) California Energy Code, 2025 Edition; (7) California Reference Standards, 2025 Edition; (8) California Existing Building Code, 2025 Edition; (9) California Residential Code, 2025 Edition, with Appendix AH; (10) California Green Building Standards Code, 2025 Edition; (11) California Fire Code, 2025 Edition; Wild Land Urban Interface Code, 2025 Edition; with local amendments thereof, as recited herein for regulating and controlling the design, erection, construction, conversion, height and area, location and maintenance, and quality of materials of all buildings and structures and plumbing, mechanical, electrical and fire suppression systems and certain equipment within the City; and

WHEREAS, pursuant to sections 17922, 17958, 17958.5, 17958.7 and 18941.5 of the California Health & Safety Code, the City may adopt the provisions of the California Building, Plumbing, Mechanical, and Electrical Codes, with certain amendments to the provisions to the

codes, which are reasonably necessary to protect the health and welfare of the citizens of Ojai because of local climatic, geological, or topographical conditions; and

WHEREAS, California Health and Safety Code section 17958 requires that cities adopt building regulations that are substantially the same as those adopted by the California Building Standards Commission and contained in the 2025 California Building Standards Code; and

WHEREAS, the 2025 California Energy Code is Part 6 of the 2025 California Building Standards Code which implements minimum energy efficiency standards in buildings through mandatory requirements, prescriptive standards, and performance standards; and

WHEREAS, California Health and Safety Code Sections 17958.5, 17958.7 and 18941.5 provide that the City of Ojai may make changes or modifications to the building standards contained in the 2025 California Building Standards Code based upon express findings that such changes or modifications are reasonably necessary because of local climatic, geological or topographical conditions and such changes support the City of Ojai's General Plan; and

WHEREAS, local governments may adopt energy conservation or energy insulation standards that differ from the California Energy Code with California Energy Commission approval, provided that local governments demonstrate, pursuant to Public Resources Code section 25402.1 (h)(2) that the requirements of their proposed standards are cost effective and do not result in buildings that consume more energy than is permitted by Title 24; and

WHEREAS, the proposed local amendments to the 2025 California Energy Code are necessary to implement a local code amendment that is adopted to align with the City of Ojai's General Plan, permit mixed-fuel residential construction consistent with federal law, and incentivize all-electric construction as part of an adopted greenhouse gas emissions reduction strategy; and

WHEREAS, greenhouse gas accumulation in the atmosphere as the result of human activity is the primary cause of the global climate crisis; and

WHEREAS, in California alone, the initial impacts of climate change have resulted in unprecedented disasters with tremendous human, economic, and environmental costs; and

WHEREAS, the Intergovernmental Panel on Climate Change estimates that global emissions need to be reduced by 45 percent from 2010 levels by 2030, and 100 percent by 2050 to prevent global catastrophe; and

WHEREAS, the State of California enacted Assembly Bill (AB) 1279 to require statewide carbon neutrality "as soon as possible," but no later than 2045; and

WHEREAS, residents and businesses have repeatedly identified climate action as a top community priority; and

WHEREAS, the City of Ojai strives to be a leader in combatting climate change, and committed to support the principles the Paris Climate agreement and supports a transition to 100% clean energy; and

WHEREAS, Resolution No. 19-30 directed the City to initiate a just global emergency mobilization effort to reverse global warming by reducing greenhouse gas emissions and safely draw down carbon from the atmosphere as quickly as possible; and

WHEREAS, the City formed a Climate Emergency Mobilization Committee which identified energy efficiency measures and electrification as key ways to reduce fossil fuel emissions in Ojai; and

WHEREAS, the inventoried greenhouse gas emissions in the City come primarily from energy use in buildings and transportation; and

WHEREAS, in order to achieve carbon neutrality, existing sources of greenhouse gas emissions need to be substantially reduced or eliminated; and

WHEREAS, the energy efficiency requirements established in this ordinance-including air sealing, duct sealing, window upgrades, R-15 wall insulation, R-19 floor insulation, and R-30 wall/ceiling insulation-provide direct fire hardening benefits by creating thermal barriers that slow fire spread, preventing ember intrusion through building envelope penetrations, reducing pathways for fire and smoke propagation through HVAC and structural systems, enhance window resistance to thermal shock and radiant heat exposure, and improve overall building compartmentalization that extends egress time and reduces structural fire damage; and

WHEREAS, these improvements create multiple layers of fire protection, improve community wildfire resilience, and support broader public safety goals while providing cost-effective dual benefits for both energy performance and fire resistance; and

WHEREAS, Public Resources Code Section 25402.1 (h)(2) and Section 10-106 of the 2025 California Administration Code establish a process which allows local agencies to adopt local amendments that are cost-effective and that require greater energy reduction/conservation than the California Energy Code provided that a determination that the standards are cost effective is adopted at a public meeting and subsequently filed with the California Energy Commission, and

WHEREAS, the California Energy Codes and Standards Statewide Utility Program, has determined specific modifications to the 2025 State Energy Code for each climate zone that are cost-effective; and that such modifications will result in designs that consume less energy than they would under the 2025 State Energy Code; and

WHEREAS, staff has reviewed the "2022 Existing Building Cost-Effectiveness Study" and associated data, and "Application of 2022 Studies to 2025 Energy Code: Existing Single

Family Building Upgrades” memo and find them sufficient to illustrate compliance with the requirements set forth under California Administrative Code Chapter 10-106; and

WHEREAS, based on these studies, the City finds the proposed local amendments to the 2025 California Energy Code to be cost-effective and buildings will be designed to consume less energy than permitted by Title 24, Part 6; and

WHEREAS, the 2025 California Energy Code offers compliance options that were established through the public rulemaking process of the code update; and

WHEREAS, the Council expressly declares that the proposed amendments to the Energy Code are reasonably necessary because of local climatic, topological, and geological conditions; and

WHEREAS, Government Code Section 36937 requires an ordinance to take effect 30 days after its passage; and

WHEREAS, pursuant to Sections 17958.5 and 17958.7 of the Health and Safety Code, the proposed amendments meet the following conditions to demonstrate local amendments are necessary: the changes are substantially equivalent to 2022 code amendment changes, and the changes are necessary to implement the standards contained in this ordinance; and

WHEREAS, on August 26, 2025, the Ojai City Council found and determined that amendments to the 2022 Energy Code were cost effective, would result in buildings designed to consume less energy than permitted by previous editions of the Energy Code, and were necessary because of local climatic, geological, or topographical conditions, and Ojai’s City Council finds and determines the conditions persist and it is necessary to adopt substantially equivalent amendments to the 2025 Energy Code with no material change in regulatory effect to the existing standards; and

WHEREAS, pursuant to Sections 17958.5 and 17958.7 of the Health and Safety Code, the proposed amendments meet the following conditions to demonstrate local amendments are necessary: the changes are necessary to align local building codes with General Plan and greenhouse gas emissions reduction strategy goals while permitting mixed-fuel residential construction and incentivizing electric construction, and the changes are necessary to implement the standards contained in this ordinance; and

WHEREAS, in 1997, the Ojai City Council adopted the City of Ojai’s General Plan which includes Air Quality Goals set to reduce energy consumption and promote energy efficiency programs, educational strategies set to provide citizen awareness and participation in efforts to reduce air pollution and greenhouse gas emissions and encourage the incorporation of energy conservation features in the design of new construction and the installation of conservation devices in existing development that aligns with the emissions reduction goals in the proposed amendments; and

WHEREAS, in 1997, the Ojai City Council adopted the General Plan which includes Air Quality goals intended to reduce pollutant emissions through trip reductions goals, traffic flow improvements, particulate and building emissions, energy conservation, and community education that aligns with the emissions reduction goals in the proposed amendments; and

WHEREAS, in alignment with the General Plan's Air Quality Element's goals and objectives, policies and implementing programs, the local amendments to the 2025 California Energy Code establish requirements which will reduce demands for local energy resources, reduce regional pollution, and promote a lower contribution to greenhouse gas emissions; and

WHEREAS, the requirements specified in this Ordinance were reviewed via public comment and through a publicly noticed public hearing process; and

WHEREAS, the California Air Resource Board has determined Ventura County to be a non-attainment area for air quality, and the City of Ojai is located within Ventura County; and, the Green Building Standards can potentially reduce greenhouse gas emissions and VOC emissions from new construction projects as well as redevelopment and renovation projects in the City; and

WHEREAS, given the City borders the Los Padres National Forest and most of its territory has been designed a very high fire hazard severity zone; and, given fire retardant construction can help limit the negative impact of forest fires on commercial and residential structures in the City.

NOW, THEREFORE, THE CITY COUNCIL OF THE CITY OF OJAI DOES ORDAIN AS FOLLOWS:

SECTION 1. Recitals. The above set forth recitals and findings are true and correct and incorporated herein by reference, as if set forth herein in full.

SECTION 2. Findings.

1. The City Council finds that each of the changes or modifications to measures referred to therein are reasonably necessary because of local climatic, geological, or topographical conditions in the area encompassed by the boundaries of the City, and the City Council adopts the following findings in support of local necessity for the changes or modifications:
 - a. Ojai is situated along a wildland-urban interface, which is an area where urban development meets undeveloped lands at risk of wildfires and where residences and other structures are adjacent to or intermixed with open space and wildland vegetation. Ojai has been identified as a Community at Risk from wildfire and is extremely vulnerable to wildfires and firestorms. Human activities releasing greenhouse gasses into the atmosphere cause increases in worldwide average temperature, drought conditions, vegetative fuel, and length of fire seasons that contribute to the likelihood and consequences of fire.

- b. Seasonal climatic conditions during the late summer and fall create numerous serious difficulties in the control and protection against fire situations in the City. The hot, dry weather in combination with the Santa Ana winds frequently results in wildfires in the vegetation-covered slopes surrounding the Ojai Valley. When a fire occurs in said areas, like the 2017 Thomas Fire that surrounded the Ojai Valley, resulted in all Ojai Valley residents being under mandatory or voluntary evacuation orders, and entered the City and damaged property, most, if not all, local fire department personnel are required to control, monitor, fight, and protect against such fire situations in an effort to protect life and preserve property and watershed land. The same conditions may result in the concurrent occurrence of one or more fires in the more populated areas of the City without adequate fire department personnel to protect against and control such a situation. Accordingly, the above-described findings support the imposition of measures to increase the efficiency of existing buildings in the City to reduce greenhouse gas emissions.
 - c. The city of Ojai is at risk of/experiencing the effects of higher intensity storms, which put at risk the jurisdiction's homes, businesses, public facilities, roads, and highways.
 - d. Failure to address and substantially reduce greenhouse gas emissions creates an increased risk to the health, safety, and welfare of City residents.
 - e. The standards imposed by this Ordinance are necessary because of local climatic, geological, or topographical conditions evidenced above and are cost-effective, as supported by the 2022 Single Family Cost Effectiveness Report prepared by the California Energy Codes and Standards Statewide Utility Program, including the study and associated cost-effectiveness data and memo applying 2022 measures to the 2025 Energy Code.
2. The City Council finds that each of the changes or modifications to measures referred to therein:
- a. Are substantially equivalent to changes or modifications that were previously passed by the Ojai City Council on August 26, 2025 and previously filed on August 26, 2025 and were in effect as of September 30, 2025 and will have no material change in regulatory effect.
 - b. Are necessary to implement a local code amendment that is adopted to align with the City of Ojai's General Plan, including, without limitation, the following aspects of the City of Ojai's General Plan:
 - i. The Housing Element, which provides that the City of Ojai strives to promote energy conservation through the use of building codes.
 - ii. The Air Quality Element, which sets forth the City of Ojai's adopted greenhouse gas emissions reduction strategy including, without limitation, the City of Ojai's goals to limit greenhouse gas emissions through the reduction of energy consumption, promotion of energy efficiency programs, and implementation of planning and building regulations that take advantage of solar heating and natural cooling and require weatherization.

- c. Permit mixed-fuel residential construction consistent with federal law, including, without limitation, the Energy Policy and Conservation Act ("EPCA").
- d. Incentivize all-electric construction as part of an adopted greenhouse gas emissions reduction strategy.

SECTION 3. 2025 California Building Standards Code Administrative Provisions

Adopted. The Administrative Provisions of the 2025 CBSC contained in Division II of Chapter I of Part 2, Title 24 California Code of Regulations are hereby adopted by reference pursuant to Government Code 50022.2 through 50022.10. All of the regulations, provisions, conditions, and terms of said division, together with their appendices, one copy of which will be on file and accessible to the public for inspection at the city clerk's office, are hereby referred to, adopted and made part of this chapter as if fully set forth in this chapter. To provide adequate protection under the local climatic, geological, and topographical conditions set forth above, the City of Ojai makes the following findings and determinations relative to the adoption of administrative amendments, and where appropriate, the adoption of more restrictive CBSC provisions:

1. Ventura County has been determined by the California Air Resources Board to be a non-attainment area for air quality, and the City of Ojai is located within Ventura County;
2. Green Building Standards can potentially reduce greenhouse gas emissions and VOC emissions from new construction projects as well as redevelopment and renovation projects in the City;
3. The City of Ojai borders the Los Padres National Forest and most of its territory has been designated very high fire hazard severity zone; and
4. Fire retardant construction can help limit the negative impact of forest fires on commercial and residential structures in the City.

SECTION 4. Amendment. Ojai Municipal Code Section 9-1.101 ("Adoption by reference") Article 3 ("State Building Standards Code") of Chapter 1 ("Uniform Codes") of Title 9 ("Building Regulations") is hereby added to read as follows, with the additions marked by underlined text and deletions marked by ~~struck through~~ text:

Sec. 9-1.101. Adoption by reference.

Pursuant to Health and Safety Code Section 17958 and Government Code Section 50022.2, the State Building Standards Code (the "State Code") and other regulations adopted pursuant to Health and Safety Code Section 17922, including, but not limited to, the 2025 editions of the following:

- (a) The California Building Code (CBC), Volumes 1 & 2, and Appendices I and J;
- (b) The California Residential Code (CRC) and Appendix H;
- (c) The California Mechanical Code (CMC);
- (d) The California Existing Building Code (CEBC);

- (e) The California Administrative Code;
- (f) The California Electrical Code (CEC);
- (g) The California Plumbing Code (CPC) and Appendices H and L;
- (h) The California Fire Code;
- (i) The California Energy Code;
- (j) The California Green Buildings Standard Code (CGBSC);
- (k) The California Reference Standards.
- (l) The California Wild Land Interface Code

SECTION 5. Amendment. Ojai Municipal Code Section 9-1.301 (“Amendments”) Article 3 (“California Building Code and the California Residential Code”) of Chapter 1 (“Uniform Codes”) of Title 9 (“Building Regulations”) is hereby added to read as follows, with the additions marked by underlined text and deletions marked by ~~struck through~~ text:

Sec. 9-1.301. Amendments.

The ~~2022-~~ 2025 California Building Code is hereby amended as follows:

- (a) CBC 105.3.2 Time Limitation of Application - An application for a permit for any proposed work will be deemed abandoned one hundred eighty (180) days after the date of filing, corrections issued or plan approval unless a permit has been issued; except that the Building Official is authorized to grant up to two extensions of time for additional periods not exceeding one hundred eighty (180) days each. The extension must be requested in writing. In order to renew action on an application after expiration, the applicant must resubmit plans and pay a new plan review fee.
- (b) CBC 105.5 Expiration - Every permit issued will become invalid, unless the work on the site authorized by such permit is commenced within three hundred sixty five (365) after its issuance, or if the work authorized on the site by such permit is suspended or abandoned for a period of one hundred eighty (180) days after the time of work is commenced. Before such work can be recommenced, a new permit must first be obtained to do so, and the applicable fee will be one half the amount required for a new permit for such work, provided no changes have been made, nor will be made, in the original plans and specifications for such work; and provided further that such suspension or abandonment has not exceeded one year. If the suspension or abandonment has exceeded one year, the permit will be considered expired. In order to renew a permit after expiration, the permittee must pay a new full permit fee. The Building Official is authorized to grant, in writing, two extensions of time, for periods not more than one hundred eighty (180) days each. The extension must be requested in writing.
- (c) CBC 109.4 Work commencing before permit issuance - Any person who commences any work on a building, structure, electrical, gas, mechanical or plumbing system before obtaining the necessary permits shall be subject to a fee equal to the permit fee, that shall be in addition to any required permit fees.
- (d) CBC 109.7 Reinspection Fees - A reinspection fee may be imposed for each inspection or reinspection, when such portion of work for which inspection is called is not complete, access

is denied, access is not available or when required corrections are not made. This section is not to be interpreted as requiring reinspection fees the first time a job is rejected for failure to comply with the requirements of the technical codes, but as a method of controlling the practice of calling inspections before the job is ready for such inspection or reinspection. Reinspection fees may be imposed when the approved plans are not readily available to the inspector; for failure to provide access on the date for which the inspection is requested; or for deviating from plans requiring the approval of the Building Official. In instances where reinspection fees have been assessed, the permit will not be finalized nor occupancy granted until the required fees have been paid. Reinspection fees are established by City Ordinance.

- (e) CBC 109.9 Refunds - The Building Official may authorize a refund of any fee that was erroneously paid or collected. The Building Official may authorize a refund of not more than eighty (80) percent of the applicable permit fee paid when no work has been done under the permit. The Building Official may authorize a refund of not more than eighty (80) percent of the plan review fee paid when an application for a permit is withdrawn or canceled before any examination time has been expended. The Building Official may not authorize a refund of any fee paid except upon written request, filed by the original permittee no later than one hundred eighty (180) days after date of fee payment.
- (f) CBC 117 All Electric Buildings – All new constructed buildings and structures shall not be supplied with natural gas for the purpose of water heating (including pools and spas), space-heating, space-cooling, cooking and clothes drying.
- (g) CBC 202 Definition. Barrier. A barrier is a fence, wall, building wall or any combination of these that completely surrounds the swimming pool and obstructs access to the swimming pool.
- (h) CBC 202 Definition. Swimming Pools. Any body of water created by artificial means which is designed, intended for use, or used for swimming or immersion purposes, which has a water depth exceeding 18 inches. The term, “pool,” includes swimming pools, spas, hot tubs, above-and below-ground, and vinyl-lined pools; pool does not include plumbing fixtures such as bathtubs nor does it apply to man-made lakes, reservoirs, farm ponds, or ponds used primarily for public park purposes, water conservation purposes, irrigation purposes or for the watering of livestock.
- (i) CBC 701A.1 Scope - This chapter applies to building materials, systems and or assemblies used in the exterior design and construction of new buildings and building alterations located within a Wild-land -Urban Interface Fire Area as defined in Section R337.2A.
- (j) CBC 701A.3 Application - New buildings and building alterations located in any Fire Hazard Severity Zone or any Wildland-Urban Interface Fire Area Designated by the enforcing agency constructed after the application date shall comply with the provisions of this chapter.
- (k) CBC 701A.3.1 Application date and where required - New buildings for which an application for a building permit is submitted on or after July 1, 2008 located in any Fire Hazard Severity

Zone or Wildland Interface Fire Area shall comply with all sections of this chapter, including all of the following areas:

- (1) All unincorporated lands designated by the State Board of Forestry and Fire Protection as State Responsibility Area (SRA) including:
 - 1.1. Moderate Fire Hazard Severity Zones
 - 1.2. High Fire Hazard Severity Zones
 - 1.3. Very-High Fire Hazard Severity Zones
- (2) Land designated as Very-High Fire Hazard Severity Zone, High Fire Hazard Severity Zone and Moderate Fire Hazard Severity Zone by cities and other local agencies.
- (3) Land designated as Wildland Interface Fire Area by cities and other local agencies.
- (l) CBC 703A.5.2 Weathering – Fire retardant-treated-wood shall meet the fire test performance requirements of this chapter after being subjected to the weathering conditions contained in the following standards, as applicable to the materials and conditions of use.
- (m) CBC 703A.5.2.2 Fire-retardant-treated wood shingles and shakes – This section is deleted in its entirety.

CBC 704A.4 Alternative methods for determining ignition-resistant materials. – This section is deleted in its entirety.
- (n) CBC Table 1505.1 Minimum Roof Covering Classification for Types of Construction – Change Table so Minimum Class A would be required for all construction types. Exception may be granted by the Building Official for City or County registered historic landmarks. The applicant shall submit evidence of historical registry and proposed materials.
- (o) CBC 1511.3 Roof replacement - Roof replacement shall include the removal of all existing layers of roof covering down to the roof deck. The entire roof covering of every existing structure where more than ten (10) percent of the total roof area is repaired or replaced within any one-year period, shall be a fire-retardant roof covering that is at least Class A. When a roof is being replaced the following must also be upgraded:
 - (1) Spark arrestors must be installed on any fireplace chimney. Manufactured fireplace must have a spark arrestor installed approved by the manufacturer.
- (p) CBC 1511.3.1.2 Roof recover upgrade entire roof – The entire roof covering of every existing structure where more than ten (10) percent of the total roof area is repaired or replaced within any one-year period, shall be a fire-retardant roof covering that is at least Class A.
- (q) CBC 1803.1 General - Geotechnical investigations shall be conducted in accordance with sections 1803.2 and reported in accordance with 1803.6. Where required by the building official or where geotechnical investigations involve in-situ testing, laboratory testing or

engineering calculations, such determination must be made by a California licensed engineer experienced in soil engineering. The Soil Expansion Index must be listed in all soils investigation reports.

- (r) CBC 3109.1 General. The design and construction of swimming pools, spas and hot tubs shall comply with this code.
- (s) CBC 3109.3 Residential swimming pools. Residential swimming pools shall be completely enclosed by a barrier complying with the requirements of SB 442.
- (t) CBC 3109.3.1 Barrier Height and Clearances. The top of the barrier must be at least 60 inches above grade measured on the side of the barrier that faces away from the swimming pool. The maximum vertical clearance between grade and the bottom of the barrier must be two inches measured on the side of the barrier that faces away from the swimming pool. Where the top of the pool structure is above grade, the barrier is authorized to be at ground level or mounted on top of the pool structure, and the maximum vertical clearance between the top of the pool structure and the bottom of the barrier must be four inches.
- (u) CBC 3109.3.1.1 Openings. Openings in the barrier must not allow passage of a 4-inch-diameter sphere.
- (v) CBC 3109.3.1.2 Solid Barrier Surfaces. Solid barrier surfaces which do not have openings shall not contain indentations or protrusions except for normal construction tolerances and tooled masonry joints.
- (w) CBC 3109.3.1.3 Closely spaced horizontal members. Where the barrier is composed of horizontal and vertical members and the distance between the tops of the horizontal members is less than 45 inches, the horizontal members shall be located on the swimming pool side of the fence. Spacing between vertical members shall not be greater than 1 ¾ inches in width. Where there are decorative cutouts within vertical members, spacing with the cutouts shall not be greater than 1 ¾ inches in width.
- (x) CBC 3109.3.1.4 Widely spaced horizontal members. Where the barrier is composed of horizontal members and the distance between the tops of the horizontal members is 45 inches or more, spacing between vertical members must not be greater than 4 inches. Where there are decorative cutouts within vertical members, spacing must not be greater than 1 ¾ inches in width.
- (y) CBC 3109.3.1.5 Chain Link Dimensions. Mesh size for chain link fences must not be greater than 1 ¾ inches in width, unless the fence is provided with slats fastened at the top or bottom that reduce the openings to not more than 1 ¾ in width.
- (z) CBC 3109.3.1.6 Diagonal members. Where the barrier is composed of diagonal members shall not be greater than 1 ¾ inches.
- (aa) CBC 3109.3.1.7 Gates. Access gates must comply with the requirements of Sections 3109.3.1 through 3109.3.1.6 and must be equipped to accommodate a locking device. Pedestrian access

gates must open outward away from the pool and must be self-closing and have a self-latching device. Doors or gates other than pedestrian access gates must have a self-latching device and must be equipped with lockable hardware or padlocks and must remain locked at all times when not in use. Release mechanisms must comply with Sections 1010.1.9 and 1109.13. Where release mechanisms of the self-latching device are located less than 60 inches above grade measured on the side of the barrier that faces away from the swimming pool, the release mechanism must be located on the pool side of the gate at least three inches below the top of the gate and the gate barrier may have no opening greater than one-half inch within 18 inches of the release mechanism.

- (bb) CBC 3109.3.1.8 Dwelling wall as a barrier. Where a wall of a dwelling serves as part of the barrier, two safety devices must be provided in accordance with Section 115922 of the California Health and Safety Code.
- (cc) CBC 3109.3.1.9 Pool structure as barrier. Where an above-ground pool structure, and the means of access is a ladder or steps, then the ladder or steps either shall be capable of being secured, locked or removed to prevent access, or the ladder or steps shall be surrounded by a barrier that meets the requirements of Sections 3109.3.1.1 through 3109.3.1.8. Where the ladder or steps are secured, locked or removed, any opening shall not allow the passage of a 4-inch-diameter sphere.
- (dd) CBC 3109.3.2 Indoor swimming pools. Wall surrounding indoor swimming pools shall not be required to comply with Section 3109.3.1.8. through 3109.3.3.
- (ee) CBC 3109.3.3 Prohibited Locations. Barriers shall be located as to prohibit permanent structures, equipment or similar objects from being used to climb the barriers. There shall be a clear zone of not less than 36" between the exterior of the enclosure and any permanent structures or equipment such as pumps, filters and heaters that can be used to climb the enclosure.

The 2025 California Residential Code is hereby amended as follows:

- (a) CRC R105.3.2 Time Limitation of Application - An application for a permit for any proposed work will be deemed abandoned one hundred eighty (180) days after the date of filing, corrections issued or plan approval unless a permit has been issued; except that the Building Official is authorized to grant up to two extensions of time for additional periods not exceeding one hundred eighty (180) days each. The extension must be requested in writing. In order to renew action on an application after expiration, the applicant must resubmit plans and pay a new plan review fee.
- (b) CRC R105.5 Expiration - Every permit issued will become invalid, unless the work on the site authorized by such permit is commenced within three hundred sixty five (365) days after its issuance, or if the work authorized on the site by such permit is suspended or abandoned for a period of 180 days after the time of work is commenced. Before such work can be recommenced, a new permit must first be obtained to do so, and the applicable fee will be one half the amount required for a new permit for such work, provided no changes have been

made, nor will be made, in the original plans and specifications for such work; and provided further that such suspension or abandonment has not exceeded one year. If the suspension or abandonment has exceeded one year, the permit will be considered expired. In order to renew a permit after expiration, the permittee must pay a new full permit fee. The Building Official is authorized to grant, in writing, two extensions of time, for periods not more than one hundred eighty (180) days each. The extension must be requested in writing.

- (c) CRC R108.5 Refunds - The Building Official may authorize a refund of any fee that was erroneously paid or collected. The Building Official may authorize a refund of not more than eighty (80) percent of the applicable permit fee paid when no work has been done under the permit. The Building Official may authorize a refund of not more than eighty (80) percent of the plan review fee paid when an application for a permit is withdrawn or canceled before any examination time has been expended. The Building Official may not authorize a refund of any fee paid except upon written request, filed by the original permittee no later than one hundred eighty (180) days after date of fee payment.
- (d) CRC R108.6 Work commencing before permit issuance - Any person who commences any work on a building, structure, electrical, gas, mechanical or plumbing system before obtaining the necessary permits shall be subject to a fee equal to the permit fee, that shall be in addition to any required permit fees.
- (e) CRC R108.7 Reinspection Fees - A reinspection fee may be imposed for each inspection or reinspection, when such portion of work for which inspection is called is not complete, access is denied, access is not available or when required corrections are not made. This section is not to be interpreted as requiring reinspection fees the first time a job is rejected for failure to comply with the requirements of the technical codes, but as a method of controlling the practice of calling inspections before the job is ready for such inspection or reinspection. Reinspection fees may be imposed when the approved plans are not readily available to the inspector; for failure to provide access on the date for which the inspection is requested; or for deviating from plans requiring the approval of the Building Official. In instances where reinspection fees have been assessed, the permit will not be finalized nor occupancy granted until the required fees have been paid. Reinspection fees are established by City Ordinance.
- (f) CRC R115 All Electric Buildings - All new constructed buildings and structures shall not be supplied with natural gas for the purpose of water heating (including pools and spas), space-heating, space-cooling, cooking and clothes drying.
- (g) CRC R314.9 Heat sensor detector.
- (h) CRC R314.9.1 General – Heat sensor shall comply with section 314.9.
- (i) CRC R314.9.1.1 Listings – Heat sensor detectors shall be listed by a listing agency approved by the Building Official.
- (j) CRC R314.9.2 Where required – Heat sensor detectors shall be installed within attached and unattached garages when any permit is issued with a valuation greater than \$500.

- (k) CRC 314.9.3 Power source – Heat sensor detectors shall be either hard wired or plugged in to an outlet receiving power from a commercial source and shall be equipped with a battery backup. Heat sensor detector shall emit a signal when the batteries are low.
- (l) CRC R337.1.1 Scope - This chapter applies to building materials, systems and or assemblies used in the exterior design and construction of new buildings and building alterations located within a Wild-land -Urban Interface Fire Area as defined in Section R337.2A.
- (m) CRC R337.1.3 Application - New buildings and building alterations located in any Fire Hazard Severity Zone or any Wildland-Urban Interface Fire Area Designated by the enforcing agency constructed after the application date shall comply with the provisions of this chapter.
- (n) CRC R337.1.3.1 Application date and where required - New buildings for which an application for a building permit is submitted on or after July 1, 2008 located in any Fire Hazard Severity Zone or Wildland Interface Fire Area shall comply with all sections of this chapter, including all of the following areas:
 - (1) All unincorporated lands designated by the State Board of Forestry and Fire Protection as State Responsibility Area (SRA) including:
 - 1.1. Moderate Fire Hazard Severity Zones
 - 1.2. High Fire Hazard Severity Zones
 - 1.3. Very-High Fire Hazard Severity Zones
 - (2) Land designated as Very-High Fire Hazard Severity Zone, High Fire Hazard Severity Zone and Moderate Fire Hazard Severity Zone by cities and other local agencies.
 - (3) Land designated as Wildland Interface Fire Area by cities and other local agencies.
- (o) CRC R337.3.5.2 Weathering – Fire retardant-treated-wood shall meet the fire test performance requirements of this chapter after being subjected to the weathering conditions contained in the following standards, as applicable to the materials and conditions of use.
- (p) CRC R337.3.5.2.2 Fire-retardant-treated wood shingles and shakes – This section is deleted in its entirety.
- (q) CRC R337.4.3 Fire-retardant-treated wood shingles and shakes – This section is deleted in its entirety.
- (r) CRC R337.3.5.2.2 Fire-retardant-treated wood shingles and shakes – This section is deleted in its entirety.

- (s) CRC R337.8.2.1 Exterior windows and exterior glazed doors assembly requirements – Exterior windows and exterior glazed doors assemblies shall comply with one of the following requirements:
- (1) Be constructed of multiplane glazing with a minimum of one tempered pane meeting the requirements of section R308 Safety Glazing, or
 - (2) Be constructed of block glass units, or
 - (3) Have a fire-resistance rating of not less than 20 minutes when tested according to NFPA 257, or
 - (4) Be tested to meet the performance requirements of SFM Standard 12-7A-2.
- (t) CRC R401.1 Application – The provisions of this chapter control the design and construction of the foundation and foundation spaces for all buildings. In addition to the provisions of this chapter, the design and construction of foundations in areas prone to flooding as established by Table R301.2(1) must meet the provisions of Section R322. Wood foundations must be designed and installed in accordance with AF&PA PWF (American Forest & Paper Association permanent wood foundation).
- Exception: The provisions of this chapter are permitted to be used for wood foundations only in the following situations:
1. In buildings that have no more than two floors and a roof.
 2. When interior basement and foundation walls are constructed at intervals not exceeding 50 feet.
 3. Wood foundations in Seismic Design Category D0, D1, D2, or E are not permitted.
- (u) CRC R403.1.2 Continuous footing in Seismic Design Categories D0, D1, D2 and E. Exterior walls of buildings located in Seismic Design Categories D0, D1, D2, and E, shall be supported by continuous solid or fully grouted masonry or concrete footings. Other footing materials or systems shall be designed in accordance with accepted engineering practice. The braced wall panels at exterior walls of buildings located in Seismic Design Categories D0, D1, D2 and E must be supported by continuous footings. All required interior braced wall panels in buildings must be supported by continuous footings. The exception is deleted in its entirety.
- (v) CRC R902.1 Roofing covering materials – Roofs shall be covered with materials as set forth in Sections R904 and R905. A minimum Class A roof shall be installed in all areas or where the edge of the roof is less than 3 feet from a lot line. Class A roofing shall be tested in accordance with UL 790 or ASTM E108.
- (w) CRC R902.1.1 Roof coverings within very-high fire hazard severity zones – The entire roof covering of every existing structure where more than ten (10) percent of the total roof area is repaired or replaced within any one-year period, the entire roof covering of every new structure, and any roof covering applied in alteration, repair or replacement of the roof or every existing structure, shall be a fire-retardant roof covering that is at least Class A.

- (x) CRC R902.1.2 Roof coverings within state responsibility zones - The entire roof covering of every existing structure where more than ten (10) percent of the total roof area is repaired or replaced within any one-year period, the entire roof covering of every new structure, and any roof covering applied in the alteration, repair or replacement of the roof of every existing structure, shall be a fire-retardant roof covering that is at least Class A.
- (y) CRC R902.1.2 Exception - The exception is deleted in its entirety.
- (z) CRC R903.1.3 Roof coverings in all other areas - The entire roof covering of every existing structure where more than ten (10) percent of the total roof area is repaired or replaced within any one-year period, the entire roof covering of every new structure, and any roof covering applied in the alteration, repair or replacement of the roof of every existing structure, shall be a fire-retardant roof covering that is at least Class A.

SECTION 6. Amendment. Ojai Municipal Code Section 9-1.302 (“CBC Appendix and CRC Appendix”) of Chapter 1 (“Uniform Codes”) of Title 9 (“Building Regulations”) is hereby added to read as follows, with the additions marked by underlined and deletions marked by ~~struck through~~ text:

Sec. 9-1.302. Amendments.

The ~~2022~~ 2025 California Building Code Appendices I and J are adopted as parts of this code.

The ~~2022~~ 2025 California Residential Code Appendix AH adopted as parts of this code.

SECTION 7. Amendment. Ojai Municipal Code Article 4 (“California Mechanical Code”) of Chapter 1 (“Building Codes”) of Title 9 (“Building Regulations”) is hereby added to read as follows, with the additions marked by underlined and deletions marked by ~~struck through~~ text:

Sec. 9-1.401. Amendments.

The ~~2022~~ 2025 California Mechanical Code is hereby amended as follows:

- (a) CMC 104.5.3 Fee Refunds – The Authority Having Jurisdiction shall be permitted to authorize the refunding of a fee as follows:
 - (1) The amount paid hereunder that was erroneously paid or collected.
 - (2) The Building Official may authorize a refund of not more than eight (80) percent of the applicable permit fee paid when no work has been done under the permit. The Building Official may authorize a refund of not more than eighty (80) percent of the plan review fee paid when an application for a permit is withdrawn or canceled before any examination time has been expended.
- (b) CMC 105.2.6 Reinspection Fees – A reinspection fee may be imposed for each inspection or reinspection, when such portion of work for which inspection is called is not complete, access is denied, access is not available or when required corrections are not made. This section is not to be interpreted as requiring reinspection fees the first time a job is rejected for failure to comply with the requirements of the technical codes, but as a method of controlling the

practice of calling inspections before the job is ready for such inspection or reinspection. Reinspection fees may be imposed when the approved plans are not readily available to the inspector; for failure to provide access on the date for which the inspection is requested; or for deviating from plans requiring the approval of the Building Official. In instances where reinspection fees have been assessed, the permit will not be finalized nor occupancy granted until the required fees have been paid. Reinspection fees are established by City Ordinance.

SECTION 8. Amendment. Ojai Municipal Code Article 5 (“California Existing Building Code”) of Chapter 1 (“Building Codes”) of Title 9 (“Building Regulations”) is hereby added to read as follows, with the additions marked by underlined and deletions marked by ~~struck through~~ text:

Sec. 9-1.501. Amendments.

That certain Code known as the “2022 The California Existing Building Code,” promulgated and published by the California Building Standards Commission, is hereby adopted and enacted as the primary Code governing the administration of this Code and is made a part of this Code by reference with the same force and effect as if fully set forth herein. Such Code will be referred to herein as the California Existing Building Code (“CEBC”).

SECTION 9. Amendment. Ojai Municipal Code Article 6 (“California Administrative Code”) of Chapter 1 (“Building Codes”) of Title 9 (“Building Regulations”) is hereby added to read as follows, with the additions marked by underlined and deletions marked by ~~struck through~~ text:

Sec. 9-1.601. Amendments.

That certain Code known as the “2022 The California Administrative Code,” promulgated and published by the California Building Standards Commission, is hereby adopted and enacted as the primary Code governing the administration of this Code and is made a part of this Code by reference with the same force as if fully set forth herein. Such Code will be referred to herein as The California Administrative Code (CAC).

SECTION 10. Amendment. Ojai Municipal Code Article 7 (“California Electrical Code”) of Chapter 1 (“Building Codes”) of Title 9 (“Building Regulations”) is hereby added to read as follows, with the additions marked by underlined text:

Sec. 9-1.701. Amendments.

The ~~2022~~ 2025 California Electrical Code is hereby amended as follows:

- (a) CEC Sec. 89.108.48. Permit Application. To obtain an electrical permit, an application shall be filed therefor and appropriate fees paid as set forth by resolution of the Council.
- (b) CEC Sec. 89.108.9.3. Authority to Disconnect. The Building Official is hereby authorized to order the discontinuance and/or disconnection of any electrical wiring, device, appliance, apparatus or equipment which is found to be hazardous to life, health or property.

- (1) It shall be unlawful for any person, firm, corporation or serving utility to make connections with a source of electrical energy or to supply electrical service to any electrical wiring, device, appliance, apparatus or equipment which has been disconnected or ordered disconnected by the Building Official until approval has been granted for reconnection of such equipment.
- (c) CEC Sec. 89.108.9.4. Connection to Electrical Installations. Except where work is done under an annual electrical maintenance permit, it shall be unlawful for any person, firm or corporation to make connection from a source of electrical wiring, device, appliance or equipment which requires a permit for installation unless such person, firm or corporation shall have obtained evidence from the Building Inspector that such equipment is authorized to be energized.
- (d) CEC Sec. 89.108.9.5. Authority to Abate. Any portion of an electrical system found by the Building Official to be unsafe as defined in this Code or which the Building Official finds is manifestly unsafe is hereby declared to be a nuisance.
 - (1) Where a nuisance exists or an electrical system is maintained in violation of this Code or any notice issued pursuant to this Section, the Building Official shall require the nuisance or violation to be abated and, where necessary, shall seek such abatement in the manner provided by law.
- (e) CEC Sec. 110.5. Conductors. Conductors normally used to carry current shall be of copper unless otherwise provided in this Code. Where the conductor material is not specified, the sizes given in this Code shall apply to copper conductors. Where other materials are used, the size shall be changed accordingly.
 - (1) For aluminum and copper-clad aluminum conductors, see Tables 310-16 through 310-19 of the NEC. Aluminum wire used under the provisions of this Code shall be a minimum of #6 A.W.G. stranded conductor.
- (f) CEC Sec. 110.8. Wiring Methods. Only wiring methods recognized as suitable are included in this Code. The recognized methods of wiring shall be permitted to be installed in any type of building or occupancy, except as otherwise provided in this Code.
 - (1) Wiring installations and equipment in existence at the time of passage of this Code may have their existing use continued if such use was legal at the time of passage and provided such continued use is not unsafe.

SECTION 11. Amendment. Ojai Municipal Code Article 8 (“California Plumbing Code”) of Chapter 1 (“Building Codes”) of Title 9 (“Building Regulations”) is hereby added to read as follows, with deletions with ~~strike-through~~, the additions marked by underlined text:

Sec. 9-1.801. Amendments.

The ~~2022~~ 2025 California Plumbing Code is hereby amended as follows:

- (a) CPC 104.5.3 Fee Refunds – The Authority Having Jurisdiction shall be permitted to authorize the refunding of a fee as follows:
 - 1. The amount paid hereunder that was erroneously paid or collected.

2. The Building Official may authorize a refund of not more than eighty (80) percent of the applicable permit fee paid when no work has been done under the permit. The Building Official may authorize a refund of not more than eighty (80) percent of the plan review fee paid when an application for a permit is withdrawn or canceled before any examination time has been expended.
- (b) CPC 105.2.6 Reinspection Fees – A reinspection fee may be imposed for each inspection or reinspection, when such portion of work for which inspection is called is not complete, access is denied, access is not available or when required corrections are not made. This section is not to be interpreted as requiring reinspection fees the first time a job is rejected for failure to comply with the requirements of the technical codes, but as a method of controlling the practice of calling inspections before the job is ready for such inspection or reinspection. Reinspection fees may be imposed when the approved plans are not readily available to the inspector; for failure to provide access on the date for which the inspection is requested; or for deviating from plans requiring the approval of the Building Official. In instances where reinspection fees have been assessed, the permit will not be finalized nor occupancy granted until the required fees have been paid. Reinspection fees are established by City Ordinance.

SECTION 12. Amendment. Ojai Municipal Code Article 9 (“California Fire Code”) of Chapter 1 (“Building Codes”) of Title 9 (“Building Regulations”) is hereby added to read as follows, with deletions in ~~strike-through~~, and the additions marked by underlined text:
Sec. 9-1.901. Adoption.

That certain Code known as the “~~2022~~ 2025 California Fire Code, most recent edition, promulgated and published by the California Building Standards Commission, is hereby adopted and enacted as the primary Fire Code of the City and made a part of this chapter by reference with the same force and effect as if fully set forth in this chapter, subject to the amendments set forth in this article. Said Code shall be referred to in this article as the California Fire Code (CFC).

SECTION 13. Amendment. Ojai Municipal Code Article 10 (“California Energy Code”) of Chapter 1 (“Building Codes”) of Title 9 (“Building Regulations”) is hereby added to read as follows, with the additions marked by underlined and deletions marked by ~~struck-through~~ text:

Section 9-1.1001 -Adoption.

The City hereby adopts the “~~2022~~ 2025 California Energy Code” except as otherwise provided herein, or as later amended in Section 9-1.701 shall be as published in the California Energy Code, ~~2022~~ 2025 Edition, and as copyrighted by the California Building Standards Commission, California Code of Regulations, Title 24, Part 6, including all of its tables, indices, appendices, addenda and footnotes. Said California Energy Code is hereby referred to and by such reference is incorporated herein as if fully set forth.

Section 9-1.701(g) of the Ojai Municipal Code is hereby added to read as follows:

(g) *Energy Efficiency Code.*

It is the purpose and intent of this section to establish standards for residential retrofits including major additions and alterations that exceed minimum ~~2022~~ 2025 California Code of Regulations Title 24 Part 6 requirements. In furtherance of this purpose, these changes shall be made to the ~~2022~~ 2025 California Energy Code and shall apply to building permit applications submitted to the City of Ojai on or after January 31, 2026:

- (1) Add the following definitions to Subchapter 1, Section 100.1(b):

MAJOR ADDITION is any change to an existing building that increases conditioned floor area by 300 or more square feet in a one-year period.

MAJOR ALTERATION is any construction or renovation to an existing structure other than a repair whose altered components cover 300 or more square feet in a one-year period. A project that consists only of roof and/or window replacement is not considered a major alteration.

- (2) Amend Section 150.0 SINGLE-FAMILY RESIDENTIAL BUILDINGS – MANDATORY FEATURES AND DEVICES to read as follows:

Single-family residential buildings shall comply with the applicable requirements of Sections 150.0(a) through 150.0(w).

- (3) Add new Section 150(w) to read as follows:

- (w) Mandatory Requirements for Existing Building Additions and Alterations. Existing Building Additions and Alterations shall meet the requirements of Items 1 through 3 below, as applicable:

1. Major addition. Any Major Addition shall install a set of measures from the Measure Menu Table, Table 150.0-I to achieve a total score that is equal to or greater than 8. Any Major Addition 1,000 square feet or greater must achieve a total score that is equal to or greater than 19. In addition, all mandatory measures listed in Table 150.0-I shall be installed. Measure verification shall be explicitly included as an addendum to the Title 24 Part 6 Certificate of Compliance to be filed pursuant to ~~2022~~ 2025 Title 24 Section 10-103. Installed measures shall meet the specifications in Table 150.0-J.
2. Major alteration. Any Major Alteration shall install a set of measures from the Measure Menu Table, Table 150.0-I to achieve a total score that is equal to or greater than 8. Any Major Alteration 1,000 square feet or greater must achieve a total score that is equal to or greater than 19. In addition, all mandatory measures listed in Table 150.0-I shall be installed. Measure verification shall be explicitly included as an addendum to the Certificate of Compliance to be filed pursuant to ~~2022~~ 2025 Title 24 Section 10-103. Installed measures shall meet the specifications in Table 150.0-J.
3. Combination alterations and additions. Any project that includes an addition and alteration whose altered components cover equal to or greater than 300

square feet shall install a set of measures from the Measure Menu Table, Table 150.0-I to achieve a total score that is equal to or greater than 8. Any project that includes an addition and alteration whose altered components cover equal to or greater than 1,000 square feet shall achieve a total score that is equal to or greater than 19. In addition, all mandatory measures listed in Table 150.0-I shall be installed. Measure verification shall be explicitly included as an addendum to the Certificate of Compliance to be filed pursuant to ~~2022~~ 2025 Title 24 Section 10-103. Installed measures shall meet the specifications in Table 150.0-J.

Exception 1 to Section 150.0(w): The project is the result of a repair as defined by Title 24 Part 2 Section 202.

Exception 2 to Section 150.0(w): If compliance costs exceed 20% of total project valuation or due to conditions specific to the project, it is technically infeasible to achieve compliance through any available set of measures, the applicant may request an exemption as set forth below. In applying for an exemption, the burden is on the applicant to allow hardship or infeasibility.

- (1) Application. Based on the following, the applicant shall identify in writing the specific requirements of the standards for compliance that the project is unable to achieve and the circumstances that make it a hardship or infeasible for the project to comply with this chapter. The applicant may not petition for relief from any requirement of the ~~2022~~ 2025 California Energy Code (Title 24, Part 6) and referenced standards, or the ~~2022~~ 2025 California Green Building Standards (Title 24, Part 11) of the California Building Standards Code. Circumstances that constitute hardship or infeasibility shall include one of the following:
 - i. That the cost of achieving compliance is disproportionate to the overall cost of the project;
 - ii. That it is technically infeasible to achieve compliance through all packages due to conditions specific to the project; That strict compliance with these standards would create or maintain a hazardous condition(s) and present a life safety risk to the occupants.

(2) Granting of exemption. If the chief building official, in consultation with the Director of Community Development, determines that it is a hardship or infeasible for the applicant to fully meet the requirements of this chapter and that granting the requested exemption will not cause the building to fail to comply with the ~~2022~~ 2025 California Energy Code (Title 24, Part 6) and referenced standards, or the ~~2022~~ 2025 California Green Building Standards (Title 24, Part 11) of the California Building Standards Code, the chief building official, in consultation with the Director of Community Development, shall determine the minimum feasible threshold of compliance reasonably achievable for the project. If an exemption is

granted, the applicant shall be required to comply with this chapter in all other respects and shall be required to achieve the threshold of compliance determined to be achievable by the chief building official, in consultation with the Director of Community Development.

(3) Denial of exemption. If the chief building official, in consultation with the Director of Community Development, determines that it is reasonably possible for the applicant to fully meet the requirements of this chapter, the request shall be denied, and the applicant shall be notified of the decision in writing. The project and compliance documentation shall be modified to comply with the standards for compliance.

(4) Appeal. Any aggrieved applicant or person may appeal, at no fee, the determination of the chief building official, in consultation with the Director of Community Development, regarding the granting or denial of an exemption or compliance with any other provision of this chapter. An appeal of a determination of the chief building official shall be filed in writing with the Building Appeals Board.

Exception 3 to Section 150.0(w): If the dwelling unit has previously installed measures from the Measure Menu, Table 150.0-I, and compliance can be demonstrated to the chief building official, in consultation with the Director of Community Development, then these measures shall not be required to be newly installed, and appropriate credit shall be included in the applicable compliance calculations.

Exception 4 to Section 150.0(w): The applicant for alterations or additions to a City landmark or contributing structure to a City-designated historic district may request an exemption to any requirements of this chapter which would impair the any City landmark or contributing structure to a City-designated historic district shall be exempt from the requirements of this section/chapter if the energy efficiency improvements would impair any character-defining element of the landmark or historic district, as determined by the Director of Community Development and as regulated by the California Historic Building Code (Title 24, Part 8). In making a determination of exemption, the Director of Community Development, or their designee, may require the submittal of an evaluation by an architectural historian or similar expert.

Exception 5 to Section 150.0(w): An alteration that consists solely of seismic and fire hardening improvements.

Exception 6 to Section 150.0(w): Buildings which are temporary (such as construction trailers).

Exception 7 to Section 150.0(w): An alteration that consists solely of roof and/or window projects.

Exception 8 to Section 150.0(w): Mobile Homes, Manufactured Housing, or Factory-built Housing as defined in Division 13 of the California Health and Safety 12 Code (commencing with Section 17000 of the Health and Safety Code).

Exception 9 to Section 150.0(w): Properties located outside of climate zone 9.

Exception 10 to Section 150.0(w): Any accessory dwelling unit or junior accessory dwelling unit allowed per state law, and/or tiny house permitted per Section 10-2.1712 of this Code.

Exception 11 to Section 150.0(w): Where the project includes an accessory dwelling unit or junior accessory dwelling unit that is attached to the primary dwelling unit, either as a new addition or converted from within the space of the primary dwelling unit, and there is not an additional combination alteration/addition to the primary dwelling unit of at least 300 square feet, then the primary dwelling unit is exempt from the requirements.

Exception 12 to Section 150.0(w): Nothing in this ordinance shall be construed so as to prohibit any one appliance covered by the Energy Policy and Conservation Act (EPCA) (42 U.S.C. § 6292). Should an applicant establish that this ordinance, as applied, prohibits a covered appliance in applicant's project, the chief building official, in consultation with the Director of Community Development, shall waive that portion of the ordinance causing such prohibition.

Exception 13 to Section 150.0(w): If the applicant demonstrates, using Commission-certified compliance software as specified by Section 10-109(c) and Section 10-116, that the Energy Budget of the Proposed Building Design would be less than or equal to the Energy Budget of the building under the project if it included any set of measures that would achieve compliance under this Section 150.0(w).

Exception 14 to Section 150.0(w): Single-family homes built after December 31, 1991.

(4) Add new Section 150(x) to read as follows:

150.0(x) Electric vehicle (EV) Charging for additions and alterations. Parking additions or electrical panel upgrades must have reserved breaker spaces and electrical capacity to accommodate one Level 2 EV Charging Receptacle in one parking space as defined in the California Green Building Standards Code Section 202. If a second parking space is provided, it shall be provided with a Level 1 EV Charging Receptacle as defined in the California Green Building Standards Code Section 202.

Exception to 150.0(x): Accessory Dwelling Units (ADU) and Junior Accessory Dwelling Units (JADU) without additional parking facilities and without electrical panel upgrade or new panel installation. Detached ADUs, attached ADUs, and JADUs without additional parking but with electrical panel upgrades or new panels must have reserved breakers and electrical capacity according to the requirements of Section 4.106.4.1 in the California Green Building Standards Code.

(5) Add new Table 150.0-I to read as follows:

Table 150.0-I: Measure Menu

Climate Zone 9		
Measures	Table 150.0-J ID	Points
Water Heating Package	E1	2
Induction Cooktop	E2	1
Heat Pump Clothes Dryer	E3	1
 Air Sealing	E4	1
 Duct Sealing	E5	3
R-49 Attic Insulation	E6	5
 Windows	E7	5
 R-15 Wall Insulation	E8	3
New Ducts + Duct Sealing	E9	7
 R-19 Floor Insulation	E10	1
 R-30 Floor Insulation	E11	2
Heat Pump Water Heater (HPWH) replacing gas	E12	12
Heat Pump Water Heater (HPWH) replacing electric	E13	5
Solar PV + Electric Ready Pre-Wire	E14	17
Heat Pump Space Heater	E15	7
Utility Room, Kitchen & Laundry-Related Electric Ready Pre-Wire	M1	Mandatory
Panel-Related Electric Ready Pre-Wire	M2	Mandatory
Lighting Measures	M3	Mandatory
Note 1: the measures in the Measure Menu table shall conform to the specifications in Table 150.0-J		

Note 2:  in addition to energy efficiency, these strategies provide direct fire hardening benefits

(1) Add new Table 150.0-J to read as follows:

Table 150.0-J: Measure Specifications

ID	Measure Specification
General Measures	
E1	Water Heating Package: 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 California Green Building Standards Code (Title 24, Part 11) Section 4.303 water efficiency requirements. Exception: Upgraded fixtures are not required if existing fixtures have rated or measured flow rates of no more than ten percent greater than 2025 California Green Building Standards Code (Title 24, Part 11) Section 4.303 water efficiency requirements.
E2	Induction Cooktop: Replace existing gas and electric resistance stove top with inductive stove top and cap the gas line.
E3	Heat Pump Clothes Dryer: Replace all existing gas and electric clothes dryers with heat pump clothes dryers.
E4	Air Sealing: Seal all accessible cracks, holes, and gaps in the building envelope at walls, floors, and ceilings. Pay special attention to penetrations including plumbing, electrical, and mechanical vents, recessed can light luminaires, and windows. Weather-strip doors if not already present. Verification shall be conducted by a certified ECC Rater that either: a) shows at least a 30 percent reduction from pre-retrofit conditions; or b) shows that the number of air changes per hour at 50 Pascals pressure difference (ACH50) does not exceed ten for Pre-1978 vintage buildings, seven for 1978 to 1991 vintage buildings and five for 1992-2010 vintage buildings. Compliance can also be demonstrated with blower door testing conducted by a certified ECC Rater no more than three years prior to the permit application date showing compliance with condition (a) or (b). If combustion appliances are located within the pressure boundary of the building, conduct a combustion safety test by a professional certified by the Building Performance Institute in accordance with the ANSI/BPI-1200-S-2017 Standard Practice for Basic Analysis of Buildings, the Whole House Combustion Appliance Safety Test Procedure for the Comfortable Home Rebates Program 2020 or the California Community Services and Development Combustion Appliance Safety Testing Protocol.

	Reducing the air leakage of a building can reduce the building's drying potential. When improving the air sealing of a building, consider if there is a need to add continuous ventilation to the building (if not already present).
E5	Duct Sealing: Air seal all space conditioning ductwork to meet the requirements of the ~~2022~~ <u>2025</u> Title 24 Section 150.2(b)1E. The duct system must be tested by a ECC Rater no more than three years prior to the alteration or addition permit application date to verify the duct sealing and confirm that the requirements have been met. This measure may not be combined with the New Ducts and Duct Sealing measure in this Table. Buildings without ductwork or where the ducts are in conditioned space may not take credit for this measure.
E6	R-49 Attic Insulation: Attic insulation shall be installed to achieve a weighted assembly U-factor of 0.020 or insulation installed at the ceiling level shall have a thermal resistance of R-49 or greater for the insulation alone. Recessed downlight luminaires in the ceiling shall be covered with insulation to the same depth as the rest of the ceiling. Luminaires not rated for insulation contact must be replaced or fitted with a fire-proof cover that allows for insulation to be installed directly over the cover. Exception: In buildings where existing R-30 is present and existing recessed downlight luminaires are not rated for insulation contact, insulation is not required to be installed over the luminaires.
E7	Windows: Replace at least 50% of existing windows with high performance windows with an area-weighted average U-factor no greater than 0.27.
E8	R-15 Wall Insulation: Install wall insulation in all exterior walls to achieve a weighted U-factor of 0.095 or install wall insulation in all exterior wall cavities that shall result in an installed thermal resistance of R-15 or greater for the insulation alone.
E9	New Ducts + Duct Sealing: Replace existing space conditioning ductwork with new R-8 ducts that meet the requirements of ~~2022~~ <u>2025</u> Title 24 Section 150.0(m)11. This measure may not be combined with the Duct Sealing measure in this Table. To qualify, a preexisting measure must have been installed no more than three years before the alteration or addition permit application date.
E10	R-19 Floor Insulation: Raised-floors shall be insulated such that the floor assembly has an assembly U-factor equal to or less than U-0.037, or shall be insulated between wood framing with insulation having an R-value equal to or greater than R-19. This measure cannot be combined with measure R-30 Floor insulation.
E11	R-30 Floor Insulation: Raised-floors shall be insulated such that the floor assembly has an assembly U-factor equal to or less than U-0.028, or shall be insulated between wood framing with insulation having an R-value equal to or

	greater than R-30. This measure cannot be combined with measure R-19 Floor insulation.
E12	Heat Pump Water Heater (HPWH) replacing gas: Replace existing natural gas storage water heater with a heat pump water heater that meets the requirements of Sections 110.3 and 150.2(b)1.H.iii.b.
E13	Heat Pump Water Heater (HPWH) replacing electric: Replace existing electric resistance storage water heater with a heat pump water heater that meets the requirements of Sections 110.3 and 150.2(b)1.H.iii.b.
E14	PV and Electric Ready Pre-Wire: Install a solar PV system that meets the requirements of ~~2022~~ <u>2025</u> Title 24 Section 150.1(c)14. In addition to the solar PV system, comply with the electric readiness components per Section 150.0(n)1 and 150.0(t) and one of: A. Energy Storage Systems (ESS) Ready, as specified in Section 150.0(s), or B. EV Charger Ready as specified in the California Green Building Code, Title 24, Part 11, Section A4.106.8.1, which otherwise applies to new construction. Exception 1: In buildings where the designated space requirement specified in Section 150.0(n)1 can be demonstrated to the chief building official, in consultation with the Director of Community Development, as infeasible, the electric readiness components per Section 150.0(n)1 are not required.
E15	Heat Pump Space Heater: Replace all existing gas and electric resistance primary space heating systems with a heat pump system that meets the requirements of Sections 110.3, 150.2(b)1.C, 150.2 (b)1.E, 150.2(b)1.F, 150.2(b)1.G.
Mandatory Measures	
M1	Utility Room, Kitchen & Laundry-Related Electric Ready Pre-Wire: If the project includes a kitchen remodel, comply with the Electric Cooktop Ready requirement, as specified in Section 150.0(u). If the project includes a laundry room remodel, comply with the Electric Clothes Dryer Ready requirement, as specified in Section 150.0(v). If the project includes a utility room remodel, comply with the electric readiness components per Section 150.0(n)1 and 150.0(t): Exception 1: If an electrical permit is not otherwise required for the project other than compliance with this measure. Exception 2: If a utility service upgrade is not otherwise required for the project other than compliance with this measure. Exception 3: In buildings where the designated space requirement specified in Section 150.0(n)1 can be demonstrated to the chief building official, in consultation with the Director of Community Development, as infeasible, the electric readiness components per Section 150.0(n)1 are not required.
M2	Panel-Related Electric Ready Pre-Wire: If the project includes a new electrical panel and electrical service upgrade to 200A or more, comply with the Water Heating Ready requirements, as specified in Section 150.0(n)1 and the Space Heating Ready Requirement 150.0(t).

	Exception 1: In buildings where the designated space requirement specified in Section 150.0(n)1 can be demonstrated to the chief building official, in consultation with the Director of Community Development, as infeasible, the electric readiness components per Section 150.0(n)1 are not required.
M3	Lighting Measures – Install lighting with an efficiency of 45 lumens per watt or greater in all interior and exterior screw-in fixtures. Install photocell, occupancy sensor or energy management system controls that meet the requirements of 150.0(k)3 in all outdoor lighting permanently mounted to a residential building or to other buildings on the same lot.

- (6) Modify Section 150.2(a) ENERGY EFFICIENCY STANDARDS FOR ADDITIONS AND ALTERATIONS TO EXISTING SINGLE FAMILY RESIDENTIAL BUILDINGS to read as follows:

Additions. Additions to existing single-family residential buildings shall meet the requirements of Sections 110.0 through 110.9, Sections 150.0(a) through (n), (p), (q), (w) and either Section 150.2(a)1 or 2.

- (7) Modify Section 150.2(b) ENERGY EFFICIENCY STANDARDS FOR ADDITIONS AND ALTERATIONS TO EXISTING SINGLE FAMILY RESIDENTIAL BUILDINGS to read as follows:

Alterations. Alterations to existing single-family residential buildings or alterations in conjunction with a change in building occupancy to a single-family residential occupancy shall meet either Item 1 or 2 below.

1. Prescriptive approach. The altered component and any newly installed equipment serving the alteration shall meet the applicable requirements of Sections 110.0 through 110.9 and all applicable requirements of Sections 150.0(a) through (l), 150.0(m)1 through 150.0 (m)10, 150.0(p) through (q), and 150.0 (w); and
 - i. Performance approach. The altered component(s) and any newly installed equipment serving the alteration shall meet the applicable requirements of Subsections A, B, and C below.

A. The altered components shall meet the applicable requirements of Sections 110.0 through 110.9, Sections 150.0(a) through (l), Sections 150.0(m)1 through 150.0 (m)10, Sections 150.0(p) through (q), and Section 150.0(w). Entirely new or complete replacement mechanical ventilation systems as these terms are used in Section 150.2(b)1L, shall comply with the requirements in Section 150.2(b)1L. Altered mechanical ventilation systems shall comply with the requirements of Section 150.2(b)1M. Entirely new or complete replacement space-conditioning systems, and entirely new or complete replacement duct systems, as these terms are used in Sections 150.2(b)1C and 150.2(b)1Diia, shall comply with the requirements of Sections 150.0(m)12 and 150.0(m)13.

SECTION 14. Amendment. Ojai Municipal Code Article 11 (“California Green Building Code”) of Chapter 1 (“Building Codes”) of Title 9 (“Building Regulations”) is hereby added to read as follows, with the additions marked by underlined text and deletions marked by ~~struck through~~ text:

Sec. 9-1.1101. Adoption.

That certain Code known as the “~~2022~~ 2025 California Green Building Code,” most recent edition, promulgated and published by the California Building Standards Commission, is hereby adopted and enacted as the primary Code of the City and made a part of this chapter by reference with the same force and effect as if fully set forth in this chapter, subject to the amendments set forth in this article. Said Code shall be referred to in this article as the California Green Building Code (CGBC).

SECTION 15. Amendment. Ojai Municipal Code Article 12 (“California Reference Standard”) of Chapter 1 (“Building Codes”) of Title 9 (“Building Regulations”) is hereby added to read as follows, with the additions marked by underlined text and deletions marked by ~~struck through~~ text.

Sec. 9-1.1201. Adoption.

That certain Code known as the “~~2022~~ 2025 California Reference Standard,” most recent edition, promulgated and published by the California Building Standards Commission, is hereby adopted and enacted as the primary Code of the City and made a part of this chapter by reference with the same force and effect as if fully set forth in this chapter, subject to the amendments set forth in this article. Said Code shall be referred to in this article as the California Reference Standard (CRS).

SECTION 16. Building Standards Commission. The City Clerk shall file a certified copy of this Ordinance with the California Building Standards Commission, under Health and Safety Code section 17958.7.

SECTION 17. California Energy Commission. The City Clerk shall file a certified copy of this Ordinance with the California Energy Commission, in accordance with California Health and Safety Code Sections 17958.5, 17958.7, and 18941.5, Public Resources Code Section 25402.1(h)(2), and California Code of Regulations, Title 24, Part 1, §10-106.

SECTION 18. Environmental Determination. The City Council determines that the following findings and conclusions reflect the independent judgement of the City Council. This ordinance is categorically exempt from the California Environmental Quality Act (CEQA) because it is an action taken by a regulatory agency for the purpose of protecting the environment, CEQA Guidelines Section 15308. The City Council finds that in accordance with section 15061(b)(3) of the California Code of Regulations, the adoption of these local amendments to the Ojai Municipal Code are exempt from the provisions of the California Environmental Quality Act because such actions are largely administrative in nature, are designed to improve and not degrade environmental quality, and the impacts of these local amendments to the building standards code

will not adversely affect the environment in any manner that could be significant. The following findings are made in support of these determinations:

1. The purpose of the implementation of a Reach Code is to reduce the amount of greenhouse gas emissions in the City that are produced from buildings.
2. The Reach Code approval process requires that the City determines that the local standards will require buildings to use no more energy than current statewide requirements. Furthermore, the California Energy Commission approval process requires that the City make the findings as part of its approval process. Therefore, the Reach Code standards can only go into effect if they protect the environment by making buildings more efficient.
3. The City recognizes that this ordinance shall not be enforced unless and until approved by the California Energy Commission.

SECTION 19. Severability. If any section, subsection, sentence, clause, phrase or portion of this Ordinance is for any reason held to be invalid or unconstitutional by the final decision of any court of competent jurisdiction, such decision shall not affect the validity of the remaining portions of this Ordinance. The City Council declares that it would have adopted this Ordinance, and each section, subsection, sentence, clause, phrase or portion thereof, irrespective of the fact that any one or more sections, subsections, clause, phrase or portions might be declared invalid or unconstitutional.

SECTION 20. Certification. The City Clerk shall cause this Ordinance to be published once, within fifteen (15) calendar days after passage, in the *Ojai Valley News*, a newspaper of general circulation, printed, published, and circulated in the City, and shall cause a copy of this Ordinance and its certification, together with proof of publication, to be entered in the Book of Ordinances of the City.

SECTION 21. Effective Date. This Ordinance shall take effect 30 days after adoption pursuant to California Government Code Section 36937, shall supersede any conflicting provision of any City of Ojai ordinance, and shall continue to be in effect until terminated by further action of the City Council in accord with the applicable law.

PASSED, APPROVED AND ADOPTED this 9th day of Dec, 2025.

CITY OF OJAI, CALIFORNIA

By 
Andy Gilman, Mayor

ATTEST:


Weston Montgomery, Chief Deputy City Clerk

APPROVED AS TO FORM:


Bethany A. Burgess, City Attorney

STATE OF CALIFORNIA)
COUNTY OF VENTURA)
CITY OF OJAI)

I, Weston Montgomery, Chief Deputy City Clerk of the City of Ojai do hereby certify that the foregoing Ordinance was introduced at a regular meeting of the City Council of the City of Ojai held on 10/28/25 and adopted at a regular meeting held on 12/9/25 by the following vote:

AYES: **Rule, Mang, Lang, Gilman, Whitman**

NOES:

ABSTAIN:

ABSENT:


Weston Montgomery
Chief Deputy City Clerk for the City of Ojai





Cost-Effectiveness Evidence

City of Ojai

Ojai Flexpath policy

Generated December 17, 2025 by the Cost-Effectiveness Explorer

<https://explorer.localenergycodes.com/policies/5310>

Cost-Effectiveness Evidence

Single Family Built before 1978 in Climate Zone 9

Study Source: Existing Single Family Building Upgrades (2025)¹ | Release Date: August 15, 2025 | Newest Version | Code Cycle: 2022/2025

Maximum Cost-Effective Target Score Calculation

Cost-Effective Measures and Packages	Energy Savings site MMBtu/year	Flexible Score annual energy savings
Solar PV	17.25	17
New Ducts, R-8 Insulation + Duct Sealing	6.71	7
R-49 Attic Insulation	5.10	5
Windows (0.27 U-factor, 0.23 SHGC)	4.56	5
R-15 Wall Insulation	3.24	3
Water Heating Package	1.67	2
Exterior Lighting Controls/Photosensor+LED	0.05	--
Maximum using available flexible measures (On-Bill (2025))	38.58	39

The maximum cost-effective score is the highest flexible score that can be met cost-effectively, based on the energy savings of measures for your policy. Any required flexible score that falls below or is equal to this maximum score has a cost-effective pathway available to permit applicants.

Single Family Built from 1978 to 1991 in Climate Zone 9

Study Source: Existing Single Family Building Upgrades (2025)¹ | Release Date: August 15, 2025 | Newest Version | Code Cycle: 2022/2025

Maximum Cost-Effective Target Score Calculation

Cost-Effective Measures and Packages	Energy Savings site MMBtu/year	Flexible Score annual energy savings
Solar PV	17.25	17
New Ducts, R-8 Insulation + Duct Sealing	4.71	5
R-49 Attic Insulation	2.32	2
Water Heating Package	1.67	2
Exterior Lighting Controls/Photosensor+LED	0.05	--
Maximum using available flexible measures (On-Bill (2025))	26.00	26

The maximum cost-effective score is the highest flexible score that can be met cost-effectively, based on the energy savings of measures for your policy. Any required flexible score that falls below or is equal to this maximum score has a cost-effective pathway available to permit applicants.

Single Family Built from 1992 to 2005 in Climate Zone 9

Study Source: Existing Single Family Building Upgrades (2025)¹ | Release Date: August 15, 2025 | Newest Version | Code Cycle: 2022/2025

Maximum Cost-Effective Target Score Calculation

Cost-Effective Measures and Packages	Energy Savings site MMBtu/year	Flexible Score annual energy savings
Water Heating Package	1.67	2
Exterior Lighting Controls/Photosensor+LED	0.05	--
Maximum using available flexible measures (On-Bill (2025))	1.72	2

The maximum cost-effective score is the highest flexible score that can be met cost-effectively, based on the energy savings of measures for your policy. Any required flexible score that falls below or is equal to this maximum score has a cost-effective pathway available to permit applicants.

Sources

¹ Existing Single Family Building Upgrades

Generated December 17, 2025 by the Cost-Effectiveness Explorer

<https://explorer.localenergycodes.com/policies/5310>



Cost-Effectiveness Evidence

City of Ojai

Ojai

Generated September 02, 2025 by the Cost-Effectiveness Explorer

<https://explorer.localenergycodes.com/policies/4975/documents>



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Single Family Built before 1978 in Climate Zone 9

Study Source: Existing Single Family Building Upgrades (2025)¹ | Release Date: August 15, 2025 | Newest Version | Code Cycle: 2022

Maximum Cost-Effective Target Score Calculation

Cost-Effective Measures and Packages	Energy Savings site MMBtu/year	Flexible Score
Solar PV	17.25	17
New Ducts, R-8 Insulation + Duct Sealing	6.71	7
R-49 Attic Insulation	5.10	5
Windows (0.27 U-factor, 0.23 SHGC)	4.56	5
R-15 Wall Insulation	3.24	3
Water Heating Package	1.67	2
Exterior Lighting Controls/Photosensor+LED	0.05	--
Maximum using available flexible measures (On-Bill (2022))	38.58	39

The maximum cost-effective score is the highest flexible score that can be met cost-effectively, based on the energy savings of measures for your policy. Any required flexible score that falls below or is equal to this maximum score has a cost-effective pathway available to permit applicants.

Single Family Built from 1978 to 1991 in Climate Zone 9

Study Source: Existing Single Family Building Upgrades (2025)¹ | Release Date: August 15, 2025 | Newest Version | Code Cycle: 2022

Maximum Cost-Effective Target Score Calculation

Cost-Effective Measures and Packages	Energy Savings site MMBtu/year	Flexible Score
Solar PV	17.25	17
New Ducts, R-8 Insulation + Duct Sealing	4.71	5
R-49 Attic Insulation	2.32	2
Water Heating Package	1.67	2
Exterior Lighting Controls/Photosensor+LED	0.05	--
Maximum using available flexible measures (On-Bill (2022))	26.00	26

The maximum cost-effective score is the highest flexible score that can be met cost-effectively, based on the energy savings of measures for your policy. Any required flexible score that falls below or is equal to this maximum score has a cost-effective pathway available to permit applicants.

Sources

- 1 Existing Single Family Building Upgrades (August 15, 2025)



Generated September 02, 2025 by the Cost-Effectiveness Explorer

<https://explorer.localenergycodes.com/policies/4975/documents>



Application of the 2022 Studies to the 2025 Energy Code: Existing Single Family Building Upgrades

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Misti Bruceri & Associates, LLC

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

Revision: 1.0
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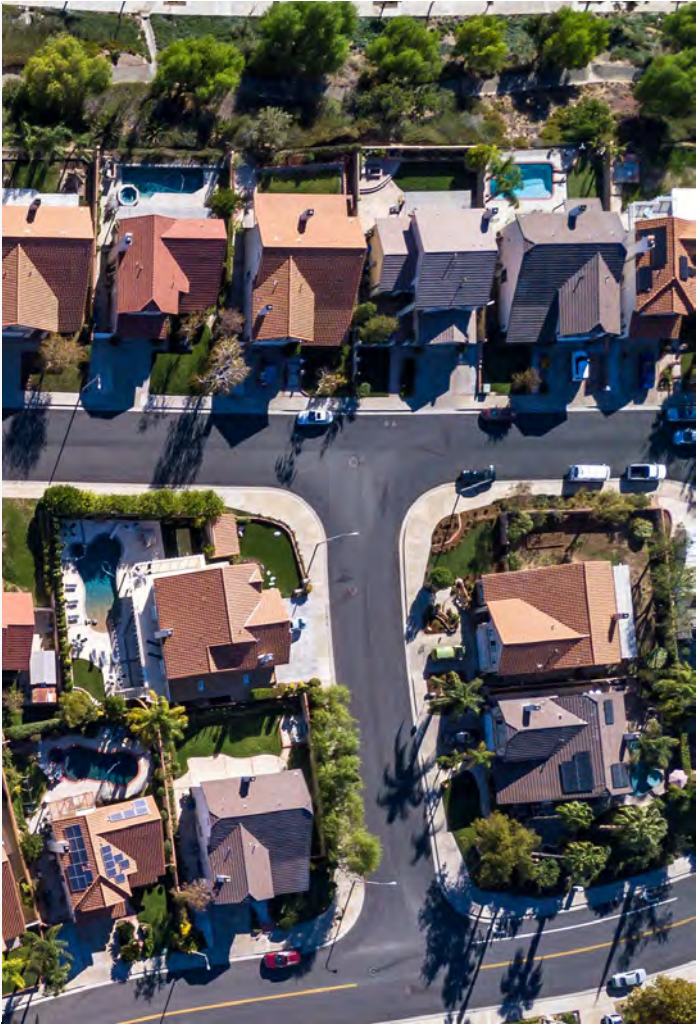


Table 1 Summary of Revisions

Date	Description	Reference (page or section)
8/15/2025	Original Release	N/A

Acronym List

B/C – Lifecycle Benefit-to-Cost Ratio

CASE – Codes and Standards Enhancement

CFL – Compact Fluorescent Lamps

CPAU – City of Palo Alto Utilities

CPUC – California Public Utilities Commission

CZ – California Climate Zone

kWh – Kilowatt Hour

NPV – Net Present Value

PG&E – Pacific Gas and Electric Company

PV – Photovoltaic

SCE – Southern California Edison

SDG&E – San Diego Gas and Electric

SMUD – Sacramento Municipal Utility District

SoCalGas – Southern California Gas Company

Therm – Unit for quantity of heat that equals 100,000 British thermal units

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1 Summary

The California Codes and Standards (C&S) 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 efficiency 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.

In April 2024, the Statewide Reach Codes Team published the [2022 Cost-Effectiveness Study: Existing Single Family Building Upgrades](#). This study focuses on existing single family buildings identifying cost-effective measures and measure package upgrades in all 16 California climate zones. The study was conducted to complement Part 6 of the California Building Code (the Energy Code) for the 2022 code cycle, effective January 1, 2023. In the 2019 code cycle the [2019 Cost-Effectiveness Study: Existing Single Family Residential Building Upgrades](#) study included outdoor lighting and a water heater package that was discontinued in the 2022 study but has been brought back in this memo by request from jurisdictions. The studies document the estimated costs, benefits, energy impacts and greenhouse gas emission reductions that may result from implementing an ordinance to help local leadership, residents, and other stakeholders make informed policy decisions.

The Statewide Reach Codes Team reviewed the cost-effectiveness study for impacts of code changes implemented in the 2025 Energy Code. Measures that are now required by code may alter the results presented in the 2022 study. Below is a summary of the changes to the additions and alterations for residential buildings sections of the 2025 Energy Code.

- Mandatory wall insulation R-value has been increased from R-13 to R-15. [Section 150.2(a) of the Energy Code]
- Prescriptive window U-factor has decreased from 0.30 to 0.27 in Climate Zones 1-5, 11-14, and 16. [Section 150.2(b)1B of the Energy Code]

The wall insulation measure has been re-evaluated with R-15 instead of R-13. There is generally a slight increase in utility cost savings as expected with the increase in efficiency. However, there is not a substantial impact on the cost-effectiveness results.

For the prescriptive window U-factor, the original study modeled U-0.28 in all climate zones. This updated memo drops the U-factor from 0.28 to 0.27 in all climate zones. The SHGC is maintained at 0.23 for climate zone 2, 4, and 6-15 and 0.35 for CZ 1, 3, 5, 16. There is minimal impact on the cost-effectiveness results due to this update. However, there are two instances in the 1978-1991 vintage where cost-effectiveness flips from cost-effective to not cost-effective. Climate zone 4 in PGE territory utilizing standard rates and the modest gas escalation is no longer cost-effective on-bill by the smallest margin. Climate zone 10 in SDGE territory utilizing CARE rates and the modest gas escalation has also become no longer cost-effective on-bill.

The 2022 study included a whole building air sealing measure defined as a 30% reduction in air leakage. A new measure – air sealing of the ceiling floor, representing a 14% reduction in air leakage – is added in this memo. Further details and cost-effectiveness results are provided in Section 2.

Lighting measures were previously presented in the [2019 Cost-Effectiveness Study: Existing Single Family Residential Building Upgrades](#) study but were not analyzed in the 2022 study. Updated cost-effectiveness analysis for this measure is presented in Section 3.

The water heating package measure was previously presented in [2019 Cost-Effectiveness Study: Existing Single Family Residential Building Upgrades](#) study. Updated cost-effectiveness analysis for this measure is presented in Section 4.

The 3 kW PV measure from the 2022 study is revised here with an updated cost-effectiveness analysis that accounts for the elimination of the Federal Solar tax credit December 31, 2025. Additional details and analysis are provided in Section 5.

The 2022 report, model ordinance language and other resources are posted on the C&S Reach Codes Program website at LocalEnergyCodes.com. Local jurisdictions that are considering adopting an ordinance may contact the program for further technical support at info@localenergycodes.com.

2 Air Sealing at the Ceiling

Unlike full air sealing, which has previously been presented, air sealing of the ceiling floor may be an attractive measure for an attic remodel project. The whole building air sealing measure estimated a 30% reduction in air leakage, while air sealing at the ceiling measure results in a 14% reduction in air leakage.

Table 2 through Table 7 present the cost-effectiveness results for the air sealing at the ceiling plane measure. The estimated incremental cost for air sealing at the ceiling plane is \$1,963 which is from the 2022 Residential Additions and Alterations CASE Report (Statewide CASE Team, 2020).

Table 2. [Pre-1978] Air Sealing at the Ceiling (Std)

Climate Zone	Electric/ Gas Utility	First Incremental Cost	First-year Utility Savings	Lifecycle NPV Savings		
				2025 LSC NPV	On-Bill NPV Modest Gas Escalation	On-Bill NPV High Gas Escalation
CZ01	PGE	\$1,963	\$33	(\$465)	(\$997)	(\$432)
CZ02	PGE	\$1,963	\$18	(\$1,114)	(\$1,433)	(\$1,118)
CZ03	PGE	\$1,963	\$17	(\$1,180)	(\$1,463)	(\$1,171)
CZ04	PGE	\$1,963	\$25	(\$1,081)	(\$1,290)	(\$979)
CZ04	CPAU	\$1,963	\$21	(\$1,081)	(\$1,379)	(\$1,069)
CZ05	PGE	\$1,963	\$16	(\$1,230)	(\$1,500)	(\$1,235)
CZ05	PGE/SCG	\$1,963	\$14	(\$1,230)	(\$1,555)	(\$1,325)
CZ06	SCE/SCG	\$1,963	(\$2)	(\$1,797)	(\$1,987)	(\$1,937)
CZ07	SDGE	\$1,963	(\$3)	(\$1,813)	(\$2,008)	(\$1,934)
CZ08	SCE/SCG	\$1,963	\$7	(\$1,680)	(\$1,775)	(\$1,703)
CZ09	SCE/SCG	\$1,963	\$10	(\$1,597)	(\$1,693)	(\$1,592)
CZ10	SCE/SCG	\$1,963	\$17	(\$1,497)	(\$1,540)	(\$1,420)
CZ10	SDGE	\$1,963	\$23	(\$1,497)	(\$1,366)	(\$1,237)
CZ11	PGE	\$1,963	\$32	(\$1,014)	(\$1,120)	(\$816)
CZ12	PGE	\$1,963	\$22	(\$1,147)	(\$1,348)	(\$1,064)
CZ12	SMUD/PGE	\$1,963	\$17	(\$1,147)	(\$1,468)	(\$1,190)
CZ13	PGE	\$1,963	\$31	(\$1,114)	(\$1,162)	(\$918)
CZ14	SCE/SCG	\$1,963	\$32	(\$897)	(\$1,130)	(\$832)
CZ14	SDGE	\$1,963	\$42	(\$897)	(\$845)	(\$519)
CZ15	SCE/SCG	\$1,963	\$40	(\$1,297)	(\$1,041)	(\$946)
CZ16	PGE	\$1,963	\$30	(\$581)	(\$1,071)	(\$551)

Table 3. [1978-1991] Air Sealing at the Ceiling (Std)

Climate Zone	Electric/ Gas Utility	First Incremental Cost	First-year Utility Savings	Lifecycle NPV Savings		
				2025 LSC NPV	On-Bill NPV Modest Gas Escalation	On-Bill NPV High Gas Escalation
CZ01	PGE	\$1,963	\$23	(\$931)	(\$1,292)	(\$903)
CZ02	PGE	\$1,963	\$13	(\$1,364)	(\$1,570)	(\$1,341)
CZ03	PGE	\$1,963	\$10	(\$1,480)	(\$1,668)	(\$1,496)
CZ04	PGE	\$1,963	\$16	(\$1,330)	(\$1,522)	(\$1,292)
CZ04	CPAU	\$1,963	\$13	(\$1,330)	(\$1,575)	(\$1,356)
CZ05	PGE	\$1,963	\$11	(\$1,447)	(\$1,649)	(\$1,466)
CZ05	PGE/SCG	\$1,963	\$10	(\$1,447)	(\$1,684)	(\$1,522)
CZ06	SCE/SCG	\$1,963	(\$1)	(\$1,830)	(\$1,967)	(\$1,934)
CZ07	SDGE	\$1,963	(\$4)	(\$1,896)	(\$2,040)	(\$1,991)
CZ08	SCE/SCG	\$1,963	\$4	(\$1,797)	(\$1,860)	(\$1,813)
CZ09	SCE/SCG	\$1,963	\$5	(\$1,747)	(\$1,823)	(\$1,764)
CZ10	SCE/SCG	\$1,963	\$10	(\$1,663)	(\$1,722)	(\$1,652)
CZ10	SDGE	\$1,963	\$14	(\$1,663)	(\$1,603)	(\$1,517)
CZ11	PGE	\$1,963	\$25	(\$1,264)	(\$1,320)	(\$1,096)
CZ12	PGE	\$1,963	\$16	(\$1,380)	(\$1,520)	(\$1,314)
CZ12	SMUD/PGE	\$1,963	\$12	(\$1,380)	(\$1,604)	(\$1,402)
CZ13	PGE	\$1,963	\$23	(\$1,364)	(\$1,373)	(\$1,199)
CZ14	SCE/SCG	\$1,963	\$22	(\$1,230)	(\$1,397)	(\$1,182)
CZ14	SDGE	\$1,963	\$28	(\$1,230)	(\$1,212)	(\$974)
CZ15	SCE/SCG	\$1,963	\$32	(\$1,463)	(\$1,225)	(\$1,154)
CZ16	PGE	\$1,963	\$21	(\$1,014)	(\$1,357)	(\$1,001)

Table 4. [1992-2010] Air Sealing at the Ceiling (Std)

Climate Zone	Electric/ Gas Utility	First Incremental Cost	First-year Utility Savings	Lifecycle NPV Savings		
				2025 LSC NPV	On-Bill NPV Modest Gas Escalation	On-Bill NPV High Gas Escalation
CZ01	PGE	\$1,963	\$14	(\$1,314)	(\$1,550)	(\$1,309)
CZ02	PGE	\$1,963	\$9	(\$1,530)	(\$1,687)	(\$1,529)
CZ03	PGE	\$1,963	\$7	(\$1,613)	(\$1,744)	(\$1,618)
CZ04	PGE	\$1,963	\$11	(\$1,530)	(\$1,653)	(\$1,501)
CZ04	CPAU	\$1,963	\$9	(\$1,530)	(\$1,701)	(\$1,557)
CZ05	PGE	\$1,963	\$7	(\$1,613)	(\$1,759)	(\$1,637)
CZ05	PGE/SCG	\$1,963	\$6	(\$1,613)	(\$1,788)	(\$1,686)
CZ06	SCE/SCG	\$1,963	\$1	(\$1,863)	(\$1,936)	(\$1,911)
CZ07	SDGE	\$1,963	\$0	(\$1,896)	(\$1,944)	(\$1,911)
CZ08	SCE/SCG	\$1,963	\$3	(\$1,830)	(\$1,885)	(\$1,851)
CZ09	SCE/SCG	\$1,963	\$3	(\$1,780)	(\$1,892)	(\$1,853)
CZ10	SCE/SCG	\$1,963	\$6	(\$1,763)	(\$1,814)	(\$1,767)
CZ10	SDGE	\$1,963	\$8	(\$1,763)	(\$1,741)	(\$1,681)
CZ11	PGE	\$1,963	\$14	(\$1,530)	(\$1,581)	(\$1,437)
CZ12	PGE	\$1,963	\$10	(\$1,580)	(\$1,693)	(\$1,560)
CZ12	SMUD/PGE	\$1,963	\$8	(\$1,580)	(\$1,737)	(\$1,606)
CZ13	PGE	\$1,963	\$12	(\$1,580)	(\$1,643)	(\$1,531)
CZ14	SCE/SCG	\$1,963	\$12	(\$1,530)	(\$1,639)	(\$1,503)
CZ14	SDGE	\$1,963	\$16	(\$1,530)	(\$1,537)	(\$1,382)
CZ15	SCE/SCG	\$1,963	\$17	(\$1,680)	(\$1,572)	(\$1,532)
CZ16	PGE	\$1,963	\$14	(\$1,314)	(\$1,556)	(\$1,314)

Table 5. [Pre-1978] Air Sealing at the Ceiling (CARE)

Climate Zone	Electric/ Gas Utility	First Incremental Cost	First-year Utility Savings	Lifecycle NPV Savings		
				2025 LSC NPV	On-Bill NPV Modest Gas Escalation	On-Bill NPV High Gas Escalation
CZ01	PGE	\$1,963	\$26	(\$465)	(\$1,212)	(\$766)
CZ02	PGE	\$1,963	\$14	(\$1,114)	(\$1,550)	(\$1,302)
CZ03	PGE	\$1,963	\$13	(\$1,180)	(\$1,574)	(\$1,343)
CZ04	PGE	\$1,963	\$18	(\$1,081)	(\$1,459)	(\$1,216)
CZ04	CPAU	\$1,963	\$0	(\$1,081)	(\$1,963)	(\$1,963)
CZ05	PGE	\$1,963	\$12	(\$1,230)	(\$1,604)	(\$1,395)
CZ05	PGE/SCG	\$1,963	\$11	(\$1,230)	(\$1,648)	(\$1,467)
CZ06	SCE/SCG	\$1,963	(\$1)	(\$1,797)	(\$1,969)	(\$1,928)
CZ07	SDGE	\$1,963	(\$1)	(\$1,813)	(\$1,976)	(\$1,918)
CZ08	SCE/SCG	\$1,963	\$5	(\$1,680)	(\$1,824)	(\$1,768)
CZ09	SCE/SCG	\$1,963	\$8	(\$1,597)	(\$1,764)	(\$1,686)
CZ10	SCE/SCG	\$1,963	\$12	(\$1,497)	(\$1,659)	(\$1,566)
CZ10	SDGE	\$1,963	\$16	(\$1,497)	(\$1,546)	(\$1,443)
CZ11	PGE	\$1,963	\$23	(\$1,014)	(\$1,353)	(\$1,116)
CZ12	PGE	\$1,963	\$17	(\$1,147)	(\$1,503)	(\$1,279)
CZ12	SMUD/PGE	\$1,963	\$11	(\$1,147)	(\$1,623)	(\$1,406)
CZ13	PGE	\$1,963	\$22	(\$1,114)	(\$1,394)	(\$1,205)
CZ14	SCE/SCG	\$1,963	\$23	(\$897)	(\$1,352)	(\$1,120)
CZ14	SDGE	\$1,963	\$30	(\$897)	(\$1,163)	(\$905)
CZ15	SCE/SCG	\$1,963	\$27	(\$1,297)	(\$1,334)	(\$1,266)
CZ16	PGE	\$1,963	\$24	(\$581)	(\$1,270)	(\$859)

Table 6. [1978-1991] Air Sealing at the Ceiling (CARE)

Climate Zone	Electric/ Gas Utility	First Incremental Cost	First-year Utility Savings	Lifecycle NPV Savings		
				2025 LSC NPV	On-Bill NPV Modest Gas Escalation	On-Bill NPV High Gas Escalation
CZ01	PGE	\$1,963	\$18	(\$931)	(\$1,442)	(\$1,135)
CZ02	PGE	\$1,963	\$10	(\$1,364)	(\$1,658)	(\$1,477)
CZ03	PGE	\$1,963	\$8	(\$1,480)	(\$1,734)	(\$1,598)
CZ04	PGE	\$1,963	\$12	(\$1,330)	(\$1,627)	(\$1,446)
CZ04	CPAU	\$1,963	\$0	(\$1,330)	(\$1,963)	(\$1,963)
CZ05	PGE	\$1,963	\$8	(\$1,447)	(\$1,719)	(\$1,575)
CZ05	PGE/SCG	\$1,963	\$7	(\$1,447)	(\$1,746)	(\$1,619)
CZ06	SCE/SCG	\$1,963	(\$0)	(\$1,830)	(\$1,959)	(\$1,933)
CZ07	SDGE	\$1,963	(\$2)	(\$1,896)	(\$2,003)	(\$1,964)
CZ08	SCE/SCG	\$1,963	\$3	(\$1,797)	(\$1,886)	(\$1,848)
CZ09	SCE/SCG	\$1,963	\$4	(\$1,747)	(\$1,859)	(\$1,813)
CZ10	SCE/SCG	\$1,963	\$7	(\$1,663)	(\$1,790)	(\$1,736)
CZ10	SDGE	\$1,963	\$10	(\$1,663)	(\$1,710)	(\$1,641)
CZ11	PGE	\$1,963	\$18	(\$1,264)	(\$1,500)	(\$1,325)
CZ12	PGE	\$1,963	\$12	(\$1,380)	(\$1,631)	(\$1,469)
CZ12	SMUD/PGE	\$1,963	\$8	(\$1,380)	(\$1,716)	(\$1,558)
CZ13	PGE	\$1,963	\$16	(\$1,364)	(\$1,545)	(\$1,411)
CZ14	SCE/SCG	\$1,963	\$16	(\$1,230)	(\$1,545)	(\$1,378)
CZ14	SDGE	\$1,963	\$20	(\$1,230)	(\$1,422)	(\$1,233)
CZ15	SCE/SCG	\$1,963	\$22	(\$1,463)	(\$1,460)	(\$1,410)
CZ16	PGE	\$1,963	\$16	(\$1,014)	(\$1,491)	(\$1,211)

Table 7. [1991-2010] Air Sealing at the Ceiling (CARE)

Climate Zone	Electric/ Gas Utility	First Incremental Cost	First-year Utility Savings	Lifecycle NPV Savings		
				2025 LSC NPV	On-Bill NPV Modest Gas Escalation	On-Bill NPV High Gas Escalation
CZ01	PGE	\$1,963	\$11	(\$1,314)	(\$1,642)	(\$1,452)
CZ02	PGE	\$1,963	\$7	(\$1,530)	(\$1,749)	(\$1,625)
CZ03	PGE	\$1,963	\$6	(\$1,613)	(\$1,793)	(\$1,693)
CZ04	PGE	\$1,963	\$8	(\$1,530)	(\$1,729)	(\$1,609)
CZ04	CPAU	\$1,963	\$0	(\$1,530)	(\$1,963)	(\$1,963)
CZ05	PGE	\$1,963	\$5	(\$1,613)	(\$1,804)	(\$1,708)
CZ05	PGE/SCG	\$1,963	\$5	(\$1,613)	(\$1,827)	(\$1,747)
CZ06	SCE/SCG	\$1,963	\$1	(\$1,863)	(\$1,940)	(\$1,920)
CZ07	SDGE	\$1,963	\$0	(\$1,896)	(\$1,944)	(\$1,918)
CZ08	SCE/SCG	\$1,963	\$2	(\$1,830)	(\$1,905)	(\$1,879)
CZ09	SCE/SCG	\$1,963	\$2	(\$1,780)	(\$1,908)	(\$1,878)
CZ10	SCE/SCG	\$1,963	\$4	(\$1,763)	(\$1,855)	(\$1,819)
CZ10	SDGE	\$1,963	\$6	(\$1,763)	(\$1,805)	(\$1,758)
CZ11	PGE	\$1,963	\$10	(\$1,530)	(\$1,685)	(\$1,572)
CZ12	PGE	\$1,963	\$7	(\$1,580)	(\$1,759)	(\$1,654)
CZ12	SMUD/PGE	\$1,963	\$5	(\$1,580)	(\$1,802)	(\$1,700)
CZ13	PGE	\$1,963	\$9	(\$1,580)	(\$1,732)	(\$1,644)
CZ14	SCE/SCG	\$1,963	\$9	(\$1,530)	(\$1,722)	(\$1,615)
CZ14	SDGE	\$1,963	\$11	(\$1,530)	(\$1,652)	(\$1,529)
CZ15	SCE/SCG	\$1,963	\$12	(\$1,680)	(\$1,696)	(\$1,667)
CZ16	PGE	\$1,963	\$11	(\$1,314)	(\$1,645)	(\$1,454)

3 Lighting Measures

LED lighting and exterior lighting control measures were previously evaluated in the [2019 Cost-Effectiveness Study: Existing Single Family Residential Building Upgrades](#) study.

These measures are not included in the [2022 Cost-Effectiveness Study: Existing Single Family Building Upgrades](#) study, but have been re-evaluated and included in this memo.

The updated analysis follows the same methodology as the 2019 study, but with updated costs for equipment and updated utility rates.

The three measures evaluated are LED lighting, exterior photosensor, and LED lighting plus photosensor. Table 8 through Table 10 show the results for the different lighting measures evaluated. Each measure is explained in more detail below.

LED Lighting: Replace screw-in (A-based for lamps) incandescent lamps and compact fluorescent lamps (CFLs) with light-emitting diode (LED) A-lamps. This analysis was conducted external to the energy model and evaluated replacement of a 13 W CFL lamp with an 9.6 W LED lamp operating 620 hours annually. Annual hour estimates were based on whole building average hours of operation from a 2010 lighting study by KEMA (KEMA, 2010). Lifetime assumptions were 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/Photosensor: 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 (CEE, 2014). Energy savings will be higher for incandescent or CFL luminaires.

Exterior Lighting Controls/Photosensor+LED: An additional evaluation was completed for exterior lighting controls on a per-luminaire basis external to the energy model and assumes a screw-in photosensor control is installed in outdoor lighting luminaires and incandescent lamps CFLs are replaced with light-emitting diode (LED) A-lamps. Energy savings of 14.3 kWh per year was applied based on the sum of the LED lighting and Exterior Lighting Controls with Photosensor kWh energy savings.

For the measures including a LED, a cost of \$3.49 for LED dimmable A19 lamp 60 W equivalent is used. A cost of \$1.74 is used for an equivalent CFL product which was used to estimate total replacement costs at years 10 and 25. Costs are based on a single LED lamp replacement. For the photosensor, an incremental cost of \$12.62, 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.

Table 8. [All Vintages] LED Lamp vs. CFL

Climate Zone	Electric/ Gas Utility	Measure Cost	Electricity Savings	First Year Utility Cost Savings	Customer On-Bill Modest Gas Escalation		Customer On-Bill High Gas Escalation	
					B/C Ratio	NPV	B/C Ratio	NPV
CZ01	PGE	\$1.75	2.2	\$0.77	10.05	\$15.82	10.58	\$16.74
CZ02	PGE	\$1.75	2.2	\$0.86	11.26	\$17.94	11.85	\$18.98
CZ03	PGE	\$1.75	2.2	\$0.78	10.14	\$15.99	10.68	\$16.92
CZ04	PGE	\$1.75	2.2	\$0.80	10.39	\$16.42	10.94	\$17.38
CZ04	CPAU	\$1.75	2.2	\$0.41	5.32	\$7.56	5.60	\$8.05
CZ05	PGE	\$1.75	2.2	\$0.78	10.14	\$15.99	10.67	\$16.92
CZ05	PGE/SCG	\$1.75	2.2	\$0.78	10.14	\$15.99	10.67	\$16.92
CZ06	SCE/SCG	\$1.75	2.2	\$0.66	8.44	\$13.01	8.99	\$13.97
CZ07	SDGE	\$1.75	2.2	\$0.95	13.15	\$21.24	13.03	\$21.04
CZ08	SCE/SCG	\$1.75	2.2	\$0.74	9.51	\$14.89	10.14	\$15.98
CZ09	SCE/SCG	\$1.75	2.2	\$0.71	9.17	\$14.29	9.77	\$15.33
CZ10	SCE/SCG	\$1.75	2.2	\$0.73	9.38	\$14.65	9.99	\$15.72
CZ10	SDGE	\$1.75	2.2	\$1.07	14.86	\$24.24	14.74	\$24.02
CZ11	PGE	\$1.75	2.2	\$0.85	11.05	\$17.57	11.63	\$18.59
CZ12	PGE	\$1.75	2.2	\$0.79	10.32	\$16.29	10.86	\$17.24
CZ12	SMUD/PGE	\$1.75	2.2	\$0.47	6.08	\$8.88	6.40	\$9.44
CZ13	PGE	\$1.75	2.2	\$0.86	11.27	\$17.96	11.86	\$19.00
CZ14	SCE/SCG	\$1.75	2.2	\$0.74	9.58	\$15.00	10.21	\$16.10
CZ14	SDGE	\$1.75	2.2	\$1.06	14.68	\$23.93	14.56	\$23.71
CZ15	SCE/SCG	\$1.75	2.2	\$0.78	10.01	\$15.75	10.66	\$16.90
CZ16	PGE	\$1.75	2.2	\$0.77	9.98	\$15.71	10.51	\$16.62

Table 9. [All Vintages] Exterior Photosensor

Climate Zone	Electric/ Gas Utility	Measure Cost	Electricity Savings	First Year Utility Cost Savings	Customer On-Bill Modest Gas Escalation		Customer On-Bill High Gas Escalation	
					B/C Ratio	NPV	B/C Ratio	NPV
CZ01	PGE	\$54.03	12.1	\$4.16	1.75	\$40.75	1.85	\$45.74
CZ02	PGE	\$54.03	12.1	\$4.16	1.75	\$40.75	1.85	\$45.74
CZ03	PGE	\$54.03	12.1	\$4.16	1.75	\$40.75	1.85	\$45.74
CZ04	PGE	\$54.03	12.1	\$4.16	1.75	\$40.75	1.85	\$45.74
CZ04	CPAU	\$54.03	12.1	\$2.12	0.89	(\$5.69)	0.94	(\$3.15)
CZ05	PGE	\$54.03	12.1	\$4.16	1.75	\$40.75	1.85	\$45.74
CZ05	PGE/SCG	\$54.03	12.1	\$4.16	1.75	\$40.75	1.85	\$45.74
CZ06	SCE/SCG	\$54.03	12.1	\$3.48	1.45	\$24.36	1.55	\$29.48
CZ07	SDGE	\$54.03	12.1	\$5.07	2.27	\$68.58	2.25	\$67.53
CZ08	SCE/SCG	\$54.03	12.1	\$3.48	1.45	\$24.36	1.55	\$29.48
CZ09	SCE/SCG	\$54.03	12.1	\$3.48	1.45	\$24.36	1.55	\$29.48
CZ10	SCE/SCG	\$54.03	12.1	\$3.48	1.45	\$24.36	1.55	\$29.48
CZ10	SDGE	\$54.03	12.1	\$5.07	2.27	\$68.58	2.25	\$67.53
CZ11	PGE	\$54.03	12.1	\$4.16	1.75	\$40.75	1.85	\$45.74
CZ12	PGE	\$54.03	12.1	\$4.16	1.75	\$40.75	1.85	\$45.74
CZ12	SMUD/PGE	\$54.03	12.1	\$1.46	0.62	(\$20.73)	0.65	(\$18.98)
CZ13	PGE	\$54.03	12.1	\$4.16	1.75	\$40.75	1.85	\$45.74
CZ14	SCE/SCG	\$54.03	12.1	\$3.48	1.45	\$24.36	1.55	\$29.48
CZ14	SDGE	\$54.03	12.1	\$5.07	2.27	\$68.58	2.25	\$67.53
CZ15	SCE/SCG	\$54.03	12.1	\$3.48	1.45	\$24.36	1.55	\$29.48
CZ16	PGE	\$54.03	12.1	\$4.16	1.75	\$40.75	1.85	\$45.74

Table 10. [All Vintages] LED and Photosensor

Climate Zone	Electric/ Gas Utility	Measure Cost	Electricity Savings	First Year Utility Cost Savings	Customer On-Bill Modest Gas Escalation		Customer On-Bill High Gas Escalation	
					B/C Ratio	NPV	B/C Ratio	NPV
CZ01	PGE	\$55.77	14.3	\$4.93	2.01	\$56.57	2.12	\$62.48
CZ02	PGE	\$55.77	14.3	\$5.02	2.05	\$58.70	2.16	\$64.72
CZ03	PGE	\$55.77	14.3	\$4.94	2.02	\$56.74	2.12	\$62.66
CZ04	PGE	\$55.77	14.3	\$4.95	2.03	\$57.17	2.13	\$63.12
CZ04	CPAU	\$55.77	14.3	\$2.53	1.03	\$1.87	1.09	\$4.90
CZ05	PGE	\$55.77	14.3	\$4.94	2.02	\$56.74	2.12	\$62.66
CZ05	PGE/SCG	\$55.77	14.3	\$4.94	2.02	\$56.74	2.12	\$62.66
CZ06	SCE/SCG	\$55.77	14.3	\$4.13	1.67	\$37.37	1.78	\$43.45
CZ07	SDGE	\$55.77	14.3	\$6.02	2.61	\$89.82	2.59	\$88.57
CZ08	SCE/SCG	\$55.77	14.3	\$4.22	1.70	\$39.25	1.82	\$45.46
CZ09	SCE/SCG	\$55.77	14.3	\$4.19	1.69	\$38.65	1.80	\$44.82
CZ10	SCE/SCG	\$55.77	14.3	\$4.21	1.70	\$39.01	1.81	\$45.20
CZ10	SDGE	\$55.77	14.3	\$6.14	2.66	\$92.82	2.64	\$91.55
CZ11	PGE	\$55.77	14.3	\$5.00	2.05	\$58.33	2.15	\$64.33
CZ12	PGE	\$55.77	14.3	\$4.95	2.02	\$57.05	2.13	\$62.98
CZ12	SMUD/PGE	\$55.77	14.3	\$1.93	0.79	(\$11.85)	0.83	(\$9.54)
CZ13	PGE	\$55.77	14.3	\$5.02	2.05	\$58.71	2.16	\$64.73
CZ14	SCE/SCG	\$55.77	14.3	\$4.22	1.71	\$39.37	1.82	\$45.58
CZ14	SDGE	\$55.77	14.3	\$6.13	2.66	\$92.51	2.64	\$91.24
CZ15	SCE/SCG	\$55.77	14.3	\$4.26	1.72	\$40.12	1.83	\$46.38
CZ16	PGE	\$55.77	14.3	\$4.92	2.01	\$56.46	2.12	\$62.36

4 Water Heating Package

This package includes the following:

- R-6 water heater blanket
- R-3 hot water pipe insulation
- Low flow fixtures: two low flow showerheads and three sink aerators.

This analysis assumes the homeowner installs these measures themselves and therefore no labor costs. Costs are based on Home Depot prices from August of 2025. The water heater package is evaluated over a 15-year analysis period and assumes the modest gas escalation rate.

Table 11. [All Vintages] Water Heating Package

Climate Zone	Electric/ Gas Utility	Measure Cost	Gas Savings (therms)	First Year Utility Cost Savings	Customer On-Bill	
					B/C Ratio	NPV
CZ01	PGE	\$125.68	14.69	\$31.11	3.96	\$371.76
CZ02	PGE	\$125.68	15.60	\$35.20	4.48	\$437.15
CZ03	PGE	\$125.68	15.70	\$31.43	4.00	\$376.88
CZ04	PGE	\$125.68	16.05	\$32.62	4.15	\$395.78
CZ04	CPAU	\$125.68	16.05	\$31.99	4.07	\$385.77
CZ05	PGE	\$125.68	15.83	\$31.37	3.99	\$375.88
CZ05	PGE/SCG	\$125.68	15.83	\$28.29	3.60	\$326.59
CZ06	SCE/SCG	\$125.68	16.67	\$29.18	3.71	\$340.84
CZ07	SDGE	\$125.68	16.75	\$37.25	4.74	\$469.81
CZ08	SCE/SCG	\$125.68	16.78	\$29.36	3.74	\$343.80
CZ09	SCE/SCG	\$125.68	16.66	\$29.27	3.72	\$342.34
CZ10	SCE/SCG	\$125.68	16.58	\$28.99	3.69	\$337.73
CZ10	SDGE	\$125.68	16.58	\$37.77	4.80	\$478.19
CZ11	PGE	\$125.68	15.87	\$32.96	4.19	\$401.32
CZ12	PGE	\$125.68	15.90	\$32.85	4.18	\$399.47
CZ12	SMUD/PGE	\$125.68	15.90	\$32.85	4.18	\$399.47
CZ13	PGE	\$125.68	16.32	\$33.00	4.20	\$401.93
CZ14	SCE/SCG	\$125.68	16.11	\$29.79	3.79	\$350.57
CZ14	SDGE	\$125.68	16.11	\$39.23	4.99	\$501.49
CZ15	SCE/SCG	\$125.68	17.40	\$30.16	3.84	\$356.50
CZ16	PGE	\$125.68	15.14	\$31.75	4.04	\$381.87

5 PV

The results for 3 kW PV have been updated from the 2022 study to remove the federal solar tax credit from the cost-effectiveness calculations. The removal of the solar tax credit has a substantial impact on many climate zones across all vintages and will impact the FlexPath.

The following describes the impacts and changes to cost-effectiveness from the 2022 study. These observations are utilizing standard rates. Previously, with the solar tax credit, the 3 kW PV measure in the pre-1978 vintage was on-bill cost effective in all climate zones using both the modest and high gas escalation rates. However, with the credit removed, Climate Zones 1-3, 5, 6, and 12 are no longer cost effective on-bill for both the modest and high gas escalations.

Previously for the 1978-1991 vintage the only cases that were not on-bill cost effective were climate zones 2 and 6 utilizing the modest gas escalation. Now, with the credit removed, many more climate zones are no longer cost effective. Using the modest gas escalation, climate zones 1-3, 5, 6, 12, and 16 are not cost effective on-bill. Using the high gas escalation, climate zones 1-3, 5, 6, and 12 (SMUD) are not cost effective on-bill.

Previously for the 1992-2010 vintage the following cases were not cost effective on-bill: climate zones 1-3, 5, and 6 utilizing the modest gas escalation and climate zone 6 using the high gas escalation. With the credit removed an increased number of climate zones are no longer cost effective. Using the modest gas escalation, climate zones 1-3, 4 (PGE) 5-9, 10 (SCE/SCG), 12, and 16 are not cost effective on-bill. Using the high gas escalation, climate zones 1-3, 4 (PGE), 5-7, 9, 12, and 16 are not cost effective on-bill.

The cost-effectiveness results are presented in Table 12 through Table 1717.

Table 12. [Pre-1978] 3 kW PV without Solar Tax Credit (Std)

Climate Zone	Electric/ Gas Utility	First Incremental Cost	On-Bill Savings			
			On-Bill B/C Modest Gas Escalation	On-Bill NPV Modest Gas Escalation	On-Bill B/C High Gas Escalation	On-Bill NPV High Gas Escalation
CZ01	PGE	\$13,726	0.80	(\$3,074)	0.85	(\$2,410)
CZ02	PGE	\$13,726	0.80	(\$3,072)	0.85	(\$2,409)
CZ03	PGE	\$13,726	0.77	(\$3,567)	0.81	(\$2,930)
CZ04	PGE	\$13,726	1.11	\$1,652	1.16	\$2,564
CZ04	CPAU	\$13,726	1.38	\$5,983	1.45	\$7,123
CZ05	PGE	\$13,726	0.78	(\$3,431)	0.82	(\$2,786)
CZ05	PGE/SCG	\$13,726	0.78	(\$3,431)	0.82	(\$2,786)
CZ06	SCE/SCG	\$13,726	0.87	(\$2,118)	0.92	(\$1,231)
CZ07	SDGE	\$13,726	1.31	\$4,886	1.30	\$4,711
CZ08	SCE/SCG	\$13,726	1.30	\$4,655	1.38	\$5,984
CZ09	SCE/SCG	\$13,726	1.18	\$2,821	1.26	\$4,030
CZ10	SCE/SCG	\$13,726	1.29	\$4,622	1.38	\$5,948
CZ10	SDGE	\$13,726	1.99	\$15,550	1.97	\$15,284
CZ11	PGE	\$13,726	1.55	\$8,684	1.64	\$9,967
CZ12	PGE	\$13,726	1.07	\$1,117	1.13	\$2,002
CZ12	SMUD/PGE	\$13,726	0.93	(\$1,109)	0.98	(\$342)
CZ13	PGE	\$13,726	1.80	\$12,597	1.90	\$14,085
CZ14	SCE/SCG	\$13,726	1.58	\$9,098	1.68	\$10,717
CZ14	SDGE	\$13,726	2.15	\$17,983	2.13	\$17,695
CZ15	SCE/SCG	\$13,726	2.24	\$19,477	2.39	\$21,774
CZ16	PGE	\$13,726	1.04	\$579	1.09	\$1,435

Table 13. [1978-1991] 3 kW PV without Solar Tax Credit (Std)

Climate Zone	Electric/ Gas Utility	First Incremental Cost	On-Bill Savings			
			On-Bill B/C Modest Gas Escalation	On-Bill NPV Modest Gas Escalation	On-Bill B/C High Gas Escalation	On-Bill NPV High Gas Escalation
CZ01	PGE	\$13,726	0.77	(\$3,570)	0.81	(\$2,932)
CZ02	PGE	\$13,726	0.71	(\$4,549)	0.75	(\$3,963)
CZ03	PGE	\$13,726	0.74	(\$4,106)	0.78	(\$3,497)
CZ04	PGE	\$13,726	1.00	\$7	1.05	\$833
CZ04	CPAU	\$13,726	1.35	\$5,517	1.42	\$6,633
CZ05	PGE	\$13,726	0.75	(\$3,985)	0.79	(\$3,369)
CZ05	PGE/SCG	\$13,726	0.75	(\$3,985)	0.79	(\$3,369)
CZ06	SCE/SCG	\$13,726	0.73	(\$4,249)	0.78	(\$3,501)
CZ07	SDGE	\$13,726	1.17	\$2,623	1.16	\$2,466
CZ08	SCE/SCG	\$13,726	1.20	\$3,086	1.27	\$4,313
CZ09	SCE/SCG	\$13,726	1.09	\$1,487	1.17	\$2,609
CZ10	SCE/SCG	\$13,726	1.18	\$2,884	1.26	\$4,097
CZ10	SDGE	\$13,726	1.85	\$13,356	1.84	\$13,108
CZ11	PGE	\$13,726	1.41	\$6,420	1.48	\$7,583
CZ12	PGE	\$13,726	0.97	(\$512)	1.02	\$287
CZ12	SMUD/PGE	\$13,726	0.93	(\$1,109)	0.98	(\$342)
CZ13	PGE	\$13,726	1.63	\$9,953	1.72	\$11,302
CZ14	SCE/SCG	\$13,726	1.42	\$6,655	1.52	\$8,115
CZ14	SDGE	\$13,726	2.00	\$15,653	1.98	\$15,386
CZ15	SCE/SCG	\$13,726	1.94	\$14,686	2.06	\$16,670
CZ16	PGE	\$13,726	0.95	(\$737)	1.00	\$49

Table 1414. [1992-2010] 3 kW PV without Solar Tax Credit (Std)

Climate Zone	Electric/ Gas Utility	First Incremental Cost	On-Bill Savings			
			On-Bill B/C Modest Gas Escalation	On-Bill NPV Modest Gas Escalation	On-Bill B/C High Gas Escalation	On-Bill NPV High Gas Escalation
CZ01	PGE	\$13,726	0.71	(\$4,475)	0.75	(\$3,885)
CZ02	PGE	\$13,726	0.73	(\$4,198)	0.77	(\$3,593)
CZ03	PGE	\$13,726	0.72	(\$4,411)	0.76	(\$3,817)
CZ04	PGE	\$13,726	0.80	(\$3,121)	0.84	(\$2,459)
CZ04	CPAU	\$13,726	1.16	\$2,477	1.22	\$3,433
CZ05	PGE	\$13,726	0.73	(\$4,299)	0.76	(\$3,700)
CZ05	PGE/SCG	\$13,726	0.73	(\$4,299)	0.76	(\$3,700)
CZ06	SCE/SCG	\$13,726	0.61	(\$6,143)	0.65	(\$5,520)
CZ07	SDGE	\$13,726	0.94	(\$931)	0.93	(\$1,057)
CZ08	SCE/SCG	\$13,726	0.98	(\$242)	1.05	\$767
CZ09	SCE/SCG	\$13,726	0.88	(\$1,890)	0.94	(\$988)
CZ10	SCE/SCG	\$13,726	0.96	(\$676)	1.02	\$305
CZ10	SDGE	\$13,726	1.51	\$8,054	1.50	\$7,852
CZ11	PGE	\$13,726	1.10	\$1,569	1.16	\$2,477
CZ12	PGE	\$13,726	0.80	(\$3,169)	0.84	(\$2,510)
CZ12	SMUD/PGE	\$13,726	0.93	(\$1,109)	0.98	(\$342)
CZ13	PGE	\$13,726	1.27	\$4,170	1.33	\$5,215
CZ14	SCE/SCG	\$13,726	1.15	\$2,295	1.22	\$3,470
CZ14	SDGE	\$13,726	1.66	\$10,386	1.65	\$10,164
CZ15	SCE/SCG	\$13,726	1.37	\$5,788	1.46	\$7,191
CZ16	PGE	\$13,726	0.81	(\$3,006)	0.85	(\$2,338)

Table 1515. [Pre-1978] 3 kW PV without Solar Tax Credit (CARE)

Climate Zone	Electric/ Gas Utility	First Incremental Cost	On-Bill Savings			
			On-Bill B/C Modest Gas Escalation	On-Bill NPV Modest Gas Escalation	On-Bill B/C High Gas Escalation	On-Bill NPV High Gas Escalation
CZ01	PGE	\$13,726	0.62	(\$6,030)	0.65	(\$5,522)
CZ02	PGE	\$13,726	0.64	(\$5,707)	0.67	(\$5,182)
CZ03	PGE	\$13,726	0.60	(\$6,344)	0.63	(\$5,853)
CZ04	PGE	\$13,726	0.83	(\$2,725)	0.87	(\$2,042)
CZ05	PGE	\$13,726	0.60	(\$6,266)	0.63	(\$5,771)
CZ05	PGE/SCG	\$13,726	0.60	(\$6,266)	0.63	(\$5,771)
CZ06	SCE/SCG	\$13,726	0.71	(\$4,578)	0.75	(\$3,852)
CZ07	SDGE	\$13,726	0.71	(\$4,508)	0.71	(\$4,604)
CZ08	SCE/SCG	\$13,726	0.97	(\$483)	1.03	\$510
CZ09	SCE/SCG	\$13,726	0.90	(\$1,530)	0.96	(\$605)
CZ10	SCE/SCG	\$13,726	0.97	(\$465)	1.03	\$530
CZ10	SDGE	\$13,726	1.19	\$3,032	1.18	\$2,872
CZ11	PGE	\$13,726	1.07	\$1,150	1.13	\$2,036
CZ12	PGE	\$13,726	0.79	(\$3,324)	0.83	(\$2,673)
CZ13	PGE	\$13,726	1.23	\$3,587	1.29	\$4,601
CZ14	SCE/SCG	\$13,726	1.17	\$2,662	1.25	\$3,861
CZ14	SDGE	\$13,726	1.28	\$4,436	1.27	\$4,264
CZ15	SCE/SCG	\$13,726	1.57	\$8,962	1.67	\$10,572
CZ16	PGE	\$13,726	0.79	(\$3,342)	0.83	(\$2,692)

Table 1616. [1978-1991] 3 kW PV without Solar Tax Credit (CARE)

Climate Zone	Electric/ Gas Utility	First Incremental Cost	On-Bill Savings			
			On-Bill B/C Modest Gas Escalation	On-Bill NPV Modest Gas Escalation	On-Bill B/C High Gas Escalation	On-Bill NPV High Gas Escalation
CZ01	PGE	\$13,726	0.60	(\$6,343)	0.63	(\$5,851)
CZ02	PGE	\$13,726	0.56	(\$6,845)	0.59	(\$6,380)
CZ03	PGE	\$13,726	0.57	(\$6,757)	0.60	(\$6,287)
CZ04	PGE	\$13,726	0.76	(\$3,715)	0.80	(\$3,085)
CZ05	PGE	\$13,726	0.57	(\$6,686)	0.60	(\$6,213)
CZ05	PGE/SCG	\$13,726	0.57	(\$6,686)	0.60	(\$6,213)
CZ06	SCE/SCG	\$13,726	0.61	(\$6,195)	0.64	(\$5,575)
CZ07	SDGE	\$13,726	0.62	(\$6,004)	0.61	(\$6,087)
CZ08	SCE/SCG	\$13,726	0.91	(\$1,483)	0.96	(\$555)
CZ09	SCE/SCG	\$13,726	0.85	(\$2,368)	0.90	(\$1,497)
CZ10	SCE/SCG	\$13,726	0.90	(\$1,597)	0.96	(\$676)
CZ10	SDGE	\$13,726	1.10	\$1,560	1.09	\$1,413
CZ11	PGE	\$13,726	0.98	(\$295)	1.03	\$515
CZ12	PGE	\$13,726	0.72	(\$4,320)	0.76	(\$3,722)
CZ13	PGE	\$13,726	1.12	\$1,893	1.18	\$2,818
CZ14	SCE/SCG	\$13,726	1.07	\$1,051	1.14	\$2,144
CZ14	SDGE	\$13,726	1.18	\$2,878	1.17	\$2,719
CZ15	SCE/SCG	\$13,726	1.37	\$5,735	1.45	\$7,135
CZ16	PGE	\$13,726	0.74	(\$4,126)	0.78	(\$3,517)

Table 1717. [1992-2010] 3 kW PV without Solar Tax Credit (CARE)

Climate Zone	Electric/ Gas Utility	First Incremental Cost	On-Bill Savings			
			On-Bill B/C Modest Gas Escalation	On-Bill NPV Modest Gas Escalation	On-Bill B/C High Gas Escalation	On-Bill NPV High Gas Escalation
CZ01	PGE	\$13,726	0.56	(\$6,963)	0.59	(\$6,504)
CZ02	PGE	\$13,726	0.26	(\$11,640)	0.20	(\$12,611)
CZ03	PGE	\$13,726	0.55	(\$6,997)	0.58	(\$6,540)
CZ04	PGE	\$13,726	0.62	(\$5,900)	0.66	(\$5,385)
CZ05	PGE	\$13,726	0.56	(\$6,932)	0.59	(\$6,471)
CZ05	PGE/SCG	\$13,726	0.56	(\$6,932)	0.59	(\$6,471)
CZ06	SCE/SCG	\$13,726	0.51	(\$7,652)	0.55	(\$7,127)
CZ07	SDGE	\$13,726	0.48	(\$8,115)	0.48	(\$8,180)
CZ08	SCE/SCG	\$13,726	0.78	(\$3,430)	0.83	(\$2,629)
CZ09	SCE/SCG	\$13,726	0.72	(\$4,462)	0.76	(\$3,728)
CZ10	SCE/SCG	\$13,726	0.76	(\$3,748)	0.81	(\$2,968)
CZ10	SDGE	\$13,726	0.86	(\$2,225)	0.85	(\$2,340)
CZ11	PGE	\$13,726	0.79	(\$3,259)	0.83	(\$2,605)
CZ12	PGE	\$13,726	0.63	(\$5,876)	0.66	(\$5,359)
CZ13	PGE	\$13,726	0.89	(\$1,678)	0.94	(\$941)
CZ14	SCE/SCG	\$13,726	0.89	(\$1,676)	0.95	(\$761)
CZ14	SDGE	\$13,726	0.95	(\$838)	0.94	(\$964)
CZ15	SCE/SCG	\$13,726	0.99	(\$142)	1.06	\$873
CZ16	PGE	\$13,726	0.63	(\$5,850)	0.66	(\$5,333)

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The adoption of reach codes can differentiate jurisdictions as efficiency leaders and help accelerate the adoption of new equipment, technologies, code compliance, and energy savings strategies.

As part of the Statewide Codes & Standards Program, the Reach Codes Subprogram is a resource available to any local jurisdiction located throughout the state of California.

Our experts develop robust toolkits as well as provide specific technical assistance to local jurisdictions (cities and counties) considering adopting energy reach codes. These include cost-effectiveness research and analysis, model ordinance language and other code development and implementation tools, and specific technical assistance throughout the code adoption process.

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2022 Cost-Effectiveness Study: Existing Single Family Building Upgrades

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Acronym List

2023 PV\$ – Present value costs in 2023

ACH50 – Air Changes per Hour at 50 pascals pressure differential

ACM – Alternative Calculation Method

ADU – Accessory Dwelling Unit

AFUE – Annual Fuel Utilization Efficiency

B/C – Lifecycle Benefit-to-Cost Ratio

BEopt – Building Energy Optimization Tool

BSC – Building Standards Commission

CA IOUs – California Investor-Owned Utilities

CASE – Codes and Standards Enhancement

CBECC-Res – Computer program developed by the California Energy Commission for use in demonstrating compliance with the California Residential Building Energy Efficiency Standards

CEER – Combined Energy Efficiency Rating

CFI – California Flexible Installation

CFM – Cubic Feet per Minute

CO₂ – Carbon Dioxide

CPAU – City of Palo Alto Utilities

CPUC – California Public Utilities Commission

CZ – California Climate Zone

DFHP – Dual Fuel Heat Pump

DHW – Domestic Hot Water

DOE – Department of Energy

DWHR – Drain Water Heat Recovery

EDR – Energy Design Rating

EER – Energy Efficiency Ratio

EF – Energy Factor



GHG – Greenhouse Gas

HERS Rater – Home Energy Rating System Rater

HPA – High Performance Attic

HPSH – Heat Pump Space Heater

HPWH – Heat Pump Water Heater

HSPF – Heating Seasonal Performance Factor

HVAC – Heating, Ventilation, and Air Conditioning

IECC – International Energy Conservation Code

IOU – Investor Owned Utility

kBtu –British thermal unit (x1000)

kWh – Kilowatt Hour

LBNL – *Lawrence Berkeley National Laboratory*

LCC – Life Cycle Cost

LLAHU – Low Leakage Air Handler Unit

VLLDCS – Verified Low Leakage Ducts in Conditioned Space

LSC – Long-term Systemwide Cost

MF – Multifamily

MSHP – Mini-Split Heat Pump

NEEA – Northwest Energy Efficiency Alliance

NEM – Net Energy Metering

NPV – Net Present Value

NREL – *National Renewable Energy Laboratory*

PG&E – Pacific Gas and Electric Company

POU – Publicly-Owned-Utilities

PV – Photovoltaic

SCE – Southern California Edison

SDG&E – San Diego Gas and Electric

SEER – Seasonal Energy Efficiency Ratio

SF – Single Family

SMUD – Sacramento Municipal Utility District

SoCalGas – Southern California Gas Company

TDV – Time Dependent Valuation

Therm – Unit for quantity of heat that equals 100,000 British thermal units

Title 24 – Title 24, Part 6

TOU – Time-Of-Use

UEF – Uniform Energy Factor

VCHP – Variable Capacity Heat Pump, Title 24 compliance credit

ZNE – Zero-net Energy

Summary of Revisions

Date	Description	Reference (page or section)
4/25/2024	Original Release	N/A

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Executive Summary

The California Codes and Standards (C&S) 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 efficiency and greenhouse gas (GHG) 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.

This report documents cost-effective measure upgrades in existing single family buildings that exceed the minimum state requirements. It evaluates efficiency measures such as adding insulation, replacing windows, and duct upgrades, fuel substitution measures that upgrade space heating and water heating to heat pumps, and solar photovoltaics (PV) across all 16 California climate zones. A 1,665 square foot single family home prototype with an attached garage was evaluated in this study.

This analysis used two different metrics to assess the cost-effectiveness of the proposed upgrades. Both methodologies require estimating and quantifying the incremental costs and energy savings associated with each energy efficiency measure over a 30-year analysis period. On-Bill cost-effectiveness is a customer-based lifecycle cost (LCC) approach that values energy based upon estimated site energy usage and customer utility bill savings using today's electricity and natural gas utility tariffs. Long-term Systemwide Cost (LSC) is the California Energy Commission's LCC methodology for the 2025 Title 24, Part 6 (Title 24) code cycle (previously referred to as Time Dependent Valuation (TDV)), which is intended to capture the long-term projected cost of energy including costs for providing energy during peak periods of demand, carbon emissions, grid transmission and distribution impacts. This is the methodology used by the Energy Commission in evaluating cost-effectiveness for efficiency measures in Title 24 code development.

The following summarizes key results from the study:

Conclusions and Discussion:

1. Envelope measures. Improving envelope performance is very cost-effective in many older homes. In addition to reducing utility costs, these measures provide many other benefits such as improving occupant comfort and satisfaction and increasing a home's ability to maintain temperatures during extreme weather events and power outages. Below is a discussion of the results of specific measures.
 - a. Adding attic insulation is cost-effective based on both LSC and On-Bill in many climate zones in homes with no more than R-19 existing attic insulation levels. Increasing attic insulation from R-30 to R-49 was still found to be cost-effective based on at least one metric in the colder and hotter climates of Climate Zone 10 (SDG&E territory only) through 16.
 - b. Insulating existing uninsulated walls is very cost-effective based on both metrics everywhere except Climate Zones 6 and 7 (in Climate Zone 8 it's only cost-effective based on LSC).
 - c. Adding R-19 or R-30 floor insulation is cost-effective based on LSC in the older two vintages (Pre-1978 and 1978-1991) in all CZ except CZ 6-10.
 - d. Replacing old single pane windows with new high-performance windows has a very high cost and is typically not done for energy savings alone. However, energy savings are substantial and justify cost-effectiveness of this measure based on at least one metric in Climate Zones 4, 8 through 12 (PG&E territory only), and 13 through 16.
 - e. At time of roof replacement, a cool roof with an aged solar reflectance of 0.25 was found to be cost-effective in Climate Zones 4, 6 through 12 (PG&E territory only), and 13 through 15. When the roof deck is replaced during a roof replacement, adding a radiant barrier is low cost and provides substantial cooling energy savings, and was found to be cost-effective in almost all climate zones and homes.
2. Duct measures: Many older homes have old, leaky duct systems that should be replaced when they reach the end of life, typically 20-30 years. In this case, installing new ducts was found to be cost-effective based on at least one metric (both in most cases) everywhere except mild Climate Zone 7 and Climate Zones 5 and 6 in

the 1978-1991 vintage. If duct systems still have remaining life they should be sealed and tested to meet 10% leakage or lower; however, duct upgrades alone were only found to be cost-effective for newer homes in Climate Zones 10 (SDG&E territory only), 11, and 13 through 16. Duct upgrades may be able to be coupled with other measures to reduce the cost.

3. Heat pump space heating: HPSHs were found to be LSC cost-effective in many cases. The Dual Fuel Heat Pump (existing furnace) was LSC cost-effective everywhere except Climate Zone 15. The HPSH was LSC cost-effective everywhere except Climate Zones 8 and 15.
 - a. Challenges to On-Bill cost-effectiveness include higher first costs and higher first-year utility costs due to higher electricity tariffs relative to gas tariffs. SMUD and CPAU are two exceptions where first year utility costs are lower for heat pumps than for gas equipment. Table 11 shows the impact of utility rates on cost-effectiveness of HPSH where the standard and high efficiency HPSH and the HPSH + PV measures are cost-effective under SMUD but not PG&E. Even with higher first year utility bills, there were some cases that still proved On-Bill cost-effective including the DFHP with an existing furnace in the central valley and northern coastal PG&E territories, the ducted MSHP in the central valley as well as Climate Zone 14 in SDG&E territory, and the HPSH + PV measure in CZ 3-5 (PGE), 7-11, and 12 (SMUD) – 15.
 - b. The ductless MSHPs were only found to be cost-effective based on either metric in Climate Zones 1 and 16. Ductless MSHPs have a high incremental cost because it is a more sophisticated system than the base model of a wall furnace with a window AC unit. However, the ductless MSHP would provide greater comfort benefits if properly installed to directly condition all habitable spaces (as is required under the VCHP compliance credit as evaluated in this study) which may be an incentive for a homeowner to upgrade their system.
 - c. Higher efficiency equipment lowered utility costs in all cases and improved cost-effectiveness in many cases, particularly with a ducted MSHP.
4. Heat pump water heating: All the HPWH measures were LSC cost-effective in all climate zones. Most measures were not On-Bill cost-effective with the exception of the HPWH + PV which was cost-effective On-Bill in CPAU, SMUD, and SDG&E territories in addition to Climate Zones 11, 13, 14, and 15. The HPWH measures share many of the same challenges as the HPSH measures to achieving cost-effectiveness including high first costs and utility rates and assumptions. Table 13 shows the impact of utility rates on cost-effectiveness where some HPWH measures are cost-effective under SMUD utility rates but are not cost-effective anywhere under PG&E rates in Climate Zone 12.
 - a. Various HPWH locations were also explored, however there are some factors outside of cost-effectiveness that should also be considered.
 - i. HPWHs in the conditioned space can provide benefits such as free-cooling during the summer, reduced tank losses, and shorter pipe lengths, and in some cases show improved cost-effectiveness over garage located HPWHs. However, there are various design considerations such as noise, comfort concerns, an additional heating load in the winter, and condensate removal. Ducting the inlet and exhaust air resolves comfort concerns but adds costs and complexity. Split heat pump water heaters address these concerns, but currently there are limited products on the market and there is a cost premium relative to the packaged products.
 - ii. Since HPWHs extract heat from the air and transfer it to water in the storage tank, they must have adequate ventilation to operate properly. Otherwise, the space cools down over time, impacting the HPWH operating efficiency. This is not a problem with garage installations but needs to be considered for water heaters located in interior or exterior closets. For the 2025 Title 24 code the CEC is proposing that all HPWH installations meet mandatory ventilation requirements (California Energy Commission, 2023).
5. The contractor surveys revealed overall higher heat pump costs than what has been found in previous analyses. This could be due to incentive availability raising demand for heat pumps and thereby increasing the price. This price increase may be temporary and may come down once the market stabilizes. There are also

new initiatives to obtain current costs including the TECH Clean California program¹ that publishes heat pump data and costs; however, at the time of this analysis, the TECH data did not contain incremental costs because it only had the heat pump costs but not the gas base case costs.

6. Table 18 shows how CARE rates and escalation rate assumptions will impact cost-effectiveness.
 - a. Applying CARE rates in the IOU territories has the overall impact to increase utility cost savings for an all-electric building compared to a code compliant mixed fuel building, improving On-Bill cost-effectiveness. This is due to the CARE discount on electricity being higher than that on gas. The reverse occurs with efficiency measures where lower utility rates reduce savings and subsequently reduce cost-effectiveness.
 - b. If gas tariffs are assumed to increase substantially over time, in-line with the escalation assumption from the 2025 LSC development, cost-effectiveness substantially improves for the heat pump measures over the 30-year analysis period and many cases become cost-effective that were not found to be cost-effective under the CPUC / 2022 TDV escalation scenario. There is much uncertainty surrounding future tariff structures as well as escalation values. While it's clear that gas rates will increase, how much and how quickly is not known. Future electricity tariff structures are expected to evolve over time, and the CPUC has an active proceeding to adopt an income-graduated fixed charge that benefits low-income customers and supports electrification measures for all customers.² The CPUC will make a decision in mid-2024 and the new rates are expected to be in place later that year or in 2025. While the anticipated impact of this rate change is lower volumetric electricity rates, the rate design is not finalized. While lower volumetric electricity rates provide many benefits, it also will make building efficiency measures harder to justify as cost-effective due to lower utility bill cost savings.
7. Under NBT, utility cost savings for PV are substantially less than what they were under prior net energy metering rules (NEM 2.0); however, savings are sufficient to be On-Bill cost-effective in all climate zones except Climate Zones 1 through 3, 5, and 6.
 - a. Combining a heat pump with PV allows the additional electricity required by the heat pump to be offset by the PV system while also increasing on-site utilization of PV generation rather than exporting the electricity back to the grid at a low rate.
 - b. While not evaluated in this study, coupling PV with battery systems can be very advantageous under NBT increasing utility cost savings because of improved on-site utilization of PV generation and fewer exports to the grid.

Recommendations:

1. There are various approaches for jurisdictions who are interested in reach codes for existing buildings. Some potential approaches are listed below along with key considerations.
 - a. Prescriptive measures: Non-preempted measures that are found to be cost-effective may be prescriptively required in a reach code. One example of this type of ordinance is a cool roof requirement at time of roof replacement. Another example is requiring specific cost-effective measures for larger remodels, such as high-performance windows when new windows are installed or duct sealing and testing when ducts are in an unconditioned space.
 - b. Replacement equipment: This flavor of reach code sets certain requirements at time of equipment replacement. This study evaluated space heating and water heating equipment. Where a heat pump measure was found to be cost-effective based on either LSC or On-Bill, this may serve as the basis of a reach code given the following considerations.
 - i. Where reach codes reduce energy usage and are not just fuel switching, cost-effectiveness calculations are required and must be based on equipment that does not exceed the federal minimum efficiency requirements.
 - ii. Where reach codes are established using cost-effectiveness based on LSC, utility bill impacts and the owner's first cost should also be reviewed and considered.

¹ [TECH Public Reporting Home Page \(techcleanca.com\)](https://techcleanca.com)

² <https://www.cpuc.ca.gov/industries-and-topics/electrical-energy/electric-costs/demand-response-dr/demand-flexibility-rulemaking>

- iii. A gas path should also be prescriptively allowed to safely satisfy federal preemption requirements considering the CRA v. Berkeley case.³ Additional requirements may apply to the gas path, as described in Section 3.3, as long as the paths are reasonably energy or cost equivalent.
 - c. “Flexible Path”, minimum energy savings target: This flexible approach establishes a target for required energy savings based on a measure or a set of measures that were found to be cost-effective based on either LSC or On-Bill. A points menu compares various potential upgrades ranging from efficiency, PV, and fuel substitution measures, based on site or source energy savings. The applicant must select upgrades that individually or in combination meet the minimum energy savings target. The maximum target value shown in the Cost-effectiveness Explorer is based on a combination of cost-effective, non-preempted measures.
2. Equipment replacement ordinances should consider appropriate exceptions for scenarios where it will be challenging to meet the requirements, such as location of the HPWH, total project cost limitations, or the need for service panel upgrades that wouldn’t have been required as part of the proposed scope of work in absence of the reach code.
3. Consider extending relevant proposals made by the CEC for the 2025 Title 24 code (California Energy Commission, 2023) in ordinances that apply under the 2022 Title 24 code, such as the following:
 - a. Mandatory ventilation requirements for HPWH installations (Section 110.3(c)7). The cost-effectiveness analysis can be found in the Multifamily Domestic Hot Water CASE report (Statewide Team, 2023).
 - b. Requirement for HERS verified refrigerant charge verification for heat pumps in all climate zones (Table 150.1-A⁴). The cost-effectiveness analysis can be found in the Residential HVAC Performance CASE report (Statewide Team, 2023).
4. When evaluating reach code strategies, the Reach Codes Team recommends that jurisdictions consider combined benefits of energy efficiency alongside electrification. Efficiency and electrification have symbiotic benefits and are both critical for decarbonization of buildings. As demand on the electric grid is increased through electrification, efficiency can reduce the negative impacts of additional electricity demand on the grid, reducing the need for increased generation and storage capacity, as well as the need to upgrade upstream transmission and distribution equipment.
5. Education and training can play a critical role in ensuring that heat pumps are installed, commissioned, and controlled properly to mitigate grid impacts and maximize occupant satisfaction. Below are select recommended strategies.
 - a. The Quality Residential HVAC Services Program⁵ is an incentive program to train California contractors in providing quality installation and maintenance while advancing energy-efficient technologies in the residential HVAC industry. Jurisdictions can market this to local contractors to increase the penetration of contractors skilled in heat pump design and installation.
 - b. Educate residents and contractors of available incentives, tax credits, and financing opportunities.
 - c. Educate contractors on code requirements. Energy Code Ace provides free tools, training, and resources to help Californians comply with the energy code. Contractors can access interactive compliance forms, fact sheets, and live and recorded trainings, among other things, on the website: <https://energycodeace.com/>. Jurisdictions can reach out to Energy Code Ace directly to discuss offerings.
6. Health and safety
 - a. 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

³ <https://www.publichealthlawcenter.org/sites/default/files/2024-01/CRA-v-Berkeley-Ninth-Circuit-Opinion-Jan2024.pdf>

⁴ This requirement does not show up in the Express Terms for alterations in Section 150.2(b)1F, but the Statewide Reach Codes Team expects that it will be added to the next release of the proposed code language in the 45-day language as it aligns with the proposal made by the Codes and Standards Enhancement Team (Statewide CASE Team, 2023).

⁵ <https://qualityhvac.frontierenergy.com/>

- if the appliances are not being replaced. It is recommended that the building department require inspection and testing of all combustion appliances located within the pressure boundary of the building after completion of retrofit work that involves air sealing or insulation measures.
- b. Jurisdictions may consider requiring mechanical ventilation in homes where air sealing has been conducted. In older buildings, outdoor air is typically introduced through leaks in the building envelope. After air sealing a building, it may be necessary to forcefully bring in fresh outdoor air using supply and/or exhaust fans to minimize potential issues associated with indoor air quality.

Local jurisdictions may also adopt ordinances that amend different Parts of the California Building Standards Code or may elect to amend other state or municipal codes. The decision regarding which code to amend will determine the specific requirements that must be followed for an ordinance to be legally enforceable. For example, reach codes that amend Part 6 of the CA Building Code and require energy performance beyond state code minimums must demonstrate the proposed changes are cost-effective and obtain approval from the Energy Commission as well as the Building Standards Commission (BSC). Amendments to Part 11, such as requirements for increased water efficiency or electric vehicle infrastructure only require BSC approval. Although a cost-effectiveness study is only required to amend Part 6 of the CA Building Code, this study provides valuable context for jurisdictions pursuing other ordinance paths to understand the economic impacts of any policy decision. This study documents the estimated costs, benefits, energy impacts and greenhouse gas emission reductions that may result from implementing an ordinance based on the results to help residents, local leadership, and other stakeholders make informed policy decisions.

This report documents the key results and conclusions from the Reach Codes Team analysis. A full dataset of all results can be downloaded at <https://localenergycodes.com/content/resources>. Results alongside policy options can also be explored using the Cost-effectiveness Explorer at <https://explorer.localenergycodes.com/>. Model ordinance language and other resources are posted on the C&S Reach Codes Program website at LocalEnergyCodes.com. Local jurisdictions that are considering adopting an ordinance may contact the program for further technical support at info@localenergycodes.com.

1 Introduction

This report documents cost-effective measure upgrades in existing single family buildings that exceed the minimum state requirements, the 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 Codes Team.

The focus of this study is on existing single family buildings and does not apply to low or high-rise multifamily buildings. Each jurisdiction must establish the appropriate structure and threshold for triggering the proposed requirements. Some common jurisdictional 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 re-roofing project. The analysis includes scenarios of individual measures and identifies cost-effective options based on the existing conditions of the building in all 16 California Climate Zones (CZ) (see Cost-Effectiveness Results for a graphical depiction of climate zone locations).

This report documents the key results and conclusions from the Reach Codes Team analysis. A full dataset of all results can be downloaded at <https://localenergycodes.com/content/resources>. Results alongside policy options can also be explored using the Cost-effectiveness Explorer at <https://explorer.localenergycodes.com/>.

The California Codes and Standards (C&S) 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 efficiency 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.

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

The Department of Energy (DOE) sets minimum efficiency standards for equipment and appliances that are federally regulated under the National Appliance Energy Conservation Act, including heating, cooling, and water heating equipment (E-CFR, 2020). Since state and local governments are prohibited from adopting higher minimum efficiencies than the federal standards require, the focus of this study is to identify and evaluate cost-effective packages that do not include high efficiency heating, cooling, and water heating equipment. High efficiency appliances are often the easiest and most affordable measure to increase energy performance. While federal preemption limits reach code mandatory requirements for covered appliances, in practice, builders may install any package of compliant measures to achieve the performance requirements.

2 Methodology and Assumptions

2.1 Analysis for Reach Codes

This section describes the approach to calculating cost-effectiveness including benefits, costs, metrics, and utility rate selection.

2.1.1 Modeling

The Reach Codes Team performed energy simulations using the 2025 research version of the Residential California Building Energy Code Compliance software (CBECC). The 2025 version of CBECC was used instead of the 2022 version to take advantage of updated weather files and metrics. Site energy results are similar between CBECC-Res 2022 and 2025; however, the 2025 compliance metrics applies assumptions reflective of an electrified future, such as high escalation for natural gas retail rates, which favors electric buildings. In addition, in 2025 the weather stations were changed in Climate Zones 4 and 6 from San Jose to Paso Robles and Torrance to Los Angeles International Airport, respectively.

Three unique building vintages are considered: pre-1978, 1978-1991, and 1992-2010. The vintages were defined based on review of historic Title 24 code requirements and defining periods with distinguishing features. Prospective energy efficiency measures were identified and modeled to determine the projected site energy (therm and kWh), source energy, GHG emissions, and LSC (long-term systemwide cost) impacts. Annual utility costs were calculated using hourly data output from CBECC, and current (as of 11/01/2023) electricity and natural gas tariffs for each of the investor-owned utilities (IOUs) appropriate for that climate zone.

Equivalent CO₂ emission reductions were calculated based on outputs from the CBECC-Res simulation software. Electricity emissions vary by region and by hour of the year. CBECC-Res applies two distinct hourly profiles, one for Climate Zones 1 through 5 and 11 through 13 and another for Climate Zones 6 through 10 and 14 through 16. Natural gas emissions do not vary hourly. To compare the mixed-fuel and all-electric cases side-by-side, GHG emissions are presented as lbs CO₂-equivalent (CO₂e) emissions.

The Statewide Reach Codes Team designed the analysis approach and selected measures for evaluation based on the 2019 existing building single family reach code analysis (Statewide Reach Codes Team, 2021) and work to support the 2025 Title 24 code development cycle as well as from outreach to architects, builders, and engineers.

2.1.2 Prototype Characteristics

The Energy Commission defines building prototypes which it uses to evaluate the cost-effectiveness of proposed changes to Title 24 requirements. Average home size has steadily increased over time,⁶ and the Energy Commission single family new construction prototypes are larger than many existing single family homes across California. For this analysis, a 1,665 square foot prototype was evaluated. Table 1 describes the basic characteristics of the single family prototype. Additions are not evaluated in this analysis as they are already addressed in Section 150.2 of Title 24, Part 6. The CEC has proposed changes to the 2025 Energy Code that would remove the allowance of gas space heating and water heating equipment for additions and instead require additions to follow the same space heating and water heating equipment requirements as new construction (California Energy Commission, 2023). The proposed prescriptive requirements for single family new construction homes are heat pump space heaters and water heaters, with gas equipment only allowed in the performance approach.

⁶ <https://www.census.gov/const/C25Ann/sfttotalmedavgsqft.pdf>

Table 1. Prototype Characteristics

	Specification
Existing Conditioned Floor Area	1,665 ft ²
Num. of Stories	1
Num. of Bedrooms	3
Window-to-Floor Area Ratio	13%
Attached Garage	2-car garage

Three building vintages were evaluated to determine sensitivity of existing building performance on cost-effectiveness of upgrades. For example, it is widely recognized that adding attic insulation in an older home with no insulation is cost-effective, however, newer homes will likely have existing attic insulation reducing the cost-effectiveness of an incremental addition of insulation. The building characteristics for each vintage were determined based on either prescriptive requirements from Title 24 that were in effect or standard construction practice during that time period. Homes built under 2001 Title 24 are subject to prescriptive envelope code requirements very similar to homes built under the 2005 code cycle, which was in effect until January 1, 2010.

Table 2 summarizes the assumptions for each of the three vintages. Additionally, the analysis assumed the following features when modeling the prototype buildings. Efficiencies were defined by year of the most recent equipment replacement based on standard equipment lifetimes.

- Individual space conditioning and water heating systems, one per single family building.
- Split-system air conditioner with natural gas furnace.
 - Scenarios with an existing natural gas wall furnace without AC were also evaluated.
- Small storage natural gas water heater.
 - Scenarios with an existing electric resistance storage water heater were also evaluated.
- Gas cooktop, oven, and clothes dryer.

The methodology applied in the analyses 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 to determine the projected energy performance and utility cost impacts relative to the baseline vintage. In some cases, where logical, measures were packaged together.

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-5 @ ceiling level for CZ 6 & 7, Vented attic, R-11 @ ceiling level (all other CZs)	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 at 50 Pascals	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 at 25 Pa	Attic, R-2.1, 25% leakage at 25 Pa	Attic, R-4.2, 15% leakage at 25 Pa
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 Type	40-gallon gas storage	40-gallon gas storage	40-gallon gas storage
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 align wall system performance with monitored field data and not overestimate energy use.

^b Window type selections were made based on conversations with window industry expert, Ken Nittler. If a technology was entering the market during the time period (e.g., Low-E during 1992-2010 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.

2.1.3 Cost-Effectiveness Approach

2.1.3.1 Benefits

This analysis used two different metrics to assess the 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 way they value energy impacts (the numerator in the benefit cost calculation):

Utility Bill Impacts (On-Bill): This customer-based lifecycle cost (LCC) approach values energy based upon estimated site energy usage and customer utility bill savings using the latest electricity and natural gas utility tariffs available at the time of writing this report. Total savings are estimated over a 30-year duration and include discounting of future utility costs, as well as assumed energy cost inflation over time.

Long-term Systemwide Cost (LSC): Formerly known as Time Dependent Valuation (TDV) energy cost savings, LSC reflects the Energy Commission's current LCC methodology, which is intended to capture the total value or cost of energy use over 30 years. This method accounts for the hourly cost of marginal generation, transmission and distribution, fuel, capacity, losses, and cap-and-trade-based CO2 emissions (California Energy Commission, 2023). This is the methodology used by the Energy Commission in evaluating cost-effectiveness for efficiency measures in the 2025 Energy Code.

2.1.3.2 Costs

The Reach Codes Team assessed the incremental costs of the measures and packages over a 30-year analysis period. Incremental costs represent the equipment, installation, replacement, and maintenance costs of the proposed measure relative to the 2022 Title 24 Standards minimum requirements or standard industry practices. Present value of replacement cost is included only for measures with lifetimes less than the 30-year evaluation period. In cases where at the end of the analysis period the measure has useful life remaining, the value of this remaining life is calculated and credited in the total lifetime cost.

2.1.3.3 Metrics

Cost-effectiveness is presented using net present value (NPV) and benefit-to-cost (B/C) ratio metrics.

NPV: Equation 1 demonstrates how lifetime NPV is calculated. If the NPV of a measure or package is positive, it is considered cost-effective. A negative value represents a net increase in costs over the 30-year lifetime.

B/C Ratio: This is the ratio of the present value of all benefits to the present value of all costs over 30 years (present value benefits divided by present value costs). A value of one indicates the NPV of the savings over the life of the measure is equivalent to the NPV of the lifetime incremental cost of that measure. A value greater than one represents a positive return on investment. The B/C ratio is calculated according to Equation 2.

Equation 1

$$NPV = \text{present value of lifetime benefit} - \text{present value of lifetime cost}$$

Equation 2

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

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 LSC savings, and the cost is represented by incremental first cost and future replacement costs. Some packages result in initial construction cost savings relative to the assumed base case scenario, 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".

The lifetime costs or benefits are calculated according to Equation 3.

Equation 3

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

Where:

1. n = analysis term in years
2. r = discount rate

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

3. Analysis term of 30 years
4. Real discount rate of three percent

Both base case measures and alternative energy efficiency measures may have different lifetime assumptions which impact life cycle economics. Future costing of many of the evaluated electrification measures are only based on current cost assumption, which may be overly conservative as the expected growth in heat pump-based technologies is growing rapidly and will likely lead to future cost reductions (at least relative to current fossil fueled equipment) as production volumes increase.

2.1.4 Utility Rates

In coordination with the CA IOU rate team (comprised of representatives from Pacific Gas and Electric (PG&E), Southern California Edison (SCE) and San Diego Gas and Electric (SDG&E)) and two Publicly-Owned-Utilities (POUs) (Sacramento Municipal Utility District (SMUD) and City of Palo Alto Utilities (CPAU)), the Reach Codes Team determined appropriate utility rates for each climate zone to calculate utility costs and determine On-Bill cost-effectiveness for the proposed measures and packages. The utility tariffs, summarized in Chapter 6.2, were determined based on the appropriate rate for each case in each territory. Utility rates were applied to each climate zone based on the predominant IOU serving the population of each zone, with a few climate zones evaluated multiple times under different utility scenarios. Climate Zones 10 and 14 were evaluated with both SCE for electricity and Southern California Gas Company (SoCalGas) for gas and SDG&E tariffs for both electricity and gas since each utility has customers within these climate zones. Climate Zone 5 is evaluated under both PG&E and SoCalGas natural gas rates. Two POU or municipal utility rates were also evaluated: SMUD in Climate Zone 12 and CPAU in Climate Zone 4.

For cases with onsite generation (i.e. solar photovoltaics (PV)), the approved NBT tariffs were applied along with monthly service fees and hourly export compensation rates for 2024.⁷ In December 2022, the California Public Utilities Commission (CPUC) issued a decision adopting NBT as a successor to NEM 2.0 that went into effect April of 2023⁸.

Utility rates are assumed to escalate over time according to the assumptions from the CPUC 2021 En Banc hearings on utility costs through 2030 (California Public Utilities Commission, 2021a). Escalation rates through the remainder of the 30-year evaluation period are based on the escalation rate assumptions within the 2022 TDV factors. The Statewide Natural Gas Residential Average Rate for 2023 through 2030 is projected to be 4.6%. The Electric Residential Average Rate for PG&E, SCE and SDG&E for 2023 through 2030 is projected to be 1.8%, 1.6% and 2.8% respectively. A second set of escalation rates were also evaluated to demonstrate the impact that utility cost changes have on cost-effectiveness over time. This utility rate escalation sensitivity analysis, presented in Section 3.2.4, was based on those used within the 2025 LSC factors (LSC replaces TDV in the 2025 code cycle) which assumed steep

⁷ Hourly export compensation rates were based on the NBT spreadsheet model created by E3 for the CPUC.
<https://www.cpuc.ca.gov/-/media/cpuc-website/divisions/energy-division/documents/net-energy-metering-nem/nemrevisit/nbt-model--12142022.xlsb>

⁸ <https://www.cpuc.ca.gov/nemrevisit>

increases in gas rates in the latter half of the analysis period. See Appendix 6.2.7 Fuel Escalation Assumptions for details.

Future electricity tariff structures are expected to evolve over time, and the CPUC has an active proceeding to adopt an income-graduated fixed charge that benefits low-income customers and supports electrification measures.¹⁰ These were not included in this analysis but may be evaluated later in 2024 once the rates are finalized.

2.1.5 Measure Cost Data Collection Approach

To support this effort, a detailed cost study was completed in the summer of 2023 to gather data from a range of contractors to inform actual installed costs in the areas they provide services. These areas include HVAC, plumbing, envelope and air-sealing, and PV installation. Home performance contractors were also approached to collect this data. Collecting this type of data is challenging, both due to contractor reticence to share cost information and due to the timing of the survey which unfortunately coincided with the summer busy season for most contractors, especially HVAC installers. With these known challenges, the outreach effort focused on leveraging existing relationships between the analysis team and contractors to both gain access and provide assurance that all cost data would remain confidential and aggregated. Contractors that provided feedback were nominally compensated for their time.

The collected cost data was intended to represent recent costs for a “typical” retrofit installation. Each home in which a contractor does work has different site-specific issues that will likely affect costs. In addition, different jurisdictions have different levels of building department installation oversight and permit fees. Finally, each contractor typically has a different manufacturer product line they prefer to install. All these factors will influence installed costs¹¹.

The most detailed and broad cost request was for the HVAC contractors, as there are a wide range of equipment replacement scenarios available for an existing ducted gas furnace with central split-system air conditioning. Options range from a base case scenario (like for like swap out), split-system heat pump replacement, dual fuel heat pumps (DFHP), ducted mini-split heat pumps, non-ducted mini-splits, etc. For plumbing contractors, a range of scenarios existed for water heater replacements including like-for-like replacement, HPWHs (in different locations- garage, indoor), need for electrical upgrade for HPWH installation, need for HPWH ducting, etc. Envelope measures focused on attic and wall insulation, window replacement, re-roofing (with Cool Roof materials or not), and attic ceiling plane air-sealing. PV costing included different system sizes, panel upgrades costs, and battery costs. Home performance contractors were asked to provide as much data as they could on the different measure options. All costing information requested was intended to represent most recent installations, in an effort to capture current pricing as best as possible.

The contractors that responded with their cost estimates work in different regions of the state, operate in different markets with (potentially) different local efficiency incentives, do varying amounts of work based on the size of their company, target different market demographic sectors, and install different brands of equipment. All these factors will contribute to price variability. The Team considered applying climate zone specific cost adjustments to reflect some of these differences, but ultimately decided not to since a climate zone is not a monolithic entity with uniform customer pricing throughout. The Team recognizes that “zip code” pricing is a reality, but for simplicity, as well as consistency with Title 24, Part 6 code development costing approaches, applied uniform statewide costs to all measures.

2.2 Measure Details and Cost

This section describes the details of the measures and documents incremental costs. All measure costs were obtained from the contractor survey unless otherwise noted. All contractor provided costs reflect the cost to the customer and

¹⁰ <https://www.cpuc.ca.gov/industries-and-topics/electrical-energy/electric-costs/demand-response-dr/demand-flexibility-rulemaking>

¹¹ One HVAC contractor mentioned that equipment brand alone may contribute to a +/-5% variation in the total bid cost.

include equipment, labor, permit fees, and required HERS testing. Additional details of the measures can be found in Appendix Section **Error! Reference source not found.**

All measures are evaluated assuming they are not otherwise required by Title 24. 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. In some cases, cost-effective measures were identified that exceed Title 24 requirements, such as attic insulation, cool roofs, and duct sealing.

2.2.1 Building Envelope & Duct Measures

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

Attic Insulation: Add attic insulation in buildings with vented attic spaces to meet either R-38 or R-49. The pre-1978 vintage assumes an existing condition of R-11, the 1978-1991 vintage assumes an existing condition of R-19, and the 1992-2010 vintage assumes R-30 as the existing insulation level. For pre-1978 vintage homes this measure was also evaluated to include air sealing of the attic. A 14% leakage reduction was modeled such that 15 ACH50 was reduced to 12.9 ACH50 in this measure. The costs for this measure include removing existing insulation.

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 homes would be leakier than newer buildings and that approximately 30 percent improvement in air leakage is 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), to ten to seven ACH50 for the 1978-1991 vintage, and 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 0.20 or 0.25 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 0.20 or 0.25. This is similar to cool roof requirements in 2022 Title 24 Section 150.2(b)1li but assumes a higher solar reflectance.

Radiant Barrier: Add radiant barrier to any existing home vintage. 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 includes a laminated radiant barrier.

Raised Floor Insulation: In existing homes with raised floors and no insulation (pre-1978 and 1978-1991 vintages), add R-19 insulation. An upgraded R-30 floor insulation, assuming no current insulation, was evaluated in the pre-1978 and 1978-1991 vintages.

Wall Insulation: Blow-in R-13 wall insulation in existing homes without wall insulation (pre-1978 vintages).

Window Replacement: Replace existing windows with a non-metal dual-pane product, which has a U-factor equal to 0.28 Btu/hour-ft²-°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 was evaluated.

Duct Sealing, New Ducts, and Duct Insulation: Air seal all ductwork to meet the requirements of the 2022 Title 24, Part 6 Section 150.2(b)1E. For this analysis, final duct leakage values of ten percent (proposed revised leakage rate for 2022 Title 24) was evaluated. The pre-1978 and 1978-1992 vintages assume leaky existing ducts (25-30% leakage). The 1992-2010 vintage assumes moderately leaky existing ducts (15-20% leakage).

Replacing existing ductwork with entirely new ductwork to meet Sections 150.2(b)1Di and 150.2(b)1Diia of the 2022 Title 24 was also evaluated. This assumed new ducts meet 5% duct leakage and the option of R-6 and R-8 duct insulation in all climate zones.

Table 3 summarizes the cost assumptions for the building envelope and HVAC duct improvement measures evaluated. All the measures in Table 3 assume a 30-year effective useful life.

Table 3. Measure Cost Assumptions – Efficiency & Duct Measures

Measure	Performance Level	Incremental Cost – Single Family Building		
		Pre 1978	1978 – 1991	1992 - 2010
Wall Insulation	R-13	\$2,950	N/A	N/A
Raised Floor Insulation	R-19	\$3,633	\$3,633	N/A
	R-30	\$4,113	\$4,113	\$4,113
Attic Insulation	R-38	\$6,762	\$2,555	\$1,781
	R-49	\$7,446	\$3,612	\$1,827
Air Sealing	10 ACH50	\$4,684	N/A	N/A
	7 ACH50	N/A	\$4,684	N/A
	5 ACH50	N/A	N/A	\$4,684
Cool Roof	0.25 Aged Solar Reflectance CZs 1-3,5-7,16	\$2,407	\$2,407	\$2,407
	0.25 Aged Solar Reflectance CZs 4, 8-15	\$1,203	\$1,203	\$1,203
Window U-factor/SHGC	0.28 U-factor. 0.23 SHGC in CZs 2,4,6-15.	\$11,463	\$11,463	\$11,463
	0.28 U-factor. 0.35 SHGC in CZs 1,3,5,26	\$11,871	\$11,871	\$11,871
Radiant Barrier	Add Radiant Barrier	\$893	\$893	\$893
Duct Sealing	10% nominal airflow	\$2,590	\$2,590	\$1,400
All New Duct System	R-6 ducts; 5% duct leakage	\$4,808	\$4,808	\$4,808
	R-8 ducts; 5% duct leakage	\$6,311	\$6,311	\$6,311

2.2.2 PV Measures

Installation of on-site PV is required in the 2022 Title 24 code for new construction homes, but there are no PV requirements for additions or alterations to existing buildings. PV was evaluated in CBECC-Res according to the California Flexible Installation (CFI) 1 assumptions and 98% solar access. To meet CFI eligibility, the requirements of 2022 Reference Appendices JA11.2.2 (California Energy Commission, 2021b) must be met. A 3 kW PV system was modeled both as a standalone measure as well as coupled with heat pump installations.

The costs for installing PV are summarized in Table 4. They include the first cost to purchase and install the system, future inverter replacement costs, and annual maintenance costs. Upfront solar PV system costs are estimated from the contractor surveys to be \$4.58/W_{DC} and are reduced by 30 percent to account for the federal income Residential Clean Energy Credit. The solar panels are estimated to have an effective useful life of 30 years and the inverter 25 years. The inverter replacement cost of \$7,000 (future value) is also from the contractor surveys. System maintenance costs are taken from the 2019 PV CASE Report (California Energy Commission, 2017) and are assumed to be

\$0.31/W_{DC} present value. These costs do not include costs associated with electrical panel upgrades, which will be necessary in some instances.

Table 4. Measure Descriptions & Cost Assumptions – PV

Measure	Performance Level	Incremental Cost		
		Pre 1978	1978 – 1991	1992 - 2010
PV	3 kW			\$9,608

2.2.3 Equipment Fuel Substitution Measures – Heat Pump Equipment

The fuel substitution measures are evaluated as replacements at the end of the life of the existing equipment. This means the baseline compared against is usually a like-for-like change-out of the natural gas equipment, and the upgrade is a heat pump.

For most of the space heating and water heating cases, costs for electrical service panel upgrades are not included as it is assumed many existing homes have the service capacity to support converting one appliance from gas to electric. For homes with existing air conditioners, any incremental electric capacity necessary to support a heat pump space heater is marginal. The same applies for homes with existing electric resistance equipment. Section 3.2.4 presents the impacts for select cases where an upgrade to the electric panel is required.

Heat Pump Space Heating

All the heat pump space heater (HPSH) measures are described below. All were evaluated with HERS verified refrigerant charge aligned with the proposed code requirements for the 2025 Title 24 code. Dual fuel heat pumps (DFHPs) were controlled to lockout furnace operation above 35°F.

DFHP (Existing Furnace): Replace existing ducted air conditioner (AC) with an electric heat pump and install controls to operate the heat pump to use the existing gas furnace for backup heat. A minimum federal efficiency (14.3 SEER2, 11.7 EER2, 7.5 HSPF2) heat pump was evaluated. Savings are compared to a new AC (14.3 SEER2, 11.7 EER2) alongside the existing furnace (78 AFUE).

DFHP (New Furnace): Replace existing ducted AC and natural gas furnace with an electric heat pump and new gas furnace plus controls to operate the heat pump and use the new gas furnace for backup heat. A minimum federal efficiency (14.3 SEER2, 11.7 EER2, 7.5 HSPF2) heat pump and furnace (80 AFUE) were evaluated to replace existing equipment. Savings are compared to a new ducted AC and natural gas furnace (14.3 SEER2, 11.7 EER2, 80 AFUE).

Heat Pump Space Heater: Replace existing ducted AC and natural gas furnace with an electric heat pump. Minimum federal efficiency (14.3 SEER2, 11.7 EER2, 7.5 HSPF2) and higher efficiency (17 SEER2, 12.48 EER2, 9.5 HSPF2) heat pumps were evaluated. Savings are compared to a new ducted natural gas furnace and AC (14.3 SEER2, 11.7 EER2, 80 AFUE).

Ducted Mini-Split Heat Pump (MSHP): Replace existing ducted AC and natural gas furnace with a ducted high efficiency MSHP (16.5 SEER2, 12.48 EER2, 9.5 HSPF2). Savings are compared to a new ducted AC and natural gas furnace (14.3 SEER2, 11.7 EER2, 80 AFUE).

Ductless MSHP: In a home without AC, replace existing wall furnace with a ductless MSHP. A standard efficiency unit meeting minimum federal efficiency standards (14.3 SEER2, 11.7 EER2, 7.5 HSPF2) was evaluated by modeling the variable capacity heat pump (VCHP) compliance credit in CBECC-Res. A premium, higher efficiency upgrade was also

evaluated using CBECC-Res' detailed VCHP model¹² by simulating the performance of a representative high efficiency product (14.3 SEER2, 11.7 EER2, 7.5 HSPF2). Savings are compared to a new natural gas wall furnace with fan distribution (75% AFUE) and window AC (9 CEER).

Over the 30-year analysis period, certain changes are assumed when the equipment is replaced that impact both lifetime costs and energy use. Table 5 presents the lifetime scenario for the DFHP (existing furnace) measure. The analysis assumed a 20-year effective useful lifetime (EUL) for a furnace, a 15-year EUL for an air conditioner and a 15-year EUL for a heat pump. Lifetimes are based on the Database for Energy Efficient Resources (DEER) (California Public Utilities Commission, 2021b). The existing furnace is assumed to be halfway through its EUL at the beginning of the analysis period. After 10 years when the furnace reaches the end of its life and needs to be replaced, it will be subject to new federal efficiency standards for residential gas furnaces that go into effect in 2028 requiring 95 AFUE¹³. 5 years later the air conditioner reaches the end of its life and is replaced with a new air conditioner.

For the DFHP upgrade case, after 10 years when the furnace fails it's expected that the furnace will be abandoned in place since the heat pump serves primary heating and was sized to provide the full design heating load. In this case it is assumed that the fan motor would be replaced with a new aftermarket unit and would operate another 5 years until the heat pump fails and is replaced with a new heat pump and air handler.

The other ducted heat pump cases similarly apply a 95 AFUE furnace in the baseline when the furnace reaches its EUL after 20 years.

Table 5. Lifetime Analysis Replacement Assumptions for DFHP (Existing Furnace) Scenario

Year	Baseline	Upgrade
0	AC fails, install new AC, keep existing furnace	AC fails, install new HP, keep existing furnace
10	Furnace fails, install new 95AFUE furnace	Furnace fails, replace fan motor
15	AC fails, install new AC	HP fails, install new HP and air handler

Costs were applied based on the system capacity from heating and cooling load calculations in CBECC-Res as presented in Table 6. Air conditioner nominal capacity was calculated as the CBECC-Res cooling load, rounded up to the nearest half ton. Heat pump nominal capacity was calculated as the maximum of either the CBECC-Res heating or cooling load, rounded up to the nearest half ton. In both cases a minimum capacity of 1.5-ton was applied as this represents the typical smallest available split system heat pump equipment. Load calculations demonstrated that Climate Zones 2 - 15 were cooling-dominated while Climate Zones 1 and 16 were heating-dominated. In the heating dominated climate zones the heat pump needed to be upsized relative to an air conditioner that only provides cooling.

¹² The detailed VCHP option allows for the user to input detailed specifications based on the published National Energy Efficiency Partnership (NEEP) manufacturer specific performance data. It is not currently available for compliance analysis.

¹³ <https://www.energy.gov/articles/doe-finalizes-energy-efficiency-standards-residential-furnaces-save-americans-15-billion#:~:text=These%20furnace%20efficiency%20standards%20were,heat%20for%20the%20living%20space.>

Table 6. System Sizing by Climate Zone

Climate Zone	Air Conditioner Capacity (tons)	Heat Pump Capacity (tons)
1	1.5	3.0
2	3.5	3.5
3	2.5	2.5
4	3.5	3.5
5	3.0	3.0
6	3.0	3.0
7	3.0	3.0
8	4.0	4.0
9	4.0	4.0
10	4.0	4.0
11	4.5	4.5
12	4.0	4.0
13	4.5	4.5
14	4.0	4.0
15	5.0	5.0
16	3.5	4.0

Table 7 presents estimated first and lifetime costs for the various ducted baseline and heat pump scenarios for 4-ton equipment. Costs include all material and installation labor including providing new 240 V electrical service to the air handler location for all new air handler installations and decommissioning of the furnace for the cases where the furnace is removed. DFHP costs incorporate controls installation and commissioning to ensure the heat pump and the furnace communicate properly and don't operate at the same time. Future replacement costs do not include any initial costs associated with 240V electrical service or furnace decommissioning.

Table 8 presents estimated first and lifetime costs for the ductless baseline and 2 heat pump scenarios, also for 4-ton heat pump equipment. EULs are based on 20 years for the gas wall furnace, 10 years for the window AC, and 15 years for the heat pump.¹⁴

¹⁴ The gas wall furnace and heat pump EULs were based on DEER (California Public Utilities Commission, 2021b). Gas wall furnace lifetime was assumed to be the same as for central gas furnace equipment. Room air conditioner EUL was based on the DOE's latest rulemaking for room air conditioned (Department of Energy, 2023). DOE determined an average lifetime of 9.3 years, which was rounded up to 10 years for this analysis.

Table 7. Ducted HVAC Measure Cost Assumptions – 4-Ton Electric Replacements

Case	AC + Coil	Gas Furnace /AC	DFHP (Existing Furnace)	DFHP (New Furnace)	Min. Eff. Heat Pump	High Eff. Heat Pump	Ducted MSHP
Base Case	-	-	AC + Coil	Gas Furnace /AC	Gas Furnace /AC	Gas Furnace /AC	Gas Furnace /AC
First Cost	\$10,402	\$16,653	\$12,362	\$20,676	\$17,825	\$20,802	\$18,075
Replacement Cost (Future Value)	\$19,365	\$19,365	\$19,025	\$19,025	\$16,825	\$19,802	\$18,075
Replacement Cost (Present Value)	\$13,346	\$11,639	\$12,334	\$12,897	\$10,800	\$12,710	\$11,601
Remaining Value at Year 30	\$0	(\$1,846)	\$0	(\$1,846)	\$0	\$0	\$0
Total Lifecycle Cost	\$23,748	\$26,446	\$24,696	\$31,727	\$28,625	\$33,512	\$29,676
Incremental Cost	-	-	\$948	\$5,281	\$2,179	\$7,066	\$3,230

Table 8. Non-Ducted HVAC Measure Cost Assumptions – 4-Ton Electric Replacements

	Wall Furnace + Window AC	Min. Eff. Ductless MSHP	High Eff. Ductless MSHP
First Cost	\$4,075	\$17,412	\$21,342
Replacement Cost (Future Value)	\$4,075	\$17,412	\$21,342
Replacement Cost (Present Value)	\$3,365	\$11,176	\$13,698
Remaining Value at Year 30	(\$532)	\$0	\$0
Total Lifecycle Cost	\$6,908	\$28,588	\$35,040
Incremental Cost	-	\$21,680	\$28,132

Heat Pump Water Heating:

The heat pump water heater (HPWH) measures are described below, and costs are presented in Table 9 and Table 10. The most typical scenario in California is a home with existing natural gas storage tank water heaters. However, there are also many existing homes with existing electric resistance storage tank water heaters and this work considers both baselines. This analysis evaluates the following 65-gallon replacement HPWHs:

1. HPWH that meets the federal minimum efficiency requirements of UEF 2.0
2. HPWH that meets the Northwest Energy Efficiency Alliance (NEEA)¹⁵ Tier 3 rating (3.45 UEF)
3. HPWH that meets the NEEA Tier 4 rating and that has demand response (DR) or load shifting control capability (4.02 UEF)
4. 120V HPWH that meets the NEEA Tier 3 rating (3.3 UEF).

¹⁵ Based on operational challenges experienced in the past, NEEA established rating test criteria to ensure newly installed HPWHs perform adequately, especially in colder climates. The NEEA rating requires an Energy Factor equal to the ENERGY STAR® performance level and includes requirements regarding noise and prioritizing heat pump use over supplemental electric resistance heating.

The four cases above were evaluated with the HPWH located within an attached garage. Additionally, three separate cases for the federal minimum efficiency HPWH were analyzed to consider the impacts of location on performance and cost-effectiveness. These locations included the following:

1. Exterior closet.
2. Interior closet, no ducting.
3. Interior closet, ducted to the outside.

Additional costs for providing electrical wiring to these locations and for providing ductwork were included. Savings are compared to a new 50-gallon natural gas storage water heater (UEF 0.63) or a new 50-gallon electric water heater (UEF 0.92).

For this analysis, a HPWH that just meets the federal minimum efficiency standards of close to 2.0 Uniform Energy Factor (UEF) was evaluated in order to satisfy preemption requirements. However, the Reach Codes Team is not aware of any 2.0 UEF products that are available on the market. The lowest UEF reported for certified products in the Northwest Energy Efficiency Alliance (NEEA)¹⁶ database is 2.73. In fact, of the four certification tiers offered by NEEA for high efficiency HPWHs, those meeting Tier 3 or Tier 4 are the dominant products on the market today. According to NEEA all major HPWH manufacturers are represented in NEEA's qualified product list¹⁷ and there are fewer than 10 integrated products certified as Tier 1 or Tier 2, all of which have UEFs greater than 3.0.¹⁸ Therefore, in this analysis, we refer to the NEEA rated HPWH as the "market standard" HPWH.

The HPWH costs for the 120V and NEEA certified units are based on a larger (60 or 65 gallon) HPWH, as most contractors are upsizing the HPWH tank size relative to an equal volume, but higher capacity gas storage water heater. Costs include all material and installation labor including providing a new 240 V electrical service to the water heater location (not needed for the 120V product). Water heating equipment lifetimes are based on DOE's recent water heater rulemaking (Department of Energy, 2022) and assume 15-year EULs for both the baseline water heaters and the HPWHs.¹⁹ Future replacement costs for 240V HPWHs do not include any initial costs associated with 240V electrical service, condensate disposal, etc.

Table 9. Water Heating Measure Cost Assumptions – Existing Gas

	Gas Storage Water Heater	240V Fed. Min. HPWH	240V Market Std. NEEA HPWH	240V Market Std. NEEA HPWH + DR	120V Market Std. NEEA HPWH	240V Fed. Min. HPWH, Exterior Closet	240V Fed. Min. HPWH, Interior Closet, Not Ducted	240V Fed. Min. HPWH, Interior Closet, Ducted
First Cost	\$2,951	\$7,283	\$8,144	\$8,144	\$5,844	\$7,702	\$7,363	\$8,442
Replacement Cost (Future Value)	\$2,951	\$6,413	\$7,274	\$7,274	\$5,101	\$6,413	\$6,413	\$6,413
Replacement Cost (Present Value)	\$1,894	\$4,116	\$4,669	\$4,669	\$3,274	\$4,116	\$4,116	\$4,116
Total Lifecycle Cost	\$4,845	\$11,399	\$12,813	\$12,813	\$9,118	\$11,818	\$11,479	\$12,558
Incremental Cost	-	\$6,554	\$7,968	\$7,968	\$4,273	\$6,973	\$6,634	\$7,713

¹⁶ Based on operational challenges experienced in the past, NEEA established rating test criteria to ensure newly installed HPWHs perform adequately, especially in colder climates. The NEEA rating requires products comply with ENERGY STAR and includes requirements regarding noise and prioritizing heat pump use over supplemental electric resistance heating.

¹⁷ <https://neea.org/success-stories/heat-pump-water-heaters>

¹⁸ As of 12/21/23: <https://neea.org/img/documents/residential-unitary-HPWH-qualified-products-list.pdf>

¹⁹ The recent DOE rulemaking references a lifetime of 14 years for gas storage water heaters and 14.8 years for electric storage water heaters. 15 years for each was used in this analysis for both types for simplification.

Table 10 presents similar costs to Table 9, except that the costs assume replacement of an existing 50-gallon electric storage water heater and does not include the 240 V electrical service cost.

Table 10. Water Heating Measure Cost Assumptions – Existing Electric Resistance

	Electric Storage Water Heater	240V Fed. Min. HPWH	240V Market Std. NEEA HPWH	240V Market Std. NEEA HPWH + DR	120V Market Std. NEEA HPWH	240V Fed. Min. HPWH, Exterior Closet	240V Fed. Min. HPWH, Interior Closet, Not Ducted	240V Fed. Min. HPWH, Interior Closet, Ducted
First Cost	\$2,583	\$6,413	\$7,274	\$7,274	\$5,101	\$6,413	\$6,413	\$7,492
Replacement Cost (Future Value)	\$2,583	\$6,413	\$7,274	\$7,274	\$5,101	\$6,413	\$6,413	\$6,413
Replacement Cost (Present Value)	\$1,658	\$4,116	\$4,669	\$4,669	\$3,274	\$4,116	\$4,116	\$4,116
Total Lifecycle Cost	\$4,241	\$10,529	\$11,943	\$11,943	\$8,375	\$10,529	\$10,529	\$11,608
Incremental Cost	-	\$6,288	\$7,702	\$7,702	\$4,134	\$6,288	\$6,288	\$7,367

3 Results

The primary objective of the evaluation is to identify cost-effective energy upgrade measures and packages for existing single family 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 at burnout of mechanical equipment. In this report, the 1992-2010 vintage is shown for the equipment measures because it is the most conservative case (lowest loads), while the pre-1978 vintage is shown for the envelope and duct measures because some of those measures only apply to the pre-1978 vintage. A full dataset of all results can be downloaded at <https://localenergycodes.com/content/resources>. Results alongside policy options can also be explored using the Cost-effectiveness Explorer at <https://explorer.localenergycodes.com/>.

3.1 Cost-Effectiveness Results

The extensive analysis for this type of report leads to an overwhelming number of scenarios including different base cases, house vintages, replacement options, and climate zones. To simplify the reporting, the Statewide Reach Codes Team has relied on graphical representation of select key cases indicating high level measure cost effectiveness from either an On-Bill perspective, an LSC perspective, both metrics, or neither. Figure 1 through Figure 13 present this reduced set of results of the LSC and On-Bill cost-effectiveness conclusions across the 16 climate zones. In the cases where there are multiple utilities serving a single climate zone, an asterisk "*" label is added to separately show the alternate utility cases. These graphs provide a general sense of the findings. A full dataset of all results can be downloaded at <https://localenergycodes.com/content/resources>. Results alongside policy options can also be explored using the Cost-effectiveness Explorer at <https://explorer.localenergycodes.com/>.

3.1.1 HPSH Measures

Figure 1 through Figure 5 show the cost-effectiveness of space heating equipment replacement measures for the 1992-2010 vintage including the following cases. The 1992-2010 vintage results are presented here as this is the most conservative scenario for HPSH measures. In general, where a HPSH measure is cost-effective for a new home it was also found to be cost-effective for older homes.

- Dual fuel heat pump with existing furnace as backup.
- Standard efficiency ducted central heat pump replacement.
- High efficiency ducted central heat pump replacement.
- Ducted mini-split heat pump replacement.
- Standard efficiency ducted central heat pump replacement with 3kW PV system.

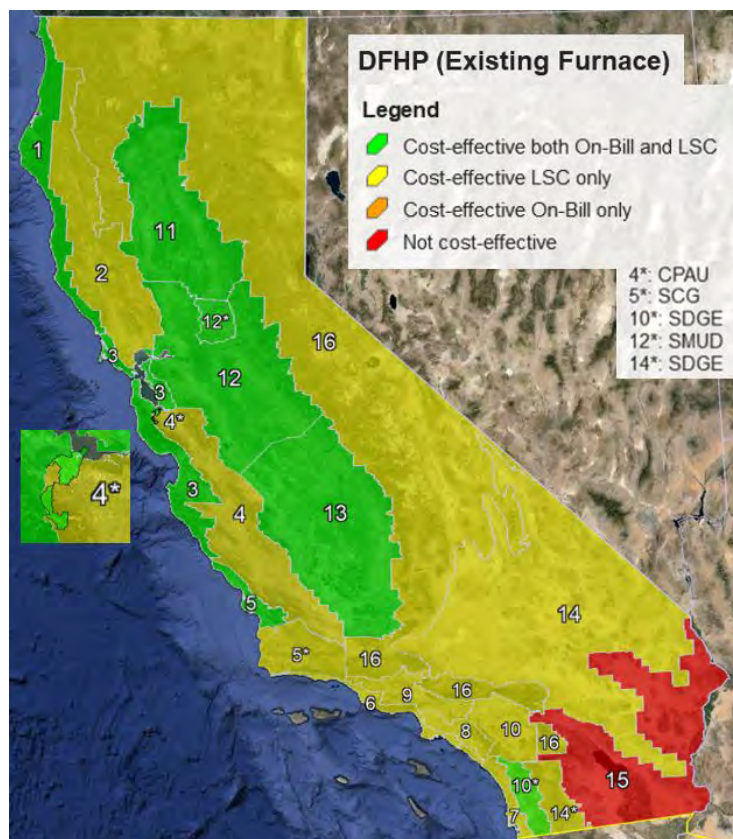


Figure 1: DFHP with Existing Furnace

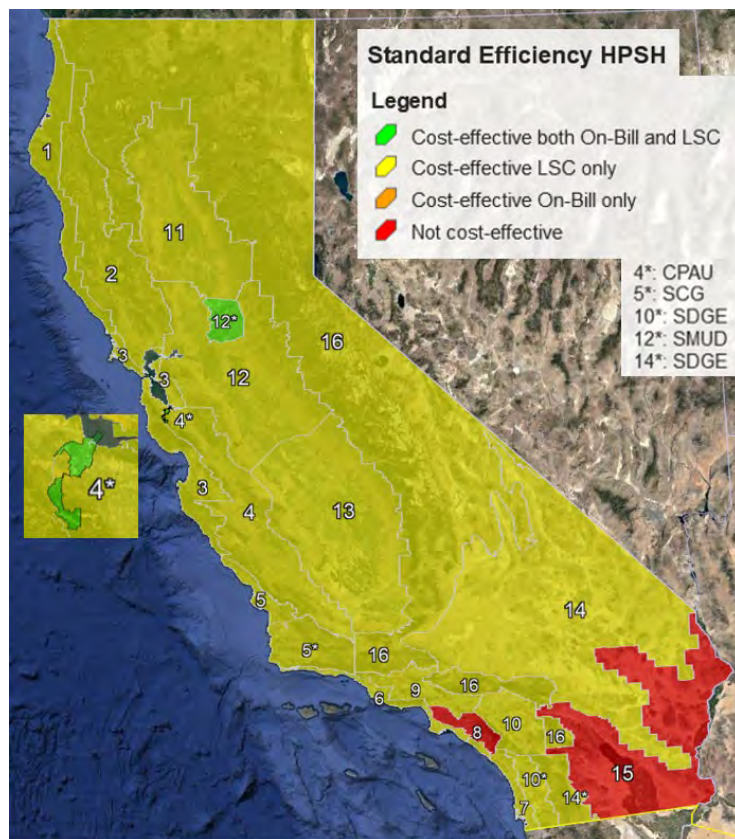


Figure 2: Standard Efficiency HPSH

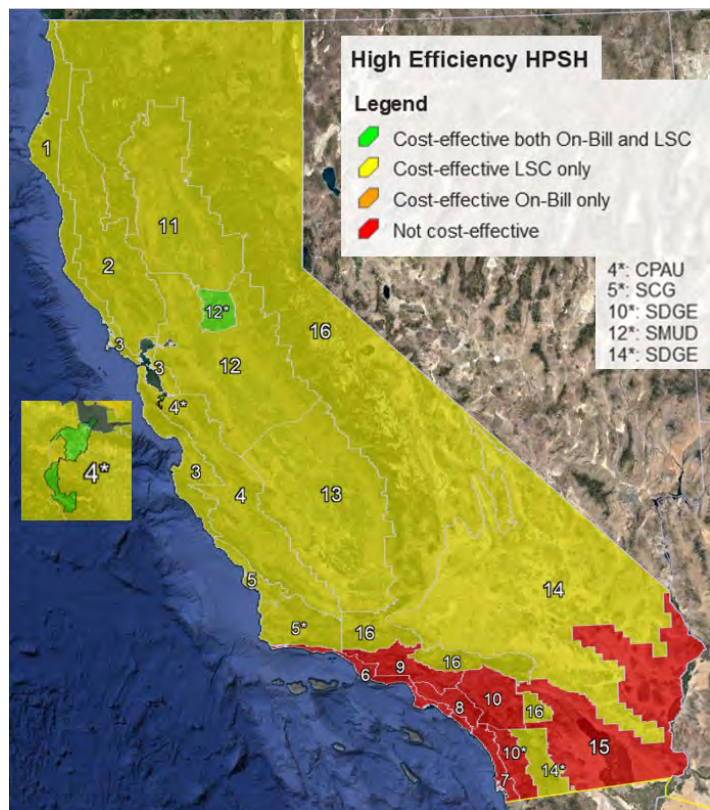


Figure 3: High Efficiency HPSH

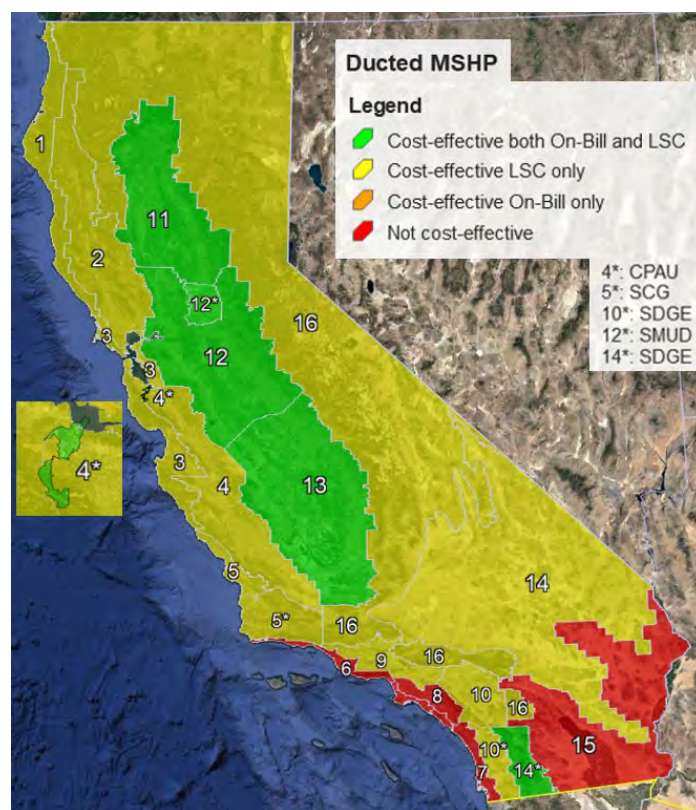


Figure 4: Ducted MSHP

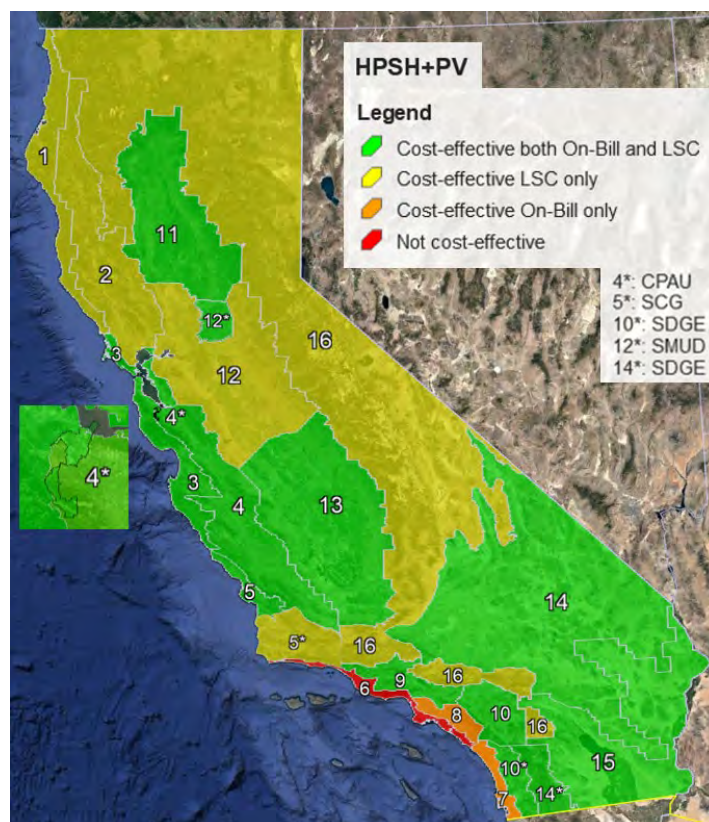


Figure 5: HPSH + PV

3.1.2 HPWH Measures

Figure 6 through Table 11 show the cost-effectiveness of water heater measures for the 1992-2010 vintage including the following cases. HPWH energy savings and LSC cost-effectiveness is not sensitive to home vintage but rather depends on the magnitude of hot water loads, which are typically driven by the number of occupants. On-Bill cost-effectiveness does vary slightly by vintage due to the impact of the electrification tariff relative to the load profile of the existing home. The impact is largest for the HPWH + PV case where On-Bill cost-effectiveness improves for older homes or homes with overall higher energy use resulting in less exports to the grid for a fixed size PV system.

- 240V federal minimum HPWH
- 240V market standard NEEA HPWH
- 120V market standard NEEA HPWH
- 240V federal minimum HPWH with 3kW PV

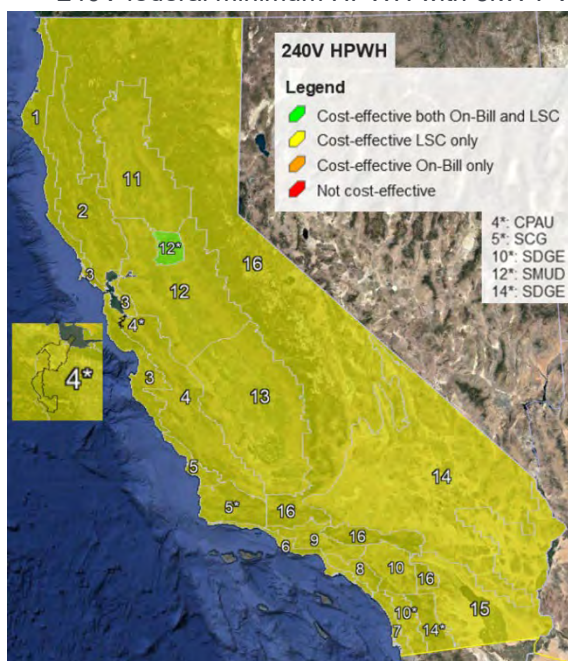


Figure 6: 240V Federal Minimum HPWH

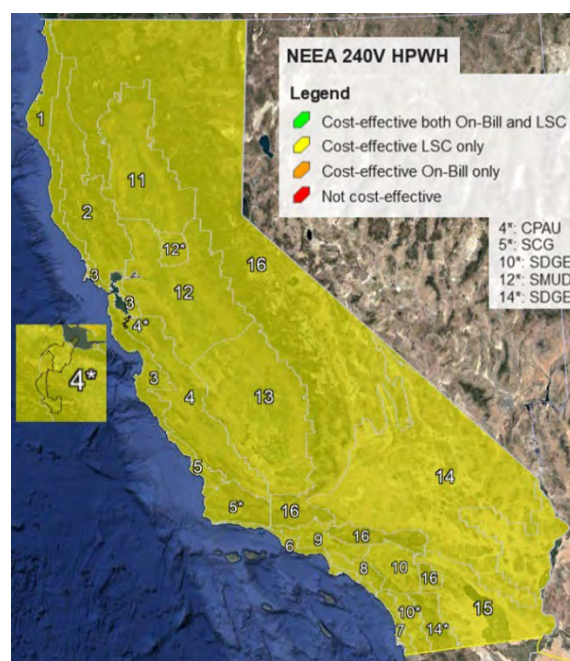


Figure 7: 240V Market Standard NEEA HPWH

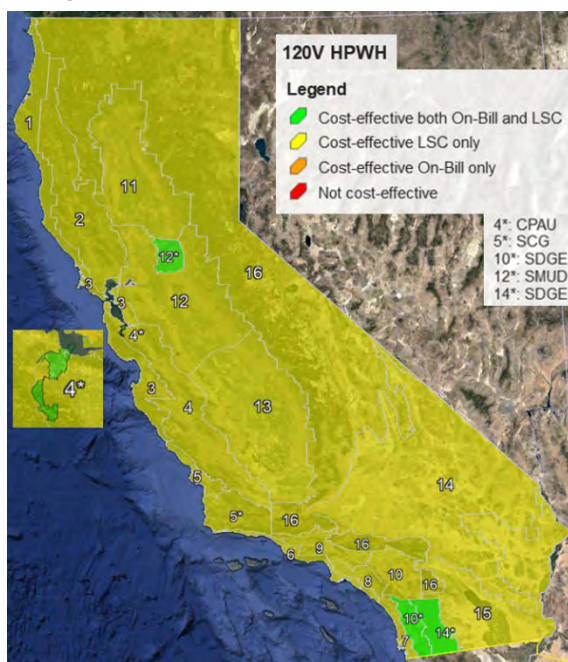


Figure 8: 120V Market Standard NEEA HPWH

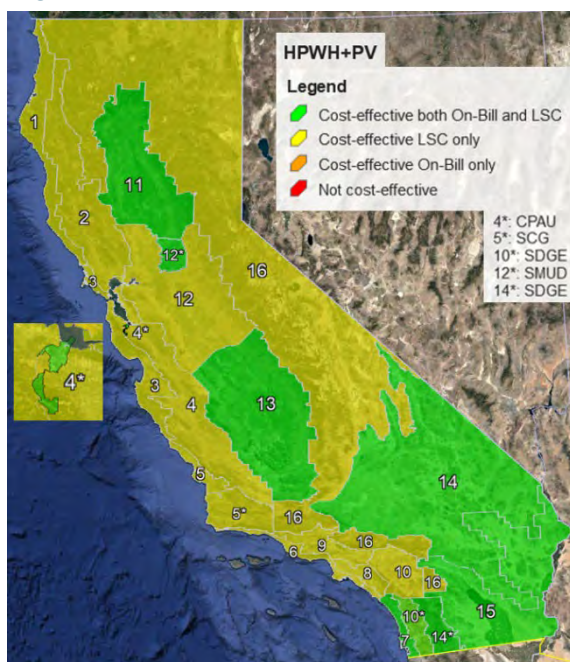
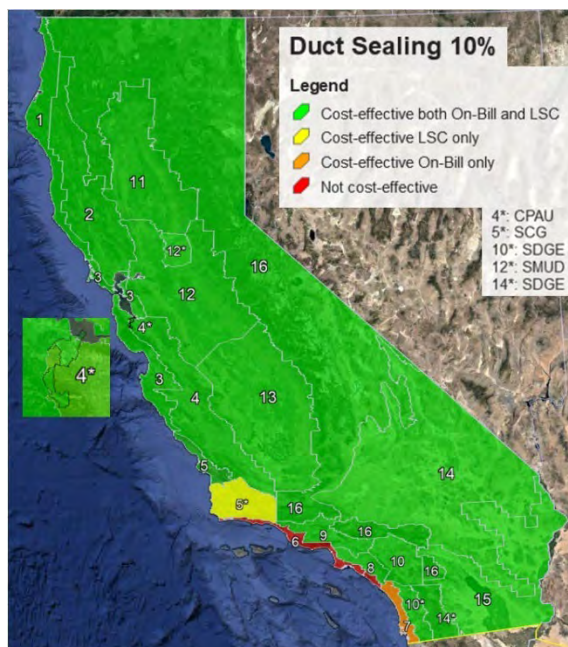
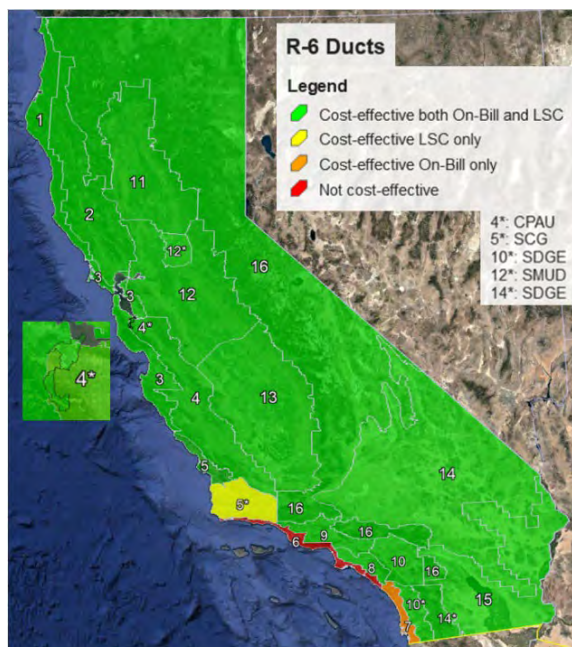


Figure 9: 240V Federal Minimum HPWH + PV

- Envelope and Duct Measures

Figure 10 through Figure 13 show the cost-effectiveness results of envelope and duct measures for the pre-1978 vintage including the following measures. The pre-1978 vintage is presented as representing the most favorable existing conditions for cost-effective upgrades. Newer homes with higher performing envelope may still benefit from these types of upgrade measures, but cost-effectiveness is reduced. Some measures, like R-13 wall insulation, aren't applicable to newer homes which would have been constructed originally with insulated walls.

- New R-6 ducts
- 10% duct leakage
- R-13 wall insulation
- R-49 attic insulation



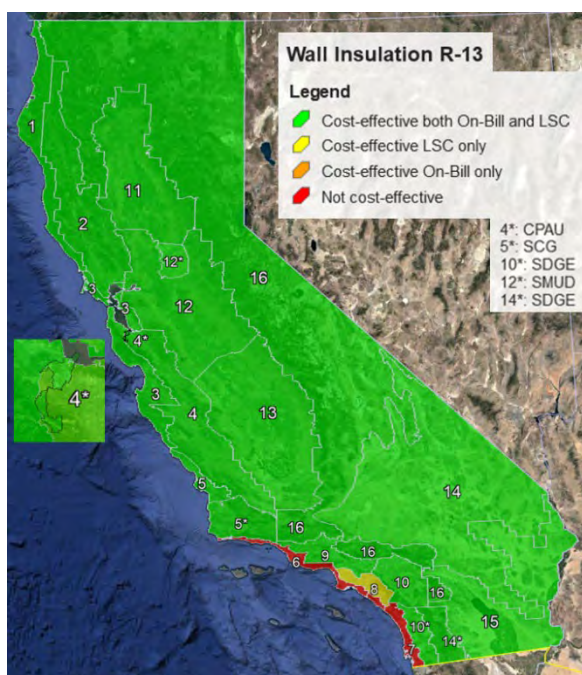


Figure 10: R-6 Ducts

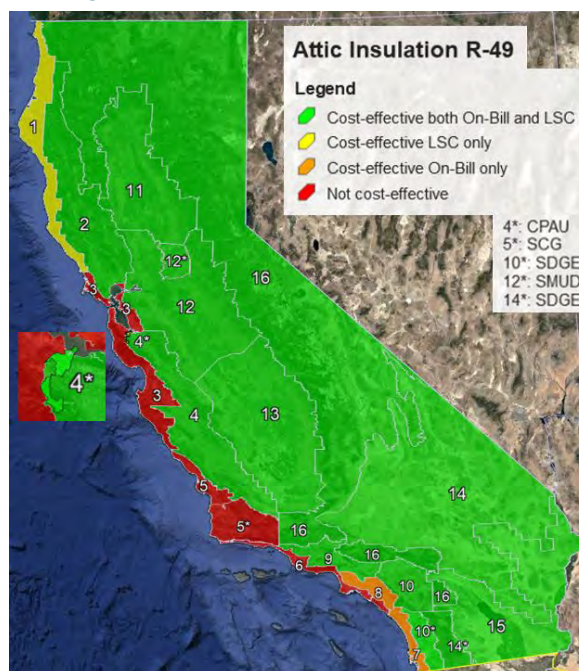


Figure 11: 10% Duct Leakage

Figure 12: R-13 Wall Insulation

Figure 13: R-49 Attic Insulation

3.2 Climate Zone Case Studies

To better understand the details of the results, a few climate zones were selected to provide a more detailed presentation of cost-effectiveness results. Section 3.2.1 through 3.2.3 show the first-year incremental cost, first-year utility savings, and NPV for a variety of cases. Section 3.2.4 shows the sensitivity of the cost effectiveness results due to varying utility escalation rates, the impact of CARE rates, future equipment cost assumptions, and the need for electrical panel upgrades. The climate zones were selected to be representative of areas of significant reach code activity. Please refer to the Cost-Effectiveness Explorer (Statewide Reach Codes, 2023) or the source dataset for the full analysis.

3.2.1 HPSH Cost-Effectiveness

Cost-effectiveness of heat pump space heating measures for Climate Zones 12 and 16 is summarized in Table 11 and Table 12 below. In Climate Zone 12, HPSH measures are cost-effective based on LSC in all cases except the ductless MSHP cases and are cost-effective On-Bill with SMUD rates in all cases except the DFHP case with a new furnace and the ductless MSHP cases. These measures are cost-effective On-Bill with PGE for the DFHP with an existing furnace and ducted MSHP measures. Climate Zone 16 provides an example of HPSH cost-effectiveness in a cold climate where almost all HPSH measures are cost effective based on LSC but not cost-effective On-Bill.

Table 11. HPSH CZ 12 [1992-2010]

Measure	First Incremental Cost	2025 LSC NPV	PGE		SMUD	
			First-year Utility Savings	On-Bill NPV	First-year Utility Savings	On-Bill NPV
DFHP Existing Furnace	\$1,960	\$7,093	(\$19)	\$1,633	\$247	\$7,693
DFHP New Furnace	\$4,023	\$3,915	(\$34)	(\$3,134)	\$234	\$2,979
HPSH (Std Efficiency)	\$1,172	\$6,990	(\$147)	(\$2,151)	\$246	\$6,812
HPSH (High Efficiency)	\$4,149	\$5,366	\$13	(\$3,368)	\$300	\$3,160
Ducted MSHP	\$1,421	\$9,136	\$10	\$378	\$298	\$6,951
Ductless MSHP (Std Efficiency)	\$13,336	(\$9,175)	\$30	(\$18,039)	\$276	(\$12,428)
Ductless MSHP (High Efficiency)	\$17,266	(\$6,753)	\$409	(\$15,853)	\$423	(\$15,532)
HPSH + PV	\$10,780	\$5,289	\$452	(\$59)	\$885	\$9,821

Table 12. HPSH CZ 16 [1992-2010]

Measure	First Incremental Cost	2025 LSC NPV	PGE	
			First-year Utility Savings	On-Bill NPV
DFHP Existing Furnace	\$2,397	\$7,289	(\$116)	(\$1,891)
DFHP New Furnace	\$4,757	\$2,457	(\$133)	(\$6,322)
HPSH (Std Efficiency)	\$2,725	\$11,142	(\$480)	(\$8,532)
HPSH (High Efficiency)	\$5,701	\$12,099	(\$204)	(\$7,125)
Ducted MSHP	\$2,155	\$16,554	(\$221)	(\$2,853)
Ductless MSHP (Std Efficiency)	\$13,336	(\$134)	(\$170)	(\$19,742)
Ductless MSHP (High Efficiency)	\$17,266	\$9,397	\$539	(\$10,031)
HPSH + PV	\$12,333	\$10,640	\$316	(\$1,949)

3.2.2 HPWH Cost-Effectiveness

Cost-effectiveness of heat pump water heating measures for Climate Zones 12 and 16 is summarized in Table 13 and Table 14 below. This sensitivity study looks at a wider range of HPWH tank locations and whether or not the unit has ducting for supply and exhaust air. All the HPWH measures in Climate Zones 12 and 16 are cost effective based on LSC.

Table 13. HPWH CZ 12 [1992-2010]

Measure	First Incremental Cost	2025 LSC NPV	PGE		SMUD	
			First-Year Utility Savings	On-Bill NPV	First-Year Utility Savings	On-Bill NPV
240V Fed. Min. HPWH	\$4,332	\$3,536	(\$213)	(\$8,738)	\$191	\$477
240V Market Std. NEEA HPWH	\$5,193	\$4,304	(\$82)	(\$7,164)	\$230	(\$56)
240V Market Std. NEEA HPWH + DR	\$5,193	\$5,536	(\$21)	(\$5,773)	\$248	\$362
120V Market Std. NEEA HPWH	\$2,893	\$9,730	(\$2)	(\$1,651)	\$254	\$4,203
240V Fed. Min. HPWH (Exterior Closet)	\$4,751	\$2,834	(\$224)	(\$9,431)	\$186	(\$78)
240V Fed. Min. HPWH (Interior Closet)	\$4,413	\$3,123	(\$71)	(\$6,138)	\$188	(\$235)
240V Fed. Min. HPWH (Interior Closet, ducted)	\$5,492	\$3,359	(\$202)	(\$9,505)	\$205	(\$231)
240V Fed. Min. HPWH + PV	\$13,940	\$3,567	\$577	(\$2,300)	\$831	\$3,486

Table 14. HPWH CZ 16 [1992-2010]

Measure	First Incremental Cost	2025 LSC NPV	PGE	
			First-Year Utility Savings	On-Bill NPV
240V Fed. Min. HPWH	\$4,332	\$4,186	(\$250)	(\$9,307)
240V Market Std. NEEA HPWH	\$5,193	\$4,088	(\$160)	(\$8,652)
240V Market Std. NEEA HPWH + DR	\$5,193	\$5,653	(\$79)	(\$6,804)
120V Market Std. NEEA HPWH	\$2,893	\$10,646	(\$13)	(\$1,602)
240V Fed. Min. HPWH (Exterior Closet)	\$4,751	\$3,317	(\$268)	(\$10,154)
240V Fed. Min. HPWH (Interior Closet)	\$4,413	\$5,004	(\$18)	(\$4,690)
240V Fed. Min. HPWH (Interior Closet, ducted)	\$5,492	\$4,857	(\$202)	(\$9,174)
240V Fed. Min. HPWH + PV	\$13,940	\$5,049	\$620	(\$1,043)

3.2.3 Envelope & Duct Improvement Cost-Effectiveness

Cost-effectiveness of envelope and duct measures for Climate Zones 3, 10, and 12 is summarized in Table 15 through Table 17.

Table 15. Envelope and Duct Measures CZ 3 [Pre-1978]

Measure	First Incremental Cost	2025 LSC NPV	PG&E	
			First-year Utility Savings	On-Bill NPV
R-6 Ducts	\$4,808	\$2,851	\$188	\$463
R-8 Ducts	\$6,311	\$1,747	\$198	(\$776)
10% Duct Sealing	\$2,590	\$1,956	\$104	\$397
R-13 Wall Insulation	\$2,950	\$3,476	\$144	\$1,221
R-38 Attic Insulation	\$6,762	(\$1,567)	\$127	(\$3,178)
R-49 Attic Insulation	\$7,446	(\$1,768)	\$139	(\$3,520)
R-30 Raised Floor Insulation	\$4,113	\$9,008	\$224	\$2,975
Cool Roof (0.20 Ref)	\$893	(\$2,419)	(\$18)	(\$1,811)

Table 16. Envelope and Duct Measures CZ 10 [Pre-1978]

Measure	First Incremental Cost	2025 LSC NPV	SCE/SCG		SDGE	
			First-year Utility Savings	On-Bill NPV	First-year Utility Savings	On-Bill NPV
R-6 Ducts	\$4,808	\$7,463	\$783	\$13,168	\$1,100	\$22,155
R-8 Ducts	\$6,311	\$6,326	\$800	\$12,076	\$1,125	\$21,268
10% Duct Sealing	\$2,590	\$3,438	\$370	\$5,969	\$518	\$10,166
R-13 Wall Insulation	\$2,950	\$1,795	\$179	\$1,476	\$250	\$3,494
R-38 Attic Insulation	\$6,762	\$664	\$416	\$2,951	\$582	\$7,654
R-49 Attic Insulation	\$7,446	\$796	\$467	\$3,435	\$655	\$8,756
R-30 Raised Floor Insulation	\$4,113	(\$999)	(\$29)	(\$4,235)	(\$46)	(\$4,687)
Cool Roof (0.20 Ref)	\$893	\$428	\$174	\$2,647	\$246	\$4,656

Table 17. Envelope and Duct Measures CZ 12 [Pre-1978]

Measure	First Incremental Cost	2025 LSC NPV	PG&E		SMUD	
			First-year Utility Savings	On-Bill NPV	First-year Utility Savings	On-Bill NPV
R-6 Ducts	\$4,808	\$11,609	\$804	\$14,727	\$413	\$5,816
R-8 Ducts	\$6,311	\$10,722	\$828	\$13,849	\$427	\$4,711
10% Duct Sealing	\$2,590	\$6,418	\$397	\$7,280	\$222	\$3,281
R-13 Wall Insulation	\$2,950	\$5,774	\$262	\$4,054	\$187	\$2,342
R-38 Attic Insulation	\$6,762	\$3,727	\$499	\$5,461	\$261	\$19
R-49 Attic Insulation	\$7,446	\$4,092	\$552	\$6,063	\$288	\$33
R-30 Raised Floor Insulation	\$4,113	\$5,245	\$27	(\$1,176)	\$156	\$1,175
Cool Roof (0.20 Ref)	\$893	(\$354)	\$154	\$2,123	\$44	(\$386)

3.2.4 Sensitivities

Table 18 shows the On-Bill NPV results of Climate Zone 12 with PG&E utility rates and the impacts of escalation rates, and CARE rates. The “Standard Results” in Table 18 assumes the escalation rates used in the analysis presented elsewhere in this report. Table 19 shows the impact of electrical panel upgrades. The “Standard Results” in Table 19 does not assume a panel upgrade is required.

Table 18. Sensitivity Analysis Results for On-Bill NPV Cost-Effectiveness in Climate Zone 12, PG&E

Measure	Vintage	Standard Results	2025 LSC Escalation	CARE
DFHP Existing Furnace	1992-2010	\$1,063	\$8,443	\$1,884
DFHP New Furnace	1992-2010	(\$6,770)	\$383	(\$5,846)
HPSH (Std Efficiency)	1992-2010	(\$2,151)	\$6,011	(\$220)
HPSH (High Efficiency)	1992-2010	(\$3,368)	\$4,987	(\$2,721)
Ducted MSHP	1992-2010	\$378	\$8,729	\$1,057
Ductless MSHP (Std Efficiency)	1992-2010	(\$18,039)	(\$10,732)	(\$17,623)
Ductless MSHP (High Efficiency)	1992-2010	(\$15,853)	(\$8,091)	(\$18,460)
HPSH + PV	1992-2010	(\$59)	\$8,822	(\$1,255)
240V Fed. Min. HPWH	1992-2010	(\$8,738)	(\$2,433)	(\$6,448)
240V Market Std. NEEA HPWH	1992-2010	(\$7,164)	(\$694)	(\$5,918)
240V Market Std. NEEA HPWH + DR	1992-2010	(\$5,773)	\$770	(5,014)
120V Market Std. NEEA HPWH	1992-2010	(\$1,651)	\$4,930	(1,038)
240V Fed. Min. HPWH (Exterior Closet)	1992-2010	(\$9,431)	(\$3,184)	(\$7,055)
240V Fed. Min. HPWH (Interior Closet)	1992-2010	(\$6,138)	(\$1,000)	(\$5,098)
240V Fed. Min. HPWH (Interior Closet, ducted)	1992-2010	(\$9,505)	(\$2,836)	(\$7,271)
240V Fed. Min. HPWH + PV	1992-2010	(\$2,300)	\$4,952	(\$4,858)
R-6 Ducts	Pre-1978	\$14,727	\$18,685	\$8,592
R-8 Ducts	Pre-1978	\$13,849	\$17,990	\$7,532
10% Duct Sealing	Pre-1978	\$7,280	\$9,752	\$4,294
R-13 Wall Insulation	Pre-1978	\$4,054	\$6,898	\$2,196
R-38 Attic Insulation	Pre-1978	\$5,461	\$8,126	\$1,668
R-49 Attic Insulation	Pre-1978	\$6,063	\$8,978	\$1,864
R-30 Raised Floor Insulation	Pre-1978	(\$1,776)	\$2,468	(\$1,602)
Cool Roof (0.20 Ref)	Pre-1978	\$2,123	\$1,848	\$851

Table 19. Electric Panel Upgrade Sensitivity for CZ 12 [1992-2010]

Measure	Standard Results		Electric Panel Upgrade	
	On-Bill NPV	LSC NPV	On-Bill NPV	LSC NPV
HPSH (Std Efficiency)	(\$2,151)	\$6,990	(\$4,931)	\$4,210
240V Fed. Min. HPWH	(\$8,738)	\$3,536	(\$11,624)	\$756

3.3 Gas Pathways for Heat Pump Replacements

Many jurisdictions are exploring policy options to accelerate the decarbonization of existing homes. A recent Ninth Circuit Court ruling in *California Rest. Ass'n v. City of Berkeley*²⁰ invalidated Berkeley's ordinance banning the installation of gas infrastructure in new construction. The ruling stated that the ordinance effectively banned covered products and was preempted by the Energy Policy and Conservation Act ("EPCA"), 42 U.S.C. § 6297(c). Given the possible impacts of that ruling, the Reach Codes Team analyzed policy options targeting equipment replacements that allow for the installation of either electric or gas-fueled equipment. These packages include gas equipment combined with additional efficiency measures resulting in options that are reasonably energy or LSC cost equivalent, to the extent feasible.

For space heating, the heat pump path is a DFHP (existing furnace).. The gas pathway is a new air conditioner with the following list of efficiency upgrades:

- 400 cfm/ton system airflow (HERS verified).
- 0.35 W/cfm fan efficacy (HERS verified).
- Refrigerant charge verification (HERS verified).
- R-8 ducts, 5% leakage (HERS verified).
- R-49 (from R-30) attic insulation.
- Air sealing of the ceiling from 7 to 6.5 ACH50.

The two pathways are presented in Figure 14 comparing total LSC energy use relative to the existing home for the 1992-2010 vintage. In most climate zones, the DFHP (existing furnace) path results in higher energy savings, in the milder climates the air conditioner path saves marginally more energy. A reach code that establishes requirements when an air conditioner is replaced or installed new, could allow for either a heat pump to be installed or an air conditioner as long as the performance measures listed above are met. Note that in this analysis a DFHP (existing furnace) was used; however, a reach code could require a different heat pump measure for the heat pump path. This approach aligns with the CEC's proposal for the 2025 Title 24 code cycle for heat pump alterations in single family homes (California Energy Commission, 2023).

²⁰ *California Rest. Ass'n v. City of Berkeley*, 65 F.4th 1045 (9th Cir. 2023) amended by 89 F.4th 1094 (9th Cir. 2024).

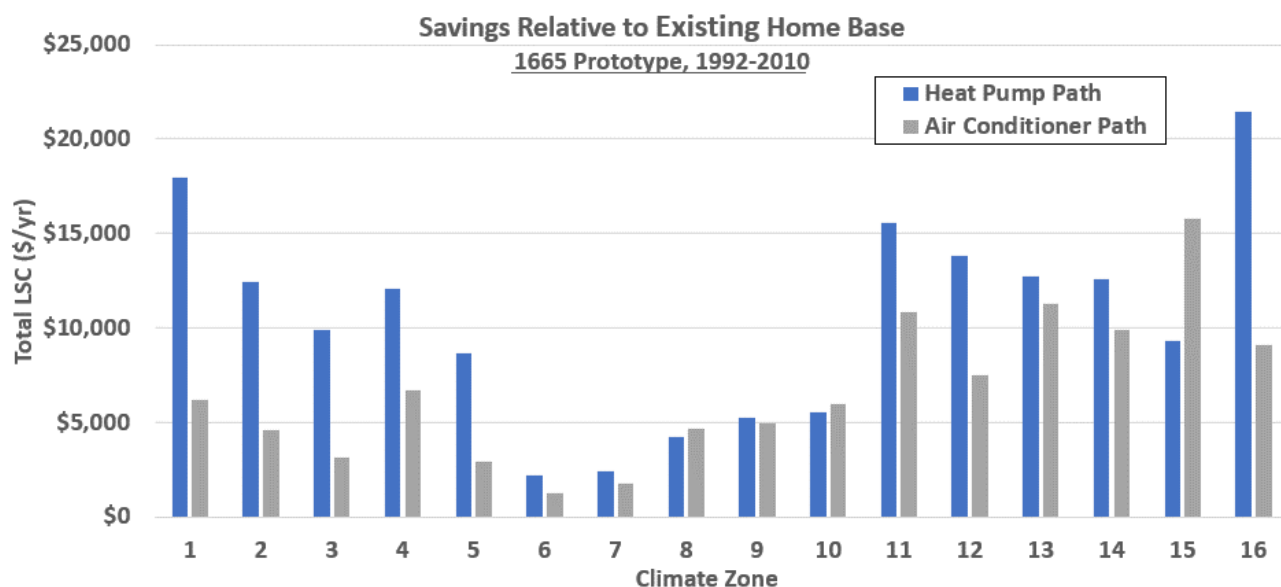


Figure 14. Heat pump space heater path compared to the air conditioner path.

For water heating, the federal minimum HPWH case was used to develop the package. The HPWH was compared to a new gas storage water heater with a 50% solar thermal backup system.

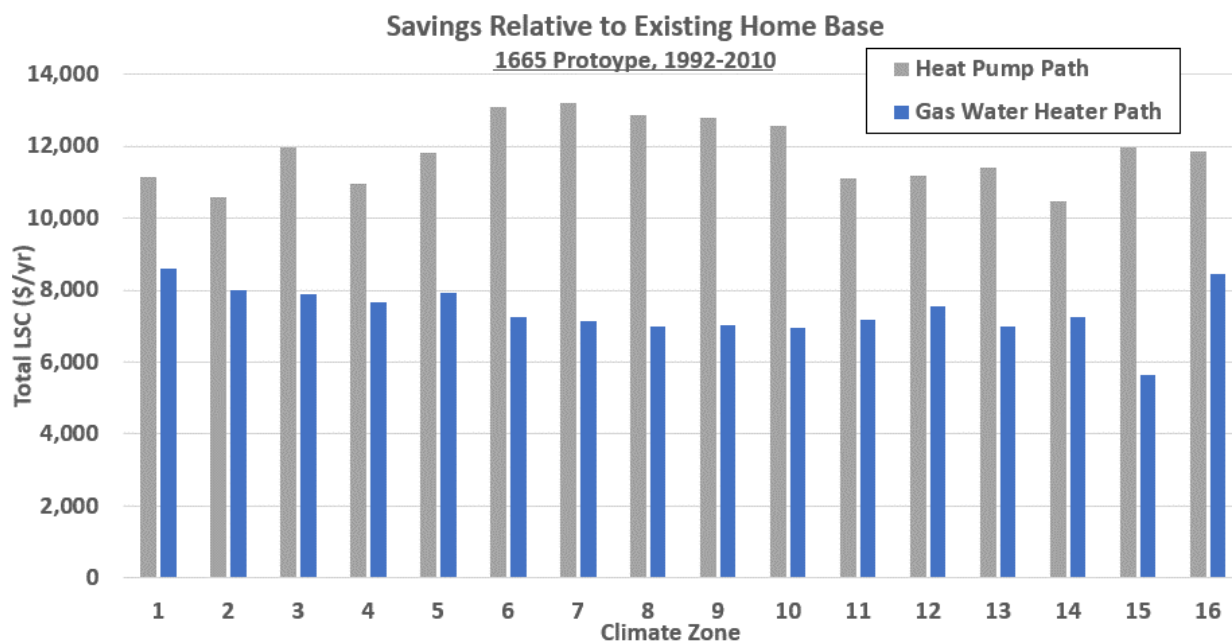


Figure 15. Heat pump water path compared to gas with solar thermal.

The two pathways are presented in Figure 15 comparing total LSC energy use relative to the existing home for the 1992-2010 vintage. In all climate zones, the heat pump path results in higher energy savings than the gas path. A reach code that establishes requirements when a water heater is replaced could allow for either a HPWH to be installed or a gas water heater in combination with a solar thermal system that meets the solar fraction requirements listed above.

4 Recommendations and Discussion

This analysis evaluated the feasibility and cost-effectiveness of retrofit measures in California existing homes built before 2010. The Statewide Reach Codes Team used both On-Bill and LSC-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.

Conclusions and Discussion:

1. Envelope measures. Improving envelope performance is very cost-effective in many older homes. In addition to reducing utility costs these measures provide many other benefits such as improving occupant comfort and satisfaction and increasing a home's ability to maintain temperatures during extreme weather events and power outages. Below is a discussion of the results of specific measures.
 - a. Adding attic insulation is cost effective based on both LSC and On-Bill in many climate zones in homes with no more than R-19 existing attic insulation levels. Increasing attic insulation from R-30 to R-49 was still found to be cost-effective based on at least one metric in the colder and hotter climates of Climate Zone 10 (SDG&E territory only) through 16.
 - b. Insulating existing uninsulated walls is very cost-effective based on both metrics everywhere except Climate Zones 6 and 7 (in Climate Zone 8 it's only cost-effective based on LSC).
 - c. Adding R-19 or R-30 floor insulation is cost-effective based on LSC in the older two vintages (Pre-1978 and 1978-1991) in all climate zones except Climate Zones 6-10.
 - d. Replacing old single pane windows with new high-performance windows has a very high cost and is typically not done for energy savings alone. However, energy savings are substantial and justify cost-effectiveness of this measure based on at least one metric in Climate Zones 4, 8 through 12 (PG&E territory only), and 13 through 16.
 - e. At time of roof replacement, a cool roof with an aged solar reflectance of 0.25 was found to be cost-effective in Climate Zones 4, 6 through 12 (PG&E territory only), and 13 through 15. When the roof deck is replaced during a roof replacement, adding a radiant barrier is low cost and provides substantial cooling energy savings to be cost-effective in almost all climate zones and homes.
2. Duct measures: Many older homes have old, leaky duct systems that should be replaced when they reach the end of life, typically 20-30 years. In this case, installing new ducts was found to be cost-effective based on at least one metric (both in most cases) everywhere except mild Climate Zone 7 and Climate Zones 5 and 6 in the 1978-1991 vintage. If duct systems still have remaining life they should be sealed and tested to meet 10% leakage or lower; however, duct upgrades alone were only found to be cost-effective for newer homes in Climate Zones 10 (SDG&E territory only), 11, and 13 through 16. Duct upgrades may be able to be coupled with other measures to reduce the cost.
3. Heat pump space heating: HPSHs were found to be LSC cost-effective in many cases. The DFHP (existing furnace) was LSC cost-effective everywhere except Climate Zone 15. The HPSH was LSC cost-effective everywhere except Climate Zones 8 and 15.
 - a. Challenges to On-Bill cost-effectiveness include higher first costs and higher first-year utility costs due to higher electricity tariffs relative to gas tariffs. SMUD and CPAU are two exceptions where first year utility costs are lower for heat pumps than for gas equipment. Table 11 shows the impact of utility rates on cost-effectiveness of HPSH where the standard and high efficiency HPSH and the HPSH + PV measures are cost-effective under SMUD but not PG&E. Even with higher first year utility bills, there were some cases that still proved On-Bill cost-effective including the DFHP with an existing furnace in the central valley and northern coastal PG&E territories, the ducted MSHP in the central valley as well as Climate Zone 14 in SDG&E territory, and the HPSH + PV measure in CZ 3-5 (PGE), 7-11, and 12 (SMUD) – 15.
 - b. The ductless MSHPs, evaluated for homes with existing ductless systems, were only found to be cost-effective based on either metric in Climate Zones 1 and 16. Ductless MSHPs have a high incremental cost because it is a more sophisticated system than the base model of a wall furnace with a window AC unit. However, the ductless MSHP would provide greater comfort benefits if properly installed to

directly condition all habitable spaces (as is required under the VCHP compliance credit as evaluated in this study) which may be an incentive for a homeowner to upgrade their system.

- c. Higher efficiency equipment lowered utility costs in all cases and improved cost-effectiveness in many cases, particularly with a ducted MSHP.
4. Heat pump water heating: All the HPWH measures were LSC cost-effective in all climate zones. Most measures were not On-Bill cost-effective with the exception of the HPWH + PV which was cost-effective On-Bill in CPAU, SMUD, and SDG&E territories in addition to Climate Zones 11, 13, 14, and 15. The HPWH measures share many of the same challenges as the HPSH measures to achieving cost-effectiveness including high first costs and utility rates and assumptions. Table 13 shows the impact of utility rates on cost-effectiveness where some HPWH measures are cost-effective under SMUD utility rates but are not cost-effective anywhere under PG&E rates in Climate Zone 12.
 - a. Various HPWH locations were also explored, however there are some factors outside of cost-effectiveness that should also be considered.
 - i. HPWHs in the conditioned space can provide benefits such as free cooling during the summer, reduced tank losses, and shorter pipe lengths, and in some cases show improved cost-effectiveness over garage located HPWHs. However, there are various design considerations such as noise, comfort concerns, and condensate removal. Ducting the inlet and exhaust air resolves comfort concerns but adds costs and complexity. Split heat pump water heaters address these concerns, but currently there are limited products on the market and there is a cost premium relative to the packaged products.
 - ii. Since HPWHs extract heat from the air and transfer it to water in the storage tank, they must have adequate ventilation to operate properly. Otherwise, the space cools down over time, impacting the HPWH operating efficiency. This is not a problem with garage installations but needs to be considered for water heaters located in interior or exterior closets. For the 2025 Title 24 code the CEC is proposing that all HPWH installations meet mandatory ventilation requirements (California Energy Commission, 2023).
 5. The contractor surveys revealed overall higher heat pump costs than what has been found in previous analyses. This could be due to incentive availability raising demand for heat pumps and thereby increasing the price. This price increase may be temporary and may come down once the market stabilizes. There are also new initiatives to obtain current costs including the TECH Clean California program²¹ that publishes heat pump data and costs; however, at the time of this analysis, the TECH data did not contain incremental costs because it only had the heat pump costs but not the gas base case costs.
 6. Table 18 shows how CARE rates and escalation rate assumptions will impact cost-effectiveness.
 - a. Applying CARE rates in the IOU territories has the overall impact to increase utility cost savings for an all-electric building compared to a code compliant mixed fuel building, improving On-Bill cost-effectiveness. This is due to the CARE discount on electricity being higher than that on gas. The reverse occurs with efficiency measures where lower utility rates reduce savings and subsequently reduce cost-effectiveness.
 - b. If gas tariffs are assumed to increase substantially over time, in-line with the escalation assumption from the 2025 LSC development, cost-effectiveness substantially improves for the heat pump measures over the 30-year analysis period and many cases become cost-effective that were not found to be cost-effective under the CPUC / 2022 TDV escalation scenario. There is much uncertainty surrounding future tariff structures as well as escalation values. While it's clear that gas rates will increase, how much and how quickly is not known. Future electricity tariff structures are expected to evolve over time, and the CPUC has an active proceeding to adopt an income-graduated fixed charge that benefits low-income customers and supports electrification measures for all customers.²² The CPUC will decide in mid-2024 and the new rates are expected to be in place later that year or in 2025.

²¹ [TECH Public Reporting Home Page \(techcleanca.com\)](https://techcleanca.com)

²² <https://www.cpuc.ca.gov/industries-and-topics/electrical-energy/electric-costs/demand-response-dr/demand-flexibility-rulemaking>

While the anticipated impact of this rate change is lower volumetric electricity rates, the rate design is not finalized. While lower volumetric electricity rates provide many benefits, it also will make building efficiency measures harder to justify as cost-effective due to lower utility bill cost savings.

7. Under NBT, utility cost savings for PV are substantially less than what they were under prior net energy metering rules (NEM 2.0); however, savings are sufficient to be On-Bill cost-effective in all climate zones except Climate Zones 1 through 3 and 5 through 6.
 - a. Combining a heat pump with PV allows the additional electricity required by the heat pump to be offset by the PV system while also increasing on-site utilization of PV generation rather than exporting the electricity back to the grid at a low rate.
 - b. While not evaluated in this study, coupling PV with battery systems can be very advantageous under NBT increasing utility cost savings because of improved on-site utilization of PV generation and fewer exports to the grid.

Recommendations:

1. There are various approaches for jurisdictions who are interested in reach codes for existing buildings. Some potential approaches are listed below along with key considerations.
 - a. Prescriptive measures: Non-preempted measures that are found to be cost-effective may be prescriptively required in a reach code. One example of this type of ordinance is a cool roof requirement at time of roof replacement. Another example is requiring specific cost-effective measures for larger remodels, such as high-performance windows when new windows are installed or duct sealing and testing where ducts are in unconditioned space.
 - b. Replacement equipment: This flavor of reach code sets certain requirements at time of equipment replacement. This study evaluated space heating and water heating equipment. Where a heat pump measure was found to be cost-effective based on either LSC or On-Bill, this may serve as the basis of a reach code given the following considerations.
 - i. Where reach codes reduce energy usage and are not just fuel switching, cost-effectiveness calculations are required and must be based on equipment that does not exceed the federal minimum efficiency requirements.
 - ii. Where reach codes are established using cost-effectiveness based on LSC, utility bill impacts and the owner's first cost should also be reviewed and considered.
 - iii. A gas path should also be prescriptively allowed to safely satisfy federal preemption requirements considering the CRA v. Berkeley case.²³ Additional requirements may apply to the gas path, as described in Section 3.3, as long as the paths are reasonably energy or cost equivalent.
 - c. "Flexible Path", minimum energy savings target: This flexible approach establishes a target for required energy savings based on a measure or a set of measures that were found to be cost-effective based on either LSC or On-Bill. A points menu compares various potential upgrades ranging from efficiency, PV, and fuel substitution measures, based on site or source energy savings. The applicant must select upgrades that individually or in combination meet the minimum energy savings target. The measures used to set the target should be non-preempted measures.
2. Equipment replacement ordinances should consider appropriate exceptions for scenarios where it will be challenging to meet the requirements, such as location of the HPWH, total project cost limitations, or the need for service panel upgrades that wouldn't have been required as part of the proposed scope of work in absence of the reach code.
3. Consider extending relevant proposals made by the CEC for the 2025 Title 24 code (California Energy Commission, 2023) in ordinances that apply under the 2022 Title 24 code, such as the following:
 - a. Mandatory ventilation requirements for HPWH installations (Section 110.3(c)7).

²³ <https://www.publichealthlawcenter.org/sites/default/files/2024-01/CRA-v-Berkeley-Ninth-Circuit-Opinion-Jan2024.pdf>

- b. Requirement for HERS verified refrigerant charge verification for heat pumps in all climate zones (Table 150.1-A²⁴).
- 4. When evaluating reach code strategies, the Reach Codes Team recommends that jurisdictions consider combined benefits of energy efficiency alongside electrification. Efficiency and electrification have symbiotic benefits and are both critical for decarbonization of buildings. As demand on the electric grid is increased through electrification, efficiency can reduce the negative impacts of additional electricity demand on the grid, reducing the need for increased generation and storage capacity, as well as the need to upgrade upstream transmission and distribution equipment.
- 5. Education and training can play a critical role in ensuring that heat pumps are installed, commissioned, and controlled properly to mitigate grid impacts and maximize occupant satisfaction. Below are select recommended strategies.
 - a. The Quality Residential HVAC Services Program²⁵ is an incentive program to train California contractors in providing quality installation and maintenance while advancing energy-efficient technologies in the residential HVAC industry. Jurisdictions can market this to local contractors to increase the penetration of contractors skilled in heat pump design and installation.
 - b. Educate residents and contractors of available incentives, tax credits, and financing opportunities.
 - c. Educate contractors on code requirements. Energy Code Ace provides free tools, trainings, and resource to help Californians comply with the energy code. Contractors can access interactive compliance forms, fact sheets, and live and recorded trainings, among other things, on the website: <https://energycodeace.com/>. Jurisdictions can reach out to Energy Code Ace directly to discuss offerings.
- 6. Health and safety
 - a. 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 located within the pressure boundary of the building after completion of retrofit work that involves air sealing or insulation measures.
 - b. Jurisdictions may consider requiring mechanical ventilation in homes where air sealing has been conducted. In older buildings, outdoor air is typically introduced through leaks in the building envelope. After air sealing a building, it may be necessary to forcefully bring in fresh outdoor air using supply and/or exhaust fans to minimize potential issues associated with indoor air quality.

²⁴ This requirement does not show up in the Express Terms for alterations in Section 150.2(b)1F, but the Statewide Reach Codes Team expects that it will be added to the next release of the proposed code language in the 45-day language as it aligns with the proposal made by the Codes and Standards Enhancement Team (Statewide CASE Team, 2023).

²⁵ <https://qualityhvac.frontierenergy.com/>

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6 Appendices

6.1 Map of California Climate Zones

Climate zone geographical boundaries are depicted in Figure 16. The map in Figure 16 along with a zip-code search directory is available at: https://ww2.energy.ca.gov/maps/renewable/building_climate_zones.html

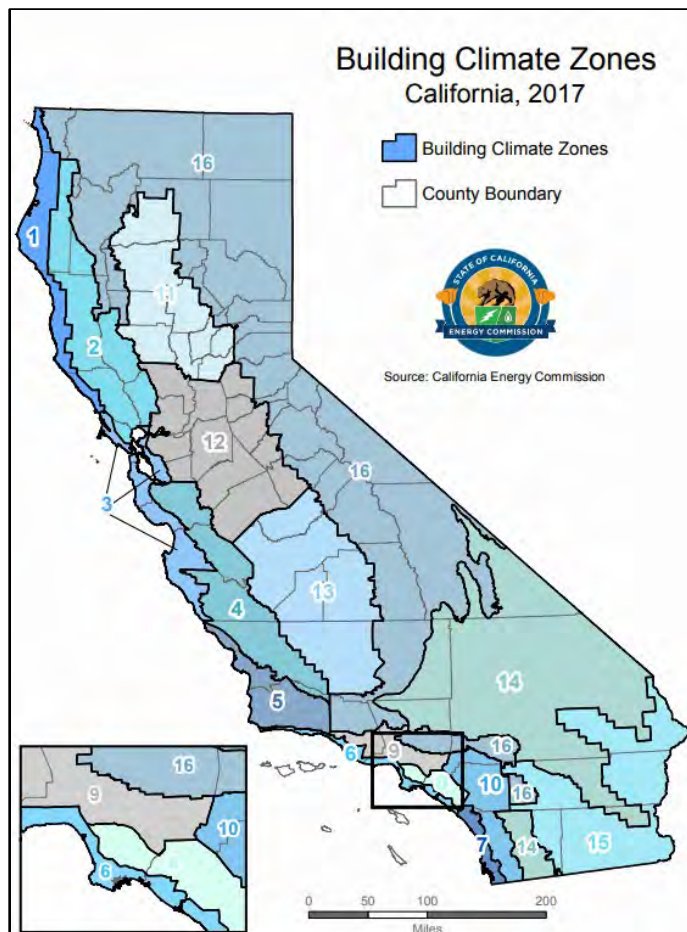


Figure 16. Map of California climate zones.

6.2 Utility Rate Schedules

The Reach Codes Team used the CA IOU and POU rate tariffs detailed below to determine the On-Bill savings for each package. The California Climate Credit was applied for both electricity and natural gas service for the IOUs using the 2023 credits shows below.²⁶ The credits were applied to reduce the total calculated annual bill, including any fixed fees or minimum bill amounts.

2023 Electric California Climate Credit Schedule

	February or March	April	May	June	July	Aug	Sept	Oct
PG&E	\$38.39							\$38.39
SCE	\$71.00							\$71.00
SDG&E	\$60.70							\$60.70

Residential Natural Gas California Climate Credit

In 2023, the 2023 Natural Gas California Climate Credit will be distributed in February or March instead of April.

	2018†	2019	2020	2021	2022	2023	Total Value Received Per Household 2018-2023
PG&E	\$30	\$25	\$27	\$25	\$48	\$52.78	\$208
SDG&E	*	\$34	\$21	\$18	\$43	\$43.40	\$162
Southwest Gas	\$22	\$25	\$27	\$28	\$49	\$56.35	\$207
SoCalGas	*	\$50	\$26	\$22	\$44	\$50.77	\$194

Electricity rates reflect the most recently approved tariffs. Monthly gas rates were estimated based on recent gas rates (November 2023) and a curve to reflect how natural gas prices fluctuate with seasonal supply and demand. The seasonal curve was estimated from monthly residential tariffs between 2014 and 2023 (between 2017 and 2023 for CPAU). 12-month curves were created from monthly gas rates for each of the ten years (Seven years for CPAU). These annual curves were then averaged to arrive at an average normalized annual curve. This was conducted separately for baseline and excess energy rates. Costs used in this analysis were then derived by establishing the most recent baseline and excess rate from the latest tariff as a reference point (November 2023), and then using the normalized curve to estimate the cost for the remaining months relative to the reference point rate.

²⁶ <https://www.cpuc.ca.gov/industries-and-topics/natural-gas/greenhouse-gas-cap-and-trade-program/california-climate-credit>

6.2.1 Pacific Gas & Electric

The following pages provide details on the PG&E electricity and natural gas tariffs applied in this study. Table 20 describes the baseline territories that were assumed for each climate zone. A net surplus compensation rate of \$0.07051/ kWh was applied to any net annual electricity generation based on a one-year average of the rates between December 2022 and November 2023.

Table 20. PG&E Baseline Territory by Climate Zone

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 according to the rates shown in Table 21. These rates are based on applying a normalization curve to the November 2023 tariff based on ten years of historical gas data. Corresponding CARE rates reflect the 20 percent discount per the GL-1 tariff.

Table 21. PG&E Monthly Gas Rate (\$/therm)

Month	Total Charge	
	Baseline	Excess
January	\$2.05	\$2.43
February	\$2.08	\$2.46
March	\$1.92	\$2.31
April	\$1.80	\$2.20
May	\$1.77	\$2.18
June	\$1.78	\$2.18
July	\$1.80	\$2.20
August	\$1.85	\$2.26
September	\$1.92	\$2.33
October	\$1.99	\$2.40
November	\$2.06	\$2.46
December	\$2.05	\$2.44

Residential GAS Baseline Territories and Quantities ^{1/}

Effective April 1, 2022 - Present

BASELINE QUANTITIES (Therms Per Day Per Dwelling Unit)

Individually Metered			
Baseline Territories	Summer (April-October) Effective Apr. 1, 2022	Winter Off-Peak (Nov, Feb, Mar) Effective Nov. 1, 2022	Winter On-Peak (Dec, Jan) Effective Dec. 1, 2022
P	0.39	1.88	2.19
Q	0.56	1.48	2.00
R	0.36	1.24	1.81
S	0.39	1.38	1.94
T	0.56	1.31	1.68
V	0.59	1.51	1.71
W	0.39	1.14	1.68
X	0.49	1.48	2.00
Y	0.72	2.22	2.58

Master Metered			
Baseline Territories	Summer (April-October) Effective Apr. 1, 2022	Winter Off-Peak (Nov, Feb, Mar) Effective Nov. 1, 2022	Winter On-Peak (Dec, Jan) Effective Dec. 1, 2022
P	0.29	1.01	1.13
Q	0.56	0.67	0.77
R	0.33	0.87	1.16
S	0.29	0.61	0.65
T	0.56	1.01	1.10
V	0.59	1.28	1.32
W	0.26	0.71	0.87
X	0.33	0.67	0.77
Y	0.52	1.01	1.13

Summer Season: Apr-Oct
 Winter Off-Peak: Nov, Feb, Mar
 Winter On-Peak: Dec, Jan

Advice Letter: 4589-G
 Decision 21-11-016
 GRC 2020 Ph II [Application 19-11-019]
 Filed: Nov 22, 2019



**Pacific Gas and
Electric Company**

U 39

Oakland, California

Cancelling Revised
Revised

Cal. P.U.C. Sheet No. 56550-E
Cal. P.U.C. Sheet No. 56229-E

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 BUNDLED RATES

Total Energy Rates (\$ per kWh)	PEAK		OFF-PEAK	
<i>Summer</i>				
Total Usage	\$0.53933	(I)	\$0.45589	(I)
Baseline Credit (Applied to Baseline Usage Only)	(\$0.08851)	(R)	(\$0.08851)	(R)
<i>Winter</i>				
Total Usage	\$0.43662	(I)	\$0.40827	(I)
Baseline Credit (Applied to Baseline Usage Only)	(\$0.08851)	(R)	(\$0.08851)	(R)
Delivery Minimum Bill Amount (\$ per meter per day)	\$0.37612			
California Climate Credit (per household, per semi-annual payment occurring in the March* and October bill cycles)	(\$38.39)			

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.

* Pursuant to D.23-02-014, disbursement of the April 2023 residential Climate Credit shall begin by March 1, 2023.

(Continued)

Advice	7009-E	Issued by	Submitted	August 25, 2023
Decision		Meredith Allen	Effective	September 1, 2023
		Vice President, Regulatory Affairs	Resolution	



**Pacific Gas and
Electric Company**
 U 39 Oakland, California

Cancelling Revised
 Revised

Cal. P.U.C. Sheet No. 56551-E
 Cal. P.U.C. Sheet No. 56230-E

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

Sheet 3

RATES:
 (Cont'd.)

UNBUNDLING OF E-TOU-C TOTAL RATES

Energy Rates by Component (\$ per kWh)	PEAK		OFF-PEAK	
Generation:				
Summer (all usage)	\$0.19776		\$0.13432	
Winter (all usage)	\$0.14918		\$0.12413	
Distribution**:				
Summer (all usage)	\$0.17029	(I)	\$0.15029	(I)
Winter (all usage)	\$0.11618	(I)	\$0.11286	(I)
Conservation Incentive Adjustment (Baseline Usage)		(\$0.02216)	(I)	
Conservation Incentive Adjustment (Over Baseline Usage)		\$0.06635	(I)	
Transmission* (all usage)		\$0.05254		
Transmission Rate Adjustments* (all usage)		\$0.00059		
Reliability Services* (all usage)		\$0.00069		
Public Purpose Programs (all usage)		\$0.02578		
Nuclear Decommissioning (all usage)		\$0.00135		
Competition Transition Charges (all usage)		\$0.00030		
Energy Cost Recovery Amount (all usage)		(\$0.00071)		
Wildfire Fund Charge (all usage)		\$0.00530		
New System Generation Charge (all usage)**		\$0.00346		
Wildfire Hardening Charge (all usage)		\$0.00254		
Recovery Bond Charge (all usage)		\$0.00528	(R)	
Recovery Bond Credit (all usage)		(\$0.00528)	(I)	
Bundled Power Charge Indifference Adjustment (all usage)***		\$0.01309		

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

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

*** Direct Access, Community Choice Aggregation and Transitional Bundled Service Customers pay the applicable Vintaged Power Charge Indifference Adjustment. Generation and Bundled PCIA are combined for presentation on bundled customer bills.

(Continued)

Advice	7009-E	Issued by	Submitted	August 25, 2023
Decision		Meredith Allen	Effective	September 1, 2023
		Vice President, Regulatory Affairs	Resolution	



**Pacific Gas and
Electric Company**

U 39

Oakland, California

Cancelling Revised

Cal. P.U.C. Sheet No. 56547-E
Cal. P.U.C. Sheet No. 56226-E

ELECTRIC SCHEDULE E-ELEC

Sheet 2

RESIDENTIAL TIME-OF-USE (ELECTRIC HOME)

SERVICE FOR CUSTOMERS WITH QUALIFYING ELECTRIC TECHNOLOGIES

RATES:(Cont'd.)

TOTAL BUNDLED RATES

Base Services Charge (\$ per meter per day)	\$0.49281		
Total Energy Rates (\$ per kWh)	PEAK	PART-PEAK	OFF-PEAK
Summer Usage	\$0.56589 (I)	\$0.40401 (I)	\$0.34733 (I)
Winter Usage	\$0.33438 (I)	\$0.31229 (I)	\$0.29843 (I)
California Climate Credit (per household, per semi-annual payment occurring in the March† and October bill cycles)	(\$38.39)		

Total bundled service charges shown on a customer's bills are unbundled according to the component rates shown below.

UNBUNDLING OF TOTAL RATES

Energy Rates by Component (\$ per kWh)	PEAK	PART-PEAK	OFF-PEAK
Generation:			
Summer Usage	\$0.28164	\$0.18253	\$0.13743
Winter Usage	\$0.11951	\$0.09954	\$0.08619
Distribution**:			
Summer Usage	\$0.17932 (I)	\$0.11655 (I)	\$0.10497 (I)
Winter Usage	\$0.10994 (I)	\$0.10782 (I)	\$0.10731 (I)
Transmission* (all usage)	\$0.05254	\$0.05254	\$0.05254
Transmission Rate Adjustments* (all usage)	\$0.00059	\$0.00059	\$0.00059
Reliability Services* (all usage)	\$0.00069	\$0.00069	\$0.00069
Public Purpose Programs (all usage)	\$0.02578	\$0.02578	\$0.02578
Nuclear Decommissioning (all usage)	\$0.00135	\$0.00135	\$0.00135
Competition Transition Charges (all usage)	\$0.00030	\$0.00030	\$0.00030
Energy Cost Recovery Amount (all usage)	(\$0.00071)	(\$0.00071)	(\$0.00071)
Wildfire Fund Charge (all usage)	\$0.00530	\$0.00530	\$0.00530
New System Generation Charge (all usage)**	\$0.00346	\$0.00346	\$0.00346
Wildfire Hardening Charge (all usage)	\$0.00254	\$0.00254	\$0.00254
Recovery Bond Charge (all usage)	\$0.00528 (R)	\$0.00528 (R)	\$0.00528 (R)
Recovery Bond Credit (all usage)	(\$0.00528) (I)	(\$0.00528) (I)	(\$0.00528) (I)
Bundled Power Charge Indifference Adjustment (all usage)***	\$0.01309	\$0.01309	\$0.01309

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

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

*** Direct Access, Community Choice Aggregation and Transitional Bundled Service Customers pay the applicable Vintaged Power Charge Indifference Adjustment. Generation and Bundled PCIA are combined for presentation on bundled customer bills.

† Pursuant to D.23-02-014, disbursement of the April 2023 residential Climate Credit shall begin by March 1, 2023.

(Continued)

Advice	7009-E	Issued by	Submitted	August 25, 2023
Decision		Meredith Allen	Effective	September 1, 2023
		Vice President, Regulatory Affairs	Resolution	



**Pacific Gas and
Electric Company**

U 39

San Francisco, California

Original Cal. P.U.C. Sheet No. 54738-E

ELECTRIC SCHEDULE E-ELEC
RESIDENTIAL TIME-OF-USE (ELECTRIC HOME)
SERVICE FOR CUSTOMERS WITH QUALIFYING ELECTRIC TECHNOLOGIES

Sheet 3

(N)

(N)

**SPECIAL
CONDITIONS:**

1. TIME PERIODS: Times of the year and times of the day are defined as follows: (N)

All Year:

Peak: 4:00 p.m. to 9:00 p.m. every day including weekends and holidays.

Partial-Peak: 3:00 p.m. to 4:00 p.m. and 9:00 p.m. to 12:00 a.m. every day including weekends and holidays.

Off-Peak: All other hours.

2. SEASONAL CHANGES: The summer season is June 1 through September 30 and the winter season is October 1 through May 31. When billing includes use in both the summer and winter periods, charges will be prorated based upon the number of days in each period.

3. ADDITIONAL METERS: If a residential dwelling unit is served by more than one electric meter, the customer must designate which meter is the primary meter and which is (are) the additional meter(s).

4. BILLING: A customer's bill is calculated based on the option applicable to the customer.

Bundled Service Customers receive generation and delivery services solely from PG&E. The customer's bill is based on the Unbundling of Total Rates set forth above.

Transitional Bundled Service (TBS) Customers take TBS as prescribed in Rules 22.1 and 23.1, or take PG&E bundled service prior to the end of the six (6) month advance notice period required to elect PG&E bundled service as prescribed in Rules 22.1 and 23.1. TBS customers shall pay all charges shown in the Unbundling of Total Rates except for the Bundled Power Charge Indifference Adjustment and the generation charge. TBS customers shall also pay for their applicable Vintaged Power Charge Indifference Adjustment provided in the table below, and the short-term commodity prices as set forth in Schedule TBCC.

(N)

(Continued)

Advice 6768-E
Decision D.21-11-016

Issued by
Meredith Allen
Vice President, Regulatory Affairs

Submitted
Effective
Resolution

November 18, 2022
December 1, 2022



Pacific Gas and Electric Company

U 39

San Francisco, California

Cancelling

Revised

Revised

Cal. P.U.C. Sheet No.

54734-E

Cal. P.U.C. Sheet No.

53424-E

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-8, E-TOU-B, E-TOU-C, E-TOU-D, EV2, E-ELEC, EM, ES, ESR, ET and EM-TOU.

(T)

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

RATES: Customers taking service on this rate schedule whose otherwise applicable rate schedule has no Delivery Minimum Bill Amount (Schedule E-ELEC) will receive a CARE percentage discount of 35.000% on their total bundled charges (except for the California Climate Credit, which will not be discounted). Customers taking service on this rate schedule whose otherwise applicable rate schedule has a Delivery Minimum Bill Amount (all other schedules) will receive a CARE percentage discount ("A" or "C" below) on their total bundled charges on their otherwise applicable rate schedule (except for the California Climate Credit, which will not be discounted) and also will receive a percentage discount ("B" or "D" 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, Recovery Bond Charge, Recovery Bond Credit, 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.

(N)

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(N)

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(T)

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.

(L)

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(L)

(Continued)



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

Cancelling	Revised	Cal. P.U.C. Sheet No.	56208-E
	Revised	Cal. P.U.C. Sheet No.	56020-E

ELECTRIC SCHEDULE D-CARE Sheet 2
LINE-ITEM DISCOUNT FOR CALIFORNIA ALTERNATE RATES FOR ENERGY (CARE)
CUSTOMERS

RATES: (Cont'd)	A. D-CARE Discount:	34.965	% (Percent)	(I)
	B. Delivery Minimum Bill Discount:	50.000	% (Percent)	
	C. Master-Meter D-CARE Discount:	34.965	% (Percent)	(I)
	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.
2. ELIGIBILITY: To be eligible to receive D-CARE the applicant must qualify under the criteria set forth in PG&E's Electric Rules 19.1, 19.2, and 19.3 and meet the certification requirements thereof to the satisfaction of PG&E. Qualifying Direct Access, Community Choice Aggregation Service, and Transitional Bundled Service customers are also eligible to take service on Schedule D-CARE. Applicants may qualify for D-CARE at their primary residence only. Customers or sub-metered tenants participating in the Family Electric Rate Assistance (FERA) program cannot concurrently participate in the CARE program.

Advice	6968-E	Issued by	Submitted	June 23, 2023
Decision		Meredith Allen	Effective	July 1, 2023
		Vice President, Regulatory Affairs	Resolution	

6.2.2 Southern California Edison

The following pages provide details on the SCE electricity tariffs applied in this study. Table 22 describes the baseline territories that were assumed for each climate zone. A net surplus compensation rate of \$ 0.06030/ kWh was applied to any net annual electricity generation based on a one-year average of the rates between December 2022 and November 2023

Table 22: SCE Baseline Territory by Climate Zone

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

- Applicable rate time periods are defined as follows:

Option 4-9 PM, Option 4-9 PM-CPP, Option PRIME, Option PRIME-CPP :

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



Southern California Edison
 Rosemead, California (U 338-E)

Revised Cal. PUC Sheet No. 85111-E
 Cancellng Revised Cal. PUC Sheet No. 74502-E

Schedule TOU-D

Sheet 2

**TIME-OF-USE
 DOMESTIC
 (Continued)**

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 days, 4:00 p.m. to 9:00 p.m., as described in Special Conditions 1 and 3, below:

Option 4-9 PM / Option 4-9 PM-CPP	Delivery Service	Generation ²	
	Total ¹	UG***	DWREC ⁴
Energy Charge - \$/kWh			
Summer Season - On-Peak	0.28829 (R)	0.28543 (I)	0.00000
Mid-Peak	0.28829 (R)	0.17767 (I)	0.00000
Off-Peak	0.24482 (R)	0.11382 (I)	0.00000
Winter Season - Mid-Peak	0.28829 (R)	0.21752 (I)	0.00000
Off-Peak	0.24482 (R)	0.13851 (I)	0.00000
Super-Off-Peak	0.22919 (R)	0.11890 (I)	0.00000
Baseline Credit**** - \$/kWh	(0.09759) (I)	0.00000	
Fixed Recovery Charge - \$/kWh	0.00090 (R)		
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	(71.00) (I)		
California Alternate Rates for Energy Discount - %	100.00*		
Family Electric Rate Assistance Discou	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		(0.67183) (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 (\$0.00003) 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 time period. Additional Baseline Allocations apply for Customers with Heat Pump Water Heaters served under this Option. The Baseline Allocations are 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 DWRBC rate component of this Schedule but instead pay the DWRBC as provided by Schedule DA-CRS or Schedule CCA-CRS.

2 Generation = The Gen rates are applicable only to Bundled Service Customers. See Special Condition below for PCIA recovery.

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)

(To be inserted by utility)

Advice 4929-E
 Decision

2/13

Issued by
 Michael Backstrom
 Vice President

(To be inserted by Cal. PUC)

Date Submitted Dec 28, 2022
 Effective Jan 1, 2023
 Resolution E-5217



Southern California Edison
Rosemead, California (U 338-E)

Cancelling Revised Cal. PUC Sheet No. 86132-E
Revised Cal. PUC Sheet No. 85624-E

Schedule TOU-D

Sheet 6

TIME-OF-USE
DOMESTIC
(Continued)

RATES (Continued)

Option PRIME / Option PRIME-CPP	Delivery Service Total ¹	Generation ²	
		UG ³	DWREC ⁴
Energy Charge - \$/kWh/Meter/Day			
Summer Season			
On-Peak	0.22789 (I)	0.42769 (I)	0.00000
Mid-Peak	0.22789 (I)	0.15221 (I)	0.00000
Off-Peak	0.15191 (I)	0.10182 (I)	0.00000
Winter Season			
Mid-Peak	0.23353 (I)	0.36028 (I)	0.00000
Off-Peak	0.14530 (I)	0.08630 (I)	0.00000
Super-Off-Peak	0.14530 (I)	0.08630 (I)	0.00000
Fixed Recovery Charge - \$/kWh	0.00260 (I)		
Basic Charge - \$/Meter/Day	0.427 (I)		
EV Meter Credit (Separately Metered E	(0.323) (N)		
EV Submeter Credit - \$/Meter/Day	(0.111) (R)		
California Climate Credit ¹⁰	(71.00)		
California Alternate Rates for			
Energy Discount - %	100.00*		
Family Electric Rate Assistance Discou	100.00		
Medical Line Item Discount - %	100.000		
Option PRIME-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		(0.71812) (R)	

* Represents 100% of the discount percentage as shown in the applicable Special Condition of this Schedule.

** The ongoing Competition Transition Charge (CTC) of (\$0.00003) per kWh is recovered in the UG component of Generation.

**** 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 DWRBC rate component of this Schedule but instead pay the DWRBC as provided by Schedule DA-CRS or Schedule CCA-CRS.

2 Generation = The Gen rates are applicable only to Bundled Service Customers. See Special Condition below for PCIA recovery.

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)

(To be inserted by utility)

Advice 5041-E
Decision _____

04/9

Issued by
Michael Backstrom
Vice President

(To be inserted by Cal. PUC)

Date Submitted May 30, 2023
Effective Jun 1, 2023
Resolution _____



Southern California Edison
Rosemead, California (U 338-E)

Revised Cal. PUC Sheet No. 85618-E
Cancelling Revised Cal. PUC Sheet No. 85109-E

Schedule D-CARE
CALIFORNIA ALTERNATE RATES FOR ENERGY
DOMESTIC SERVICE

Sheet 1

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 29.8 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 \$0.00888 per kWh and the Wildfire Fund Non-Bypassable Charge of \$0.00530 per kWh. (R) The 29.8 percent discount, in addition to these exemptions result in an average effective CARE Discount of 32.5 percent.

(Continued)

(To be inserted by utility)

Advice 4977-E

Decision 23-01-002

1H12 22-12-031

Issued by
Michael Backstrom
Vice President

(To be inserted by Cal. PUC)

Date Submitted Feb 27, 2023

Effective Mar 1, 2023

Resolution

6.2.3 Southern California Gas

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

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 according to the rates shown in Table 24. These rates are based on applying a normalization curve to the November 2023 tariff based on ten years of historical gas data. Long-term historical natural gas rate data was only available for SoCalGas' procurement charges.²⁷ The baseline and excess transmission charges were found to be consistent over the course of a year and applied for the entire year based on 2023 rates. 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
January	\$0.72	\$0.86	\$1.31	\$1.92	\$2.36
February	\$0.50	\$0.86	\$1.31	\$1.57	\$2.02
March	\$0.44	\$0.86	\$1.31	\$1.48	\$1.93
April	\$0.39	\$0.86	\$1.31	\$1.39	\$1.84
May	\$0.41	\$0.86	\$1.31	\$1.43	\$1.87
June	\$0.46	\$0.86	\$1.31	\$1.49	\$1.93
July	\$0.47	\$0.86	\$1.31	\$1.51	\$1.96
August	\$0.51	\$0.86	\$1.31	\$1.58	\$2.03
September	\$0.46	\$0.86	\$1.31	\$1.52	\$1.96
October	\$0.45	\$0.86	\$1.31	\$1.48	\$1.92
November	\$0.48	\$0.86	\$1.31	\$1.54	\$1.99
December	\$0.57	\$0.86	\$1.31	\$1.63	\$2.08

Southern California Gas Company Residential Rates Nov-23									
Customer Type		Commodity	Rate	Procurement	Transportation	New Rate	New Rate	Absolute	%
Rate Schedule		Charge	Type	Charge ¢/therm	Charge ¢/therm	Effective 11/1/2023	Effective 10/1/2023	Rate Change	Change
Residential Individually Metered									
Schedule No. GR		GR	Baseline	67.806	86.490	154.296	125.096	29.200	23.3%
Res. Service		GR	Non Baseline	67.806	131.037	198.843	169.726	29.117	17.2%
		GT-R	Baseline	00.000	86.490	86.490	87.038	-00.548	-0.6%
		GT-R	Non Baseline	00.000	131.037	131.037	131.668	-00.631	-0.5%

²⁷ The SoCalGas procurement and transmission charges were obtained from the following site:
<https://www.socalgas.com/for-your-business/energy-market-services/gas-prices/RES2023.xlsx> (live.com)

6.2.4 San Diego Gas & Electric

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. A net surplus compensation rate of \$0.04542/ kWh was applied to any net annual electricity generation based on a one-year average of the rates between December 2022 and November 2023.

Table 25. SDG&E Baseline Territory by Climate Zone

Climate Zone	Baseline Territory
CZ07	Coastal
CZ10	Inland
CZ14	Mountain

The SDG&E monthly gas rate in \$/therm was applied on a monthly basis according to the rates shown in Table 26. These rates are based on applying a normalization curve to the November 2023 tariff based on ten years of historical gas data. CARE rates reflect the 20 percent discount per the G-CARE tariff.

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

Month	Total Charge	
	Baseline	Excess
January	\$2.34	\$2.63
February	\$2.28	\$2.57
March	\$2.21	\$2.51
April	\$2.14	\$2.45
May	\$2.18	\$2.48
June	\$2.23	\$2.55
July	\$2.26	\$2.57
August	\$2.32	\$2.62
September	\$2.26	\$2.59
October	\$2.21	\$2.55
November	\$2.24	\$2.57
December	\$2.38	\$2.70

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

<u>All Customers:</u>	<u>Daily Therm Allowance</u>
Summer (May to Oct)	0.359
Winter On-Peak (Dec, Jan & Feb)	1.233
Winter Off-Peak (Nov, Mar, & Apr)	0.692



San Diego Gas & Electric Company
San Diego, California

Revised Cal. P.U.C. Sheet No. 37022-E

Canceling Revised Cal. P.U.C. Sheet No. 36337-E

SCHEDULE TOU-DR1

Sheet 2

RESIDENTIAL TIME-OF-USE

RATES

Total Rates:

Description – TOU DR1	UDC Total Rate	DWR BC + WF-NBC	EECC Rate + DWR Credit	Total Rate
Summer:				
On-Peak	0.25752	R 0.00530	I 0.57043	I 0.83325
Off-Peak	0.25752	R 0.00530	I 0.25697	I 0.51979
Super Off-Peak	0.25752	R 0.00530	I 0.09233	I 0.35515
Winter:				
On-Peak	0.43809	I 0.00530	I 0.19307	I 0.63646
Off-Peak	0.43809	I 0.00530	I 0.10855	I 0.55194
Super Off-Peak	0.43809	I 0.00530	I 0.08402	I 0.52741
Summer Baseline Adjustment Credit up to 130% of Baseline	(0.11724)	R		(0.11724) R
Winter Baseline Adjustment Credit up to 130% of Baseline	(0.11724)	R		(0.11724) R
Minimum Bill (\$/day)	0.380	I		0.380 I

Description – TOU DR1-CARE	UDC Total Rate	DWR BC + WF-NBC	EECC Rate + DWR Credit	Total Rate	Total Effective Care Rate
Summer – CARE Rates:					
On-Peak	0.25682	R 0.00000	0.57043 I	0.82725 I	0.55368 I
Off-Peak	0.25682	R 0.00000	0.25697 I	0.51379 I	0.33965 I
Super Off-Peak	0.25682	R 0.00000	0.09233 I	0.34915 I	0.22725 I
Winter – CARE Rates:					
On-Peak	0.43739	I 0.00000	0.19307 I	0.63046 I	0.41930 I
Off-Peak	0.43739	I 0.00000	0.10855 I	0.54594 I	0.38160 I
Super Off-Peak	0.43739	I 0.00000	0.08402 I	0.52141 I	0.34485 I
Summer Baseline Adjustment Credit up to 130% of Baseline	(0.11724)	R		(0.11724) R	(0.08004) R
Winter Baseline Adjustment Credit up to 130% of Baseline	(0.11724)	R		(0.11724) R	(0.08004) R
Minimum Bill (\$/day)	0.190	I		0.190 I	0.190 I

Note:

- (1) Total Rates consist of UDC, Schedule DWR-BC (Department of Water Resources Bond Charge), Schedule WF-NBC (CA Wildfire Fund charge) and Schedule EECC (Electric Energy Commodity Cost) rates, with the EECC rates reflecting a DWR Credit. EECC rates are applicable to bundled customers only. See Special Condition 16 for PCIA (Power Charge Indifference Adjustment) recovery.
- (2) Total Rates presented are for customers that receive commodity supply and delivery service from Utility.
- (3) DWR-BC and WF-NBC 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.
- (5) WF-NBC rate is 0.00530 + DWR-BC Bond Charge is 0.00000.

R. I.

(Continued)

2C8

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Dan Skopec
Senior Vice President
Regulatory Affairs

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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.



San Diego Gas & Electric Company
San Diego, California

Revised Cal. P.U.C. Sheet No. 37217-E

Canceling Revised Cal. P.U.C. Sheet No. 37016-E

SCHEDULE EV-TOU-5

Sheet 1

COST-BASED DOMESTIC TIME-OF-USE FOR HOUSEHOLDS WITH ELECTRIC VEHICLES

APPLICABILITY

Service under this schedule is specifically limited to customers who require service for charging of a currently registered Motor Vehicle, as defined by the California Motor Vehicle Code, which is: 1) a battery electric vehicle (BEV) or plug-in hybrid electric vehicle (PHEV) recharged via a recharging outlet at the customer's premises; or 2) a natural gas vehicle (NGV) refueled via a home refueling appliance (HRA) at the customer's premises. This schedule is not available to customers with a conventional charge sustaining (battery recharged solely from the vehicle's on-board generator) hybrid electric vehicle (HEV).

Residential customers taking service on Schedule NBT, who are required to utilize EV-TOU-5 as their otherwise applicable schedule (OAS) for electric service, do not require a qualifying motor vehicle, as described above to participate on Schedule EV-TOU-5.

N
N
N

Customers on this schedule may also qualify for a semi-annual California Climate Credit \$(60.70) per Schedule GHG-ARR.

TERRITORY

Within the entire territory served by the utility.

RATES

Total Rates:

Description – EV-TOU-5 Rates	UDC Total Rate	DWR BC + WF-NBC	EECC Rate + DWR Credit	Total Rate
Basic Service Fee	16.00			16.00
Summer				
On-Peak	0.28032 I	0.00530 I	0.53067 I	0.81629 I
Off-Peak	0.28032 I	0.00530 I	0.19567 I	0.48129 I
Super Off-Peak	0.05588 I	0.00530 I	0.09233 I	0.15351 I
Winter				
On-Peak	0.28032 I	0.00530 I	0.22587 I	0.51149 I
Off-Peak	0.28032 I	0.00530 I	0.16213 I	0.44775 I
Super Off-Peak	0.05588 I	0.00530 I	0.08402 I	0.14520 I

(Continued)

1C5

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San Diego, California

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SCHEDULE EV-TOU-5

Sheet 4

COST-BASED DOMESTIC TIME-OF-USE FOR HOUSEHOLDS WITH ELECTRIC VEHICLES

Notes: Transmission Energy charges include the Transmission Revenue Balancing Account Adjustment (TRBAA) of \$(0.00242) per kWh and the Transmission Access Charge Balancing Account Adjustment (TACBAA) of \$(0.01631) per kWh. PPP Energy charges includes Low Income PPP rate (LI-PPP) \$0.01669/kWh, Non-low Income PPP rate (Non-LI-PPP) \$0.00333/kWh (pursuant to PU Code Section 399.8, the Non-LI-PPP rate may not exceed January 1, 2000 levels), Procurement Energy Efficiency Surcharge Rate of \$0.00422 /kWh, California Solar Initiative rate (CSI) of \$0.00000/kWh and Self-Generation Incentive Program rate (SGIP) \$0.00122/kWh. The basic service fee of \$16 per month is applied to a customer's bill and a 50% discount is applied for CARE, Medical Baseline, or Family Electric Rate Assistance Program (FERA) customers resulting in their basic service fees to be \$8 per month.

Rate Components

The Utility Distribution Company Total Rates (UDC Total) shown above are comprised of the following components (if applicable): (1) Transmission (Trans) Charges, (2) Distribution (Distr) Charges, (3) Public Purpose Program (PPP) Charges, (4) Nuclear Decommissioning (ND) Charge, (5) Ongoing Competition Transition Charges (CTC), (6) Local Generation Charge (LGC), (7) Reliability Services (RS), and (8) the Total Rate Adjustment Component (TRAC).

Certain Direct Access customers are exempt from the TRAC, as defined in Rule 1 – Definitions.

Franchise Fee Differential

A Franchise Fee Differential of 5.78% will be applied to the monthly billings calculated under this schedule for all customers within the corporate limits of the City of San Diego. Such Franchise Fee Differential shall be so indicated and added as a separate item to bills rendered to such customers.

Time Periods:

All time periods listed are applicable to actual "clock" time)

TOU Period – 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

(Continued)

4C8

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Senior Vice President
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San Diego Gas & Electric Company
San Diego, California

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SCHEDULE TOU-ELEC

Sheet 1

DOMESTIC TIME-OF-USE FOR HOUSEHOLDS WITH ELECTRIC VEHICLES, ENERGY STORAGE, OR ELECTRIC HEAT PUMPS

APPLICABILITY

Service under this schedule is available on a voluntary basis for all residential customers who meet one or more of the following criteria: 1) require service for charging of a currently registered Motor Vehicle, as defined by the California Motor Vehicle Code, which is: a) a battery electric vehicle (BEV) or plug-in hybrid electric vehicle (PHEV) recharged via a recharging outlet at the customer's premises; or b) a natural gas vehicle (NGV) refueled via a home refueling appliance (HRA) at the customer's premises; 2) have a behind-the-meter energy storage device that is interconnected through Electric Rule 21; or 3) have an electric heat pump for water heating or climate control. This schedule is not available to customers with a conventional charge sustaining (battery recharged solely from the vehicle's on-board generator) hybrid electric vehicle (HEV).

This schedule is also available to customers who meet the above criteria as well as qualify for the California Alternate Rates for Energy (CARE) Program as outlined in Schedule E-CARE, and/or Medical Baseline as outlined in Special Condition (SC) 5. The rates for CARE customers and/or Medical Baseline are identified in the rate tables below as TOU-ELEC-CARE and TOU-ELEC-MB rates, respectively.

There is a cap of 10,000 customers who may take service on this rate, as defined in SC 10.

Pursuant to D.22-11-022, customers that opt-in to schedule TOU-ELEC within its first year of being offered have the option to return to their previous rate schedule prior to the 12-month requirement. See SC4 Terms of Service for all requirements.

Customers on this schedule may also qualify for a semi-annual California Climate Credit \$(60.70) per Schedule GHG-ARR.

TERRITORY

Within the entire territory served by the utility.

RATES

Total Rates:

Description – TOU-ELEC Rates	UDC Total Rate	DWR BC + WF-NBC	EECC Rate	Total Rate
Monthly Service Fee	16.00			16.00
Summer				
On-Peak	0.22228	0.00530	0.51568	0.74326
Off-Peak	0.22228	0.00530	0.14844	0.37402
Super Off-Peak	0.22228	0.00530	0.09785	0.32543
Winter				
On-Peak	0.22228	0.00530	0.27480	0.50218
Off-Peak	0.22228	0.00530	0.13323	0.36081
Super Off-Peak	0.22228	0.00530	0.08905	0.31663

(Continued)

1/16

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 San Diego, California

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SCHEDULE TOU-ELEC

Sheet 2

**DOMESTIC TIME-OF-USE FOR HOUSEHOLDS WITH ELECTRIC VEHICLES, ENERGY STORAGE,
 OR ELECTRIC HEAT PUMPS**

RATES (Continued)

Description – TOU-ELEC CARE Rates	UDC Total Rate	DWR BC + WF-NBC	EECC Rate	Total Rate	Total Effective CARE Rate
Monthly Service Fee	16.00			16.00	16.00
Summer – CARE Rates:					
On-Peak	0.22158	0.00000	0.51588	0.73726	0.49222
Off-Peak	0.22158	0.00000	0.14644	0.36802	0.24013
Super Off-Peak	0.22158	0.00000	0.09785	0.31943	0.20896
Winter – CARE Rates:					
On-Peak	0.22158	0.00000	0.27460	0.49618	0.32763
Off-Peak	0.22158	0.00000	0.13323	0.35481	0.23111
Super Off-Peak	0.22158	0.00000	0.08905	0.31063	0.20095

Description – TOU-ELEC MB Rates	UDC Total Rate	DWR BC + WF-NBC	EECC Rate	Total Rate	Total Effective MB Rate
Monthly Service Fee	16.00			16.00	16.00
Summer – MB Rates:					
On-Peak	0.22228	0.00000	0.51588	0.73796	0.59037
Off-Peak	0.22228	0.00000	0.14644	0.36872	0.29498
Super Off-Peak	0.22228	0.00000	0.09785	0.32013	0.25610
Winter – MB Rates:					
On-Peak	0.22228	0.00000	0.27460	0.49688	0.39750
Off-Peak	0.22228	0.00000	0.13323	0.35551	0.28441
Super Off-Peak	0.22228	0.00000	0.08905	0.31133	0.24906

Note:

- Total Rates consist of UDC, Schedule DWR-BC (Department of Water Resources Bond Charge), Schedule WF-NBC (CA Wildfire Fund charge) and Schedule EECC (Electric Energy Commodity Cost) rates. EECC rates are applicable to bundled customers only. See Special Condition 9 for PCIA (Power Charge Indifference Adjustment) recovery.
- 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.
- DWR-BC and WF-NBC charges do not apply to CARE or Medical Baseline customers.
- WF-NBC rate is 0.00530 + DWR-BC Bond Charge is 0.00000

2H5

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San Diego, California

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SCHEDULE TOU-ELEC

Sheet 3

DOMESTIC TIME-OF-USE FOR HOUSEHOLDS WITH ELECTRIC VEHICLES, ENERGY STORAGE, OR ELECTRIC HEAT PUMPS

RATES (CONTINUED)

UDC Rates

Description - TOU-ELEC	Transm	Distr	PPP	ND	CTC	LGC	RS	TRAC	UDC Total
Monthly Service Fee (\$/Mo)		16.00							16.00
Summer:									
On-Peak	0.07340	0.10796	0.02546	0.00007	0.00153	0.01383	0.00003	0.00000	0.22228
Off-Peak	0.07340	0.10796	0.02546	0.00007	0.00153	0.01383	0.00003	0.00000	0.22228
Super Off-Peak	0.07340	0.10796	0.02546	0.00007	0.00153	0.01383	0.00003	0.00000	0.22228
Winter:									
On-Peak	0.07340	0.10796	0.02546	0.00007	0.00153	0.01383	0.00003	0.00000	0.22228
Off-Peak	0.07340	0.10796	0.02546	0.00007	0.00153	0.01383	0.00003	0.00000	0.22228
Super Off-Peak	0.07340	0.10796	0.02546	0.00007	0.00153	0.01383	0.00003	0.00000	0.22228

Description - TOU-ELEC - CARE Rates	Transm	Distr	PPP	ND	CTC	LGC	RS	TRAC	UDC Total
Monthly Service Fee (\$/Mo)		16.00							16.00
Summer CARE Rates:									
On-Peak	0.07340	0.10726	0.02546	0.00007	0.00153	0.01383	0.00003	0.00000	0.22158
Off-Peak	0.07340	0.10726	0.02546	0.00007	0.00153	0.01383	0.00003	0.00000	0.22158
Super Off-Peak	0.07340	0.10726	0.02546	0.00007	0.00153	0.01383	0.00003	0.00000	0.22158
Winter CARE Rates:									
On-Peak	0.07340	0.10726	0.02546	0.00007	0.00153	0.01383	0.00003	0.00000	0.22158
Off-Peak	0.07340	0.10726	0.02546	0.00007	0.00153	0.01383	0.00003	0.00000	0.22158
Super Off-Peak	0.07340	0.10726	0.02546	0.00007	0.00153	0.01383	0.00003	0.00000	0.22158

Description - TOU-ELEC - MB Rates	Transm	Distr	PPP	ND	CTC	LGC	RS	TRAC	UDC Total
Monthly Service Fee (\$/Mo)		16.00							16.00
Summer - MB Rates									
On-Peak	0.07340	0.10796	0.02546	0.00007	0.00153	0.01383	0.00003	0.00000	0.22228
Off-Peak	0.07340	0.10796	0.02546	0.00007	0.00153	0.01383	0.00003	0.00000	0.22228
Super Off-Peak	0.07340	0.10796	0.02546	0.00007	0.00153	0.01383	0.00003	0.00000	0.22228
Winter - MB Rates									
On-Peak	0.07340	0.10796	0.02546	0.00007	0.00153	0.01383	0.00003	0.00000	0.22228
Off-Peak	0.07340	0.10796	0.02546	0.00007	0.00153	0.01383	0.00003	0.00000	0.22228
Super Off-Peak	0.07340	0.10796	0.02546	0.00007	0.00153	0.01383	0.00003	0.00000	0.22228

(Continued)

3H11

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San Diego, California

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SCHEDULE TOU-ELEC

Sheet 4

DOMESTIC TIME-OF-USE FOR HOUSEHOLDS WITH ELECTRIC VEHICLES, ENERGY STORAGE, OR ELECTRIC HEAT PUMPS

Notes: Transmission Energy charges include the Transmission Revenue Balancing Account Adjustment (TRBAA) of \$(0.00242) per kWh and the Transmission Access Charge Balancing Account Adjustment (TACBAA) of \$(0.01631) per kWh. PPP Energy charges includes Low Income PPP rate (LI-PPP) \$0.01669/kWh, Non-low Income PPP rate (Non-LI-PPP) \$0.00333/kWh (pursuant to PU Code Section 399.8, the Non-LI-PPP rate may not exceed January 1, 2000 levels), Procurement Energy Efficiency Surcharge Rate of \$0.00422 /kWh, California Solar Initiative rate (CSI) of \$0.00000/kWh and Self-Generation Incentive Program rate (SGIP) \$0.00122/kWh.

Rate Components

The Utility Distribution Company Total Rates (UDC Total) shown above are comprised of the following components (if applicable): (1) Transmission (Trans) Charges, (2) Distribution (Distr) Charges, (3) Public Purpose Program (PPP) Charges, (4) Nuclear Decommissioning (ND) Charge, (5) Ongoing Competition Transition Charges (CTC), (6) Local Generation Charge (LGC), (7) Reliability Services (RS), and (8) the Total Rate Adjustment Component (TRAC).

Certain Direct Access customers are exempt from the TRAC, as defined in Rule 1 – Definitions.

Franchise Fee Differential

A Franchise Fee Differential of 5.78% will be applied to the monthly billings calculated under this schedule for all customers within the corporate limits of the City of San Diego. Such Franchise Fee Differential shall be so indicated and added as a separate item to bills rendered to such customers.

Time Periods:

All time periods listed are applicable to actual "clock" time)

TOU Period – 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

(Continued)

4H7

Issued by

Submitted Jan 31, 2023

Advice Ltr. No. 4152-E

Effective Jan 31, 2023

Decision No. D.22-11-022

Resolution No.



San Diego Gas & Electric Company
San Diego, California

Revised Cal. P.U.C. Sheet No. 35718-E
Canceling Revised Cal. P.U.C. Sheet No. 32576-E

SCHEDULE E-CARE

Sheet 1

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; (c) the California Wildfire Fund Charge (WF-NBC) and (d) 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

(Continued)

IC5

Advice Ltr. No. 3928-E

Issued by
Dan Skopec
Vice President

Submitted Dec 30, 2021
Effective Jan 1, 2022

6.2.5 City of Palo Alto Utilities

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 according to the rates shown in Table 27. These rates are based on applying a normalization curve to the October 2023 tariff based on seven years of historical gas data. The monthly service charge applied was \$14.01 per month per the November 2023 G-1 tariff.

Table 27. CPAU Monthly Gas Rate (\$/therm)

Month	G1 Volumetric Total Baseline	G1 Volumetric Total Excess
January	\$1.83532	\$3.35639
February	\$1.38055	\$2.59947
March	\$1.32506	\$2.47695
April	\$1.29680	\$2.44038
May	\$1.29511	\$2.43804
June	\$1.32034	\$2.45406
July	\$1.35688	\$2.61519
August	\$1.40696	\$2.67944
September	\$1.42130	\$2.70301
October	\$1.42310	\$2.48300
November	\$1.46286	\$2.45547
December	\$1.62415	\$2.62128

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:

<u>Per kilowatt-hour (kWh)</u>	<u>Commodity</u>	<u>Distribution</u>	<u>Public Benefits</u>	<u>Total</u>
Tier 1 usage	\$ 0.09999	\$ 0.06954	\$ 0.00568	\$ 0.17521
Tier 2 usage Any usage over Tier 1	0.13873	0.10225	0.00568	0.24666
<u>Minimum Bill (\$/day)</u>				0.4181

D. SPECIAL NOTES:

1. Calculation of Cost Components

The actual bill amount is calculated based on the applicable rates in Section C above and adjusted for any applicable discounts, surcharges and/or taxes. On a Customer's bill statement, the bill amount may be broken down into appropriate components as calculated under Section C.

2. Calculation of Usage Tiers

Tier 1 Electricity usage shall be calculated and billed based upon a level of 11 kWh per day, prorated by Meter reading days of Service. As an example, for a 30-day bill, the Tier 1 level would be 330 kWh. For further discussion of bill calculation and proration, refer to Rule and Regulation 11.

{End}

CITY OF PALO ALTO UTILITIES

Issued by the City Council

Supersedes Sheet No E-1-1
 dated 7-1-2022



Sheet No **E-1-1**
 Effective 7-1-2023

6.2.6 Sacramento Municipal Utilities District (Electric Only)

Following are the SMUD electricity tariffs applied in this study. The rates effective January 2023 were used.

Residential Time-of-Day Service Rate Schedule R-TOD

II. Firm Service Rates

A. Time-of-Day (5-8 p.m.) Rate

	Effective as of January 1, 2023	Effective as of January 1, 2024	Effective as of May 1, 2024	Effective as of January 1, 2025	Effective as of May 1, 2025
Time-of-Day (5-8 p.m.) Rate (RT02)					
Non-Summer Season (October - May)					
System Infrastructure Fixed Charge <i>per month per meter</i>	\$23.50	\$24.15	\$24.80	\$25.50	\$26.20
Electricity Usage Charge					
Peak \$/k Wh	\$0.1547	\$0.1590	\$0.1633	\$0.1678	\$0.1724
Off-Peak \$/k Wh	\$0.1120	\$0.1151	\$0.1183	\$0.1215	\$0.1248
Summer Season (June - September)					
System Infrastructure Fixed Charge <i>per month per meter</i>	\$23.50	\$24.15	\$24.80	\$25.50	\$26.20
Electricity Usage Charge					
Peak \$/k Wh	\$0.3279	\$0.3369	\$0.3462	\$0.3557	\$0.3655
Mid-Peak \$/k Wh	\$0.1864	\$0.1914	\$0.1967	\$0.2021	\$0.2077
Off-Peak \$/k Wh	\$0.1350	\$0.1387	\$0.1425	\$0.1464	\$0.1505

B. Optional Critical Peak Pricing Rate

- The CPP Rate base prices per time-of-day period are the same as the prices per time-of-day period for TOD (5-8 p.m.).
- The CPP Rate provides a discount per kWh on the Mid-Peak and Off-Peak prices during summer months.
- During CPP Events, customers will be charged for energy used at the applicable time-of-day period rate plus the CPP Rate Event Price per kWh as shown on www.smud.org.
- During CPP Events, energy exported to the grid will be compensated at the CPP Rate Event Price per kWh as shown on www.smud.org.
- The CPP Rate Event Price and discount will be updated annually at SMUD's discretion and posted on www.smud.org.

C. Plug-In Electric Vehicle Credit (rate categories RT02 and RTC1)

This credit is for residential customers who have a licensed passenger battery electric plug-in or plug-in hybrid electric vehicle.

Credit applies to all electricity usage charges from midnight to 6:00 a.m. daily.

Electric Vehicle Credit..... ~~-\$0.0150/kWh~~

III. Electricity Usage Surcharges

Refer to the following rate schedules for details on these surcharges.

A. Hydro Generation Adjustment (HGA). Refer to Rate Schedule HGA.

IV. Rate Option Menu

- Energy Assistance Program Rate.** Refer to Rate Schedule EAPR.
- Medical Equipment Discount Program.** Refer to Rate Schedule MED.
- Joint Participation in Medical Equipment Discount and Energy Assistance Program Rate.** Refer to Rate Schedule MED.

SACRAMENTO MUNICIPAL UTILITY DISTRICT
 Resolution No. 23-09-09 adopted September 21, 2023

Sheet No. **R-TOD-2**
 Effective: **September 22, 2023**

A. Time-of-Day (5-8 p.m.) Rate (rate category RT02)

1. The TOD (5-8 p.m.) Rate is the standard rate for SMUD's residential customers. Eligible customers can elect the Fixed Rate under Rate Schedule R as an alternative rate.
2. The TOD (5-8 p.m.) Rate is an optional rate for customers who have an eligible renewable electrical generation facility under Rate Schedule NEM1 that was approved for installation by SMUD prior to January 1, 2018.
3. This rate has five kilowatt-hour (kWh) prices, depending on the time-of-day and season as shown below. Holidays are detailed in Section V. Conditions of Service.

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 .

¹ See Section V. Conditions of Service

6.2.7 Fuel 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, 2021a). Escalation rates through the remainder of the 30-year evaluation period are based on the escalation rate assumptions within the 2022 TDV factors. No data was available to estimate electricity escalation rates for CPAU and SMUD, therefore electricity escalation rates for PG&E and statewide natural gas escalation rates were applied. Table 29 presents the average annual escalation rates used in the utility rate escalation sensitivity analysis shown in Section 3.2.4. Rates were applied for the same 30-year period and are based on the escalation rate assumptions within the 2025 LSC factors from 2027 through 2053.²⁸ These rates were developed for electricity use statewide (not utility-specific) and assume steep increases in gas rates in the latter half of the analysis period. Data was not available for the years 2024, 2025, and 2026 and so the CPUC En Banc assumptions were applied for those years using the average rate across the three IOUs for statewide electricity escalation.

Table 28: Real Utility Rate Escalation Rate Assumptions, CPUC En Banc and 2022 TDV Basis

	Statewide Natural Gas Residential Average Rate (%/year, real)	Electric Residential Average Rate (%/year, real)		
		PG&E	SCE	SDG&E
2024	4.6%	1.8%	1.6%	2.8%
2025	4.6%	1.8%	1.6%	2.8%
2026	4.6%	1.8%	1.6%	2.8%
2027	4.6%	1.8%	1.6%	2.8%
2028	4.6%	1.8%	1.6%	2.8%
2029	4.6%	1.8%	1.6%	2.8%
2030	4.6%	1.8%	1.6%	2.8%
2031	2.0%	0.6%	0.6%	0.6%
2032	2.4%	0.6%	0.6%	0.6%
2033	2.1%	0.6%	0.6%	0.6%
2034	1.9%	0.6%	0.6%	0.6%
2035	1.9%	0.6%	0.6%	0.6%
2036	1.8%	0.6%	0.6%	0.6%
2037	1.7%	0.6%	0.6%	0.6%
2038	1.6%	0.6%	0.6%	0.6%
2039	2.1%	0.6%	0.6%	0.6%
2040	1.6%	0.6%	0.6%	0.6%
2041	2.2%	0.6%	0.6%	0.6%
2042	2.2%	0.6%	0.6%	0.6%
2043	2.3%	0.6%	0.6%	0.6%
2044	2.4%	0.6%	0.6%	0.6%
2045	2.5%	0.6%	0.6%	0.6%
2046	1.5%	0.6%	0.6%	0.6%
2047	1.3%	0.6%	0.6%	0.6%
2048	1.6%	0.6%	0.6%	0.6%
2049	1.3%	0.6%	0.6%	0.6%
2050	1.5%	0.6%	0.6%	0.6%
2051	1.8%	0.6%	0.6%	0.6%
2052	1.8%	0.6%	0.6%	0.6%
2053	1.8%	0.6%	0.6%	0.6%

²⁸<https://www.energy.ca.gov/files/2025-energy-code-hourly-factors>. Actual escalation factors were provided by consultants E3.

Table 29: Real Utility Rate Escalation Rate Assumptions, 2025 LSC Basis

Year	Statewide Natural Gas Residential Average Rate (%/year, real)	Statewide Electricity Residential Average Rate (%/year, real)
2024	4.6%	2.1%
2025	4.6%	2.1%
2026	4.6%	2.1%
2027	4.2%	0.6%
2028	3.2%	1.9%
2029	3.6%	1.6%
2030	6.6%	1.3%
2031	6.7%	1.0%
2032	7.7%	1.2%
2033	8.2%	1.1%
2034	8.2%	1.1%
2035	8.2%	0.9%
2036	8.2%	1.1%
2037	8.2%	1.1%
2038	8.2%	1.0%
2039	8.2%	1.1%
2040	8.2%	1.1%
2041	8.2%	1.1%
2042	8.2%	1.1%
2043	8.2%	1.1%
2044	8.2%	1.1%
2045	8.2%	1.1%
2046	8.2%	1.1%
2047	3.1%	1.1%
2048	-0.5%	1.1%
2049	-0.6%	1.1%
2050	-0.5%	1.1%
2051	-0.6%	1.1%
2052	-0.6%	1.1%
2053	-0.6%	1.1%

Get In Touch

The adoption of reach codes can differentiate jurisdictions as efficiency leaders and help accelerate the adoption of new equipment, technologies, code compliance, and energy savings strategies.

As part of the Statewide Codes & Standards Program, the Reach Codes Subprogram is a resource available to any local jurisdiction located throughout the state of California.

Our experts develop robust toolkits as well as provide specific technical assistance to local jurisdictions (cities and counties) considering adopting energy reach codes. These include Cost-effectiveness research and analysis, model ordinance language and other code development and implementation tools, and specific technical assistance throughout the code adoption process.

If you are interested in finding out more about local energy reach codes, the Reach Codes Team stands ready to assist jurisdictions at any stage of a reach code project.



Visit LocalEnergyCodes.com to access our resources and sign up for newsletters.



Contact info@localenergycodes.com for no-charge assistance from expert Reach Code advisors



Follow us on LinkedIn

Single Family FlexPath

Referenced Studies

Title: [Single Family Residential Retrofits \(FlexPath and Specific Measures\)](#)

Backup Data: [SF Retrofits Study Data](#)

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

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

Last Modified: 2024/04/25

Title: [2019 Residential Retrofits](#)

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

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

Last Modified: 2021/08/27

Title: [Application of 2022 Studies to 2025 Energy Code: Existing Single Family Building Upgrades](#)

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

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

Last Modified: 2025/08/15

Proposed Requirements

The ordinance requires that major alterations or additions above a certain size select a subset of energy measures from a list to incorporate into their scope.

Cost-Effectiveness Results

Please see attached output from the Cost-Effectiveness Explorer. The memo describes the application of the results of the previous two cost-effectiveness studies to the current ordinance.

2022 Cost-Effectiveness Study: Existing Single Family Building Upgrades

Prepared by:

Ada Shen, Alea German, Rebecca Evans, & Marc Hoeschele, Frontier Energy, Inc
Misti Bruceri, Misti Bruceri & Associates, LLC

Prepared for:

Kelly Cunningham, Codes and Standards Program, Pacific Gas and Electric

Legal Notice

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Acronym List

2023 PV\$ – Present value costs in 2023

ACH50 – Air Changes per Hour at 50 pascals pressure differential

ACM – Alternative Calculation Method

ADU – Accessory Dwelling Unit

AFUE – Annual Fuel Utilization Efficiency

B/C – Lifecycle Benefit-to-Cost Ratio

BEopt – Building Energy Optimization Tool

BSC – Building Standards Commission

CA IOUs – California Investor-Owned Utilities

CASE – Codes and Standards Enhancement

CBEEC-Res – Computer program developed by the California Energy Commission for use in demonstrating compliance with the California Residential Building Energy Efficiency Standards

CEER – Combined Energy Efficiency Rating

CFI – California Flexible Installation

CFM – Cubic Feet per Minute

CO₂ – Carbon Dioxide

CPAU – City of Palo Alto Utilities

CPUC – California Public Utilities Commission

CZ – California Climate Zone

DFHP – Dual Fuel Heat Pump

DHW – Domestic Hot Water

DOE – Department of Energy

DWHR – Drain Water Heat Recovery

EDR – Energy Design Rating

EER – Energy Efficiency Ratio

EF – Energy Factor



GHG – Greenhouse Gas

HERS Rater – Home Energy Rating System Rater

HPA – High Performance Attic

HPSH – Heat Pump Space Heater

HPWH – Heat Pump Water Heater

HSPF – Heating Seasonal Performance Factor

HVAC – Heating, Ventilation, and Air Conditioning

IECC – International Energy Conservation Code

IOU – Investor Owned Utility

kBtu –British thermal unit (x1000)

kWh – Kilowatt Hour

LBNL – *Lawrence Berkeley National Laboratory*

LCC – Life Cycle Cost

LLAHU – Low Leakage Air Handler Unit

VLLDCS – Verified Low Leakage Ducts in Conditioned Space

LSC – Long-term Systemwide Cost

MF – Multifamily

MSHP – Mini-Split Heat Pump

NEEA – Northwest Energy Efficiency Alliance

NEM – Net Energy Metering

NPV – Net Present Value

NREL – *National Renewable Energy Laboratory*

PG&E – Pacific Gas and Electric Company

POU – Publicly-Owned-Utilities

PV – Photovoltaic

SCE – Southern California Edison

SDG&E – San Diego Gas and Electric

SEER – Seasonal Energy Efficiency Ratio

SF – Single Family

SMUD – Sacramento Municipal Utility District

SoCalGas – Southern California Gas Company

TDV – Time Dependent Valuation

Therm – Unit for quantity of heat that equals 100,000 British thermal units

Title 24 – Title 24, Part 6

TOU – Time-Of-Use

UEF – Uniform Energy Factor

VCHP – Variable Capacity Heat Pump, Title 24 compliance credit

ZNE – Zero-net Energy

Summary of Revisions

Date	Description	Reference (page or section)
4/25/2024	Original Release	N/A

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Executive Summary

The California Codes and Standards (C&S) 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 efficiency and greenhouse gas (GHG) 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.

This report documents cost-effective measure upgrades in existing single family buildings that exceed the minimum state requirements. It evaluates efficiency measures such as adding insulation, replacing windows, and duct upgrades, fuel substitution measures that upgrade space heating and water heating to heat pumps, and solar photovoltaics (PV) across all 16 California climate zones. A 1,665 square foot single family home prototype with an attached garage was evaluated in this study.

This analysis used two different metrics to assess the cost-effectiveness of the proposed upgrades. Both methodologies require estimating and quantifying the incremental costs and energy savings associated with each energy efficiency measure over a 30-year analysis period. On-Bill cost-effectiveness is a customer-based lifecycle cost (LCC) approach that values energy based upon estimated site energy usage and customer utility bill savings using today's electricity and natural gas utility tariffs. Long-term Systemwide Cost (LSC) is the California Energy Commission's LCC methodology for the 2025 Title 24, Part 6 (Title 24) code cycle (previously referred to as Time Dependent Valuation (TDV)), which is intended to capture the long-term projected cost of energy including costs for providing energy during peak periods of demand, carbon emissions, grid transmission and distribution impacts. This is the methodology used by the Energy Commission in evaluating cost-effectiveness for efficiency measures in Title 24 code development.

The following summarizes key results from the study:

Conclusions and Discussion:

1. Envelope measures. Improving envelope performance is very cost-effective in many older homes. In addition to reducing utility costs, these measures provide many other benefits such as improving occupant comfort and satisfaction and increasing a home's ability to maintain temperatures during extreme weather events and power outages. Below is a discussion of the results of specific measures.
 - a. Adding attic insulation is cost-effective based on both LSC and On-Bill in many climate zones in homes with no more than R-19 existing attic insulation levels. Increasing attic insulation from R-30 to R-49 was still found to be cost-effective based on at least one metric in the colder and hotter climates of Climate Zone 10 (SDG&E territory only) through 16.
 - b. Insulating existing uninsulated walls is very cost-effective based on both metrics everywhere except Climate Zones 6 and 7 (in Climate Zone 8 it's only cost-effective based on LSC).
 - c. Adding R-19 or R-30 floor insulation is cost-effective based on LSC in the older two vintages (Pre-1978 and 1978-1991) in all CZ except CZ 6-10.
 - d. Replacing old single pane windows with new high-performance windows has a very high cost and is typically not done for energy savings alone. However, energy savings are substantial and justify cost-effectiveness of this measure based on at least one metric in Climate Zones 4, 8 through 12 (PG&E territory only), and 13 through 16.
 - e. At time of roof replacement, a cool roof with an aged solar reflectance of 0.25 was found to be cost-effective in Climate Zones 4, 6 through 12 (PG&E territory only), and 13 through 15. When the roof deck is replaced during a roof replacement, adding a radiant barrier is low cost and provides substantial cooling energy savings, and was found to be cost-effective in almost all climate zones and homes.
2. Duct measures: Many older homes have old, leaky duct systems that should be replaced when they reach the end of life, typically 20-30 years. In this case, installing new ducts was found to be cost-effective based on at least one metric (both in most cases) everywhere except mild Climate Zone 7 and Climate Zones 5 and 6 in

the 1978-1991 vintage. If duct systems still have remaining life they should be sealed and tested to meet 10% leakage or lower; however, duct upgrades alone were only found to be cost-effective for newer homes in Climate Zones 10 (SDG&E territory only), 11, and 13 through 16. Duct upgrades may be able to be coupled with other measures to reduce the cost.

3. Heat pump space heating: HPSHs were found to be LSC cost-effective in many cases. The Dual Fuel Heat Pump (existing furnace) was LSC cost-effective everywhere except Climate Zone 15. The HPSH was LSC cost-effective everywhere except Climate Zones 8 and 15.
 - a. Challenges to On-Bill cost-effectiveness include higher first costs and higher first-year utility costs due to higher electricity tariffs relative to gas tariffs. SMUD and CPAU are two exceptions where first year utility costs are lower for heat pumps than for gas equipment. Table 11 shows the impact of utility rates on cost-effectiveness of HPSH where the standard and high efficiency HPSH and the HPSH + PV measures are cost-effective under SMUD but not PG&E. Even with higher first year utility bills, there were some cases that still proved On-Bill cost-effective including the DFHP with an existing furnace in the central valley and northern coastal PG&E territories, the ducted MSHP in the central valley as well as Climate Zone 14 in SDG&E territory, and the HPSH + PV measure in CZ 3-5 (PGE), 7-11, and 12 (SMUD) – 15.
 - b. The ductless MSHPs were only found to be cost-effective based on either metric in Climate Zones 1 and 16. Ductless MSHPs have a high incremental cost because it is a more sophisticated system than the base model of a wall furnace with a window AC unit. However, the ductless MSHP would provide greater comfort benefits if properly installed to directly condition all habitable spaces (as is required under the VCHP compliance credit as evaluated in this study) which may be an incentive for a homeowner to upgrade their system.
 - c. Higher efficiency equipment lowered utility costs in all cases and improved cost-effectiveness in many cases, particularly with a ducted MSHP.
4. Heat pump water heating: All the HPWH measures were LSC cost-effective in all climate zones. Most measures were not On-Bill cost-effective with the exception of the HPWH + PV which was cost-effective On-Bill in CPAU, SMUD, and SDG&E territories in addition to Climate Zones 11, 13, 14, and 15. The HPWH measures share many of the same challenges as the HPSH measures to achieving cost-effectiveness including high first costs and utility rates and assumptions. Table 13 shows the impact of utility rates on cost-effectiveness where some HPWH measures are cost-effective under SMUD utility rates but are not cost-effective anywhere under PG&E rates in Climate Zone 12.
 - a. Various HPWH locations were also explored, however there are some factors outside of cost-effectiveness that should also be considered.
 - i. HPWHs in the conditioned space can provide benefits such as free-cooling during the summer, reduced tank losses, and shorter pipe lengths, and in some cases show improved cost-effectiveness over garage located HPWHs. However, there are various design considerations such as noise, comfort concerns, an additional heating load in the winter, and condensate removal. Ducting the inlet and exhaust air resolves comfort concerns but adds costs and complexity. Split heat pump water heaters address these concerns, but currently there are limited products on the market and there is a cost premium relative to the packaged products.
 - ii. Since HPWHs extract heat from the air and transfer it to water in the storage tank, they must have adequate ventilation to operate properly. Otherwise, the space cools down over time, impacting the HPWH operating efficiency. This is not a problem with garage installations but needs to be considered for water heaters located in interior or exterior closets. For the 2025 Title 24 code the CEC is proposing that all HPWH installations meet mandatory ventilation requirements (California Energy Commission, 2023).
5. The contractor surveys revealed overall higher heat pump costs than what has been found in previous analyses. This could be due to incentive availability raising demand for heat pumps and thereby increasing the price. This price increase may be temporary and may come down once the market stabilizes. There are also

new initiatives to obtain current costs including the TECH Clean California program¹ that publishes heat pump data and costs; however, at the time of this analysis, the TECH data did not contain incremental costs because it only had the heat pump costs but not the gas base case costs.

6. Table 18 shows how CARE rates and escalation rate assumptions will impact cost-effectiveness.
 - a. Applying CARE rates in the IOU territories has the overall impact to increase utility cost savings for an all-electric building compared to a code compliant mixed fuel building, improving On-Bill cost-effectiveness. This is due to the CARE discount on electricity being higher than that on gas. The reverse occurs with efficiency measures where lower utility rates reduce savings and subsequently reduce cost-effectiveness.
 - b. If gas tariffs are assumed to increase substantially over time, in-line with the escalation assumption from the 2025 LSC development, cost-effectiveness substantially improves for the heat pump measures over the 30-year analysis period and many cases become cost-effective that were not found to be cost-effective under the CPUC / 2022 TDV escalation scenario. There is much uncertainty surrounding future tariff structures as well as escalation values. While it's clear that gas rates will increase, how much and how quickly is not known. Future electricity tariff structures are expected to evolve over time, and the CPUC has an active proceeding to adopt an income-graduated fixed charge that benefits low-income customers and supports electrification measures for all customers.² The CPUC will make a decision in mid-2024 and the new rates are expected to be in place later that year or in 2025. While the anticipated impact of this rate change is lower volumetric electricity rates, the rate design is not finalized. While lower volumetric electricity rates provide many benefits, it also will make building efficiency measures harder to justify as cost-effective due to lower utility bill cost savings.
7. Under NBT, utility cost savings for PV are substantially less than what they were under prior net energy metering rules (NEM 2.0); however, savings are sufficient to be On-Bill cost-effective in all climate zones except Climate Zones 1 through 3, 5, and 6.
 - a. Combining a heat pump with PV allows the additional electricity required by the heat pump to be offset by the PV system while also increasing on-site utilization of PV generation rather than exporting the electricity back to the grid at a low rate.
 - b. While not evaluated in this study, coupling PV with battery systems can be very advantageous under NBT increasing utility cost savings because of improved on-site utilization of PV generation and fewer exports to the grid.

Recommendations:

1. There are various approaches for jurisdictions who are interested in reach codes for existing buildings. Some potential approaches are listed below along with key considerations.
 - a. Prescriptive measures: Non-preempted measures that are found to be cost-effective may be prescriptively required in a reach code. One example of this type of ordinance is a cool roof requirement at time of roof replacement. Another example is requiring specific cost-effective measures for larger remodels, such as high-performance windows when new windows are installed or duct sealing and testing when ducts are in an unconditioned space.
 - b. Replacement equipment: This flavor of reach code sets certain requirements at time of equipment replacement. This study evaluated space heating and water heating equipment. Where a heat pump measure was found to be cost-effective based on either LSC or On-Bill, this may serve as the basis of a reach code given the following considerations.
 - i. Where reach codes reduce energy usage and are not just fuel switching, cost-effectiveness calculations are required and must be based on equipment that does not exceed the federal minimum efficiency requirements.
 - ii. Where reach codes are established using cost-effectiveness based on LSC, utility bill impacts and the owner's first cost should also be reviewed and considered.

¹ TECH Public Reporting Home Page (techcleanca.com)

² <https://www.cpuc.ca.gov/industries-and-topics/electrical-energy/electric-costs/demand-response-dr/demand-flexibility-rulemaking>

- iii. A gas path should also be prescriptively allowed to safely satisfy federal preemption requirements considering the CRA v. Berkeley case.³ Additional requirements may apply to the gas path, as described in Section 3.3, as long as the paths are reasonably energy or cost equivalent.
 - c. “Flexible Path”, minimum energy savings target: This flexible approach establishes a target for required energy savings based on a measure or a set of measures that were found to be cost-effective based on either LSC or On-Bill. A points menu compares various potential upgrades ranging from efficiency, PV, and fuel substitution measures, based on site or source energy savings. The applicant must select upgrades that individually or in combination meet the minimum energy savings target. The maximum target value shown in the Cost-effectiveness Explorer is based on a combination of cost-effective, non-preempted measures.
2. Equipment replacement ordinances should consider appropriate exceptions for scenarios where it will be challenging to meet the requirements, such as location of the HPWH, total project cost limitations, or the need for service panel upgrades that wouldn’t have been required as part of the proposed scope of work in absence of the reach code.
3. Consider extending relevant proposals made by the CEC for the 2025 Title 24 code (California Energy Commission, 2023) in ordinances that apply under the 2022 Title 24 code, such as the following:
 - a. Mandatory ventilation requirements for HPWH installations (Section 110.3(c)7). The cost-effectiveness analysis can be found in the Multifamily Domestic Hot Water CASE report (Statewide Team, 2023).
 - b. Requirement for HERS verified refrigerant charge verification for heat pumps in all climate zones (Table 150.1-A⁴). The cost-effectiveness analysis can be found in the Residential HVAC Performance CASE report (Statewide Team, 2023).
4. When evaluating reach code strategies, the Reach Codes Team recommends that jurisdictions consider combined benefits of energy efficiency alongside electrification. Efficiency and electrification have symbiotic benefits and are both critical for decarbonization of buildings. As demand on the electric grid is increased through electrification, efficiency can reduce the negative impacts of additional electricity demand on the grid, reducing the need for increased generation and storage capacity, as well as the need to upgrade upstream transmission and distribution equipment.
5. Education and training can play a critical role in ensuring that heat pumps are installed, commissioned, and controlled properly to mitigate grid impacts and maximize occupant satisfaction. Below are select recommended strategies.
 - a. The Quality Residential HVAC Services Program⁵ is an incentive program to train California contractors in providing quality installation and maintenance while advancing energy-efficient technologies in the residential HVAC industry. Jurisdictions can market this to local contractors to increase the penetration of contractors skilled in heat pump design and installation.
 - b. Educate residents and contractors of available incentives, tax credits, and financing opportunities.
 - c. Educate contractors on code requirements. Energy Code Ace provides free tools, training, and resources to help Californians comply with the energy code. Contractors can access interactive compliance forms, fact sheets, and live and recorded trainings, among other things, on the website: <https://energycodeace.com/>. Jurisdictions can reach out to Energy Code Ace directly to discuss offerings.
6. Health and safety
 - a. 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

³ <https://www.publichealthlawcenter.org/sites/default/files/2024-01/CRA-v-Berkeley-Ninth-Circuit-Opinion-Jan2024.pdf>

⁴ This requirement does not show up in the Express Terms for alterations in Section 150.2(b)1F, but the Statewide Reach Codes Team expects that it will be added to the next release of the proposed code language in the 45-day language as it aligns with the proposal made by the Codes and Standards Enhancement Team (Statewide CASE Team, 2023).

⁵ <https://qualityhvac.frontierenergy.com/>

if the appliances are not being replaced. It is recommended that the building department require inspection and testing of all combustion appliances located within the pressure boundary of the building after completion of retrofit work that involves air sealing or insulation measures.

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

Local jurisdictions may also adopt ordinances that amend different Parts of the California Building Standards Code or may elect to amend other state or municipal codes. The decision regarding which code to amend will determine the specific requirements that must be followed for an ordinance to be legally enforceable. For example, reach codes that amend Part 6 of the CA Building Code and require energy performance beyond state code minimums must demonstrate the proposed changes are cost-effective and obtain approval from the Energy Commission as well as the Building Standards Commission (BSC). Amendments to Part 11, such as requirements for increased water efficiency or electric vehicle infrastructure only require BSC approval. Although a cost-effectiveness study is only required to amend Part 6 of the CA Building Code, this study provides valuable context for jurisdictions pursuing other ordinance paths to understand the economic impacts of any policy decision. This study documents the estimated costs, benefits, energy impacts and greenhouse gas emission reductions that may result from implementing an ordinance based on the results to help residents, local leadership, and other stakeholders make informed policy decisions.

This report documents the key results and conclusions from the Reach Codes Team analysis. A full dataset of all results can be downloaded at <https://localenergycodes.com/content/resources>. Results alongside policy options can also be explored using the Cost-effectiveness Explorer at <https://explorer.localenergycodes.com/>. Model ordinance language and other resources are posted on the C&S Reach Codes Program website at LocalEnergyCodes.com. Local jurisdictions that are considering adopting an ordinance may contact the program for further technical support at info@localenergycodes.com.

1 Introduction

This report documents cost-effective measure upgrades in existing single family buildings that exceed the minimum state requirements, the 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 Codes Team.

The focus of this study is on existing single family buildings and does not apply to low or high-rise multifamily buildings. Each jurisdiction must establish the appropriate structure and threshold for triggering the proposed requirements. Some common jurisdictional 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 re-roofing project. The analysis includes scenarios of individual measures and identifies cost-effective options based on the existing conditions of the building in all 16 California Climate Zones (CZ) (see Cost-Effectiveness Results for a graphical depiction of climate zone locations).

This report documents the key results and conclusions from the Reach Codes Team analysis. A full dataset of all results can be downloaded at <https://localenergycodes.com/content/resources>. Results alongside policy options can also be explored using the Cost-effectiveness Explorer at <https://explorer.localenergycodes.com/>.

The California Codes and Standards (C&S) 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 efficiency 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.

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

The Department of Energy (DOE) sets minimum efficiency standards for equipment and appliances that are federally regulated under the National Appliance Energy Conservation Act, including heating, cooling, and water heating equipment (E-CFR, 2020). Since state and local governments are prohibited from adopting higher minimum efficiencies than the federal standards require, the focus of this study is to identify and evaluate cost-effective packages that do not include high efficiency heating, cooling, and water heating equipment. High efficiency appliances are often the easiest and most affordable measure to increase energy performance. While federal preemption limits reach code mandatory requirements for covered appliances, in practice, builders may install any package of compliant measures to achieve the performance requirements.

2 Methodology and Assumptions

2.1 Analysis for Reach Codes

This section describes the approach to calculating cost-effectiveness including benefits, costs, metrics, and utility rate selection.

2.1.1 Modeling

The Reach Codes Team performed energy simulations using the 2025 research version of the Residential California Building Energy Code Compliance software (CBECC). The 2025 version of CBECC was used instead of the 2022 version to take advantage of updated weather files and metrics. Site energy results are similar between CBECC-Res 2022 and 2025; however, the 2025 compliance metrics applies assumptions reflective of an electrified future, such as high escalation for natural gas retail rates, which favors electric buildings. In addition, in 2025 the weather stations were changed in Climate Zones 4 and 6 from San Jose to Paso Robles and Torrance to Los Angeles International Airport, respectively.

Three unique building vintages are considered: pre-1978, 1978-1991, and 1992-2010. The vintages were defined based on review of historic Title 24 code requirements and defining periods with distinguishing features. Prospective energy efficiency measures were identified and modeled to determine the projected site energy (therm and kWh), source energy, GHG emissions, and LSC (long-term systemwide cost) impacts. Annual utility costs were calculated using hourly data output from CBECC, and current (as of 11/01/2023) electricity and natural gas tariffs for each of the investor-owned utilities (IOUs) appropriate for that climate zone.

Equivalent CO₂ emission reductions were calculated based on outputs from the CBECC-Res simulation software. Electricity emissions vary by region and by hour of the year. CBECC-Res applies two distinct hourly profiles, one for Climate Zones 1 through 5 and 11 through 13 and another for Climate Zones 6 through 10 and 14 through 16. Natural gas emissions do not vary hourly. To compare the mixed-fuel and all-electric cases side-by-side, GHG emissions are presented as lbs CO₂-equivalent (CO₂e) emissions.

The Statewide Reach Codes Team designed the analysis approach and selected measures for evaluation based on the 2019 existing building single family reach code analysis (Statewide Reach Codes Team, 2021) and work to support the 2025 Title 24 code development cycle as well as from outreach to architects, builders, and engineers.

2.1.2 Prototype Characteristics

The Energy Commission defines building prototypes which it uses to evaluate the cost-effectiveness of proposed changes to Title 24 requirements. Average home size has steadily increased over time,⁶ and the Energy Commission single family new construction prototypes are larger than many existing single family homes across California. For this analysis, a 1,665 square foot prototype was evaluated. Table 1 describes the basic characteristics of the single family prototype. Additions are not evaluated in this analysis as they are already addressed in Section 150.2 of Title 24, Part 6. The CEC has proposed changes to the 2025 Energy Code that would remove the allowance of gas space heating and water heating equipment for additions and instead require additions to follow the same space heating and water heating equipment requirements as new construction (California Energy Commission, 2023). The proposed prescriptive requirements for single family new construction homes are heat pump space heaters and water heaters, with gas equipment only allowed in the performance approach.

⁶ <https://www.census.gov/const/C25Ann/sfttotalmedavgsqft.pdf>

Table 1. Prototype Characteristics

	Specification
Existing Conditioned Floor Area	1,665 ft ²
Num. of Stories	1
Num. of Bedrooms	3
Window-to-Floor Area Ratio	13%
Attached Garage	2-car garage

Three building vintages were evaluated to determine sensitivity of existing building performance on cost-effectiveness of upgrades. For example, it is widely recognized that adding attic insulation in an older home with no insulation is cost-effective, however, newer homes will likely have existing attic insulation reducing the cost-effectiveness of an incremental addition of insulation. The building characteristics for each vintage were determined based on either prescriptive requirements from Title 24 that were in effect or standard construction practice during that time period. Homes built under 2001 Title 24 are subject to prescriptive envelope code requirements very similar to homes built under the 2005 code cycle, which was in effect until January 1, 2010.

Table 2 summarizes the assumptions for each of the three vintages. Additionally, the analysis assumed the following features when modeling the prototype buildings. Efficiencies were defined by year of the most recent equipment replacement based on standard equipment lifetimes.

- Individual space conditioning and water heating systems, one per single family building.
- Split-system air conditioner with natural gas furnace.
 - Scenarios with an existing natural gas wall furnace without AC were also evaluated.
- Small storage natural gas water heater.
 - Scenarios with an existing electric resistance storage water heater were also evaluated.
- Gas cooktop, oven, and clothes dryer.

The methodology applied in the analyses 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 to determine the projected energy performance and utility cost impacts relative to the baseline vintage. In some cases, where logical, measures were packaged together.

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-5 @ ceiling level for CZ 6 & 7, Vented attic, R-11 @ ceiling level (all other CZs)	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 at 50 Pascals	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 at 25 Pa	Attic, R-2.1, 25% leakage at 25 Pa	Attic, R-4.2, 15% leakage at 25 Pa
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 Type	40-gallon gas storage	40-gallon gas storage	40-gallon gas storage
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 align wall system performance with monitored field data and not overestimate energy use.

^b Window type selections were made based on conversations with window industry expert, Ken Nittler. If a technology was entering the market during the time period (e.g., Low-E during 1992-2010 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.

2.1.3 Cost-Effectiveness Approach

2.1.3.1 Benefits

This analysis used two different metrics to assess the 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 way they value energy impacts (the numerator in the benefit cost calculation):

Utility Bill Impacts (On-Bill): This customer-based lifecycle cost (LCC) approach values energy based upon estimated site energy usage and customer utility bill savings using the latest electricity and natural gas utility tariffs available at the time of writing this report. Total savings are estimated over a 30-year duration and include discounting of future utility costs, as well as assumed energy cost inflation over time.

Long-term Systemwide Cost (LSC): Formerly known as Time Dependent Valuation (TDV) energy cost savings, LSC reflects the Energy Commission's current LCC methodology, which is intended to capture the total value or cost of energy use over 30 years. This method accounts for the hourly cost of marginal generation, transmission and distribution, fuel, capacity, losses, and cap-and-trade-based CO2 emissions (California Energy Commission, 2023). This is the methodology used by the Energy Commission in evaluating cost-effectiveness for efficiency measures in the 2025 Energy Code.

2.1.3.2 Costs

The Reach Codes Team assessed the incremental costs of the measures and packages over a 30-year analysis period. Incremental costs represent the equipment, installation, replacement, and maintenance costs of the proposed measure relative to the 2022 Title 24 Standards minimum requirements or standard industry practices. Present value of replacement cost is included only for measures with lifetimes less than the 30-year evaluation period. In cases where at the end of the analysis period the measure has useful life remaining, the value of this remaining life is calculated and credited in the total lifetime cost.

2.1.3.3 Metrics

Cost-effectiveness is presented using net present value (NPV) and benefit-to-cost (B/C) ratio metrics.

NPV: Equation 1 demonstrates how lifetime NPV is calculated. If the NPV of a measure or package is positive, it is considered cost-effective. A negative value represents a net increase in costs over the 30-year lifetime.

B/C Ratio: This is the ratio of the present value of all benefits to the present value of all costs over 30 years (present value benefits divided by present value costs). A value of one indicates the NPV of the savings over the life of the measure is equivalent to the NPV of the lifetime incremental cost of that measure. A value greater than one represents a positive return on investment. The B/C ratio is calculated according to Equation 2.

Equation 1

$$NPV = \text{present value of lifetime benefit} - \text{present value of lifetime cost}$$

Equation 2

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

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 LSC savings, and the cost is represented by incremental first cost and future replacement costs. Some packages result in initial construction cost savings relative to the assumed base case scenario, 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".

The lifetime costs or benefits are calculated according to Equation 3.

Equation 3

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

Where:

1. n = analysis term in years
2. r = discount rate

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

3. Analysis term of 30 years
4. Real discount rate of three percent

Both base case measures and alternative energy efficiency measures may have different lifetime assumptions which impact life cycle economics. Future costing of many of the evaluated electrification measures are only based on current cost assumption, which may be overly conservative as the expected growth in heat pump-based technologies is growing rapidly and will likely lead to future cost reductions (at least relative to current fossil fueled equipment) as production volumes increase.

2.1.4 Utility Rates

In coordination with the CA IOU rate team (comprised of representatives from Pacific Gas and Electric (PG&E), Southern California Edison (SCE) and San Diego Gas and Electric (SDG&E)) and two Publicly-Owned-Utilities (POUs) (Sacramento Municipal Utility District (SMUD) and City of Palo Alto Utilities (CPAU)), the Reach Codes Team determined appropriate utility rates for each climate zone to calculate utility costs and determine On-Bill cost-effectiveness for the proposed measures and packages. The utility tariffs, summarized in Chapter 6.2, were determined based on the appropriate rate for each case in each territory. Utility rates were applied to each climate zone based on the predominant IOU serving the population of each zone, with a few climate zones evaluated multiple times under different utility scenarios. Climate Zones 10 and 14 were evaluated with both SCE for electricity and Southern California Gas Company (SoCalGas) for gas and SDG&E tariffs for both electricity and gas since each utility has customers within these climate zones. Climate Zone 5 is evaluated under both PG&E and SoCalGas natural gas rates. Two POU or municipal utility rates were also evaluated: SMUD in Climate Zone 12 and CPAU in Climate Zone 4.

For cases with onsite generation (i.e. solar photovoltaics (PV)), the approved NBT tariffs were applied along with monthly service fees and hourly export compensation rates for 2024.⁷ In December 2022, the California Public Utilities Commission (CPUC) issued a decision adopting NBT as a successor to NEM 2.0 that went into effect April of 2023⁸.

Utility rates are assumed to escalate over time according to the assumptions from the CPUC 2021 En Banc hearings on utility costs through 2030 (California Public Utilities Commission, 2021a). Escalation rates through the remainder of the 30-year evaluation period are based on the escalation rate assumptions within the 2022 TDV factors. The Statewide Natural Gas Residential Average Rate for 2023 through 2030 is projected to be 4.6%. The Electric Residential Average Rate for PG&E, SCE and SDG&E for 2023 through 2030 is projected to be 1.8%, 1.6% and 2.8% respectively. A second set of escalation rates were also evaluated to demonstrate the impact that utility cost changes have on cost-effectiveness over time. This utility rate escalation sensitivity analysis, presented in Section 3.2.4, was based on those used within the 2025 LSC factors (LSC replaces TDV in the 2025 code cycle) which assumed steep

⁷ Hourly export compensation rates were based on the NBT spreadsheet model created by E3 for the CPUC.
<https://www.cpuc.ca.gov/-/media/cpuc-website/divisions/energy-division/documents/net-energy-metering-nem/nemrevisit/nbt-model--12142022.xlsb>

⁸ <https://www.cpuc.ca.gov/nemrevisit>

increases in gas rates in the latter half of the analysis period. See Appendix 6.2.7 Fuel Escalation Assumptions for details.

Future electricity tariff structures are expected to evolve over time, and the CPUC has an active proceeding to adopt an income-graduated fixed charge that benefits low-income customers and supports electrification measures.¹⁰ These were not included in this analysis but may be evaluated later in 2024 once the rates are finalized.

2.1.5 Measure Cost Data Collection Approach

To support this effort, a detailed cost study was completed in the summer of 2023 to gather data from a range of contractors to inform actual installed costs in the areas they provide services. These areas include HVAC, plumbing, envelope and air-sealing, and PV installation. Home performance contractors were also approached to collect this data. Collecting this type of data is challenging, both due to contractor reticence to share cost information and due to the timing of the survey which unfortunately coincided with the summer busy season for most contractors, especially HVAC installers. With these known challenges, the outreach effort focused on leveraging existing relationships between the analysis team and contractors to both gain access and provide assurance that all cost data would remain confidential and aggregated. Contractors that provided feedback were nominally compensated for their time.

The collected cost data was intended to represent recent costs for a “typical” retrofit installation. Each home in which a contractor does work has different site-specific issues that will likely affect costs. In addition, different jurisdictions have different levels of building department installation oversight and permit fees. Finally, each contractor typically has a different manufacturer product line they prefer to install. All these factors will influence installed costs¹¹.

The most detailed and broad cost request was for the HVAC contractors, as there are a wide range of equipment replacement scenarios available for an existing ducted gas furnace with central split-system air conditioning. Options range from a base case scenario (like for like swap out), split-system heat pump replacement, dual fuel heat pumps (DFHP), ducted mini-split heat pumps, non-ducted mini-splits, etc. For plumbing contractors, a range of scenarios existed for water heater replacements including like-for-like replacement, HPWHs (in different locations- garage, indoor), need for electrical upgrade for HPWH installation, need for HPWH ducting, etc. Envelope measures focused on attic and wall insulation, window replacement, re-roofing (with Cool Roof materials or not), and attic ceiling plane air-sealing. PV costing included different system sizes, panel upgrades costs, and battery costs. Home performance contractors were asked to provide as much data as they could on the different measure options. All costing information requested was intended to represent most recent installations, in an effort to capture current pricing as best as possible.

The contractors that responded with their cost estimates work in different regions of the state, operate in different markets with (potentially) different local efficiency incentives, do varying amounts of work based on the size of their company, target different market demographic sectors, and install different brands of equipment. All these factors will contribute to price variability. The Team considered applying climate zone specific cost adjustments to reflect some of these differences, but ultimately decided not to since a climate zone is not a monolithic entity with uniform customer pricing throughout. The Team recognizes that “zip code” pricing is a reality, but for simplicity, as well as consistency with Title 24, Part 6 code development costing approaches, applied uniform statewide costs to all measures.

2.2 Measure Details and Cost

This section describes the details of the measures and documents incremental costs. All measure costs were obtained from the contractor survey unless otherwise noted. All contractor provided costs reflect the cost to the customer and

¹⁰ <https://www.cpuc.ca.gov/industries-and-topics/electrical-energy/electric-costs/demand-response-dr/demand-flexibility-rulemaking>

¹¹ One HVAC contractor mentioned that equipment brand alone may contribute to a +/-5% variation in the total bid cost.

include equipment, labor, permit fees, and required HERS testing. Additional details of the measures can be found in Appendix Section **Error! Reference source not found.**

All measures are evaluated assuming they are not otherwise required by Title 24. 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. In some cases, cost-effective measures were identified that exceed Title 24 requirements, such as attic insulation, cool roofs, and duct sealing.

2.2.1 Building Envelope & Duct Measures

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

Attic Insulation: Add attic insulation in buildings with vented attic spaces to meet either R-38 or R-49. The pre-1978 vintage assumes an existing condition of R-11, the 1978-1991 vintage assumes an existing condition of R-19, and the 1992-2010 vintage assumes R-30 as the existing insulation level. For pre-1978 vintage homes this measure was also evaluated to include air sealing of the attic. A 14% leakage reduction was modeled such that 15 ACH50 was reduced to 12.9 ACH50 in this measure. The costs for this measure include removing existing insulation.

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 homes would be leakier than newer buildings and that approximately 30 percent improvement in air leakage is 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), to ten to seven ACH50 for the 1978-1991 vintage, and 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 0.20 or 0.25 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 0.20 or 0.25. This is similar to cool roof requirements in 2022 Title 24 Section 150.2(b)1li but assumes a higher solar reflectance.

Radiant Barrier: Add radiant barrier to any existing home vintage. 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 includes a laminated radiant barrier.

Raised Floor Insulation: In existing homes with raised floors and no insulation (pre-1978 and 1978-1991 vintages), add R-19 insulation. An upgraded R-30 floor insulation, assuming no current insulation, was evaluated in the pre-1978 and 1978-1991 vintages.

Wall Insulation: Blow-in R-13 wall insulation in existing homes without wall insulation (pre-1978 vintages).

Window Replacement: Replace existing windows with a non-metal dual-pane product, which has a U-factor equal to 0.28 Btu/hour-ft²-°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 was evaluated.

Duct Sealing, New Ducts, and Duct Insulation: Air seal all ductwork to meet the requirements of the 2022 Title 24, Part 6 Section 150.2(b)1E. For this analysis, final duct leakage values of ten percent (proposed revised leakage rate for 2022 Title 24) was evaluated. The pre-1978 and 1978-1992 vintages assume leaky existing ducts (25-30% leakage). The 1992-2010 vintage assumes moderately leaky existing ducts (15-20% leakage).

Replacing existing ductwork with entirely new ductwork to meet Sections 150.2(b)1Di and 150.2(b)1Diia of the 2022 Title 24 was also evaluated. This assumed new ducts meet 5% duct leakage and the option of R-6 and R-8 duct insulation in all climate zones.

Table 3 summarizes the cost assumptions for the building envelope and HVAC duct improvement measures evaluated. All the measures in Table 3 assume a 30-year effective useful life.

Table 3. Measure Cost Assumptions – Efficiency & Duct Measures

Measure	Performance Level	Incremental Cost – Single Family Building		
		Pre 1978	1978 – 1991	1992 - 2010
Wall Insulation	R-13	\$2,950	N/A	N/A
Raised Floor Insulation	R-19	\$3,633	\$3,633	N/A
	R-30	\$4,113	\$4,113	\$4,113
Attic Insulation	R-38	\$6,762	\$2,555	\$1,781
	R-49	\$7,446	\$3,612	\$1,827
Air Sealing	10 ACH50	\$4,684	N/A	N/A
	7 ACH50	N/A	\$4,684	N/A
	5 ACH50	N/A	N/A	\$4,684
Cool Roof	0.25 Aged Solar Reflectance CZs 1-3,5-7,16	\$2,407	\$2,407	\$2,407
	0.25 Aged Solar Reflectance CZs 4, 8-15	\$1,203	\$1,203	\$1,203
Window U-factor/SHGC	0.28 U-factor. 0.23 SHGC in CZs 2,4,6-15.	\$11,463	\$11,463	\$11,463
	0.28 U-factor. 0.35 SHGC in CZs 1,3,5,26	\$11,871	\$11,871	\$11,871
Radiant Barrier	Add Radiant Barrier	\$893	\$893	\$893
Duct Sealing	10% nominal airflow	\$2,590	\$2,590	\$1,400
All New Duct System	R-6 ducts; 5% duct leakage	\$4,808	\$4,808	\$4,808
	R-8 ducts; 5% duct leakage	\$6,311	\$6,311	\$6,311

2.2.2 PV Measures

Installation of on-site PV is required in the 2022 Title 24 code for new construction homes, but there are no PV requirements for additions or alterations to existing buildings. PV was evaluated in CBECC-Res according to the California Flexible Installation (CFI) 1 assumptions and 98% solar access. To meet CFI eligibility, the requirements of 2022 Reference Appendices JA11.2.2 (California Energy Commission, 2021b) must be met. A 3 kW PV system was modeled both as a standalone measure as well as coupled with heat pump installations.

The costs for installing PV are summarized in Table 4. They include the first cost to purchase and install the system, future inverter replacement costs, and annual maintenance costs. Upfront solar PV system costs are estimated from the contractor surveys to be \$4.58/W_{DC} and are reduced by 30 percent to account for the federal income Residential Clean Energy Credit. The solar panels are estimated to have an effective useful life of 30 years and the inverter 25 years. The inverter replacement cost of \$7,000 (future value) is also from the contractor surveys. System maintenance costs are taken from the 2019 PV CASE Report (California Energy Commission, 2017) and are assumed to be

\$0.31/W_{DC} present value. These costs do not include costs associated with electrical panel upgrades, which will be necessary in some instances.

Table 4. Measure Descriptions & Cost Assumptions – PV

Measure	Performance Level	Incremental Cost		
		Pre 1978	1978 – 1991	1992 - 2010
PV	3 kW		\$9,608	

2.2.3 Equipment Fuel Substitution Measures – Heat Pump Equipment

The fuel substitution measures are evaluated as replacements at the end of the life of the existing equipment. This means the baseline compared against is usually a like-for-like change-out of the natural gas equipment, and the upgrade is a heat pump.

For most of the space heating and water heating cases, costs for electrical service panel upgrades are not included as it is assumed many existing homes have the service capacity to support converting one appliance from gas to electric. For homes with existing air conditioners, any incremental electric capacity necessary to support a heat pump space heater is marginal. The same applies for homes with existing electric resistance equipment. Section 3.2.4 presents the impacts for select cases where an upgrade to the electric panel is required.

Heat Pump Space Heating

All the heat pump space heater (HPSH) measures are described below. All were evaluated with HERS verified refrigerant charge aligned with the proposed code requirements for the 2025 Title 24 code. Dual fuel heat pumps (DFHPs) were controlled to lockout furnace operation above 35°F.

DFHP (Existing Furnace): Replace existing ducted air conditioner (AC) with an electric heat pump and install controls to operate the heat pump to use the existing gas furnace for backup heat. A minimum federal efficiency (14.3 SEER2, 11.7 EER2, 7.5 HSPF2) heat pump was evaluated. Savings are compared to a new AC (14.3 SEER2, 11.7 EER2) alongside the existing furnace (78 AFUE).

DFHP (New Furnace): Replace existing ducted AC and natural gas furnace with an electric heat pump and new gas furnace plus controls to operate the heat pump and use the new gas furnace for backup heat. A minimum federal efficiency (14.3 SEER2, 11.7 EER2, 7.5 HSPF2) heat pump and furnace (80 AFUE) were evaluated to replace existing equipment. Savings are compared to a new ducted AC and natural gas furnace (14.3 SEER2, 11.7 EER2, 80 AFUE).

Heat Pump Space Heater: Replace existing ducted AC and natural gas furnace with an electric heat pump. Minimum federal efficiency (14.3 SEER2, 11.7 EER2, 7.5 HSPF2) and higher efficiency (17 SEER2, 12.48 EER2, 9.5 HSPF2) heat pumps were evaluated. Savings are compared to a new ducted natural gas furnace and AC (14.3 SEER2, 11.7 EER2, 80 AFUE).

Ducted Mini-Split Heat Pump (MSHP): Replace existing ducted AC and natural gas furnace with a ducted high efficiency MSHP (16.5 SEER2, 12.48 EER2, 9.5 HSPF2). Savings are compared to a new ducted AC and natural gas furnace (14.3 SEER2, 11.7 EER2, 80 AFUE).

Ductless MSHP: In a home without AC, replace existing wall furnace with a ductless MSHP. A standard efficiency unit meeting minimum federal efficiency standards (14.3 SEER2, 11.7 EER2, 7.5 HSPF2) was evaluated by modeling the variable capacity heat pump (VCHP) compliance credit in CBECC-Res. A premium, higher efficiency upgrade was also

evaluated using CBECC-Res' detailed VCHP model¹² by simulating the performance of a representative high efficiency product (14.3 SEER2, 11.7 EER2, 7.5 HSPF2). Savings are compared to a new natural gas wall furnace with fan distribution (75% AFUE) and window AC (9 CEER).

Over the 30-year analysis period, certain changes are assumed when the equipment is replaced that impact both lifetime costs and energy use. Table 5 presents the lifetime scenario for the DFHP (existing furnace) measure. The analysis assumed a 20-year effective useful lifetime (EUL) for a furnace, a 15-year EUL for an air conditioner and a 15-year EUL for a heat pump. Lifetimes are based on the Database for Energy Efficient Resources (DEER) (California Public Utilities Commission, 2021b). The existing furnace is assumed to be halfway through its EUL at the beginning of the analysis period. After 10 years when the furnace reaches the end of its life and needs to be replaced, it will be subject to new federal efficiency standards for residential gas furnaces that go into effect in 2028 requiring 95 AFUE¹³. 5 years later the air conditioner reaches the end of its life and is replaced with a new air conditioner.

For the DFHP upgrade case, after 10 years when the furnace fails it's expected that the furnace will be abandoned in place since the heat pump serves primary heating and was sized to provide the full design heating load. In this case it is assumed that the fan motor would be replaced with a new aftermarket unit and would operate another 5 years until the heat pump fails and is replaced with a new heat pump and air handler.

The other ducted heat pump cases similarly apply a 95 AFUE furnace in the baseline when the furnace reaches its EUL after 20 years.

Table 5. Lifetime Analysis Replacement Assumptions for DFHP (Existing Furnace) Scenario

Year	Baseline	Upgrade
0	AC fails, install new AC, keep existing furnace	AC fails, install new HP, keep existing furnace
10	Furnace fails, install new 95AFUE furnace	Furnace fails, replace fan motor
15	AC fails, install new AC	HP fails, install new HP and air handler

Costs were applied based on the system capacity from heating and cooling load calculations in CBECC-Res as presented in Table 6. Air conditioner nominal capacity was calculated as the CBECC-Res cooling load, rounded up to the nearest half ton. Heat pump nominal capacity was calculated as the maximum of either the CBECC-Res heating or cooling load, rounded up to the nearest half ton. In both cases a minimum capacity of 1.5-ton was applied as this represents the typical smallest available split system heat pump equipment. Load calculations demonstrated that Climate Zones 2 - 15 were cooling-dominated while Climate Zones 1 and 16 were heating-dominated. In the heating dominated climate zones the heat pump needed to be upsized relative to an air conditioner that only provides cooling.

¹² The detailed VCHP option allows for the user to input detailed specifications based on the published National Energy Efficiency Partnership (NEEP) manufacturer specific performance data. It is not currently available for compliance analysis.

¹³ <https://www.energy.gov/articles/doe-finalizes-energy-efficiency-standards-residential-furnaces-save-americans-15-billion#:~:text=These%20furnace%20efficiency%20standards%20were,heat%20for%20the%20living%20space.>

Table 6. System Sizing by Climate Zone

Climate Zone	Air Conditioner Capacity (tons)	Heat Pump Capacity (tons)
1	1.5	3.0
2	3.5	3.5
3	2.5	2.5
4	3.5	3.5
5	3.0	3.0
6	3.0	3.0
7	3.0	3.0
8	4.0	4.0
9	4.0	4.0
10	4.0	4.0
11	4.5	4.5
12	4.0	4.0
13	4.5	4.5
14	4.0	4.0
15	5.0	5.0
16	3.5	4.0

Table 7 presents estimated first and lifetime costs for the various ducted baseline and heat pump scenarios for 4-ton equipment. Costs include all material and installation labor including providing new 240 V electrical service to the air handler location for all new air handler installations and decommissioning of the furnace for the cases where the furnace is removed. DFHP costs incorporate controls installation and commissioning to ensure the heat pump and the furnace communicate properly and don't operate at the same time. Future replacement costs do not include any initial costs associated with 240V electrical service or furnace decommissioning.

Table 8 presents estimated first and lifetime costs for the ductless baseline and 2 heat pump scenarios, also for 4-ton heat pump equipment. EULs are based on 20 years for the gas wall furnace, 10 years for the window AC, and 15 years for the heat pump.¹⁴

¹⁴ The gas wall furnace and heat pump EULs were based on DEER (California Public Utilities Commission, 2021b). Gas wall furnace lifetime was assumed to be the same as for central gas furnace equipment. Room air conditioner EUL was based on the DOE's latest rulemaking for room air conditioned (Department of Energy, 2023). DOE determined an average lifetime of 9.3 years, which was rounded up to 10 years for this analysis.

Table 7. Ducted HVAC Measure Cost Assumptions – 4-Ton Electric Replacements

Case	AC + Coil	Gas Furnace /AC	DFHP (Existing Furnace)	DFHP (New Furnace)	Min. Eff. Heat Pump	High Eff. Heat Pump	Ducted MSHP
Base Case	-	-	AC + Coil	Gas Furnace /AC	Gas Furnace /AC	Gas Furnace /AC	Gas Furnace /AC
First Cost	\$10,402	\$16,653	\$12,362	\$20,676	\$17,825	\$20,802	\$18,075
Replacement Cost (Future Value)	\$19,365	\$19,365	\$19,025	\$19,025	\$16,825	\$19,802	\$18,075
Replacement Cost (Present Value)	\$13,346	\$11,639	\$12,334	\$12,897	\$10,800	\$12,710	\$11,601
Remaining Value at Year 30	\$0	(\$1,846)	\$0	(\$1,846)	\$0	\$0	\$0
Total Lifecycle Cost	\$23,748	\$26,446	\$24,696	\$31,727	\$28,625	\$33,512	\$29,676
Incremental Cost	-	-	\$948	\$5,281	\$2,179	\$7,066	\$3,230

Table 8. Non-Ducted HVAC Measure Cost Assumptions – 4-Ton Electric Replacements

	Wall Furnace + Window AC	Min. Eff. Ductless MSHP	High Eff. Ductless MSHP
First Cost	\$4,075	\$17,412	\$21,342
Replacement Cost (Future Value)	\$4,075	\$17,412	\$21,342
Replacement Cost (Present Value)	\$3,365	\$11,176	\$13,698
Remaining Value at Year 30	(\$532)	\$0	\$0
Total Lifecycle Cost	\$6,908	\$28,588	\$35,040
Incremental Cost	-	\$21,680	\$28,132

Heat Pump Water Heating:

The heat pump water heater (HPWH) measures are described below, and costs are presented in Table 9 and Table 10. The most typical scenario in California is a home with existing natural gas storage tank water heaters. However, there are also many existing homes with existing electric resistance storage tank water heaters and this work considers both baselines. This analysis evaluates the following 65-gallon replacement HPWHs:

1. HPWH that meets the federal minimum efficiency requirements of UEF 2.0
2. HPWH that meets the Northwest Energy Efficiency Alliance (NEEA)¹⁵ Tier 3 rating (3.45 UEF)
3. HPWH that meets the NEEA Tier 4 rating and that has demand response (DR) or load shifting control capability (4.02 UEF)
4. 120V HPWH that meets the NEEA Tier 3 rating (3.3 UEF).

¹⁵ Based on operational challenges experienced in the past, NEEA established rating test criteria to ensure newly installed HPWHs perform adequately, especially in colder climates. The NEEA rating requires an Energy Factor equal to the ENERGY STAR® performance level and includes requirements regarding noise and prioritizing heat pump use over supplemental electric resistance heating.

The four cases above were evaluated with the HPWH located within an attached garage. Additionally, three separate cases for the federal minimum efficiency HPWH were analyzed to consider the impacts of location on performance and cost-effectiveness. These locations included the following:

1. Exterior closet.
2. Interior closet, no ducting.
3. Interior closet, ducted to the outside.

Additional costs for providing electrical wiring to these locations and for providing ductwork were included. Savings are compared to a new 50-gallon natural gas storage water heater (UEF 0.63) or a new 50-gallon electric water heater (UEF 0.92).

For this analysis, a HPWH that just meets the federal minimum efficiency standards of close to 2.0 Uniform Energy Factor (UEF) was evaluated in order to satisfy preemption requirements. However, the Reach Codes Team is not aware of any 2.0 UEF products that are available on the market. The lowest UEF reported for certified products in the Northwest Energy Efficiency Alliance (NEEA)¹⁶ database is 2.73. In fact, of the four certification tiers offered by NEEA for high efficiency HPWHs, those meeting Tier 3 or Tier 4 are the dominant products on the market today. According to NEEA all major HPWH manufacturers are represented in NEEA's qualified product list¹⁷ and there are fewer than 10 integrated products certified as Tier 1 or Tier 2, all of which have UEFs greater than 3.0.¹⁸ Therefore, in this analysis, we refer to the NEEA rated HPWH as the "market standard" HPWH.

The HPWH costs for the 120V and NEEA certified units are based on a larger (60 or 65 gallon) HPWH, as most contractors are upsizing the HPWH tank size relative to an equal volume, but higher capacity gas storage water heater. Costs include all material and installation labor including providing a new 240 V electrical service to the water heater location (not needed for the 120V product). Water heating equipment lifetimes are based on DOE's recent water heater rulemaking (Department of Energy, 2022) and assume 15-year EULs for both the baseline water heaters and the HPWHs.¹⁹ Future replacement costs for 240V HPWHs do not include any initial costs associated with 240V electrical service, condensate disposal, etc.

Table 9. Water Heating Measure Cost Assumptions – Existing Gas

	Gas Storage Water Heater	240V Fed. Min. HPWH	240V Market Std. NEEA HPWH	240V Market Std. NEEA HPWH + DR	120V Market Std. NEEA HPWH	240V Fed. Min. HPWH, Exterior Closet	240V Fed. Min. HPWH, Interior Closet, Not Ducted	240V Fed. Min. HPWH, Interior Closet, Ducted
First Cost	\$2,951	\$7,283	\$8,144	\$8,144	\$5,844	\$7,702	\$7,363	\$8,442
Replacement Cost (Future Value)	\$2,951	\$6,413	\$7,274	\$7,274	\$5,101	\$6,413	\$6,413	\$6,413
Replacement Cost (Present Value)	\$1,894	\$4,116	\$4,669	\$4,669	\$3,274	\$4,116	\$4,116	\$4,116
Total Lifecycle Cost	\$4,845	\$11,399	\$12,813	\$12,813	\$9,118	\$11,818	\$11,479	\$12,558
Incremental Cost	-	\$6,554	\$7,968	\$7,968	\$4,273	\$6,973	\$6,634	\$7,713

¹⁶ Based on operational challenges experienced in the past, NEEA established rating test criteria to ensure newly installed HPWHs perform adequately, especially in colder climates. The NEEA rating requires products comply with ENERGY STAR and includes requirements regarding noise and prioritizing heat pump use over supplemental electric resistance heating.

¹⁷ <https://neea.org/success-stories/heat-pump-water-heaters>

¹⁸ As of 12/21/23: <https://neea.org/img/documents/residential-unitary-HPWH-qualified-products-list.pdf>

¹⁹ The recent DOE rulemaking references a lifetime of 14 years for gas storage water heaters and 14.8 years for electric storage water heaters. 15 years for each was used in this analysis for both types for simplification.

Table 10 presents similar costs to Table 9, except that the costs assume replacement of an existing 50-gallon electric storage water heater and does not include the 240 V electrical service cost.

Table 10. Water Heating Measure Cost Assumptions – Existing Electric Resistance

	Electric Storage Water Heater	240V Fed. Min. HPWH	240V Market Std. NEEA HPWH	240V Market Std. NEEA HPWH + DR	120V Market Std. NEEA HPWH	240V Fed. Min. HPWH, Exterior Closet	240V Fed. Min. HPWH, Interior Closet, Not Ducted	240V Fed. Min. HPWH, Interior Closet, Ducted
First Cost	\$2,583	\$6,413	\$7,274	\$7,274	\$5,101	\$6,413	\$6,413	\$7,492
Replacement Cost (Future Value)	\$2,583	\$6,413	\$7,274	\$7,274	\$5,101	\$6,413	\$6,413	\$6,413
Replacement Cost (Present Value)	\$1,658	\$4,116	\$4,669	\$4,669	\$3,274	\$4,116	\$4,116	\$4,116
Total Lifecycle Cost	\$4,241	\$10,529	\$11,943	\$11,943	\$8,375	\$10,529	\$10,529	\$11,608
Incremental Cost	-	\$6,288	\$7,702	\$7,702	\$4,134	\$6,288	\$6,288	\$7,367

3 Results

The primary objective of the evaluation is to identify cost-effective energy upgrade measures and packages for existing single family 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 at burnout of mechanical equipment. In this report, the 1992-2010 vintage is shown for the equipment measures because it is the most conservative case (lowest loads), while the pre-1978 vintage is shown for the envelope and duct measures because some of those measures only apply to the pre-1978 vintage. A full dataset of all results can be downloaded at <https://localenergycodes.com/content/resources>. Results alongside policy options can also be explored using the Cost-effectiveness Explorer at <https://explorer.localenergycodes.com/>.

3.1 Cost-Effectiveness Results

The extensive analysis for this type of report leads to an overwhelming number of scenarios including different base cases, house vintages, replacement options, and climate zones. To simplify the reporting, the Statewide Reach Codes Team has relied on graphical representation of select key cases indicating high level measure cost effectiveness from either an On-Bill perspective, an LSC perspective, both metrics, or neither. Figure 1 through Figure 13 present this reduced set of results of the LSC and On-Bill cost-effectiveness conclusions across the 16 climate zones. In the cases where there are multiple utilities serving a single climate zone, an asterisk “*” label is added to separately show the alternate utility cases. These graphs provide a general sense of the findings. A full dataset of all results can be downloaded at <https://localenergycodes.com/content/resources>. Results alongside policy options can also be explored using the Cost-effectiveness Explorer at <https://explorer.localenergycodes.com/>.

3.1.1 HPSH Measures

Figure 1 through Figure 5 show the cost-effectiveness of space heating equipment replacement measures for the 1992-2010 vintage including the following cases. The 1992-2010 vintage results are presented here as this is the most conservative scenario for HPSH measures. In general, where a HPSH measure is cost-effective for a new home it was also found to be cost-effective for older homes.

- Dual fuel heat pump with existing furnace as backup.
- Standard efficiency ducted central heat pump replacement.
- High efficiency ducted central heat pump replacement.
- Ducted mini-split heat pump replacement.
- Standard efficiency ducted central heat pump replacement with 3kW PV system.

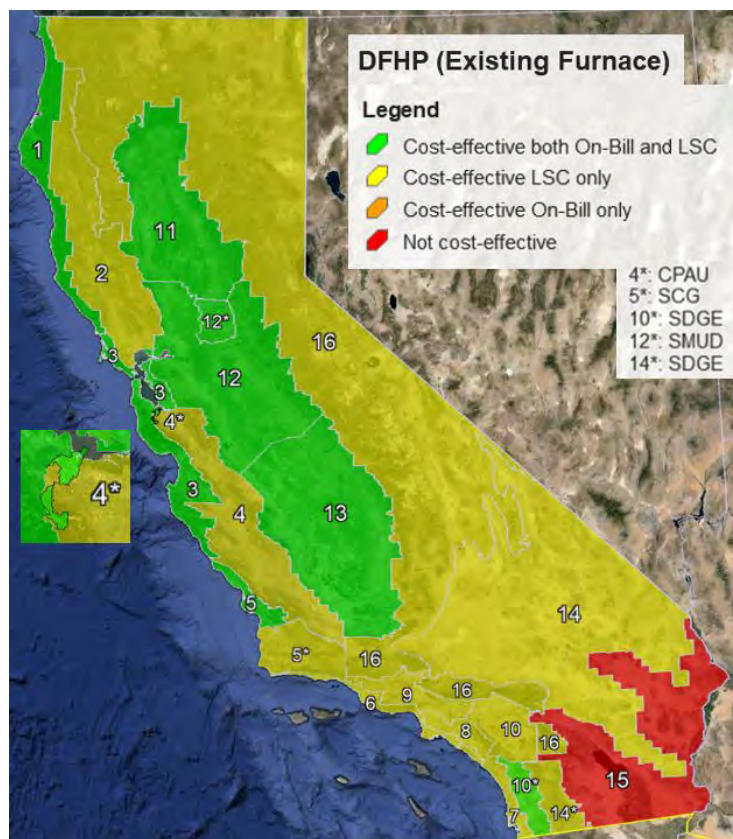


Figure 1: DFHP with Existing Furnace

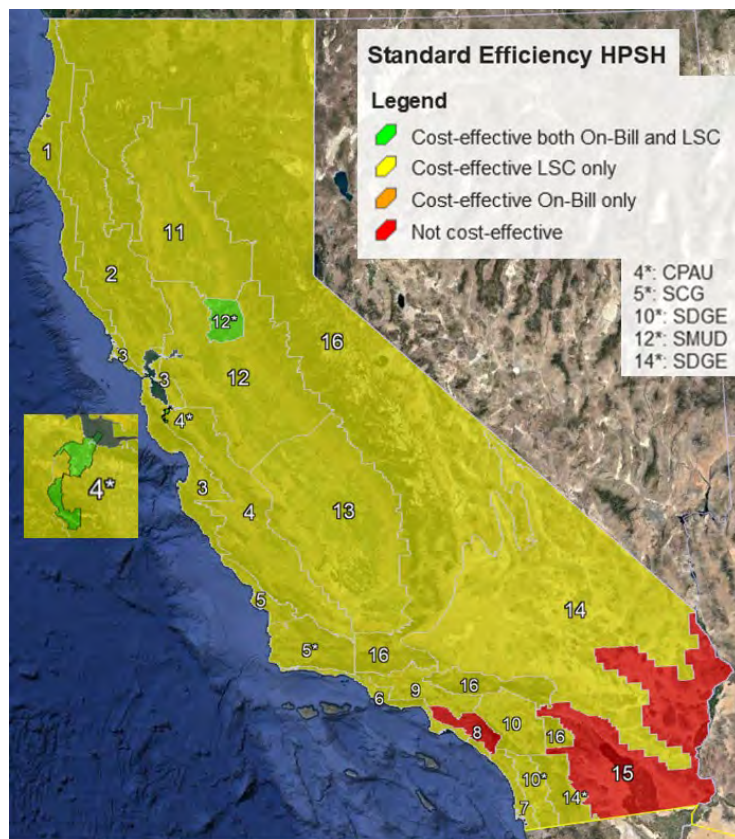


Figure 2: Standard Efficiency HPSH

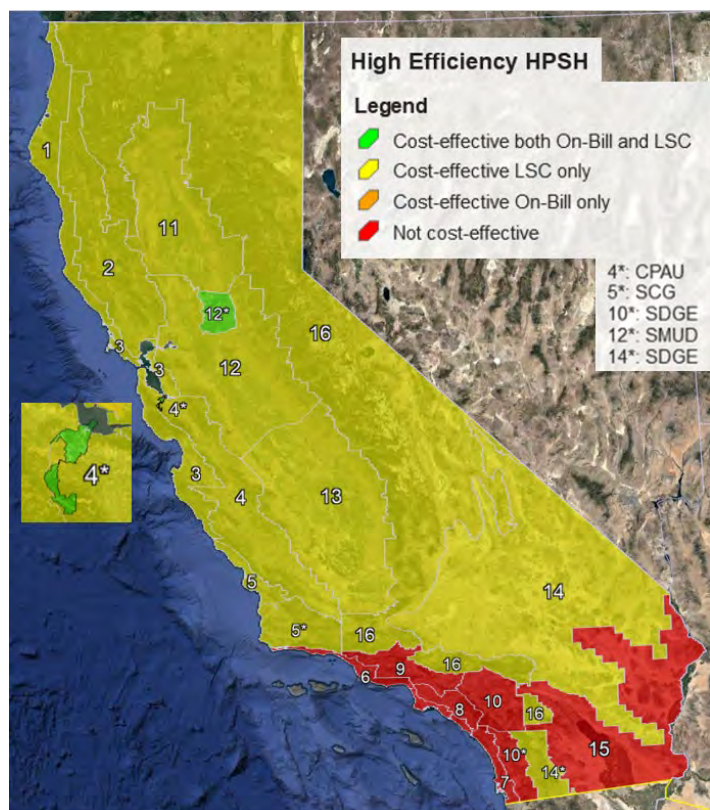


Figure 3: High Efficiency HPSH

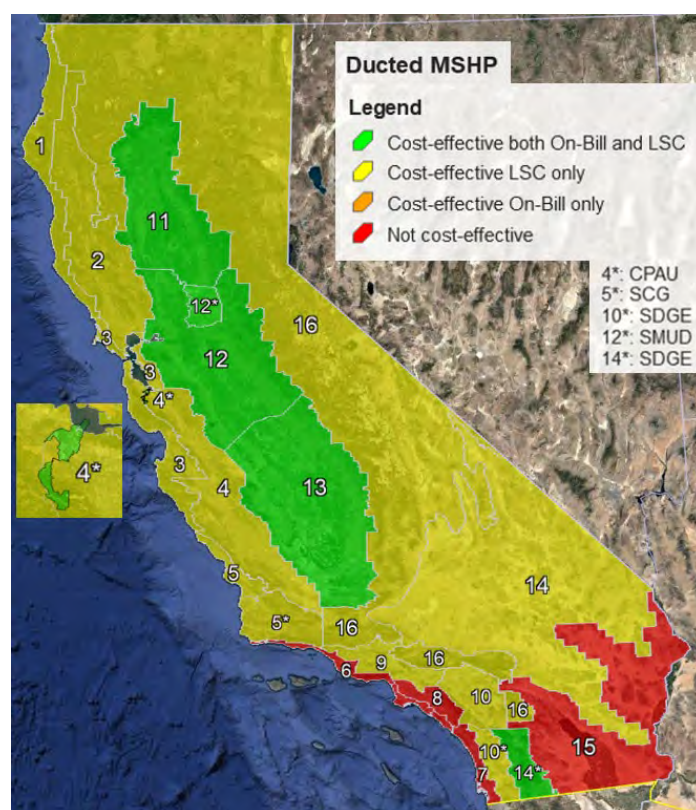


Figure 4: Ducted MSHP

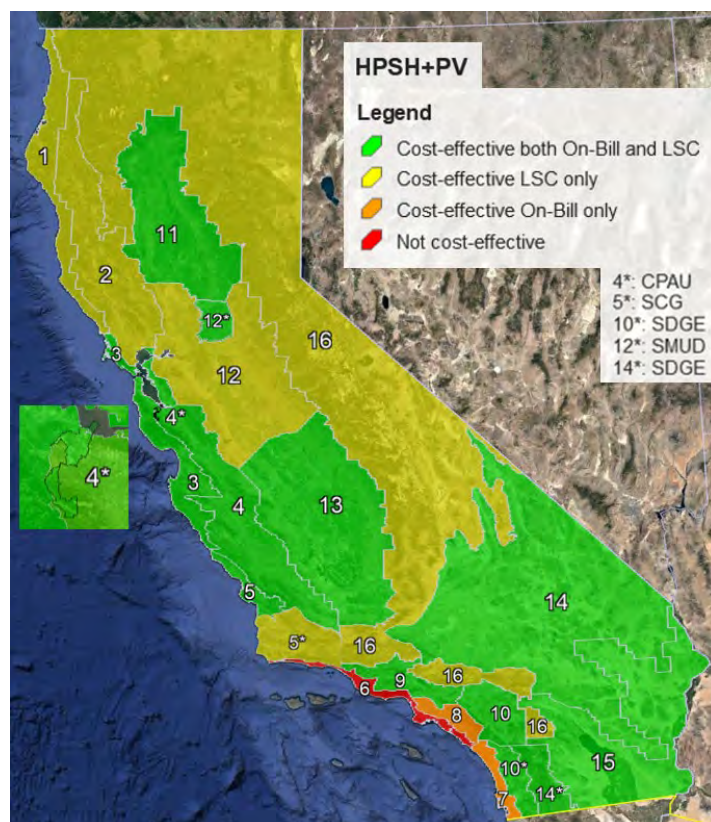


Figure 5: HPSH + PV

3.1.2 HPWH Measures

Figure 6 through Table 11 show the cost-effectiveness of water heater measures for the 1992-2010 vintage including the following cases. HPWH energy savings and LSC cost-effectiveness is not sensitive to home vintage but rather depends on the magnitude of hot water loads, which are typically driven by the number of occupants. On-Bill cost-effectiveness does vary slightly by vintage due to the impact of the electrification tariff relative to the load profile of the existing home. The impact is largest for the HPWH + PV case where On-Bill cost-effectiveness improves for older homes or homes with overall higher energy use resulting in less exports to the grid for a fixed size PV system.

- 240V federal minimum HPWH
- 240V market standard NEEA HPWH
- 120V market standard NEEA HPWH
- 240V federal minimum HPWH with 3kW PV

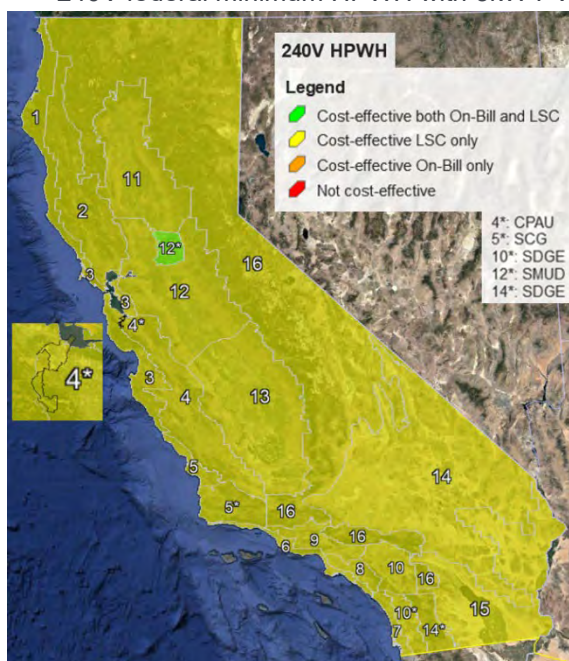


Figure 6: 240V Federal Minimum HPWH

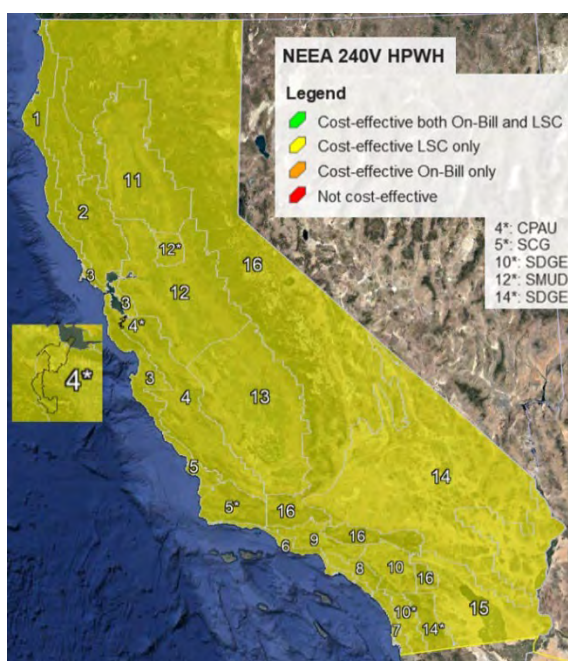


Figure 7: 240V Market Standard NEEA HPWH

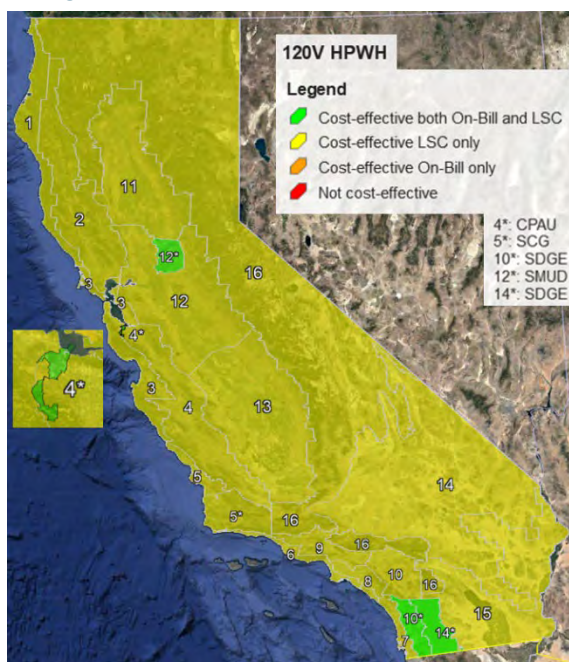


Figure 8: 120V Market Standard NEEA HPWH

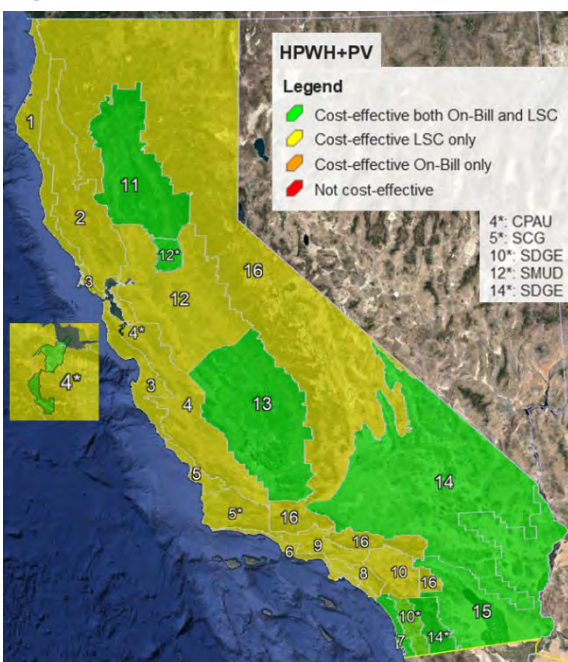
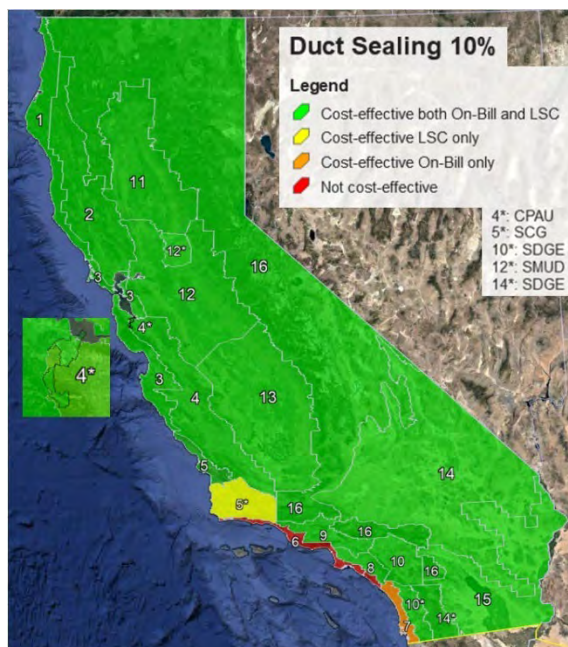
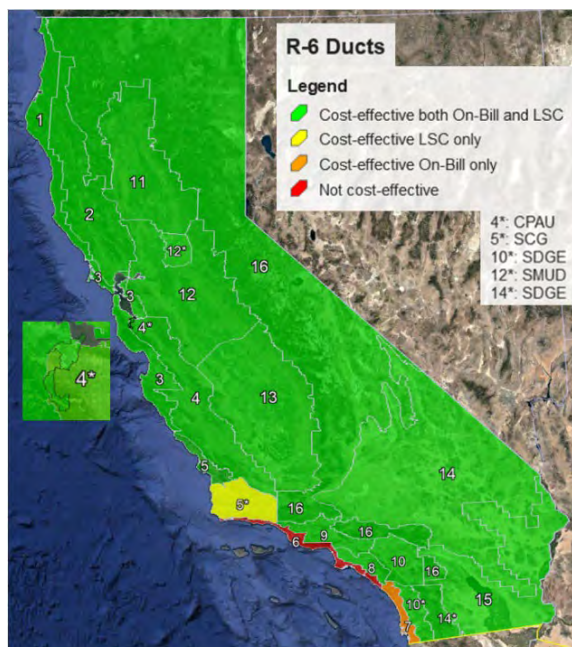


Figure 9: 240V Federal Minimum HPWH + PV

- Envelope and Duct Measures

Figure 10 through Figure 13 show the cost-effectiveness results of envelope and duct measures for the pre-1978 vintage including the following measures. The pre-1978 vintage is presented as representing the most favorable existing conditions for cost-effective upgrades. Newer homes with higher performing envelope may still benefit from these types of upgrade measures, but cost-effectiveness is reduced. Some measures, like R-13 wall insulation, aren't applicable to newer homes which would have been constructed originally with insulated walls.

- New R-6 ducts
- 10% duct leakage
- R-13 wall insulation
- R-49 attic insulation



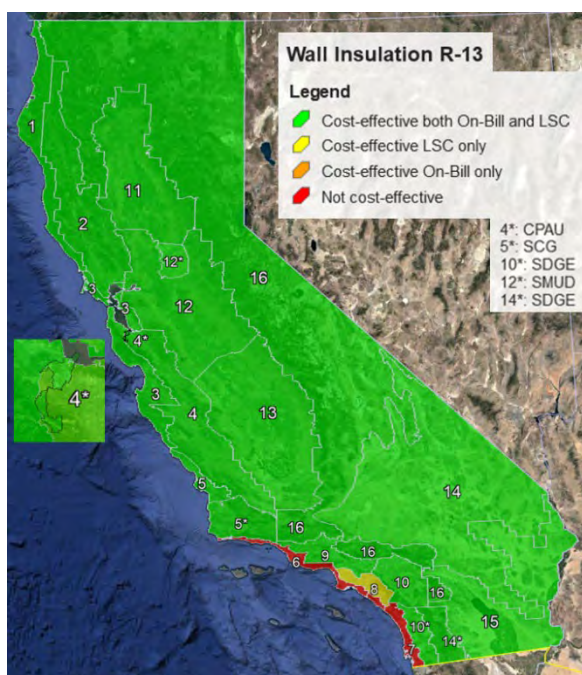


Figure 10: R-6 Ducts

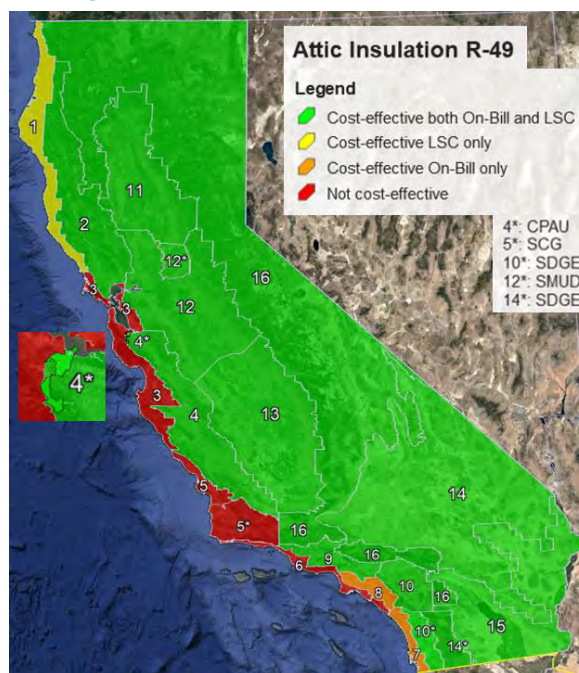


Figure 11: 10% Duct Leakage

Figure 12: R-13 Wall Insulation

Figure 13: R-49 Attic Insulation

3.2 Climate Zone Case Studies

To better understand the details of the results, a few climate zones were selected to provide a more detailed presentation of cost-effectiveness results. Section 3.2.1 through 3.2.3 show the first-year incremental cost, first-year utility savings, and NPV for a variety of cases. Section 3.2.4 shows the sensitivity of the cost effectiveness results due to varying utility escalation rates, the impact of CARE rates, future equipment cost assumptions, and the need for electrical panel upgrades. The climate zones were selected to be representative of areas of significant reach code activity. Please refer to the Cost-Effectiveness Explorer (Statewide Reach Codes, 2023) or the source dataset for the full analysis.

3.2.1 HPSH Cost-Effectiveness

Cost-effectiveness of heat pump space heating measures for Climate Zones 12 and 16 is summarized in Table 11 and Table 12 below. In Climate Zone 12, HPSH measures are cost-effective based on LSC in all cases except the ductless MSHP cases and are cost-effective On-Bill with SMUD rates in all cases except the DFHP case with a new furnace and the ductless MSHP cases. These measures are cost-effective On-Bill with PGE for the DFHP with an existing furnace and ducted MSHP measures. Climate Zone 16 provides an example of HPSH cost-effectiveness in a cold climate where almost all HPSH measures are cost effective based on LSC but not cost-effective On-Bill.

Table 11. HPSH CZ 12 [1992-2010]

Measure	First Incremental Cost	2025 LSC NPV	PGE		SMUD	
			First-year Utility Savings	On-Bill NPV	First-year Utility Savings	On-Bill NPV
DFHP Existing Furnace	\$1,960	\$7,093	(\$19)	\$1,633	\$247	\$7,693
DFHP New Furnace	\$4,023	\$3,915	(\$34)	(\$3,134)	\$234	\$2,979
HPSH (Std Efficiency)	\$1,172	\$6,990	(\$147)	(\$2,151)	\$246	\$6,812
HPSH (High Efficiency)	\$4,149	\$5,366	\$13	(\$3,368)	\$300	\$3,160
Ducted MSHP	\$1,421	\$9,136	\$10	\$378	\$298	\$6,951
Ductless MSHP (Std Efficiency)	\$13,336	(\$9,175)	\$30	(\$18,039)	\$276	(\$12,428)
Ductless MSHP (High Efficiency)	\$17,266	(\$6,753)	\$409	(\$15,853)	\$423	(\$15,532)
HPSH + PV	\$10,780	\$5,289	\$452	(\$59)	\$885	\$9,821

Table 12. HPSH CZ 16 [1992-2010]

Measure	First Incremental Cost	2025 LSC NPV	PGE	
			First-year Utility Savings	On-Bill NPV
DFHP Existing Furnace	\$2,397	\$7,289	(\$116)	(\$1,891)
DFHP New Furnace	\$4,757	\$2,457	(\$133)	(\$6,322)
HPSH (Std Efficiency)	\$2,725	\$11,142	(\$480)	(\$8,532)
HPSH (High Efficiency)	\$5,701	\$12,099	(\$204)	(\$7,125)
Ducted MSHP	\$2,155	\$16,554	(\$221)	(\$2,853)
Ductless MSHP (Std Efficiency)	\$13,336	(\$134)	(\$170)	(\$19,742)
Ductless MSHP (High Efficiency)	\$17,266	\$9,397	\$539	(\$10,031)
HPSH + PV	\$12,333	\$10,640	\$316	(\$1,949)

3.2.2 HPWH Cost-Effectiveness

Cost-effectiveness of heat pump water heating measures for Climate Zones 12 and 16 is summarized in Table 13 and Table 14 below. This sensitivity study looks at a wider range of HPWH tank locations and whether or not the unit has ducting for supply and exhaust air. All the HPWH measures in Climate Zones 12 and 16 are cost effective based on LSC.

Table 13. HPWH CZ 12 [1992-2010]

Measure	First Incremental Cost	2025 LSC NPV	PGE		SMUD	
			First-Year Utility Savings	On-Bill NPV	First-Year Utility Savings	On-Bill NPV
240V Fed. Min. HPWH	\$4,332	\$3,536	(\$213)	(\$8,738)	\$191	\$477
240V Market Std. NEEA HPWH	\$5,193	\$4,304	(\$82)	(\$7,164)	\$230	(\$56)
240V Market Std. NEEA HPWH + DR	\$5,193	\$5,536	(\$21)	(\$5,773)	\$248	\$362
120V Market Std. NEEA HPWH	\$2,893	\$9,730	(\$2)	(\$1,651)	\$254	\$4,203
240V Fed. Min. HPWH (Exterior Closet)	\$4,751	\$2,834	(\$224)	(\$9,431)	\$186	(\$78)
240V Fed. Min. HPWH (Interior Closet)	\$4,413	\$3,123	(\$71)	(\$6,138)	\$188	(\$235)
240V Fed. Min. HPWH (Interior Closet, ducted)	\$5,492	\$3,359	(\$202)	(\$9,505)	\$205	(\$231)
240V Fed. Min. HPWH + PV	\$13,940	\$3,567	\$577	(\$2,300)	\$831	\$3,486

Table 14. HPWH CZ 16 [1992-2010]

Measure	First Incremental Cost	2025 LSC NPV	PGE	
			First-Year Utility Savings	On-Bill NPV
240V Fed. Min. HPWH	\$4,332	\$4,186	(\$250)	(\$9,307)
240V Market Std. NEEA HPWH	\$5,193	\$4,088	(\$160)	(\$8,652)
240V Market Std. NEEA HPWH + DR	\$5,193	\$5,653	(\$79)	(\$6,804)
120V Market Std. NEEA HPWH	\$2,893	\$10,646	(\$13)	(\$1,602)
240V Fed. Min. HPWH (Exterior Closet)	\$4,751	\$3,317	(\$268)	(\$10,154)
240V Fed. Min. HPWH (Interior Closet)	\$4,413	\$5,004	(\$18)	(\$4,690)
240V Fed. Min. HPWH (Interior Closet, ducted)	\$5,492	\$4,857	(\$202)	(\$9,174)
240V Fed. Min. HPWH + PV	\$13,940	\$5,049	\$620	(\$1,043)

3.2.3 Envelope & Duct Improvement Cost-Effectiveness

Cost-effectiveness of envelope and duct measures for Climate Zones 3, 10, and 12 is summarized in Table 15 through Table 17.

Table 15. Envelope and Duct Measures CZ 3 [Pre-1978]

Measure	First Incremental Cost	2025 LSC NPV	PG&E	
			First-year Utility Savings	On-Bill NPV
R-6 Ducts	\$4,808	\$2,851	\$188	\$463
R-8 Ducts	\$6,311	\$1,747	\$198	(\$776)
10% Duct Sealing	\$2,590	\$1,956	\$104	\$397
R-13 Wall Insulation	\$2,950	\$3,476	\$144	\$1,221
R-38 Attic Insulation	\$6,762	(\$1,567)	\$127	(\$3,178)
R-49 Attic Insulation	\$7,446	(\$1,768)	\$139	(\$3,520)
R-30 Raised Floor Insulation	\$4,113	\$9,008	\$224	\$2,975
Cool Roof (0.20 Ref)	\$893	(\$2,419)	(\$18)	(\$1,811)

Table 16. Envelope and Duct Measures CZ 10 [Pre-1978]

Measure	First Incremental Cost	2025 LSC NPV	SCE/SCG		SDGE	
			First-year Utility Savings	On-Bill NPV	First-year Utility Savings	On-Bill NPV
R-6 Ducts	\$4,808	\$7,463	\$783	\$13,168	\$1,100	\$22,155
R-8 Ducts	\$6,311	\$6,326	\$800	\$12,076	\$1,125	\$21,268
10% Duct Sealing	\$2,590	\$3,438	\$370	\$5,969	\$518	\$10,166
R-13 Wall Insulation	\$2,950	\$1,795	\$179	\$1,476	\$250	\$3,494
R-38 Attic Insulation	\$6,762	\$664	\$416	\$2,951	\$582	\$7,654
R-49 Attic Insulation	\$7,446	\$796	\$467	\$3,435	\$655	\$8,756
R-30 Raised Floor Insulation	\$4,113	(\$999)	(\$29)	(\$4,235)	(\$46)	(\$4,687)
Cool Roof (0.20 Ref)	\$893	\$428	\$174	\$2,647	\$246	\$4,656

Table 17. Envelope and Duct Measures CZ 12 [Pre-1978]

Measure	First Incremental Cost	2025 LSC NPV	PG&E		SMUD	
			First-year Utility Savings	On-Bill NPV	First-year Utility Savings	On-Bill NPV
R-6 Ducts	\$4,808	\$11,609	\$804	\$14,727	\$413	\$5,816
R-8 Ducts	\$6,311	\$10,722	\$828	\$13,849	\$427	\$4,711
10% Duct Sealing	\$2,590	\$6,418	\$397	\$7,280	\$222	\$3,281
R-13 Wall Insulation	\$2,950	\$5,774	\$262	\$4,054	\$187	\$2,342
R-38 Attic Insulation	\$6,762	\$3,727	\$499	\$5,461	\$261	\$19
R-49 Attic Insulation	\$7,446	\$4,092	\$552	\$6,063	\$288	\$33
R-30 Raised Floor Insulation	\$4,113	\$5,245	\$27	(\$1,176)	\$156	\$1,175
Cool Roof (0.20 Ref)	\$893	(\$354)	\$154	\$2,123	\$44	(\$386)

3.2.4 Sensitivities

Table 18 shows the On-Bill NPV results of Climate Zone 12 with PG&E utility rates and the impacts of escalation rates, and CARE rates. The “Standard Results” in Table 18 assumes the escalation rates used in the analysis presented elsewhere in this report. Table 19 shows the impact of electrical panel upgrades. The “Standard Results” in Table 19 does not assume a panel upgrade is required.

Table 18. Sensitivity Analysis Results for On-Bill NPV Cost-Effectiveness in Climate Zone 12, PG&E

Measure	Vintage	Standard Results	2025 LSC Escalation	CARE
DFHP Existing Furnace	1992-2010	\$1,063	\$8,443	\$1,884
DFHP New Furnace	1992-2010	(\$6,770)	\$383	(\$5,846)
HPSH (Std Efficiency)	1992-2010	(\$2,151)	\$6,011	(\$220)
HPSH (High Efficiency)	1992-2010	(\$3,368)	\$4,987	(\$2,721)
Ducted MSHP	1992-2010	\$378	\$8,729	\$1,057
Ductless MSHP (Std Efficiency)	1992-2010	(\$18,039)	(\$10,732)	(\$17,623)
Ductless MSHP (High Efficiency)	1992-2010	(\$15,853)	(\$8,091)	(\$18,460)
HPSH + PV	1992-2010	(\$59)	\$8,822	(\$1,255)
240V Fed. Min. HPWH	1992-2010	(\$8,738)	(\$2,433)	(\$6,448)
240V Market Std. NEEA HPWH	1992-2010	(\$7,164)	(\$694)	(\$5,918)
240V Market Std. NEEA HPWH + DR	1992-2010	(\$5,773)	\$770	(5,014)
120V Market Std. NEEA HPWH	1992-2010	(\$1,651)	\$4,930	(1,038)
240V Fed. Min. HPWH (Exterior Closet)	1992-2010	(\$9,431)	(\$3,184)	(\$7,055)
240V Fed. Min. HPWH (Interior Closet)	1992-2010	(\$6,138)	(\$1,000)	(\$5,098)
240V Fed. Min. HPWH (Interior Closet, ducted)	1992-2010	(\$9,505)	(\$2,836)	(\$7,271)
240V Fed. Min. HPWH + PV	1992-2010	(\$2,300)	\$4,952	(\$4,858)
R-6 Ducts	Pre-1978	\$14,727	\$18,685	\$8,592
R-8 Ducts	Pre-1978	\$13,849	\$17,990	\$7,532
10% Duct Sealing	Pre-1978	\$7,280	\$9,752	\$4,294
R-13 Wall Insulation	Pre-1978	\$4,054	\$6,898	\$2,196
R-38 Attic Insulation	Pre-1978	\$5,461	\$8,126	\$1,668
R-49 Attic Insulation	Pre-1978	\$6,063	\$8,978	\$1,864
R-30 Raised Floor Insulation	Pre-1978	(\$1,776)	\$2,468	(\$1,602)
Cool Roof (0.20 Ref)	Pre-1978	\$2,123	\$1,848	\$851

Table 19. Electric Panel Upgrade Sensitivity for CZ 12 [1992-2010]

Measure	Standard Results		Electric Panel Upgrade	
	On-Bill NPV	LSC NPV	On-Bill NPV	LSC NPV
HPSH (Std Efficiency)	(\$2,151)	\$6,990	(\$4,931)	\$4,210
240V Fed. Min. HPWH	(\$8,738)	\$3,536	(\$11,624)	\$756

3.3 Gas Pathways for Heat Pump Replacements

Many jurisdictions are exploring policy options to accelerate the decarbonization of existing homes. A recent Ninth Circuit Court ruling in *California Rest. Ass'n v. City of Berkeley*²⁰ invalidated Berkeley's ordinance banning the installation of gas infrastructure in new construction. The ruling stated that the ordinance effectively banned covered products and was preempted by the Energy Policy and Conservation Act ("EPCA"), 42 U.S.C. § 6297(c). Given the possible impacts of that ruling, the Reach Codes Team analyzed policy options targeting equipment replacements that allow for the installation of either electric or gas-fueled equipment. These packages include gas equipment combined with additional efficiency measures resulting in options that are reasonably energy or LSC cost equivalent, to the extent feasible.

For space heating, the heat pump path is a DFHP (existing furnace).. The gas pathway is a new air conditioner with the following list of efficiency upgrades:

- 400 cfm/ton system airflow (HERS verified).
- 0.35 W/cfm fan efficacy (HERS verified).
- Refrigerant charge verification (HERS verified).
- R-8 ducts, 5% leakage (HERS verified).
- R-49 (from R-30) attic insulation.
- Air sealing of the ceiling from 7 to 6.5 ACH50.

The two pathways are presented in Figure 14 comparing total LSC energy use relative to the existing home for the 1992-2010 vintage. In most climate zones, the DFHP (existing furnace) path results in higher energy savings, in the milder climates the air conditioner path saves marginally more energy. A reach code that establishes requirements when an air conditioner is replaced or installed new, could allow for either a heat pump to be installed or an air conditioner as long as the performance measures listed above are met. Note that in this analysis a DFHP (existing furnace) was used; however, a reach code could require a different heat pump measure for the heat pump path. This approach aligns with the CEC's proposal for the 2025 Title 24 code cycle for heat pump alterations in single family homes (California Energy Commission, 2023).

²⁰ *California Rest. Ass'n v. City of Berkeley*, 65 F.4th 1045 (9th Cir. 2023) amended by 89 F.4th 1094 (9th Cir. 2024).

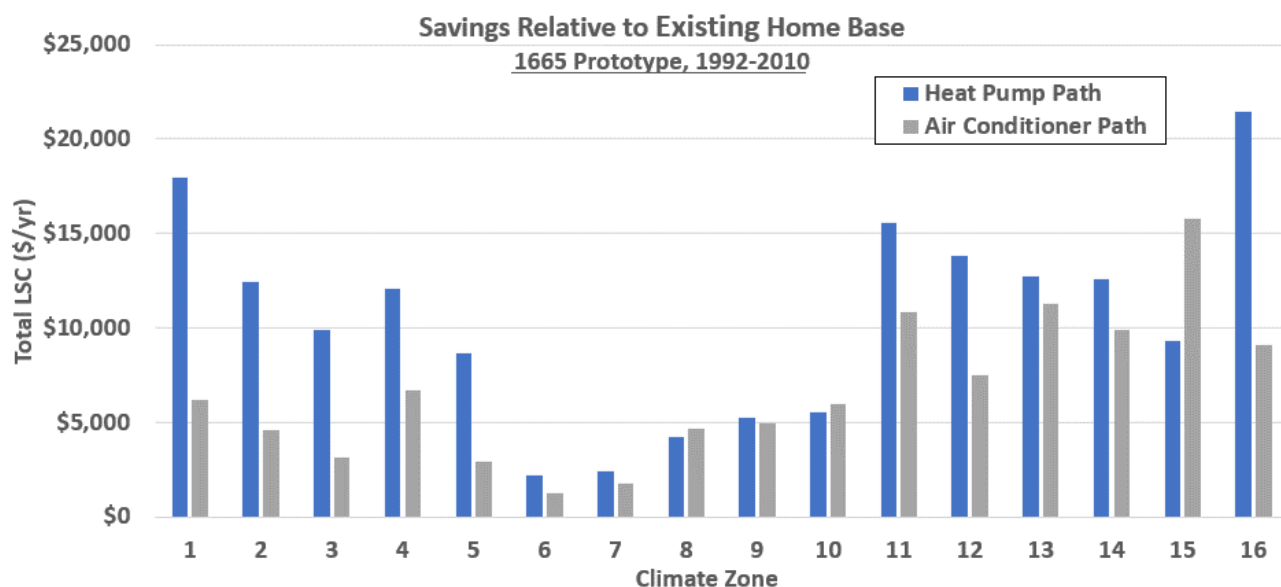


Figure 14. Heat pump space heater path compared to the air conditioner path.

For water heating, the federal minimum HPWH case was used to develop the package. The HPWH was compared to a new gas storage water heater with a 50% solar thermal backup system.

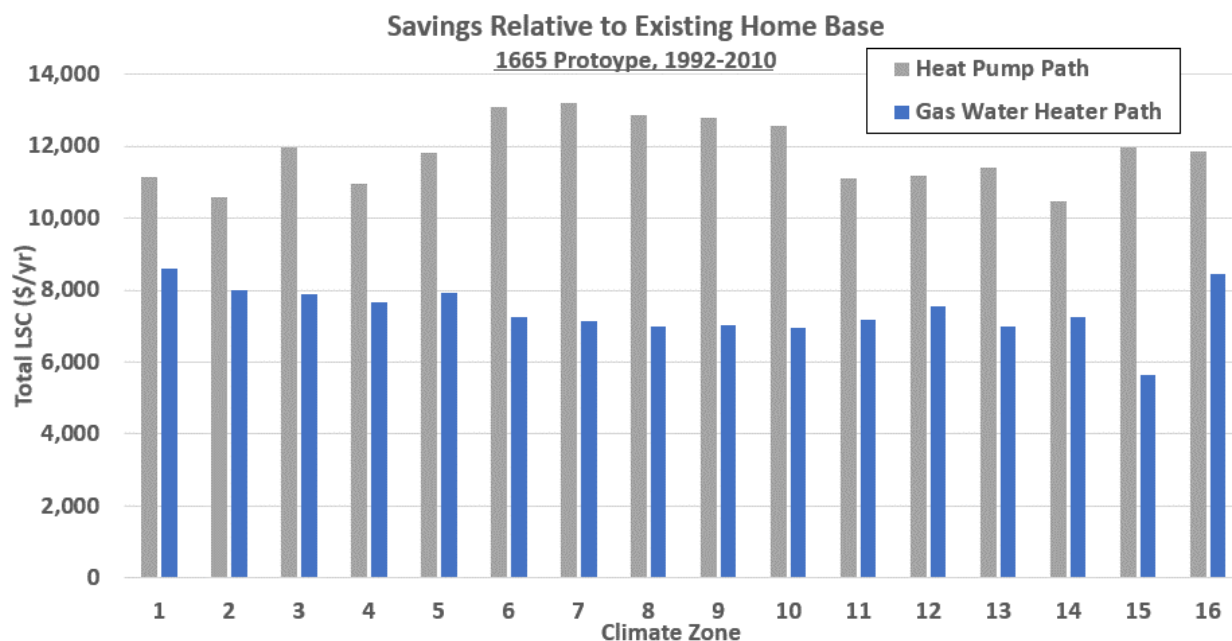


Figure 15. Heat pump water path compared to gas with solar thermal.

The two pathways are presented in Figure 15 comparing total LSC energy use relative to the existing home for the 1992-2010 vintage. In all climate zones, the heat pump path results in higher energy savings than the gas path. A reach code that establishes requirements when a water heater is replaced could allow for either a HPWH to be installed or a gas water heater in combination with a solar thermal system that meets the solar fraction requirements listed above.

4 Recommendations and Discussion

This analysis evaluated the feasibility and cost-effectiveness of retrofit measures in California existing homes built before 2010. The Statewide Reach Codes Team used both On-Bill and LSC-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.

Conclusions and Discussion:

1. Envelope measures. Improving envelope performance is very cost-effective in many older homes. In addition to reducing utility costs these measures provide many other benefits such as improving occupant comfort and satisfaction and increasing a home's ability to maintain temperatures during extreme weather events and power outages. Below is a discussion of the results of specific measures.
 - a. Adding attic insulation is cost effective based on both LSC and On-Bill in many climate zones in homes with no more than R-19 existing attic insulation levels. Increasing attic insulation from R-30 to R-49 was still found to be cost-effective based on at least one metric in the colder and hotter climates of Climate Zone 10 (SDG&E territory only) through 16.
 - b. Insulating existing uninsulated walls is very cost-effective based on both metrics everywhere except Climate Zones 6 and 7 (in Climate Zone 8 it's only cost-effective based on LSC).
 - c. Adding R-19 or R-30 floor insulation is cost-effective based on LSC in the older two vintages (Pre-1978 and 1978-1991) in all climate zones except Climate Zones 6-10.
 - d. Replacing old single pane windows with new high-performance windows has a very high cost and is typically not done for energy savings alone. However, energy savings are substantial and justify cost-effectiveness of this measure based on at least one metric in Climate Zones 4, 8 through 12 (PG&E territory only), and 13 through 16.
 - e. At time of roof replacement, a cool roof with an aged solar reflectance of 0.25 was found to be cost-effective in Climate Zones 4, 6 through 12 (PG&E territory only), and 13 through 15. When the roof deck is replaced during a roof replacement, adding a radiant barrier is low cost and provides substantial cooling energy savings to be cost-effective in almost all climate zones and homes.
2. Duct measures: Many older homes have old, leaky duct systems that should be replaced when they reach the end of life, typically 20-30 years. In this case, installing new ducts was found to be cost-effective based on at least one metric (both in most cases) everywhere except mild Climate Zone 7 and Climate Zones 5 and 6 in the 1978-1991 vintage. If duct systems still have remaining life they should be sealed and tested to meet 10% leakage or lower; however, duct upgrades alone were only found to be cost-effective for newer homes in Climate Zones 10 (SDG&E territory only), 11, and 13 through 16. Duct upgrades may be able to be coupled with other measures to reduce the cost.
3. Heat pump space heating: HPSHs were found to be LSC cost-effective in many cases. The DFHP (existing furnace) was LSC cost-effective everywhere except Climate Zone 15. The HPSH was LSC cost-effective everywhere except Climate Zones 8 and 15.
 - a. Challenges to On-Bill cost-effectiveness include higher first costs and higher first-year utility costs due to higher electricity tariffs relative to gas tariffs. SMUD and CPAU are two exceptions where first year utility costs are lower for heat pumps than for gas equipment. Table 11 shows the impact of utility rates on cost-effectiveness of HPSH where the standard and high efficiency HPSH and the HPSH + PV measures are cost-effective under SMUD but not PG&E. Even with higher first year utility bills, there were some cases that still proved On-Bill cost-effective including the DFHP with an existing furnace in the central valley and northern coastal PG&E territories, the ducted MSHP in the central valley as well as Climate Zone 14 in SDG&E territory, and the HPSH + PV measure in CZ 3-5 (PGE), 7-11, and 12 (SMUD) – 15.
 - b. The ductless MSHPs, evaluated for homes with existing ductless systems, were only found to be cost-effective based on either metric in Climate Zones 1 and 16. Ductless MSHPs have a high incremental cost because it is a more sophisticated system than the base model of a wall furnace with a window AC unit. However, the ductless MSHP would provide greater comfort benefits if properly installed to

directly condition all habitable spaces (as is required under the VCHP compliance credit as evaluated in this study) which may be an incentive for a homeowner to upgrade their system.

- c. Higher efficiency equipment lowered utility costs in all cases and improved cost-effectiveness in many cases, particularly with a ducted MSHP.
4. Heat pump water heating: All the HPWH measures were LSC cost-effective in all climate zones. Most measures were not On-Bill cost-effective with the exception of the HPWH + PV which was cost-effective On-Bill in CPAU, SMUD, and SDG&E territories in addition to Climate Zones 11, 13, 14, and 15. The HPWH measures share many of the same challenges as the HPSH measures to achieving cost-effectiveness including high first costs and utility rates and assumptions. Table 13 shows the impact of utility rates on cost-effectiveness where some HPWH measures are cost-effective under SMUD utility rates but are not cost-effective anywhere under PG&E rates in Climate Zone 12.
 - a. Various HPWH locations were also explored, however there are some factors outside of cost-effectiveness that should also be considered.
 - i. HPWHs in the conditioned space can provide benefits such as free cooling during the summer, reduced tank losses, and shorter pipe lengths, and in some cases show improved cost-effectiveness over garage located HPWHs. However, there are various design considerations such as noise, comfort concerns, and condensate removal. Ducting the inlet and exhaust air resolves comfort concerns but adds costs and complexity. Split heat pump water heaters address these concerns, but currently there are limited products on the market and there is a cost premium relative to the packaged products.
 - ii. Since HPWHs extract heat from the air and transfer it to water in the storage tank, they must have adequate ventilation to operate properly. Otherwise, the space cools down over time, impacting the HPWH operating efficiency. This is not a problem with garage installations but needs to be considered for water heaters located in interior or exterior closets. For the 2025 Title 24 code the CEC is proposing that all HPWH installations meet mandatory ventilation requirements (California Energy Commission, 2023).
 5. The contractor surveys revealed overall higher heat pump costs than what has been found in previous analyses. This could be due to incentive availability raising demand for heat pumps and thereby increasing the price. This price increase may be temporary and may come down once the market stabilizes. There are also new initiatives to obtain current costs including the TECH Clean California program²¹ that publishes heat pump data and costs; however, at the time of this analysis, the TECH data did not contain incremental costs because it only had the heat pump costs but not the gas base case costs.
 6. Table 18 shows how CARE rates and escalation rate assumptions will impact cost-effectiveness.
 - a. Applying CARE rates in the IOU territories has the overall impact to increase utility cost savings for an all-electric building compared to a code compliant mixed fuel building, improving On-Bill cost-effectiveness. This is due to the CARE discount on electricity being higher than that on gas. The reverse occurs with efficiency measures where lower utility rates reduce savings and subsequently reduce cost-effectiveness.
 - b. If gas tariffs are assumed to increase substantially over time, in-line with the escalation assumption from the 2025 LSC development, cost-effectiveness substantially improves for the heat pump measures over the 30-year analysis period and many cases become cost-effective that were not found to be cost-effective under the CPUC / 2022 TDV escalation scenario. There is much uncertainty surrounding future tariff structures as well as escalation values. While it's clear that gas rates will increase, how much and how quickly is not known. Future electricity tariff structures are expected to evolve over time, and the CPUC has an active proceeding to adopt an income-graduated fixed charge that benefits low-income customers and supports electrification measures for all customers.²² The CPUC will decide in mid-2024 and the new rates are expected to be in place later that year or in 2025.

²¹ [TECH Public Reporting Home Page \(techcleanca.com\)](https://techcleanca.com)

²² <https://www.cpuc.ca.gov/industries-and-topics/electrical-energy/electric-costs/demand-response-dr/demand-flexibility-rulemaking>

While the anticipated impact of this rate change is lower volumetric electricity rates, the rate design is not finalized. While lower volumetric electricity rates provide many benefits, it also will make building efficiency measures harder to justify as cost-effective due to lower utility bill cost savings.

7. Under NBT, utility cost savings for PV are substantially less than what they were under prior net energy metering rules (NEM 2.0); however, savings are sufficient to be On-Bill cost-effective in all climate zones except Climate Zones 1 through 3 and 5 through 6.
 - a. Combining a heat pump with PV allows the additional electricity required by the heat pump to be offset by the PV system while also increasing on-site utilization of PV generation rather than exporting the electricity back to the grid at a low rate.
 - b. While not evaluated in this study, coupling PV with battery systems can be very advantageous under NBT increasing utility cost savings because of improved on-site utilization of PV generation and fewer exports to the grid.

Recommendations:

1. There are various approaches for jurisdictions who are interested in reach codes for existing buildings. Some potential approaches are listed below along with key considerations.
 - a. Prescriptive measures: Non-preempted measures that are found to be cost-effective may be prescriptively required in a reach code. One example of this type of ordinance is a cool roof requirement at time of roof replacement. Another example is requiring specific cost-effective measures for larger remodels, such as high-performance windows when new windows are installed or duct sealing and testing where ducts are in unconditioned space.
 - b. Replacement equipment: This flavor of reach code sets certain requirements at time of equipment replacement. This study evaluated space heating and water heating equipment. Where a heat pump measure was found to be cost-effective based on either LSC or On-Bill, this may serve as the basis of a reach code given the following considerations.
 - i. Where reach codes reduce energy usage and are not just fuel switching, cost-effectiveness calculations are required and must be based on equipment that does not exceed the federal minimum efficiency requirements.
 - ii. Where reach codes are established using cost-effectiveness based on LSC, utility bill impacts and the owner's first cost should also be reviewed and considered.
 - iii. A gas path should also be prescriptively allowed to safely satisfy federal preemption requirements considering the CRA v. Berkeley case.²³ Additional requirements may apply to the gas path, as described in Section 3.3, as long as the paths are reasonably energy or cost equivalent.
 - c. "Flexible Path", minimum energy savings target: This flexible approach establishes a target for required energy savings based on a measure or a set of measures that were found to be cost-effective based on either LSC or On-Bill. A points menu compares various potential upgrades ranging from efficiency, PV, and fuel substitution measures, based on site or source energy savings. The applicant must select upgrades that individually or in combination meet the minimum energy savings target. The measures used to set the target should be non-preempted measures.
2. Equipment replacement ordinances should consider appropriate exceptions for scenarios where it will be challenging to meet the requirements, such as location of the HPWH, total project cost limitations, or the need for service panel upgrades that wouldn't have been required as part of the proposed scope of work in absence of the reach code.
3. Consider extending relevant proposals made by the CEC for the 2025 Title 24 code (California Energy Commission, 2023) in ordinances that apply under the 2022 Title 24 code, such as the following:
 - a. Mandatory ventilation requirements for HPWH installations (Section 110.3(c)7).

²³ <https://www.publichealthlawcenter.org/sites/default/files/2024-01/CRA-v-Berkeley-Ninth-Circuit-Opinion-Jan2024.pdf>

- b. Requirement for HERS verified refrigerant charge verification for heat pumps in all climate zones (Table 150.1-A²⁴).
- 4. When evaluating reach code strategies, the Reach Codes Team recommends that jurisdictions consider combined benefits of energy efficiency alongside electrification. Efficiency and electrification have symbiotic benefits and are both critical for decarbonization of buildings. As demand on the electric grid is increased through electrification, efficiency can reduce the negative impacts of additional electricity demand on the grid, reducing the need for increased generation and storage capacity, as well as the need to upgrade upstream transmission and distribution equipment.
- 5. Education and training can play a critical role in ensuring that heat pumps are installed, commissioned, and controlled properly to mitigate grid impacts and maximize occupant satisfaction. Below are select recommended strategies.
 - a. The Quality Residential HVAC Services Program²⁵ is an incentive program to train California contractors in providing quality installation and maintenance while advancing energy-efficient technologies in the residential HVAC industry. Jurisdictions can market this to local contractors to increase the penetration of contractors skilled in heat pump design and installation.
 - b. Educate residents and contractors of available incentives, tax credits, and financing opportunities.
 - c. Educate contractors on code requirements. Energy Code Ace provides free tools, trainings, and resource to help Californians comply with the energy code. Contractors can access interactive compliance forms, fact sheets, and live and recorded trainings, among other things, on the website: <https://energycodeace.com/>. Jurisdictions can reach out to Energy Code Ace directly to discuss offerings.
- 6. Health and safety
 - a. 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 located within the pressure boundary of the building after completion of retrofit work that involves air sealing or insulation measures.
 - b. Jurisdictions may consider requiring mechanical ventilation in homes where air sealing has been conducted. In older buildings, outdoor air is typically introduced through leaks in the building envelope. After air sealing a building, it may be necessary to forcefully bring in fresh outdoor air using supply and/or exhaust fans to minimize potential issues associated with indoor air quality.

²⁴ This requirement does not show up in the Express Terms for alterations in Section 150.2(b)1F, but the Statewide Reach Codes Team expects that it will be added to the next release of the proposed code language in the 45-day language as it aligns with the proposal made by the Codes and Standards Enhancement Team (Statewide CASE Team, 2023).

²⁵ <https://qualityhvac.frontierenergy.com/>

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6 Appendices

6.1 Map of California Climate Zones

Climate zone geographical boundaries are depicted in Figure 16. The map in Figure 16 along with a zip-code search directory is available at: https://ww2.energy.ca.gov/maps/renewable/building_climate_zones.html

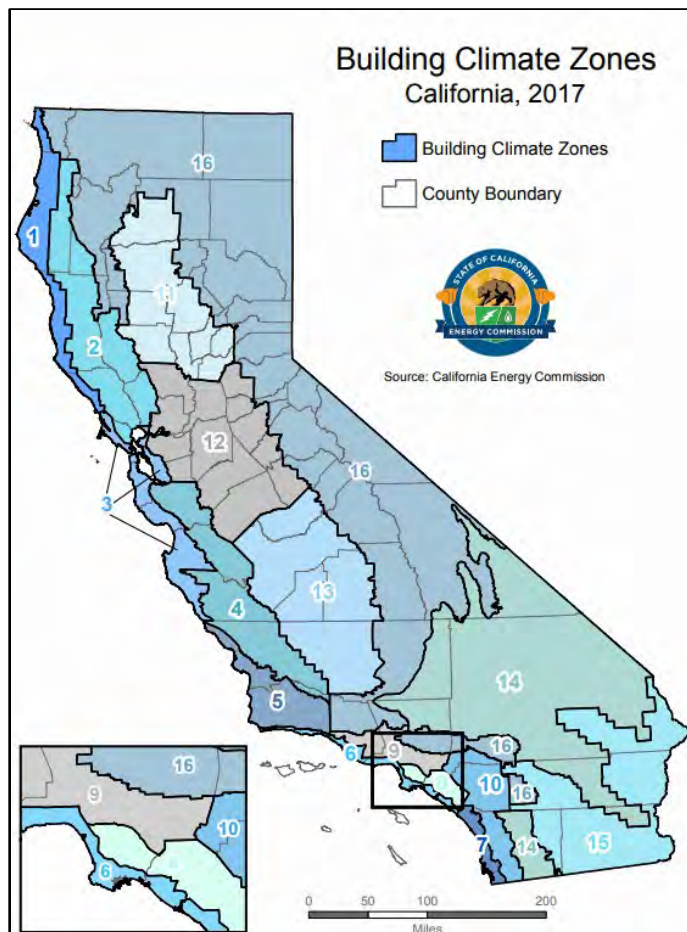


Figure 16. Map of California climate zones.

6.2 Utility Rate Schedules

The Reach Codes Team used the CA IOU and POU rate tariffs detailed below to determine the On-Bill savings for each package. The California Climate Credit was applied for both electricity and natural gas service for the IOUs using the 2023 credits shows below.²⁶ The credits were applied to reduce the total calculated annual bill, including any fixed fees or minimum bill amounts.

2023 Electric California Climate Credit Schedule

	February or March	April	May	June	July	Aug	Sept	Oct
PG&E	\$38.39							\$38.39
SCE	\$71.00							\$71.00
SDG&E	\$60.70							\$60.70

Residential Natural Gas California Climate Credit

In 2023, the 2023 Natural Gas California Climate Credit will be distributed in February or March instead of April.

	2018†	2019	2020	2021	2022	2023	Total Value Received Per Household 2018-2023
PG&E	\$30	\$25	\$27	\$25	\$48	\$52.78	\$208
SDG&E	*	\$34	\$21	\$18	\$43	\$43.40	\$162
Southwest Gas	\$22	\$25	\$27	\$28	\$49	\$56.35	\$207
SoCalGas	*	\$50	\$26	\$22	\$44	\$50.77	\$194

Electricity rates reflect the most recently approved tariffs. Monthly gas rates were estimated based on recent gas rates (November 2023) and a curve to reflect how natural gas prices fluctuate with seasonal supply and demand. The seasonal curve was estimated from monthly residential tariffs between 2014 and 2023 (between 2017 and 2023 for CPAU). 12-month curves were created from monthly gas rates for each of the ten years (Seven years for CPAU). These annual curves were then averaged to arrive at an average normalized annual curve. This was conducted separately for baseline and excess energy rates. Costs used in this analysis were then derived by establishing the most recent baseline and excess rate from the latest tariff as a reference point (November 2023), and then using the normalized curve to estimate the cost for the remaining months relative to the reference point rate.

²⁶ <https://www.cpuc.ca.gov/industries-and-topics/natural-gas/greenhouse-gas-cap-and-trade-program/california-climate-credit>

6.2.1 Pacific Gas & Electric

The following pages provide details on the PG&E electricity and natural gas tariffs applied in this study. Table 20 describes the baseline territories that were assumed for each climate zone. A net surplus compensation rate of \$0.07051/ kWh was applied to any net annual electricity generation based on a one-year average of the rates between December 2022 and November 2023.

Table 20. PG&E Baseline Territory by Climate Zone

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 according to the rates shown in Table 21. These rates are based on applying a normalization curve to the November 2023 tariff based on ten years of historical gas data. Corresponding CARE rates reflect the 20 percent discount per the GL-1 tariff.

Table 21. PG&E Monthly Gas Rate (\$/therm)

Month	Total Charge	
	Baseline	Excess
January	\$2.05	\$2.43
February	\$2.08	\$2.46
March	\$1.92	\$2.31
April	\$1.80	\$2.20
May	\$1.77	\$2.18
June	\$1.78	\$2.18
July	\$1.80	\$2.20
August	\$1.85	\$2.26
September	\$1.92	\$2.33
October	\$1.99	\$2.40
November	\$2.06	\$2.46
December	\$2.05	\$2.44

Residential GAS Baseline Territories and Quantities ^{1/} Effective April 1, 2022 - Present

BASELINE QUANTITIES (Therms Per Day Per Dwelling Unit)

Individually Metered			
Baseline Territories	Summer (April-October) Effective Apr. 1, 2022	Winter Off-Peak (Nov, Feb, Mar) Effective Nov. 1, 2022	Winter On-Peak (Dec, Jan) Effective Dec. 1, 2022
P	0.39	1.88	2.19
Q	0.56	1.48	2.00
R	0.36	1.24	1.81
S	0.39	1.38	1.94
T	0.56	1.31	1.68
V	0.59	1.51	1.71
W	0.39	1.14	1.68
X	0.49	1.48	2.00
Y	0.72	2.22	2.58

Master Metered			
Baseline Territories	Summer (April-October) Effective Apr. 1, 2022	Winter Off-Peak (Nov, Feb, Mar) Effective Nov. 1, 2022	Winter On-Peak (Dec, Jan) Effective Dec. 1, 2022
P	0.29	1.01	1.13
Q	0.56	0.67	0.77
R	0.33	0.87	1.16
S	0.29	0.61	0.65
T	0.56	1.01	1.10
V	0.59	1.28	1.32
W	0.26	0.71	0.87
X	0.33	0.67	0.77
Y	0.52	1.01	1.13

Summer Season: Apr-Oct
 Winter Off-Peak: Nov, Feb, Mar
 Winter On-Peak: Dec, Jan

Advice Letter: 4589-G
 Decision 21-11-016
 GRC 2020 Ph II [Application 19-11-019]
 Filed: Nov 22, 2019



**Pacific Gas and
Electric Company**

U 39

Oakland, California

Cancelling

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Cal. P.U.C. Sheet No.

56550-E

Cal. P.U.C. Sheet No.

56229-E

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 BUNDLED RATES

Total Energy Rates (\$ per kWh)	PEAK		OFF-PEAK	
<i>Summer</i>				
Total Usage	\$0.53933	(I)	\$0.45589	(I)
Baseline Credit (Applied to Baseline Usage Only)	(\$0.08851)	(R)	(\$0.08851)	(R)
<i>Winter</i>				
Total Usage	\$0.43662	(I)	\$0.40827	(I)
Baseline Credit (Applied to Baseline Usage Only)	(\$0.08851)	(R)	(\$0.08851)	(R)
Delivery Minimum Bill Amount (\$ per meter per day)	\$0.37612			
California Climate Credit (per household, per semi-annual payment occurring in the March* and October bill cycles)	(\$38.39)			

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.

* Pursuant to D.23-02-014, disbursement of the April 2023 residential Climate Credit shall begin by March 1, 2023.

(Continued)

Advice	7009-E	Issued by	Submitted	August 25, 2023
Decision		Meredith Allen	Effective	September 1, 2023
		Vice President, Regulatory Affairs	Resolution	



**Pacific Gas and
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 U 39 Oakland, California

Cancelling Revised
 Revised

Cal. P.U.C. Sheet No. 56551-E
 Cal. P.U.C. Sheet No. 56230-E

ELECTRIC SCHEDULE E-TOU-C Sheet 3
 RESIDENTIAL TIME-OF-USE (PEAK PRICING 4 - 9 p.m. EVERY DAY)

RATES:
 (Cont'd.)

UNBUNDLING OF E-TOU-C TOTAL RATES

Energy Rates by Component (\$ per kWh)	PEAK		OFF-PEAK	
Generation:				
Summer (all usage)	\$0.19776		\$0.13432	
Winter (all usage)	\$0.14916		\$0.12413	
Distribution**:				
Summer (all usage)	\$0.17029	(I)	\$0.15029	(I)
Winter (all usage)	\$0.11618	(I)	\$0.11286	(I)
Conservation Incentive Adjustment (Baseline Usage)		(\$0.02216)	(I)	
Conservation Incentive Adjustment (Over Baseline Usage)		\$0.06635	(I)	
Transmission* (all usage)		\$0.05254		
Transmission Rate Adjustments* (all usage)		\$0.00059		
Reliability Services* (all usage)		\$0.00069		
Public Purpose Programs (all usage)		\$0.02578		
Nuclear Decommissioning (all usage)		\$0.00135		
Competition Transition Charges (all usage)		\$0.00030		
Energy Cost Recovery Amount (all usage)		(\$0.00071)		
Wildfire Fund Charge (all usage)		\$0.00530		
New System Generation Charge (all usage)**		\$0.00346		
Wildfire Hardening Charge (all usage)		\$0.00254		
Recovery Bond Charge (all usage)		\$0.00528	(R)	
Recovery Bond Credit (all usage)		(\$0.00528)	(I)	
Bundled Power Charge Indifference Adjustment (all usage)***		\$0.01309		

- * Transmission, Transmission Rate Adjustments and Reliability Service charges are combined for presentation on customer bills.
 ** Distribution and New System Generation Charges are combined for presentation on customer bills.
 *** Direct Access, Community Choice Aggregation and Transitional Bundled Service Customers pay the applicable Vintaged Power Charge Indifference Adjustment. Generation and Bundled PCIA are combined for presentation on bundled customer bills.

(Continued)

Advice	7009-E	Issued by	Submitted	August 25, 2023
Decision		Meredith Allen	Effective	September 1, 2023
		Vice President, Regulatory Affairs	Resolution	



**Pacific Gas and
Electric Company**

U 39

Oakland, California

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Cal. P.U.C. Sheet No. 56547-E

Cal. P.U.C. Sheet No. 56226-E

ELECTRIC SCHEDULE E-ELEC

Sheet 2

RESIDENTIAL TIME-OF-USE (ELECTRIC HOME)

SERVICE FOR CUSTOMERS WITH QUALIFYING ELECTRIC TECHNOLOGIES

RATES:(Cont'd.)

TOTAL BUNDLED RATES

Base Services Charge (\$ per meter per day)	\$0.49281		
Total Energy Rates (\$ per kWh)	PEAK	PART-PEAK	OFF-PEAK
Summer Usage	\$0.56589 (I)	\$0.40401 (I)	\$0.34733 (I)
Winter Usage	\$0.33438 (I)	\$0.31229 (I)	\$0.29843 (I)
California Climate Credit (per household, per semi-annual payment occurring in the March† and October bill cycles)	(\$38.39)		

Total bundled service charges shown on a customer's bills are unbundled according to the component rates shown below.

UNBUNDLING OF TOTAL RATES

Energy Rates by Component (\$ per kWh)	PEAK	PART-PEAK	OFF-PEAK
Generation:			
Summer Usage	\$0.28164	\$0.18253	\$0.13743
Winter Usage	\$0.11951	\$0.09954	\$0.08619
Distribution**:			
Summer Usage	\$0.17932 (I)	\$0.11655 (I)	\$0.10497 (I)
Winter Usage	\$0.10994 (I)	\$0.10782 (I)	\$0.10731 (I)
Transmission* (all usage)	\$0.05254	\$0.05254	\$0.05254
Transmission Rate Adjustments* (all usage)	\$0.00059	\$0.00059	\$0.00059
Reliability Services* (all usage)	\$0.00069	\$0.00069	\$0.00069
Public Purpose Programs (all usage)	\$0.02578	\$0.02578	\$0.02578
Nuclear Decommissioning (all usage)	\$0.00135	\$0.00135	\$0.00135
Competition Transition Charges (all usage)	\$0.00030	\$0.00030	\$0.00030
Energy Cost Recovery Amount (all usage)	(\$0.00071)	(\$0.00071)	(\$0.00071)
Wildfire Fund Charge (all usage)	\$0.00530	\$0.00530	\$0.00530
New System Generation Charge (all usage)**	\$0.00346	\$0.00346	\$0.00346
Wildfire Hardening Charge (all usage)	\$0.00254	\$0.00254	\$0.00254
Recovery Bond Charge (all usage)	\$0.00528 (R)	\$0.00528 (R)	\$0.00528 (R)
Recovery Bond Credit (all usage)	(\$0.00528) (I)	(\$0.00528) (I)	(\$0.00528) (I)
Bundled Power Charge Indifference Adjustment (all usage)***	\$0.01309	\$0.01309	\$0.01309

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

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

*** Direct Access, Community Choice Aggregation and Transitional Bundled Service Customers pay the applicable Vintaged Power Charge Indifference Adjustment. Generation and Bundled PCIA are combined for presentation on bundled customer bills.

† Pursuant to D.23-02-014, disbursement of the April 2023 residential Climate Credit shall begin by March 1, 2023.

(Continued)

Advice	7009-E	Issued by	Submitted	August 25, 2023
Decision		Meredith Allen	Effective	September 1, 2023
		Vice President, Regulatory Affairs	Resolution	



**Pacific Gas and
Electric Company**

U 39

San Francisco, California

Original

Cal. P.U.C. Sheet No. 54738-E

ELECTRIC SCHEDULE E-ELEC
RESIDENTIAL TIME-OF-USE (ELECTRIC HOME)
SERVICE FOR CUSTOMERS WITH QUALIFYING ELECTRIC TECHNOLOGIES

Sheet 3

(N)

(N)

**SPECIAL
CONDITIONS:**

1. TIME PERIODS: Times of the year and times of the day are defined as follows:

(N)

All Year:

Peak: 4:00 p.m. to 9:00 p.m. every day including weekends and holidays.

Partial-Peak: 3:00 p.m. to 4:00 p.m. and 9:00 p.m. to 12:00 a.m. every day including weekends and holidays.

Off-Peak: All other hours.

2. SEASONAL CHANGES: The summer season is June 1 through September 30 and the winter season is October 1 through May 31. When billing includes use in both the summer and winter periods, charges will be prorated based upon the number of days in each period.

3. ADDITIONAL METERS: If a residential dwelling unit is served by more than one electric meter, the customer must designate which meter is the primary meter and which is (are) the additional meter(s).

4. BILLING: A customer's bill is calculated based on the option applicable to the customer.

Bundled Service Customers receive generation and delivery services solely from PG&E. The customer's bill is based on the Unbundling of Total Rates set forth above.

Transitional Bundled Service (TBS) Customers take TBS as prescribed in Rules 22.1 and 23.1, or take PG&E bundled service prior to the end of the six (6) month advance notice period required to elect PG&E bundled service as prescribed in Rules 22.1 and 23.1. TBS customers shall pay all charges shown in the Unbundling of Total Rates except for the Bundled Power Charge Indifference Adjustment and the generation charge. TBS customers shall also pay for their applicable Vintaged Power Charge Indifference Adjustment provided in the table below, and the short-term commodity prices as set forth in Schedule TBCC.

(N)

(Continued)

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

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 Revised

Revised
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Cal. P.U.C. Sheet No.
 Cal. P.U.C. Sheet No.

54734-E
 53424-E

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, E-ELEC, EM, ES, ESR, ET and EM-TOU. (T)

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

RATES: Customers taking service on this rate schedule whose otherwise applicable rate schedule has no Delivery Minimum Bill Amount (Schedule E-ELEC) will receive a CARE percentage discount of 35,000% on their total bundled charges (except for the California Climate Credit, which will not be discounted). Customers taking service on this rate schedule whose otherwise applicable rate schedule has a Delivery Minimum Bill Amount (all other schedules) will receive a CARE percentage discount ("A" or "C" below) on their total bundled charges on their otherwise applicable rate schedule (except for the California Climate Credit, which will not be discounted) and also will receive a percentage discount ("B" or "D" 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, Recovery Bond Charge, Recovery Bond Credit, 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. (N)
 |
 |
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 (T)
 (T)

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.

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(Continued)



**Pacific Gas and
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U 39

San Francisco, California

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Cal. P.U.C. Sheet No.

56208-E

Cal. P.U.C. Sheet No.

56020-E

ELECTRIC SCHEDULE D-CARE

Sheet 2

LINE-ITEM DISCOUNT FOR CALIFORNIA ALTERNATE RATES FOR ENERGY (CARE) CUSTOMERS

RATES: (Cont'd)	A. D-CARE Discount:	34.985	% (Percent)	(I)
	B. Delivery Minimum Bill Discount:	50.000	% (Percent)	
	C. Master-Meter D-CARE Discount:	34.985	% (Percent)	(I)
	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.			
	2. ELIGIBILITY: To be eligible to receive D-CARE the applicant must qualify under the criteria set forth in PG&E's Electric Rules 19.1, 19.2, and 19.3 and meet the certification requirements thereof to the satisfaction of PG&E. Qualifying Direct Access, Community Choice Aggregation Service, and Transitional Bundled Service customers are also eligible to take service on Schedule D-CARE. Applicants may qualify for D-CARE at their primary residence only. Customers or sub-metered tenants participating in the Family Electric Rate Assistance (FERA) program cannot concurrently participate in the CARE program.			

Advice
Decision

6968-E

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Meredith Allen
Vice President, Regulatory Affairs

Submitted
Effective
Resolution

June 23, 2023
July 1, 2023

6.2.2 Southern California Edison

The following pages provide details on the SCE electricity tariffs applied in this study. Table 22 describes the baseline territories that were assumed for each climate zone. A net surplus compensation rate of \$ 0.06030/ kWh was applied to any net annual electricity generation based on a one-year average of the rates between December 2022 and November 2023

Table 22: SCE Baseline Territory by Climate Zone

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

- Applicable rate time periods are defined as follows:

Option 4-9 PM, Option 4-9 PM-CPP, Option PRIME, Option PRIME-CPP :

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



Southern California Edison
 Rosemead, California (U 338-E)

Revised Cal. PUC Sheet No. 85111-E
 C Cancelling Revised Cal. PUC Sheet No. 74502-E

Schedule TOU-D

Sheet 2

TIME-OF-USE

DOMESTIC

(Continued)

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 days, 4:00 p.m. to 9:00 p.m., as described in Special Conditions 1 and 3, below:

	Delivery Service Total ¹	Generation ²	
		UG ³	DWREC ⁴
Option 4-9 PM / Option 4-9 PM-CPP			
Energy Charge - \$/kWh			
Summer Season - On-Peak	0.28829 (R)	0.28543 (I)	0.00000
Mid-Peak	0.28829 (R)	0.17707 (I)	0.00000
Off-Peak	0.24482 (R)	0.11382 (I)	0.00000
Winter Season - Mid-Peak	0.28829 (R)	0.21752 (I)	0.00000
Off-Peak	0.24482 (R)	0.13851 (I)	0.00000
Super-Off-Peak	0.22919 (R)	0.11890 (I)	0.00000
Baseline Credit**** - \$/kWh	(0.09759) (I)	0.00000	
Fixed Recovery Charge - \$/kWh	0.00090 (R)		
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	(71.00) (I)		
California Alternate Rates for Energy Discount - %	100.00*		
Family Electric Rate Assistance Discou	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		(0.67183) (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 (\$0.00003) 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 time period. Additional Baseline Allocations apply for Customers with Heat Pump Water Heaters served under this Option. The Baseline Allocations are 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 DWRBC rate component of this Schedule but instead pay the DWRBC as provided by Schedule DA-CRS or Schedule CCA-CRS.

2 Generation = The Gen rates are applicable only to Bundled Service Customers. See Special Condition below for PCIA recovery.

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)

(To be inserted by utility)

Advice 4929-E
 Decision

2/1/13

Issued by
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 Vice President

(To be inserted by Cal. PUC)

Date Submitted Dec 28, 2022
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Southern California Edison
Rosemead, California (U 338-E)

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Cancelling Revised Cal. PUC Sheet No. 85624-E

Schedule TOU-D

Sheet 6

TIME-OF-USE
DOMESTIC
(Continued)

RATES (Continued)

Option PRIME / Option PRIME-CPP	Delivery Service Total ¹	Generation ²	
		UG ³	DWREC ⁴
Energy Charge - \$/kWh/Meter/Day			
Summer Season			
On-Peak	0.22789 (I)	0.42769 (I)	0.00000
Mid-Peak	0.22789 (I)	0.15221 (I)	0.00000
Off-Peak	0.15191 (I)	0.10182 (I)	0.00000
Winter Season			
Mid-Peak	0.23353 (I)	0.36028 (I)	0.00000
Off-Peak	0.14530 (I)	0.08630 (I)	0.00000
Super-Off-Peak	0.14530 (I)	0.08630 (I)	0.00000
Fixed Recovery Charge - \$/kWh	0.00260 (I)		
Basic Charge - \$/Meter/Day	0.427 (I)		
EV Meter Credit (Separately Metered E	(0.323) (N)		
EV Submeter Credit - \$/Meter/Day	(0.111) (R)		
California Climate Credit ¹⁰	(71.00)		
California Alternate Rates for			
Energy Discount - %	100.00*		
Family Electric Rate Assistance Discou	100.00		
Medical Line Item Discount - %	100.000		
Option PRIME-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		(0.71812) (R)	

* Represents 100% of the discount percentage as shown in the applicable Special Condition of this Schedule.

*** The ongoing Competition Transition Charge (CTC) of (\$0.00003) per kWh is recovered in the UG component of Generation.

**** 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 DWRBC rate component of this Schedule but instead pay the DWRBC as provided by Schedule DA-CRS or Schedule CCA-CRS.

2 Generation = The Gen rates are applicable only to Bundled Service Customers. See Special Condition below for PCIA recovery.

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)

(To be inserted by utility)

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6/19

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Vice President

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Resolution _____



Southern California Edison
Rosemead, California (U 338-E)

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Cancelling Revised Cal. PUC Sheet No. 85109-E

Schedule D-CARE
CALIFORNIA ALTERNATE RATES FOR ENERGY
DOMESTIC SERVICE

Sheet 1

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 29.8 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 \$0.00888 per kWh and the Wildfire Fund Non-Bypassable Charge of \$0.00530 per kWh. (R) The 29.8 percent discount, in addition to these exemptions result in an average effective CARE Discount of 32.5 percent.

(Continued)

(To be inserted by utility)

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Decision 23-01-002
TH12 22-12-031

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Vice President

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6.2.3 Southern California Gas

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

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 according to the rates shown in Table 24. These rates are based on applying a normalization curve to the November 2023 tariff based on ten years of historical gas data. Long-term historical natural gas rate data was only available for SoCalGas' procurement charges.²⁷ The baseline and excess transmission charges were found to be consistent over the course of a year and applied for the entire year based on 2023 rates. 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
January	\$0.72	\$0.86	\$1.31	\$1.92	\$2.36
February	\$0.50	\$0.86	\$1.31	\$1.57	\$2.02
March	\$0.44	\$0.86	\$1.31	\$1.48	\$1.93
April	\$0.39	\$0.86	\$1.31	\$1.39	\$1.84
May	\$0.41	\$0.86	\$1.31	\$1.43	\$1.87
June	\$0.46	\$0.86	\$1.31	\$1.49	\$1.93
July	\$0.47	\$0.86	\$1.31	\$1.51	\$1.96
August	\$0.51	\$0.86	\$1.31	\$1.58	\$2.03
September	\$0.46	\$0.86	\$1.31	\$1.52	\$1.96
October	\$0.45	\$0.86	\$1.31	\$1.48	\$1.92
November	\$0.48	\$0.86	\$1.31	\$1.54	\$1.99
December	\$0.57	\$0.86	\$1.31	\$1.63	\$2.08

Southern California Gas Company Residential Rates Nov-23									
Customer Type		Commodity	Rate	Procurement	Transportation	New Rate	New Rate	Absolute	%
Rate Schedule		Charge	Type	Charge ¢/therm	Charge ¢/therm	Effective 11/1/2023	Effective 10/1/2023	Rate Change	Change
Residential Individually Metered									
Schedule No. GR		GR	Baseline	67.806	86.490	154.296	125.096	29.200	23.3%
Res. Service		GR	Non Baseline	67.806	131.037	198.843	169.726	29.117	17.2%
		GT-R	Baseline	00.000	86.490	86.490	87.038	-00.548	-0.6%
		GT-R	Non Baseline	00.000	131.037	131.037	131.668	-00.631	-0.5%

²⁷ The SoCalGas procurement and transmission charges were obtained from the following site:
<https://www.socalgas.com/for-your-business/energy-market-services/gas-prices/RES2023.xlsx> (live.com)

6.2.4 San Diego Gas & Electric

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. A net surplus compensation rate of \$0.04542/ kWh was applied to any net annual electricity generation based on a one-year average of the rates between December 2022 and November 2023.

Table 25. SDG&E Baseline Territory by Climate Zone

Climate Zone	Baseline Territory
CZ07	Coastal
CZ10	Inland
CZ14	Mountain

The SDG&E monthly gas rate in \$/therm was applied on a monthly basis according to the rates shown in Table 26. These rates are based on applying a normalization curve to the November 2023 tariff based on ten years of historical gas data. CARE rates reflect the 20 percent discount per the G-CARE tariff.

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

Month	Total Charge	
	Baseline	Excess
January	\$2.34	\$2.63
February	\$2.28	\$2.57
March	\$2.21	\$2.51
April	\$2.14	\$2.45
May	\$2.18	\$2.48
June	\$2.23	\$2.55
July	\$2.26	\$2.57
August	\$2.32	\$2.62
September	\$2.26	\$2.59
October	\$2.21	\$2.55
November	\$2.24	\$2.57
December	\$2.38	\$2.70

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

<u>All Customers:</u>	<u>Daily Therm Allowance</u>
Summer (May to Oct)	0.359
Winter On-Peak (Dec, Jan & Feb)	1.233
Winter Off-Peak (Nov, Mar, & Apr)	0.692



San Diego Gas & Electric Company
San Diego, California

Revised Cal. P.U.C. Sheet No. 37022-E

Canceling Revised Cal. P.U.C. Sheet No. 36337-E

SCHEDULE TOU-DR1

Sheet 2

RESIDENTIAL TIME-OF-USE

RATES

Total Rates:

Description – TOU DR1	UDC Total Rate	DWR BC + WF-NBC	EECC Rate + DWR Credit	Total Rate
Summer:				
On-Peak	0.25752	R 0.00530	I 0.57043	I 0.83325
Off-Peak	0.25752	R 0.00530	I 0.25697	I 0.51979
Super Off-Peak	0.25752	R 0.00530	I 0.09233	I 0.35515
Winter:				
On-Peak	0.43809	I 0.00530	I 0.19307	I 0.63646
Off-Peak	0.43809	I 0.00530	I 0.10855	I 0.55194
Super Off-Peak	0.43809	I 0.00530	I 0.08402	I 0.52741
Summer Baseline Adjustment Credit up to 130% of Baseline	(0.11724)	R		(0.11724) R
Winter Baseline Adjustment Credit up to 130% of Baseline	(0.11724)	R		(0.11724) R
Minimum Bill (\$/day)	0.380	I		0.380 I

Description – TOU DR1-CARE	UDC Total Rate	DWR BC + WF-NBC	EECC Rate + DWR Credit	Total Rate	Total Effective Care Rate
Summer – CARE Rates:					
On-Peak	0.25682	R 0.00000	I 0.57043	I 0.82725	I 0.55366
Off-Peak	0.25682	R 0.00000	I 0.25697	I 0.51379	I 0.33965
Super Off-Peak	0.25682	R 0.00000	I 0.09233	I 0.34915	I 0.22725
Winter – CARE Rates:					
On-Peak	0.43739	I 0.00000	I 0.19307	I 0.63046	I 0.41930
Off-Peak	0.43739	I 0.00000	I 0.10855	I 0.54594	I 0.36160
Super Off-Peak	0.43739	I 0.00000	I 0.08402	I 0.52141	I 0.34485
Summer Baseline Adjustment Credit up to 130% of Baseline	(0.11724)	R		(0.11724) R	(0.08004) R
Winter Baseline Adjustment Credit up to 130% of Baseline	(0.11724)	R		(0.11724) R	(0.08004) R
Minimum Bill (\$/day)	0.190	I		0.190	I 0.190

Note:

- (1) Total Rates consist of UDC, Schedule DWR-BC (Department of Water Resources Bond Charge), Schedule WF-NBC (CA Wildfire Fund charge) and Schedule EECC (Electric Energy Commodity Cost) rates, with the EECC rates reflecting a DWR Credit. EECC rates are applicable to bundled customers only. See Special Condition 16 for PCIA (Power Charge Indifference Adjustment) recovery.
- (2) Total Rates presented are for customers that receive commodity supply and delivery service from Utility.
- (3) DWR-BC and WF-NBC 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.
- (5) WF-NBC rate is 0.00530 + DWR-BC Bond Charge is 0.00000.

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(Continued)

2C8

Advice Ltr. No. 4129-E

Decision No.

Issued by
Dan Skopec
Senior Vice President
Regulatory Affairs

Submitted Dec 30, 2022

Effective Jan 1, 2023

Resolution No. E-5217

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.



San Diego Gas & Electric Company
San Diego, California

Revised Cal. P.U.C. Sheet No. 37217-E

Canceling Revised Cal. P.U.C. Sheet No. 37016-E

SCHEDULE EV-TOU-5

Sheet 1

COST-BASED DOMESTIC TIME-OF-USE FOR HOUSEHOLDS WITH ELECTRIC VEHICLES

APPLICABILITY

Service under this schedule is specifically limited to customers who require service for charging of a currently registered Motor Vehicle, as defined by the California Motor Vehicle Code, which is: 1) a battery electric vehicle (BEV) or plug-in hybrid electric vehicle (PHEV) recharged via a recharging outlet at the customer's premises; or 2) a natural gas vehicle (NGV) refueled via a home refueling appliance (HRA) at the customer's premises. This schedule is not available to customers with a conventional charge sustaining (battery recharged solely from the vehicle's on-board generator) hybrid electric vehicle (HEV).

Residential customers taking service on Schedule NBT, who are required to utilize EV-TOU-5 as their otherwise applicable schedule (OAS) for electric service, do not require a qualifying motor vehicle, as described above to participate on Schedule EV-TOU-5.

N
N
N

Customers on this schedule may also qualify for a semi-annual California Climate Credit \$(60.70) per Schedule GHG-ARR.

TERRITORY

Within the entire territory served by the utility.

RATES

Total Rates:

Description – EV-TOU-5 Rates	UDC Total Rate	DWR BC + WF-NBC	EECC Rate + DWR Credit	Total Rate
Basic Service Fee	16.00			16.00
Summer				
On-Peak	0.28032	I 0.00530	I 0.53067	I 0.81629
Off-Peak	0.28032	I 0.00530	I 0.19567	I 0.48129
Super Off-Peak	0.05588	I 0.00530	I 0.09233	I 0.15351
Winter				
On-Peak	0.28032	I 0.00530	I 0.22587	I 0.51149
Off-Peak	0.28032	I 0.00530	I 0.16213	I 0.44775
Super Off-Peak	0.05588	I 0.00530	I 0.08402	I 0.14520

(Continued)

1C5

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San Diego Gas & Electric Company
San Diego, California

Revised Cal. P.U.C. Sheet No. 37019-E

Canceled Revised Cal. P.U.C. Sheet No. 35912-E

SCHEDULE EV-TOU-5

Sheet 4

COST-BASED DOMESTIC TIME-OF-USE FOR HOUSEHOLDS WITH ELECTRIC VEHICLES

Notes: Transmission Energy charges include the Transmission Revenue Balancing Account Adjustment (TRBAA) of \$(0.00242) per kWh and the Transmission Access Charge Balancing Account Adjustment (TACBAA) of \$(0.01631) per kWh. PPP Energy charges includes Low Income PPP rate (LI-PPP) \$0.01669/kWh, Non-low Income PPP rate (Non-LI-PPP) \$0.00333/kWh (pursuant to PU Code Section 399.8, the Non-LI-PPP rate may not exceed January 1, 2000 levels), Procurement Energy Efficiency Surcharge Rate of \$0.00422 /kWh, California Solar Initiative rate (CSI) of \$0.00000/kWh and Self-Generation Incentive Program rate (SGIP) \$0.00122/kWh. The basic service fee of \$16 per month is applied to a customer's bill and a 50% discount is applied for CARE, Medical Baseline, or Family Electric Rate Assistance Program (FERA) customers resulting in their basic service fees to be \$8 per month.

Rate Components

The Utility Distribution Company Total Rates (UDC Total) shown above are comprised of the following components (if applicable): (1) Transmission (Trans) Charges, (2) Distribution (Distr) Charges, (3) Public Purpose Program (PPP) Charges, (4) Nuclear Decommissioning (ND) Charge, (5) Ongoing Competition Transition Charges (CTC), (6) Local Generation Charge (LGC), (7) Reliability Services (RS), and (8) the Total Rate Adjustment Component (TRAC).

Certain Direct Access customers are exempt from the TRAC, as defined in Rule 1 – Definitions.

Franchise Fee Differential

A Franchise Fee Differential of 5.78% will be applied to the monthly billings calculated under this schedule for all customers within the corporate limits of the City of San Diego. Such Franchise Fee Differential shall be so indicated and added as a separate item to bills rendered to such customers.

Time Periods:

All time periods listed are applicable to actual "clock" time)

TOU Period – 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

(Continued)

4C8

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Dan Skopec

Senior Vice President
Regulatory Affairs

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San Diego Gas & Electric Company
San Diego, California

Original Cal. P.U.C. Sheet No. 37195-E
Canceling Cal. P.U.C. Sheet No.

SCHEDULE TOU-ELEC

Sheet 1

DOMESTIC TIME-OF-USE FOR HOUSEHOLDS WITH ELECTRIC VEHICLES, ENERGY STORAGE, OR ELECTRIC HEAT PUMPS

APPLICABILITY

Service under this schedule is available on a voluntary basis for all residential customers who meet one or more of the following criteria: 1) require service for charging of a currently registered Motor Vehicle, as defined by the California Motor Vehicle Code, which is: a) a battery electric vehicle (BEV) or plug-in hybrid electric vehicle (PHEV) recharged via a recharging outlet at the customer's premises; or b) a natural gas vehicle (NGV) refueled via a home refueling appliance (HRA) at the customer's premises; 2) have a behind-the-meter energy storage device that is interconnected through Electric Rule 21; or 3) have an electric heat pump for water heating or climate control. This schedule is not available to customers with a conventional charge sustaining (battery recharged solely from the vehicle's on-board generator) hybrid electric vehicle (HEV).

This schedule is also available to customers who meet the above criteria as well as qualify for the California Alternate Rates for Energy (CARE) Program as outlined in Schedule E-CARE, and/or Medical Baseline as outlined in Special Condition (SC) 5. The rates for CARE customers and/or Medical Baseline are identified in the rate tables below as TOU-ELEC-CARE and TOU-ELEC-MB rates, respectively.

There is a cap of 10,000 customers who may take service on this rate, as defined in SC 10.

Pursuant to D.22-11-022, customers that opt-in to schedule TOU-ELEC within its first year of being offered have the option to return to their previous rate schedule prior to the 12-month requirement. See SC4 Terms of Service for all requirements.

Customers on this schedule may also qualify for a semi-annual California Climate Credit \$(60.70) per Schedule GHG-ARR.

TERRITORY

Within the entire territory served by the utility.

RATES

Total Rates:

Description – TOU-ELEC Rates	UDC Total Rate	DWR BC + WF-NBC	EECC Rate	Total Rate
Monthly Service Fee	16.00			16.00
Summer				
On-Peak	0.22228	0.00530	0.51568	0.74326
Off-Peak	0.22228	0.00530	0.14644	0.37402
Super Off-Peak	0.22228	0.00530	0.09785	0.32543
Winter				
On-Peak	0.22228	0.00530	0.27460	0.50218
Off-Peak	0.22228	0.00530	0.13323	0.36081
Super Off-Peak	0.22228	0.00530	0.08905	0.31663

(Continued)

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San Diego Gas & Electric Company
San Diego, California

Original Cal. P.U.C. Sheet No. 37196-E

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SCHEDULE TOU-ELEC

Sheet 2

DOMESTIC TIME-OF-USE FOR HOUSEHOLDS WITH ELECTRIC VEHICLES, ENERGY STORAGE, OR ELECTRIC HEAT PUMPS

RATES (Continued)

Description – TOU-ELEC CARE Rates	UDC Total Rate	DWR BC + WF-NBC	EECC Rate	Total Rate	Total Effective CARE Rate
Monthly Service Fee	16.00			16.00	16.00
Summer – CARE Rates:					
On-Peak	0.22158	0.00000	0.51568	0.73726	0.49222
Off-Peak	0.22158	0.00000	0.14644	0.36802	0.24013
Super Off-Peak	0.22158	0.00000	0.09785	0.31943	0.20696
Winter – CARE Rates:					
On-Peak	0.22158	0.00000	0.27460	0.49618	0.32763
Off-Peak	0.22158	0.00000	0.13323	0.35481	0.23111
Super Off-Peak	0.22158	0.00000	0.08905	0.31063	0.20095

Description – TOU-ELEC MB Rates	UDC Total Rate	DWR BC + WF-NBC	EECC Rate	Total Rate	Total Effective MB Rate
Monthly Service Fee	16.00			16.00	16.00
Summer – MB Rates:					
On-Peak	0.22228	0.00000	0.51568	0.73796	0.59037
Off-Peak	0.22228	0.00000	0.14644	0.36872	0.29498
Super Off-Peak	0.22228	0.00000	0.09785	0.32013	0.25610
Winter – MB Rates:					
On-Peak	0.22228	0.00000	0.27460	0.49688	0.39750
Off-Peak	0.22228	0.00000	0.13323	0.35551	0.28441
Super Off-Peak	0.22228	0.00000	0.08905	0.31133	0.24906

Note:

- Total Rates consist of UDC, Schedule DWR-BC (Department of Water Resources Bond Charge), Schedule WF-NBC (CA Wildfire Fund charge) and Schedule EECC (Electric Energy Commodity Cost) rates. EECC rates are applicable to bundled customers only. See Special Condition 9 for PCIA (Power Charge Indifference Adjustment) recovery.
- 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.
- DWR-BC and WF-NBC charges do not apply to CARE or Medical Baseline customers.
- WF-NBC rate is 0.00530 + DWR-BC Bond Charge is 0.00000

2H5

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San Diego Gas & Electric Company
San Diego, California

Original _____ Cal. P.U.C. Sheet No. 37197-E
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SCHEDULE TOU-ELEC

Sheet 3

**DOMESTIC TIME-OF-USE FOR HOUSEHOLDS WITH ELECTRIC VEHICLES, ENERGY STORAGE,
OR ELECTRIC HEAT PUMPS**

RATES (CONTINUED)

UDC Rates

Description - TOU-ELEC	Transm	Distr	PPP	ND	CTC	LGC	RS	TRAC	UDC Total
Monthly Service Fee (\$/Mo)		16.00							16.00
Summer:									
On-Peak	0.07340	0.10796	0.02546	0.00007	0.00153	0.01383	0.00003	0.00000	0.22226
Off-Peak	0.07340	0.10796	0.02546	0.00007	0.00153	0.01383	0.00003	0.00000	0.22226
Super Off-Peak	0.07340	0.10796	0.02546	0.00007	0.00153	0.01383	0.00003	0.00000	0.22226
Winter:									
On-Peak	0.07340	0.10796	0.02546	0.00007	0.00153	0.01383	0.00003	0.00000	0.22226
Off-Peak	0.07340	0.10796	0.02546	0.00007	0.00153	0.01383	0.00003	0.00000	0.22226
Super Off-Peak	0.07340	0.10796	0.02546	0.00007	0.00153	0.01383	0.00003	0.00000	0.22226

Description - TOU-ELEC - CARE Rates	Transm	Distr	PPP	ND	CTC	LGC	RS	TRAC	UDC Total
Monthly Service Fee (\$/Mo)		16.00							16.00
Summer CARE Rates:									
On-Peak	0.07340	0.10726	0.02546	0.00007	0.00153	0.01383	0.00003	0.00000	0.22158
Off-Peak	0.07340	0.10726	0.02546	0.00007	0.00153	0.01383	0.00003	0.00000	0.22158
Super Off-Peak	0.07340	0.10726	0.02546	0.00007	0.00153	0.01383	0.00003	0.00000	0.22158
Winter CARE Rates:									
On-Peak	0.07340	0.10726	0.02546	0.00007	0.00153	0.01383	0.00003	0.00000	0.22158
Off-Peak	0.07340	0.10726	0.02546	0.00007	0.00153	0.01383	0.00003	0.00000	0.22158
Super Off-Peak	0.07340	0.10726	0.02546	0.00007	0.00153	0.01383	0.00003	0.00000	0.22158

Description - TOU-ELEC - MB Rates	Transm	Distr	PPP	ND	CTC	LGC	RS	TRAC	UDC Total
Monthly Service Fee (\$/Mo)		16.00							16.00
Summer - MB Rates									
On-Peak	0.07340	0.10796	0.02546	0.00007	0.00153	0.01383	0.00003	0.00000	0.22226
Off-Peak	0.07340	0.10796	0.02546	0.00007	0.00153	0.01383	0.00003	0.00000	0.22226
Super Off-Peak	0.07340	0.10796	0.02546	0.00007	0.00153	0.01383	0.00003	0.00000	0.22226
Winter - MB Rates									
On-Peak	0.07340	0.10796	0.02546	0.00007	0.00153	0.01383	0.00003	0.00000	0.22226
Off-Peak	0.07340	0.10796	0.02546	0.00007	0.00153	0.01383	0.00003	0.00000	0.22226
Super Off-Peak	0.07340	0.10796	0.02546	0.00007	0.00153	0.01383	0.00003	0.00000	0.22226

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3H17

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 San Diego, California

Original Cal. P.U.C. Sheet No. 37198-E
 Canceling Cal. P.U.C. Sheet No.

SCHEDULE TOU-ELEC

Sheet 4

DOMESTIC TIME-OF-USE FOR HOUSEHOLDS WITH ELECTRIC VEHICLES, ENERGY STORAGE, OR ELECTRIC HEAT PUMPS

Notes: Transmission Energy charges include the Transmission Revenue Balancing Account Adjustment (TRBAA) of \$(0.00242) per kWh and the Transmission Access Charge Balancing Account Adjustment (TACBAA) of \$(0.01631) per kWh. PPP Energy charges includes Low Income PPP rate (LI-PPP) \$0.01669/kWh, Non-low Income PPP rate (Non-LI-PPP) \$0.00333/kWh (pursuant to PU Code Section 399.8, the Non-LI-PPP rate may not exceed January 1, 2000 levels). Procurement Energy Efficiency Surcharge Rate of \$0.00422 /kWh, California Solar Initiative rate (CSI) of \$0.00000/kWh and Self-Generation Incentive Program rate (SGIP) \$0.00122/kWh.

Rate Components

The Utility Distribution Company Total Rates (UDC Total) shown above are comprised of the following components (if applicable): (1) Transmission (Trans) Charges, (2) Distribution (Distr) Charges, (3) Public Purpose Program (PPP) Charges, (4) Nuclear Decommissioning (ND) Charge, (5) Ongoing Competition Transition Charges (CTC), (6) Local Generation Charge (LGC), (7) Reliability Services (RS), and (8) the Total Rate Adjustment Component (TRAC).

Certain Direct Access customers are exempt from the TRAC, as defined in Rule 1 – Definitions.

Franchise Fee Differential

A Franchise Fee Differential of 5.78% will be applied to the monthly billings calculated under this schedule for all customers within the corporate limits of the City of San Diego. Such Franchise Fee Differential shall be so indicated and added as a separate item to bills rendered to such customers.

Time Periods:

All time periods listed are applicable to actual "clock" time)

TOU Period – 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

(Continued)

4H7

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Submitted Jan 31, 2023

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San Diego Gas & Electric Company
San Diego, California

Revised Cal. P.U.C. Sheet No. 35718-E

Canceling Revised Cal. P.U.C. Sheet No. 32576-E

SCHEDULE E-CARE

Sheet 1

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; (c) the California Wildfire Fund Charge (WF-NBC) and (d) 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

(Continued)

1C5

Advice Ltr. No. 3928-E

Issued by
Dan Skopec
Vice President

Submitted Dec 30, 2021
Effective Jan 1, 2022

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 according to the rates shown in Table 27. These rates are based on applying a normalization curve to the October 2023 tariff based on seven years of historical gas data. The monthly service charge applied was \$14.01 per month per the November 2023 G-1 tariff.

Month	G1 Volumetric Total Baseline	G1 Volumetric Total Excess
January	\$1.83532	\$3.35639
February	\$1.38055	\$2.59947
March	\$1.32506	\$2.47695
April	\$1.29680	\$2.44038
May	\$1.29511	\$2.43804
June	\$1.32034	\$2.45406
July	\$1.35688	\$2.61519
August	\$1.40696	\$2.67944
September	\$1.42130	\$2.70301
October	\$1.42310	\$2.48300
November	\$1.46286	\$2.45547
December	\$1.62415	\$2.62128

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:

<u>Per kilowatt-hour (kWh)</u>	<u>Commodity</u>	<u>Distribution</u>	<u>Public Benefits</u>	<u>Total</u>
Tier 1 usage	\$ 0.09999	\$ 0.06954	\$ 0.00568	\$ 0.17521
Tier 2 usage Any usage over Tier 1	0.13873	0.10225	0.00568	0.24666
<u>Minimum Bill (\$/day)</u>				0.4181

D. SPECIAL NOTES:

1. Calculation of Cost Components

The actual bill amount is calculated based on the applicable rates in Section C above and adjusted for any applicable discounts, surcharges and/or taxes. On a Customer's bill statement, the bill amount may be broken down into appropriate components as calculated under Section C.

2. Calculation of Usage Tiers

Tier 1 Electricity usage shall be calculated and billed based upon a level of 11 kWh per day, prorated by Meter reading days of Service. As an example, for a 30-day bill, the Tier 1 level would be 330 kWh. For further discussion of bill calculation and proration, refer to Rule and Regulation 11.

{End}

CITY OF PALO ALTO UTILITIES

Issued by the City Council

Supersedes Sheet No E-1-1
 dated 7-1-2022



CITY OF
PALO ALTO
 UTILITIES

Sheet No **E-1-1**
 Effective 7-1-2023

6.2.6 Sacramento Municipal Utilities District (Electric Only)

Following are the SMUD electricity tariffs applied in this study. The rates effective January 2023 were used.

Residential Time-of-Day Service Rate Schedule R-TOD

II. Firm Service Rates

A. Time-of-Day (5-8 p.m.) Rate

	Effective as of January 1, 2023	Effective as of January 1, 2024	Effective as of May 1, 2024	Effective as of January 1, 2025	Effective as of May 1, 2025
Time-of-Day (5-8 p.m.) Rate (RT02)					
Non-Summer Season (October - May)					
System Infrastructure Fixed Charge <i>per month per meter</i>	\$23.50	\$24.15	\$24.80	\$25.50	\$26.20
Electricity Usage Charge					
Peak \$/k Wh	\$0.1547	\$0.1590	\$0.1633	\$0.1678	\$0.1724
Off-Peak \$/k Wh	\$0.1120	\$0.1151	\$0.1183	\$0.1215	\$0.1248
Summer Season (June - September)					
System Infrastructure Fixed Charge <i>per month per meter</i>	\$23.50	\$24.15	\$24.80	\$25.50	\$26.20
Electricity Usage Charge					
Peak \$/k Wh	\$0.3279	\$0.3369	\$0.3462	\$0.3557	\$0.3655
Mid-Peak \$/k Wh	\$0.1864	\$0.1914	\$0.1967	\$0.2021	\$0.2077
Off-Peak \$/k Wh	\$0.1350	\$0.1387	\$0.1425	\$0.1464	\$0.1505

B. Optional Critical Peak Pricing Rate

- The CPP Rate base prices per time-of-day period are the same as the prices per time-of-day period for TOD (5-8 p.m.).
- The CPP Rate provides a discount per kWh on the Mid-Peak and Off-Peak prices during summer months.
- During CPP Events, customers will be charged for energy used at the applicable time-of-day period rate plus the CPP Rate Event Price per kWh as shown on www.smud.org.
- During CPP Events, energy exported to the grid will be compensated at the CPP Rate Event Price per kWh as shown on www.smud.org.
- The CPP Rate Event Price and discount will be updated annually at SMUD's discretion and posted on www.smud.org.

C. Plug-In Electric Vehicle Credit (rate categories RT02 and RTC1)

This credit is for residential customers who have a licensed passenger battery electric plug-in or plug-in hybrid electric vehicle.

Credit applies to all electricity usage charges from midnight to 6:00 a.m. daily.

Electric Vehicle Credit..... ~~-\$0.0150/kWh~~

III. Electricity Usage Surcharges

Refer to the following rate schedules for details on these surcharges.

A. Hydro Generation Adjustment (HGA). Refer to Rate Schedule HGA.

IV. Rate Option Menu

- Energy Assistance Program Rate.** Refer to Rate Schedule EAPR.
- Medical Equipment Discount Program.** Refer to Rate Schedule MED.
- Joint Participation in Medical Equipment Discount and Energy Assistance Program Rate.** Refer to Rate Schedule MED.

SACRAMENTO MUNICIPAL UTILITY DISTRICT
 Resolution No. 23-09-09 adopted September 21, 2023

Sheet No. **R-TOD-2**
 Effective: **September 22, 2023**

A. Time-of-Day (5-8 p.m.) Rate (rate category RT02)

1. The TOD (5-8 p.m.) Rate is the standard rate for SMUD's residential customers. Eligible customers can elect the Fixed Rate under Rate Schedule R as an alternative rate.
2. The TOD (5-8 p.m.) Rate is an optional rate for customers who have an eligible renewable electrical generation facility under Rate Schedule NEM1 that was approved for installation by SMUD prior to January 1, 2018.
3. This rate has five kilowatt-hour (kWh) prices, depending on the time-of-day and season as shown below. Holidays are detailed in Section V. Conditions of Service.

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 .

¹ See Section V. Conditions of Service

6.2.7 Fuel 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, 2021a). Escalation rates through the remainder of the 30-year evaluation period are based on the escalation rate assumptions within the 2022 TDV factors. No data was available to estimate electricity escalation rates for CPAU and SMUD, therefore electricity escalation rates for PG&E and statewide natural gas escalation rates were applied. Table 29 presents the average annual escalation rates used in the utility rate escalation sensitivity analysis shown in Section 3.2.4. Rates were applied for the same 30-year period and are based on the escalation rate assumptions within the 2025 LSC factors from 2027 through 2053.²⁸ These rates were developed for electricity use statewide (not utility-specific) and assume steep increases in gas rates in the latter half of the analysis period. Data was not available for the years 2024, 2025, and 2026 and so the CPUC En Banc assumptions were applied for those years using the average rate across the three IOUs for statewide electricity escalation.

Table 28: Real Utility Rate Escalation Rate Assumptions, CPUC En Banc and 2022 TDV Basis

	Statewide Natural Gas Residential Average Rate (%/year, real)	Electric Residential Average Rate (%/year, real)		
		PG&E	SCE	SDG&E
2024	4.6%	1.8%	1.6%	2.8%
2025	4.6%	1.8%	1.6%	2.8%
2026	4.6%	1.8%	1.6%	2.8%
2027	4.6%	1.8%	1.6%	2.8%
2028	4.6%	1.8%	1.6%	2.8%
2029	4.6%	1.8%	1.6%	2.8%
2030	4.6%	1.8%	1.6%	2.8%
2031	2.0%	0.6%	0.6%	0.6%
2032	2.4%	0.6%	0.6%	0.6%
2033	2.1%	0.6%	0.6%	0.6%
2034	1.9%	0.6%	0.6%	0.6%
2035	1.9%	0.6%	0.6%	0.6%
2036	1.8%	0.6%	0.6%	0.6%
2037	1.7%	0.6%	0.6%	0.6%
2038	1.6%	0.6%	0.6%	0.6%
2039	2.1%	0.6%	0.6%	0.6%
2040	1.6%	0.6%	0.6%	0.6%
2041	2.2%	0.6%	0.6%	0.6%
2042	2.2%	0.6%	0.6%	0.6%
2043	2.3%	0.6%	0.6%	0.6%
2044	2.4%	0.6%	0.6%	0.6%
2045	2.5%	0.6%	0.6%	0.6%
2046	1.5%	0.6%	0.6%	0.6%
2047	1.3%	0.6%	0.6%	0.6%
2048	1.6%	0.6%	0.6%	0.6%
2049	1.3%	0.6%	0.6%	0.6%
2050	1.5%	0.6%	0.6%	0.6%
2051	1.8%	0.6%	0.6%	0.6%
2052	1.8%	0.6%	0.6%	0.6%
2053	1.8%	0.6%	0.6%	0.6%

²⁸<https://www.energy.ca.gov/files/2025-energy-code-hourly-factors>. Actual escalation factors were provided by consultants E3.

Table 29: Real Utility Rate Escalation Rate Assumptions, 2025 LSC Basis

Year	Statewide Natural Gas Residential Average Rate (%/year, real)	Statewide Electricity Residential Average Rate (%/year, real)
2024	4.6%	2.1%
2025	4.6%	2.1%
2026	4.6%	2.1%
2027	4.2%	0.6%
2028	3.2%	1.9%
2029	3.6%	1.6%
2030	6.6%	1.3%
2031	6.7%	1.0%
2032	7.7%	1.2%
2033	8.2%	1.1%
2034	8.2%	1.1%
2035	8.2%	0.9%
2036	8.2%	1.1%
2037	8.2%	1.1%
2038	8.2%	1.0%
2039	8.2%	1.1%
2040	8.2%	1.1%
2041	8.2%	1.1%
2042	8.2%	1.1%
2043	8.2%	1.1%
2044	8.2%	1.1%
2045	8.2%	1.1%
2046	8.2%	1.1%
2047	3.1%	1.1%
2048	-0.5%	1.1%
2049	-0.6%	1.1%
2050	-0.5%	1.1%
2051	-0.6%	1.1%
2052	-0.6%	1.1%
2053	-0.6%	1.1%

Get In Touch

The adoption of reach codes can differentiate jurisdictions as efficiency leaders and help accelerate the adoption of new equipment, technologies, code compliance, and energy savings strategies.

As part of the Statewide Codes & Standards Program, the Reach Codes Subprogram is a resource available to any local jurisdiction located throughout the state of California.

Our experts develop robust toolkits as well as provide specific technical assistance to local jurisdictions (cities and counties) considering adopting energy reach codes. These include Cost-effectiveness research and analysis, model ordinance language and other code development and implementation tools, and specific technical assistance throughout the code adoption process.

If you are interested in finding out more about local energy reach codes, the Reach Codes Team stands ready to assist jurisdictions at any stage of a reach code project.



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2019 Cost-Effectiveness Study: Existing Single Family Residential Building Upgrades

Last Modified: 2021-08-27

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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 ₂ e	Carbon Dioxide (CO ₂)-equivalent
CPAU	City of Palo Alto Utilities
CRRC	Cool Roof Rating Council
CZ	California 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 and Electric Company
PV	Photovoltaic
SCE	Southern California Edison
SDG&E	San Diego Gas and Electric
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	Title 24, Part 6
TOU	Time-of-Use
UEF	Uniform Energy Factor
V	Volt
W	Watt
W _{DC}	Watt Direct Current

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1 Overview

The California Statewide Codes and Standards Reach Codes Team (Statewide Reach Code Team) has updated the prior cost-effectiveness study for existing building upgrades completed in February 2020 (Statewide Reach Codes Team, 2020). This analysis evaluates the feasibility and cost effectiveness of retrofit measures in California existing single family homes built before 2010. A lifecycle cost (LCC) approach to evaluating cost effectiveness was applied quantifying the savings associated with energy efficiency measures compared to measure costs. The focus of this study was to revisit the recommended retrofit efficiency measure and package cost effectiveness based on latest utility rates, updated measure costs and evaluate cost effectiveness of additional efficiency and grid integration measures, including:

- Revisit base case assumptions for different vintages.
- Additional efficiency upgrade options including:
 - o High-efficiency equipment replacement as alternative to non-preempted upgrade measures.
 - o Higher ceiling insulation requirements.
 - o Improved duct insulation and reduced duct leakage.
- PV system installation.
- Evaluation of electrification measures at equipment change-out and electrification-ready measures.
- Electrification measures tied to installation of PV system.
- Battery storage measures.

2 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](https://www.localenergycodes.com).

The California Building Energy Efficiency Standards, or Title 24, Part 6 (Title 24) (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 (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. In addition, the jurisdiction must obtain approval from the Energy Commission and file the ordinance with the BSC for the ordinance to be legally enforceable.

This report documents cost-effective combinations of measures that exceed the minimum state requirements, the 2019 Building Energy Efficiency Standards, effective January 1, 2020. 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 single family buildings. This analysis does not apply to low- or high-rise multifamily buildings. Each jurisdiction must establish the appropriate structure and threshold for triggering the 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 reroof. The analysis includes scenarios of individual measures, as well as package upgrades, and identifies cost-effective options based on the existing conditions of the building in all 16 California Climate Zones (CZ) (see Appendix A: Map of California Climate Zones for a graphical depiction of climate zone locations).

This analysis does not evaluate the impact of retrofit measures on Title 24 compliance margins, as the proposed measures are required in addition to achieving compliance with all codes.

3 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 societal value or cost of energy use including long-term projected costs, such as the cost of providing energy during peak periods of demand and other societal costs, such as projected costs for carbon emissions, as well as grid transmission and distribution impacts. This metric values energy use differently depending on the fuel source (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 et al., 2014). This is the methodology used by the Energy Commission in evaluating cost effectiveness for efficiency measures in Title 24. Both 2019 and 2022 TDV multipliers 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 single family homes. Three unique building vintages are considered: pre-1978, 1978-1991, and 1992-2010. The vintages were defined based on review of historic Title 24 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) 2019.1.2 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 2020 for the 2019 Title 24 (Statewide Reach Codes Team, 2020) and has been updated to reflect changes in measure costs over time as well as current utility tariffs. Energy simulations were re-evaluated in CBECC-Res 2019 to evaluate cost effectiveness from a TDV perspective under the 2019 Title 24. TDV cost effectiveness was also completed using the 2022 TDV and weather files to evaluate cost effectiveness with the latest version of the software for future code cycles.

3.1 Building Prototypes

The Energy Commission defines building prototypes which it uses to evaluate the cost effectiveness of proposed changes to Title 24 requirements. Average home size has steadily increased over time,¹ and the Energy Commission single family new construction prototypes are larger than many existing single family homes across California. For this analysis, an existing home prototype developed by the Energy Commission for residential ACM testing² was used with the following revisions. The original prototype includes an existing 1,440 square foot (ft²) space and a 225 ft² addition. For this analysis, the entire 1,665 ft² was evaluated as existing space and features (i.e., insulation levels, glazing) were applied consistently across the entire building consistent with the existing home specifications in Table 2. Additions are not evaluated in this analysis as they are already addressed in Section 150.2 of Title 24, Part 6. Table 1 describes the basic characteristics of the single family prototype.

¹ <https://www.census.gov/const/C25Ann/sfttotalmedavgsgft.pdf>

² Residential ACM test U12 can be accessed at the following website: <http://www.bwilcox.com/BEES/cbecc2016.html>

Table 1: Prototype Characteristics

	<u>Single Family</u>
Existing Conditioned Floor Area	1,665 ft ²
Num. of Stories	1
Num. of Bedrooms	3
Window-to-Floor Area Ratio	13%
Attached Garage	2-car garage

Three building vintages were evaluated to determine sensitivity of existing building performance on cost effectiveness of upgrades. For example, it is widely recognized that adding attic insulation in an older home with no insulation is cost-effective, however, newer homes will likely have at least some existing insulation in the attic reducing the potential savings from the measure. The building characteristics for each vintage were determined based on either prescriptive requirements from Title 24 that were in effect or standard construction practice during that time period. Homes built under 2001 Title 24 are subject to prescriptive envelope code requirements very similar to homes built under the 2005 code cycle, which was in effect until January 1, 2010.

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 single family building.
- Split-system air conditioner with natural gas furnace. Efficiency defined by year of the most recent equipment replacement (based on standard equipment lifetime).
- Small storage natural gas water heater. Efficiency defined by year of most recent equipment replacement (based on standard equipment lifetime).
- Gas cooktop, oven, and clothes dryer.

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 16inch on center wood frame, R-11	2x4 16inch 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	40-gallon uninsulated tank	40-gallon uninsulated tank
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. 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.

3.2 Efficiency Measures

The methodology used in the analyses for each of the prototypical building types begins with a design that matches the specifications as described in Table 2 for each of the three vintages. Prospective energy efficiency measures were modeled in each of the prototypes to determine the projected electricity and natural gas energy savings relative to the baseline vintage. In some cases, where logical, measures were packaged together. Unless specified otherwise, all measures were evaluated using CBECC-Res.

All measures are evaluated assuming they are not otherwise required by Title 24. 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. In some cases, cost-effective measures were identified that exceed Title 24 requirements, such as attic insulation, cool roofs, and duct sealing.

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

3.2.1 Building Envelope/Non-Preempted Measures

Attic Insulation: Add attic insulation in buildings with vented attic spaces to meet R-49. For pre-1992 vintage homes this measure was also evaluated to include retrofitting of existing recessed can luminaires that are not rated for insulation contact (IC) to be airtight and allow for insulation contact. This can be accomplished by installing a recessed light cover over existing non-compliant luminaires and sealing the covers to the ceiling plane with foam or replacing non-IC-rated luminaires with IC-rated luminaires. The energy analysis includes savings from adding insulation and upgrading compact fluorescent lamp (CFL) recessed cans to LED lighting but does not include any reduced infiltration benefits. Newer vintage homes are assumed to have IC-rated recessed light luminaires that can be covered in insulation.

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 homes 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 to 1991 vintage, and from seven to five ACH50 in the 1992 to 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 Section 150.2(b)1Ii but assumes a higher solar reflectance.

Raised Floor Insulation: In existing homes with raised floors and no insulation, add R-19 insulation.

Wall Insulation: Blow-in R-13 wall insulation in existing homes 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-ft²-°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 was evaluated. 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.

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, final duct leakage values of both 15 percent (which corresponds to Option i in the Title 24 section referenced), and ten percent (proposed revised leakage rate for 2022 Title 24) were evaluated. Replacing existing ductwork with entirely new ductwork to meet Sections 150.2(b)1Di and 150.2(b)1Diia of the 2019 Title 24 was also evaluated. This assumed new ducts meet five percent duct leakage and R-8 duct insulation in all climates.

Water Heater Blanket: Add R-6 insulation to the exterior of existing residential tank storage water heaters. For the analysis, the water heater was modeled within conditioned space, which is a typical configuration for older homes. This assumption is conservative since a water heater located in unconditioned space will tend to have higher tank losses and installing a water heater blanket in those situations will result in additional savings. The energy savings for this measure reflect 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 the majority of 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 located in the attic, crawlspace, or are otherwise more accessible, energy savings will be higher than those presented in this analysis. This measure was evaluated using BEopt and EnergyPlus.

Low-Flow Fixtures: Upgrade sink and shower fittings to meet current 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 whole house hot water use was based on BEopt assumptions and this measure assumed the upgraded fixtures reduce flow rates by ten percent for showerheads and 20 percent for all faucets based on a 2010 water use study (ConSol, 2010). This measure was evaluated using BEopt and EnergyPlus.

LED Lighting: Replace screw-in (A-based for lamps) incandescent lamps and CFLs with light-emitting diode (LED) A-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, 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 (CEE, 2014). Energy savings will be higher for incandescent or CFL luminaires.

3.2.2 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 1,665 ft² home or sized to offset 100 percent of annual building electricity use, whichever was smaller. Based on prior studies, PV system cost effectiveness was not sensitive to system sizing up to 90 percent of annual electricity use (Statewide Reach Codes Team, 2019). The system is sized to offset a portion of annual building electricity use for a new construction home and avoid oversizing which would violate net energy metering (NEM) rules. In only one case was the PV system downsized to ensure that over-generation did not occur. 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: Single Family PV Sizing for 1,665 ft² home by Climate Zone (kW_{DC})

CA Climate Zone	PV Capacity (kW _{DC}) ^a	CA Climate Zone	PV Capacity (kW _{DC}) ^a
1	2.59	9	2.38
2	2.25	10	2.45
3	2.17	11	2.83
4	2.19	12	2.42
5	2.03	13	3.00
6	2.22 (2.19 1992-2010 vintage) ^b	14	2.49
7	2.10	15	4.07
8	2.35	16	2.20

^a PV system sized using residential new construction sizing methodology based on climate zone and house size.

^b PV system was downsized for this vintage to prevent over-generation of PV.

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 ten kWh battery system was evaluated in CBECC-Res in conjunction with a PV system sized to the 2019 new construction standards, with control type set to “Time of Use” (TOU) and with default efficiencies of 95 percent for both charging and discharging (round trip efficiency of 90 percent). The TOU option assumes batteries are charged anytime PV generation is greater than the house load but controls when the battery storage system discharges. During the summer months (July – September) the battery begins to discharge at the beginning of the peak period at a maximum rate until fully discharged. During discharge the battery first serves the house load but will discharge to the electric grid if there is excess energy available. During other months, the battery discharges whenever the PV system does not cover the entire house load and does not discharge to the electric grid. This control option is considered to be most reflective of the current products on the market. This control option requires an input for the “First Hour of the Summer Peak” and the Statewide Reach Codes Team applied the default hour in CBECC-Res which differs by climate zone (either a 6pm or 7pm start).

3.2.3 Equipment Fuel Substitution Measures – Heat Pump Replacements

The baseline for the retrofit analysis assumed a mixed-fuel baseline for all cases, with natural gas-fired furnaces for space heating and natural gas storage tank water heaters for domestic hot water (DHW). For fuel substitution cases, the natural gas appliances were assumed to be replaced with heat pump technology at the end of equipment life, when the equipment is being replaced.

Ducted Heat Pump: Replace existing ducted natural gas furnace and air conditioner (AC) with an electric heat pump. Minimum federal efficiency (14 SEER, 11.7 EER, 8.2 HSPF) and higher efficiency (21 SEER, 13.5 EER, 11 HSPF) heat pumps were evaluated as replacements to existing equipment. Savings are relative to a new ducted natural gas furnace/AC (14 SEER, 11.7 EER, 80 AFUE).

Heat Pump Water Heater (HPWH): Replace existing natural gas storage tank water heater with either a minimum efficiency (UEF 2.0) 50-gallon HPWH, or a HPWH that meets the Northwest Energy Efficiency Alliance

(NEEA)³ Tier 3 rating. The evaluated NEEA HPWH is an 80-gallon unit with a UEF of 3.45. Savings are relative to a new 50-gallon natural gas storage water heater (UEF 0.63).

3.3 Efficiency Packages

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

3.3.1 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. When the building shell is being improved, 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 even 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 to 1991 vintage, and five ACH50 for the 1992 to 2010 vintage.
 - Retrofitting all non-IC-rated recessed light luminaires to be airtight and allow for coverage by insulation. This submeasure only applies to homes without IC-rated recessed can luminaires.
2. **R-49 Attic Insulation and Duct Sealing:** This package includes attic insulation and duct sealing measures, as described below:
 - R-49 attic insulation installed in attic.
 - Ductwork sealed to ten percent of nominal airflow.
 - Retrofitting all non-IC-rated recessed light luminaires to be airtight and allow for coverage by insulation. This submeasure only applies to homes without IC-rated recessed can luminaires.
3. **R-49 Attic Insulation, Air Sealing, and Duct Sealing:** This package includes attic insulation, air sealing, and duct sealing measures, as described below:
 - R-49 attic insulation installed in attic.
 - Ductwork sealed to ten 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 to 1991 vintage, and five ACH50 for the 1992 to 2010 vintage.
 - Retrofitting all non-IC-rated recessed light luminaires to be airtight and allow for coverage by insulation. This submeasure only applies to homes without IC-rated recessed can luminaires.

³ Based on operational challenges experienced in the past, NEEA established rating test criteria to ensure newly installed HPWHs perform adequately, especially in colder climates. The NEEA rating requires an Energy Factor equal to the ENERGY STAR® performance level and includes requirements regarding noise and prioritizing heat pump use over supplemental electric resistance heating.

- 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 house.
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 to 1991 vintage, and five ACH50 for the 1992 to 2010 vintage.
 - Retrofitting all non-IC-rated recessed light luminaires to be airtight and allow for coverage by insulation. This submeasure only applies to homes without IC-rated recessed can luminaires.
 - 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 house.
5. **Advanced Envelope Package: Attic Insulation, Recessed Cans, 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 homes with no wall cavity insulation and single-pane windows.
- R-49 attic insulation installed in attic.
 - Ductwork sealed to ten 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 to 1991 vintage, and five ACH50 for the 1992 to 2010 vintage.
 - Retrofitting all non-IC-rated recessed light luminaires to be airtight and allow for coverage by insulation. This submeasure only applies to homes without IC-rated recessed can luminaires.
 - 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).
 - 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 house.

3.3.2 Additional Packages

Water Heating Package: Includes 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. Additional water savings measures and model language are documented on the LocalEnergyCodes.com website.⁴

PV plus Batteries: PV sized to Residential New Construction Standards and a ten kWh battery system with TOU control.

⁴ <https://localenergycodes.com/>

PV plus Heat Pump: PV sized to 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 furnace and water heater 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 the attic and the water heater location in the garage, and panel upgrade to allow for installation of future electric appliances at a future date.

3.4 Measure Cost

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

3.4.1 Building Envelope/Non-Preempted Measures

Table 4 summarizes the cost assumptions for the building envelope and non-preempted HVAC measures evaluated.

3.4.2 PV and Battery Measures

The costs for installing PV and batteries are summarized in Table 5. 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 income 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 at least 75 percent of the energy used to charge the battery comes from a renewable source.

Table 4: Measure Descriptions & Cost Assumptions - Non-Preempted Measures^a

Measure	Performance Level	Incremental Cost – Single Family Building			Source	Notes
		Pre 1978	1978 – 1991	1992 - 2010		
Building Envelope						
Wall Insulation	R-13	\$3,360	N/A	N/A	Retrofit contractor ^b	\$2.14/ ft ² exterior wall area. Drill 2-inch holes from outside.
Raised Floor Insulation	R-19	\$3,147	N/A	N/A	Retrofit contractor ^b	\$1.89/ ft ² of raised floor area. Assumes installation of R-19 batt insulation when existing condition is no insulation.
Attic Insulation	R-49	\$2,851	\$2,393	\$1,852	2022 Alterations CASE Report (Statewide CASE Team, 2020)	\$1.71/ ft ² ceiling area to add insulation to existing R-11 insulation. \$1.44/ ft ² to add insulation to existing R-19 insulation.
	R-49 + Recessed Can Retrofit	\$3,332	\$2,874	\$2,333		Added cost of \$0.29/ ft ² ceiling area to retrofit non-IC-rated to be airtight and allow coverage with insulation and seal the covers to the ceiling plane with foam. Added cost used for pre-1992 homes.
Air Sealing	10 ACH50	\$1,474	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	\$1,474	N/A		
	5 ACH50	N/A	N/A	\$1,474		
Cool Roof	Aged Solar Reflectance ≥ 0.25	\$778	\$778	\$778	2022 Alterations CASE Report (Statewide CASE Team, 2020)	Based on \$0.32/ ft ² 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	\$9,810	N/A	N/A	Retrofit contractor ^c	Based on \$45/ ft ² window area installed cost.
HVAC/DHW						
Duct Sealing	15% nominal airflow	\$423	\$423	N/A	HVAC contractor	Assume ducts in attic with 5 wye branches, 8 supplies & 1 return. \$223 in labor (~2 hours at \$120/hour) and \$20 material for 15% leakage from a starting point of 25-30% and for 10% from a starting point of 15%. \$463 in labor (~4 hours at \$120/hour) and \$40 material for 10% leakage from a starting point of 25-30%. \$180 for HERS Rater.
	10% nominal airflow	\$683	\$683	\$423		

Measure	Performance Level	Incremental Cost – Single Family Building			Source	Notes
		Pre 1978	1978 – 1991	1992 - 2010		
Entirely New Ducts	R-8 ducts; 5% duct leakage	\$3,986	\$3,986	\$3,986	Retrofit contractor ^b	Based on duct layout provided for prototype single story model, and all ducts located in attic.
Water Heater Blanket	R-6	\$40			Internet search	\$20 blanket + ½-hour labor (\$40.30/hour laborer rate). ^d Six-year life assuming that the water heater will need to be replaced after 6 years on average.
Hot Water Pipe Insulation	3/4 inch (R-3)	\$42			Internet search	\$0.20/ft of ¾ inch pipe insulation. 10ft total + 1-hour labor (\$40.30/hour common labor rate). ^d 15-year life assumed.
Low-flow Fixtures	CALGreen	\$126			Retrofit contractor ^c	Showerheads at \$34.74 each + sink aerators at \$5.37 each + 1-hour labor (\$40.30/hour common labor rate). ^d 2 showerheads & 3 aerators assumed for single family. 15-year life assumed.
Lighting						
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	\$10.50/device			Internet search	Incremental cost of \$10.50, 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.

^a Costs include contractor overhead and profit.

^b Source: Retrofit contractor pricing. 2020. Phone outreach.

^c Source: Retrofit contractor pricing obtained by Davis Energy Group through the Stockton Energy Challenge neighborhood retrofit program (DEG, 2017).

Table 5: Measure Descriptions & Cost Assumptions – PV and Batteries^a

Measure	Performance Level	Incremental Cost – Single Family Building			Source	Notes
		Pre 1978	1978 – 1991	1992 - 2010		
PV/Batteries						
PV	Sized to 2019 New Construction Standards: System size varies by climate (2.03-4.07 kW)	\$3.18/W _{DC} \$6,467 - \$12,933			(LBNL, 2019)	First costs are from LBNL’s Tracking the Sun 2019 costs (Barbose et al., 2019) and represent costs for the first half of 2019 of \$3.70/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	10 kWh, TOU controls	\$11,372 \$1,137/kWh			(SGIP, 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.

3.4.3 Equipment Fuel Substitution Measures – Heat Pump Equipment

The cost assumptions used for fuel substitution measures are summarized in Table 6 and Table 7. 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, 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 it is assumed many existing homes have the service capacity to support converting one appliance from gas to electric. In some homes and in cases where multiple end uses are electrified, a larger electrical panel may be necessary. Cost assumptions for electric ready measures including panel upgrade for future equipment fuel substitution measures are included in Table 8.

Ducted Heat Pump: 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 6 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, 2021). 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 6: HVAC Measure Cost Assumptions – Electric Replacements

	Gas Furnace/ AC	14 SEER Heat Pump	21 SEER Heat Pump	Notes
First Cost	\$8,738	\$9,101	\$11,247	Equipment costs from on-line sources and HVAC contractors. Other supply and labor costs from 2019 report on residential building electrification in California (Energy & Environmental Economics, 2019). First cost includes disposal, electrical upgrade, and labor costs.
Replacement Cost (Future Value)	\$8,738	\$6,729	\$8,445	Future total replacement costs for the heat pumps are reduced by 20% to account for cost reductions because of a maturing market and electrical upgrade costs are removed.
Replacement Cost (Present Value)	\$5,209	\$4,319	\$5,421	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	(\$1,029)	\$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	\$12,918	\$13,419	\$16,667	
Incremental Cost	-	\$501	\$3,749	

Heat Pump Water Heater (HPWH): Table 7 presents estimated costs for the replacement of a natural gas storage water heater located in a garage 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 (SMUD, 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 7: 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 (SMUD, 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 8 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 the attic and the water heater location in the garage. Panel upgrade costs are based on upgrading from 100 A to 200 A service to allow for electric appliance installation at a future date.

Table 8: 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. (E3, 2019)
Panel upgrade	\$3,181	(TRC, 2016)

3.5 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 prescriptive Title 24 requirements.

Additional analysis included evaluating the measures using both the 2019 and proposed 2022 TDV multipliers. The proposed 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

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

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

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

Where:

- n = analysis term
- r = discount rate

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

- Analysis term of 30 years
 - o 15-year analysis term for the water heating package
 - o Five-year analysis term for the exterior light controls
- Real discount rate of three percent

3.5.1 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 9. 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. For the PV cases annual electric production was always less than annual electricity consumption; and therefore, no credits for surplus generation were necessary. Future changes to the NEM tariffs are likely; however, there is uncertainty about what those changes will be and if they will become effective during the 2019 Title 24 code cycle (2020-2022).

Utility rates were applied to each climate zone based on the predominant IOU serving the population of each zone according to Table 9. 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 9: IOU 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.

Utility rates are assumed to escalate over time, using assumptions from research conducted by Energy and Environmental Economics (E3) in the 2019 study Residential Building Electrification in California study (Energy & Environmental Economics, 2019). Escalation of natural gas rates between 2019 and 2022 is based on the currently filed General Rate Cases (GRCs) for PG&E, SoCalGas, and SDG&E. From 2023 through 2025, natural gas rates are assumed to escalate at four percent per year above inflation, which reflects historical rate increases between 2013 and 2018. Escalation of electricity rates from 2019 through 2025 is assumed to be two percent per year above inflation, based on electric utility estimates. After 2025, escalation rates for both natural gas and electric rates are assumed to drop to a more conservative one percent escalation per year above inflation for long-term rate trajectories beginning in 2026 through 2050. See Appendix B: Utility Rate Schedules – Escalation Assumptions for additional 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 homeowner and are not assumed to be financed. Present value of replacement cost is included for measures with equipment lifetimes less than the evaluation period.

3.5.2 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. 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 code cycles for residential buildings, was used.

Like the customer B/C ratio, a TDV B/C ratio value of one indicates the savings over the life of the measure are equivalent to the incremental cost of that measure. A value greater than one represents a positive return on investment. The ratio is calculated according to Equation 3. In calculating TDV cost effectiveness, incremental first costs were not assumed to be financed into a mortgage or loan.

Equation 3

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

3.5.2.1 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 report (Energy & Environmental Economics, 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 Codes 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.

3.6 Greenhouse Gas (GHG) Emissions Reductions

Equivalent CO₂ emission reductions were calculated based on outputs from the CBECC-Res 2022.0.1 simulation software. Electricity emissions vary by region and by hour of the year. CBECC-Res applies two distinct hourly profiles, one for Climate Zones 1 through 5 and 11 through 13 and another for Climate Zones 6 through 10 and 14 through 16. For natural gas, a fixed factor of 9.9 pounds (lbs) per therm is used. To compare the mixed-fuel and all-electric cases side-by-side, GHG emissions are presented as lbs CO₂-equivalent (CO₂e) emissions for the 1,665 ft² prototype.

3.7 Energy Performance Equivalency of Retrofit Measures and Packages

Efficiency measures were evaluated based on three distinct vintage homes with typical characteristics applied to each. However, the existing building stock is quite varied, and year of construction is not always

an accurate indicator of efficiency and performance as homes may have been upgraded over time. To provide flexibility in the ordinance structure, the Statewide Reach Codes Team developed an energy performance equivalency methodology where the efficiency characteristics of a home and upgrades are valued relative to one another. This provides a flexible approach in two forms:

- 1) Where retrofit requirements are based on home vintage, applicants can value upgrades that may have been completed on their home (HERS Rater verified) to determine the closest vintage bin their house falls into, providing credit for improvements made to the house after it was constructed.
- 2) Applicants can pick from a menu of efficiency upgrades that in combination result in equivalent performance as a prescriptive package of measures or single measure that may be required as part of a retrofit reach code.

Energy performance equivalency is based on the source energy use metric (Energy Design Rating (EDR)

1) developed for the 2022 code cycle and is calculated by climate zone relative to the pre-1978 prototype home used in this analysis. The scoring is unique to each climate zone where different heating and cooling loads contribute to distinct values for various upgrades. For example, high efficiency heating equipment has a greater impact on score in heating dominated climates such as Climate Zone 1 and 16 as compared to Climate Zone 15, a cooling dominated climate.

As an example, the pre-1978 prototype home in Climate Zone 12 has an EDR1 score of 39 kBtu/ft²-year and the pre-1978 prototype home with upgraded R-49 attic insulation has an EDR1 score of 36 kBtu/ft²-year, the equivalent energy performance for R-49 insulation in Climate Zone 12 is valued at 3. The same approach is applied to packages of measures. Equivalent energy performance was calculated for most of the retrofit measures and packages described in Section 3.2 and Section 3.3, as well as a variety of additional building efficiency characteristics (see Appendix E – Details on Energy Performance Equivalency for a complete list).

4 Results

The primary objective of the evaluation is to identify cost-effective energy upgrade measures and packages for existing single family 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 single family prototype designs representing buildings features commonly used during each of three vintages.

Table 11 through Table 14 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 3.5. Detailed cost-effectiveness analysis results, along with energy savings are presented in Appendix D – Measure Cost-Effectiveness Tables, in Table 30 through Table 113, 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. A summary of these results is provided below.

Cost effectiveness by metric for each climate zone and building vintage is represented in the tables as summarized in Table 10:

Table 10: 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 assumes savings based on 2022 weather files.

4.1 Building Envelope/Non-Preempted Measures

A summary of the cost effectiveness of individual efficiency measures is summarized in Table 11 based on both the On-Bill and 2019 TDV metrics.

R-49 Attic Insulation: R-49 attic insulation is cost-effective both On-Bill and TDV in older vintage homes except some coastal climates (Climate Zones 1, 3, and 5), and less cost-effective in newer vintage homes because of reduced energy savings.

Air Sealing: Reducing building leakage by 30 percent alone is only cost-effective in a handful of climates.

Duct Sealing: Duct sealing to ten percent of nominal airflow has the best economics of the envelope/duct measures in most climates and vintages and is cost-effective. It is not cost-effective in Climate Zones 3 and 5 through 7 in the 1992-2010 vintage homes.

New Ducts: Replacing old ductwork with new R-8 ducts sealed to five percent of nominal airflow has similar economics as the duct sealing measure and is cost-effective in many cases. It is not cost-effective in Climate Zones 3, 5, and 7 in any vintage and is only cost-effective in a handful of climate zones in 1992-2010 vintage homes.

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

Wall Insulation: Blowing in wall insulation into exterior walls is only practical in pre-1978 homes with no insulation installed in the wall cavities. It is cost-effective On-Bill in Climate Zones 1 and 11 through 16, and it is cost-effective based on TDV in Climate Zones 1, 2, and 9 through 16.

Window Replacement: Window replacements are only cost-effective in homes built before 1978 in Climate Zones 10 through 15, and in Climate Zones 11 through 15; in addition, window replacements are also cost-effective in Climate Zone 10 for 1978 through 1991 vintage homes in SDG&E territory.

Table 11: Summary of Single Family 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	N/A	Both	N/A	Both	N/A	Both	Both	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 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	TDV	N/A	On-Bill	N/A On-Bill	Both	N/A
Air Sealing	Pre-1978	On-Bill	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	Both	N/A	N/A	TDV Both	Both	Both
	1978-1991	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	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	N/A	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	Both	Both	Both TDV	Both	On-Bill	Both	Both	Both	Both	Both	Both	Both	Both	Both
	1992-2010	Both	TDV	N/A	TDV	N/A	N/A	N/A	Both	Both	Both	Both	Both	Both	Both	Both	Both
New Ducts	Pre-1978	Both	Both	N/A	Both	N/A	TDV	On-Bill	Both	Both	Both	Both	Both	Both	Both	Both	Both
	1978-1991	Both	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	Both	TDV	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	TDV	N/A	Both TDV	N/A	Both	Both	Both	Both	Both	Both	Both	Both	Both	Both	N/A
	1992-2010	N/A	N/A	N/A	N/A	N/A	N/A	N/A	Both	Both	TDV Both	Both	Both TDV	Both	Both	Both	N/A
Insulate Walls	Pre-1978	Both	Both	N/A	N/A	N/A	N/A	N/A	N/A	TDV	TDV	Both	Both TDV	Both	Both	Both	Both
Windows	Pre-1978	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	Both	Both	Both TDV	Both	Both	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	Both	TDV	Both	TDV Both	Both	N/A

^a Duct Sealing requires sealing all ductwork to 10% of nominal airflow (as proposed in 2022 Title 24).

^b Air Sealing requires sealing all accessible cracks, holes, and gaps in the building envelope at walls, floors, and ceilings.

4.2 Envelope and Duct Packages

Cost effectiveness of the various envelope and duct packages are summarized in Table 12 based on both the On-Bill and 2019 TDV metrics. Cost effectiveness tends to be better in older vintage homes 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 except Climate Zones 3 and 5 in pre-1978 homes, and 1 and 3 through 8 in 1978 to 1991 vintage homes. 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 3 and 5 in pre-1978 homes, and 3 and 5 through 7 in 1978 to 1991 vintage homes. In newer vintage homes (1992-2010) this package is cost-effective On-Bill in Climate Zones 11, 13, 15, and in SDG&E territory in Climate Zones 10 and 14. The newer vintage is cost-effective based on TDV in Climate Zones 9 through 15.
- 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 additional measures on their own. All three of these measures are cost-effective for the following vintages and climates:
 - Pre-1978: Climate Zones 1, 2, 4, and 7 through 16 (On-Bill), and 6 (TDV only).
 - 1978-1991: Climate Zones 1, 8 through 16 (On-Bill), and 2 and 4 (TDV only).
 - 1992-2010: Climate Zones 13 and 15 (On-Bill), and 11, and 13 through 15 (TDV only).
- 4. R-49 Attic Insulation, Air Sealing, and New Ducts:** Results for this package are not presented in Table 12 but cost effectiveness is similar to Package 3.
- 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 homes without wall insulation. It is cost-effective in the following climates:
 - On-Bill: Climate Zones 10 through 16, except SMUD.
 - TDV: Climate Zones 2, 4, and 9 through 16.

4.3 Water Heating and Lighting Measures/Packages

Cost effectiveness of water heating and lighting measures are also summarized in Table 12. Cost effectiveness was evaluated based on customer On-Bill basis only. TDV cost effectiveness was not evaluated because the evaluation periods for these measures was less than the 30-year evaluation period used for TDV in some cases.

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.

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 report cost effectiveness for replacement of CFLs with LED lamps. Replacement of incandescent with LED lamps results in better cost effectiveness. Savings for exterior photocell controls assume LED luminaires. Exterior photocell controls are cost-effective in all cases except in Climate Zone 4 with CPAU rates and Climate Zone 12 with SMUD rates.

Table 12: Summary of Single Family 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	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	N/A	N/A	N/A	N/A	N/A	TDV	Both	Both	Both TDV	Both	Both	Both	On-Bill
	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	N/A	Both	N/A	Both	Both	Both	Both	Both	Both	Both	Both	Both	Both	Both
	1978-1991	Both	Both	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	TDV	TDV Both	Both	TDV	Both	Both	Both	N/A
R-49, Air Sealing & Duct Sealing Package	Pre-1978	Both	Both	N/A	Both	N/A	Both	On-Bill	Both	Both	Both	Both	Both	Both	Both	Both	Both
	1978-1991	On-Bill	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
Advanced Envelope Package	Pre-1978	N/A	TDV	N/A	TDV	N/A	N/A	N/A	N/A	TDV	Both	Both	Both TDV	Both	Both	Both	Both

Existing Building Efficiency Upgrade Cost-Effectiveness Study

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
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	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
Exterior Photosensor	All Vintages	On-Bill	On-Bill	On-Bill	On-Bill N/A	On-Bill	On-Bill	On-Bill	On-Bill	On-Bill	On-Bill	On-Bill	On-Bill	On-Bill	On-Bill	On-Bill	On-Bill

^a Duct Sealing requires sealing all ductwork to 10% of nominal airflow (as proposed in 2022 Title 24).

^b Air Sealing requires sealing all accessible cracks, holes, and gaps in the building envelope at walls, floors, and ceilings.

^c Water heating package includes water heater blanket, hot water pipe insulation, and low-flow fixtures.

^d Lighting package includes replacement of screw-in CFL and incandescent lamps with LED luminaires and installation of photocell control on exterior lighting luminaires.

4.4 PV and Batteries

On-Bill and 2019 TDV cost effectiveness for PV and PV with batteries are summarized in Table 13. Cost effectiveness for PV is not sensitive to building vintage but when paired with batteries results differ by vintage and the package is not as cost-effective with newer vintage homes.

PV: For this analysis, a PV system sized to offset the electricity use per the 2019 new construction standards by climate zone was assumed. 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 marginal 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.

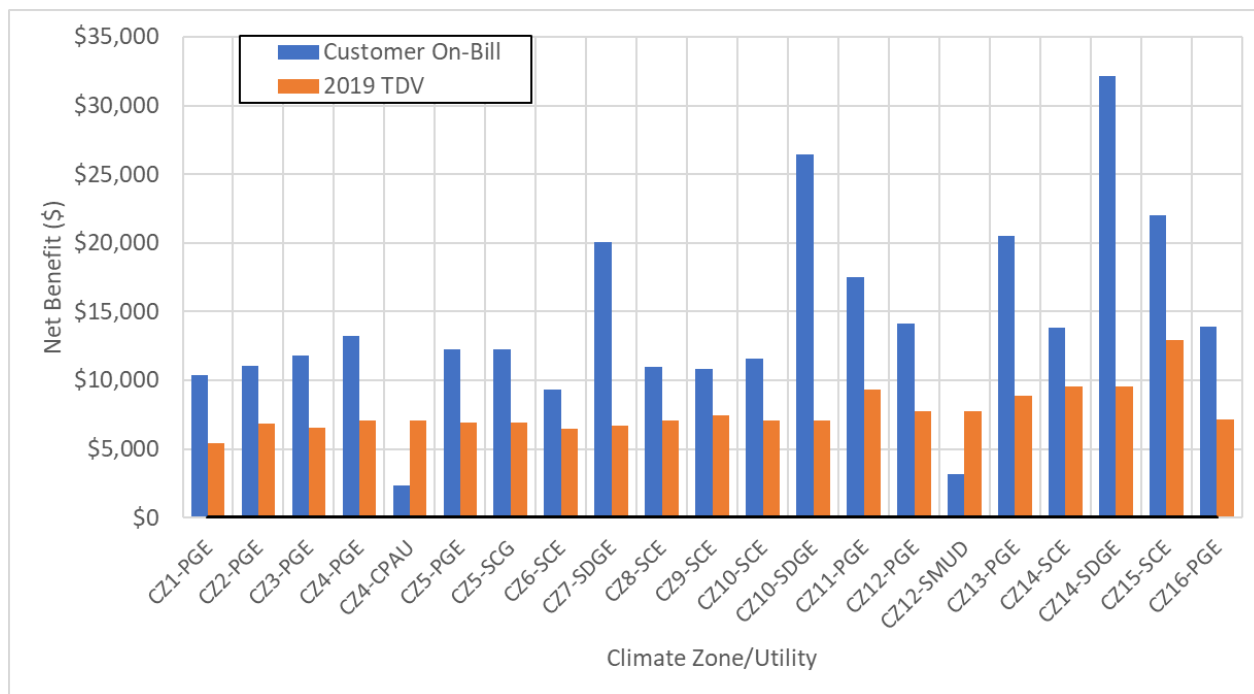


Figure 1: Net Benefit–Rooftop PV system sized to new construction standards (2-4 kW): 1992-2010.

PV and Batteries: Pairing a ten kWh battery storage system with a PV system sized to the 2019 new construction sizing criteria is cost-effective for the following vintages and climates:

- Pre-1978: Climate Zones 3 through 16 based on TDV; On-Bill everywhere except Climate Zones 4 under CPAU and 12 under SMUD municipal utility rates.
- 1978-1991: Climate Zones 3 through 16 based on TDV; On-Bill everywhere except Climate Zones 1; 4 under CPAU and 12 under SMUD municipal utility rates.
- 1992-2010: Climate Zones 3 through 16 based on TDV; On-Bill everywhere except Climate Zones 1, 2, 6; 4 under CPAU and 12 under SMUD municipal utility rates..

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.

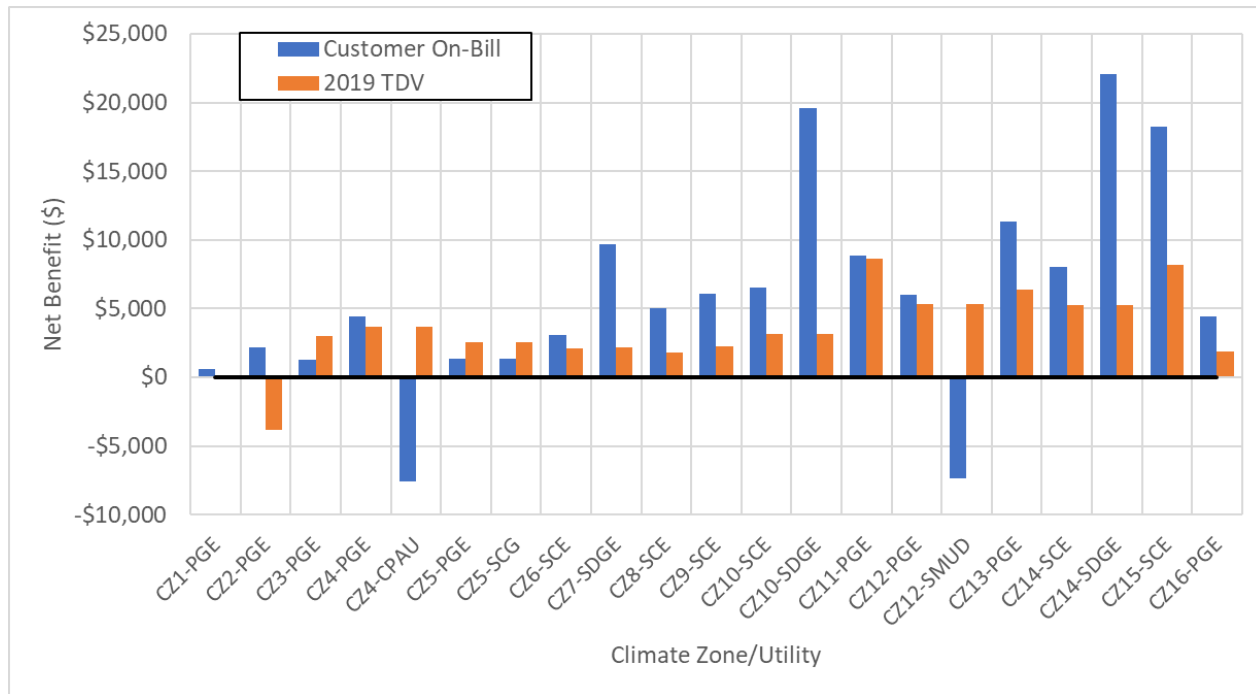


Figure 2: Net benefit - rooftop PV + 10 kWh battery, TOU control: pre-1978.

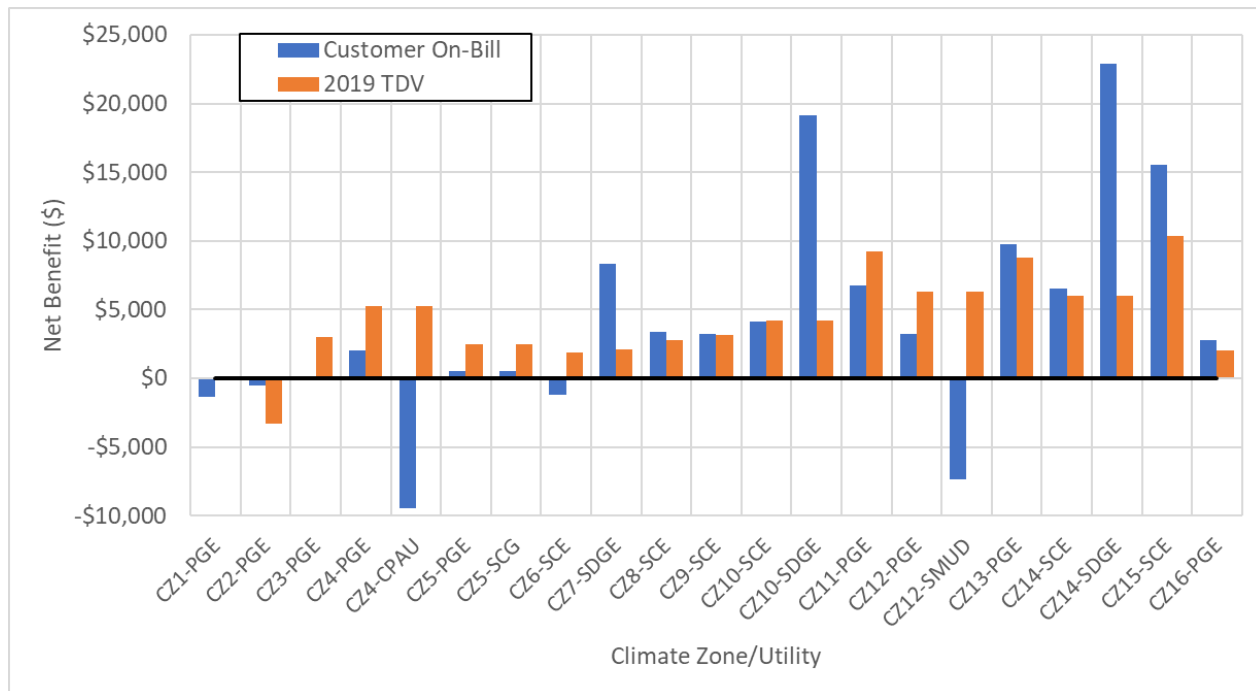


Figure 3: Net benefit - rooftop PV + 10 kWh battery, TOU control: 1992-2010.

Table 13: Summary of Single Family 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	Pre-1978	On-Bill	On-Bill	Both	Both TDV	Both	Both	Both	Both	Both	Both	Both	Both TDV	Both	Both	Both	Both
	1978-1991	N/A	On-Bill	Both	Both TDV	Both	Both	Both	Both	Both	Both	Both	Both TDV	Both	Both	Both	Both
	1992-2010	N/A	N/A	Both	Both TDV	Both	TDV	Both	Both	Both	Both	Both	Both TDV	Both	Both	Both	Both

4.5 Equipment Fuel Substitution Measures

On-Bill and TDV (both 2019 and 2022) cost effectiveness for electric fuel substitution measures are summarized in Table 14 and Table 15. 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 homes tend to be more cost-effective than in older vintage homes.

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 SMUDS's favorable electricity utility rates relative to natural gas rates. In all other climates, shifting from natural gas to electricity for space heating with a minimum efficiency heat pump 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 where it is cost-effective in the newer vintage homes in Climate Zones 2 through 4 and 11 through 13, and cost-effective in older vintage homes in Climate Zones 1 through 4, 9, and 11 through 13. Figure 4 compares lifecycle net benefit of the heat pump installation based on customer On-Bill, 2019 TDV, and 2022 TDV for newer vintage homes.

Cost effectiveness for the no AC scenario 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.

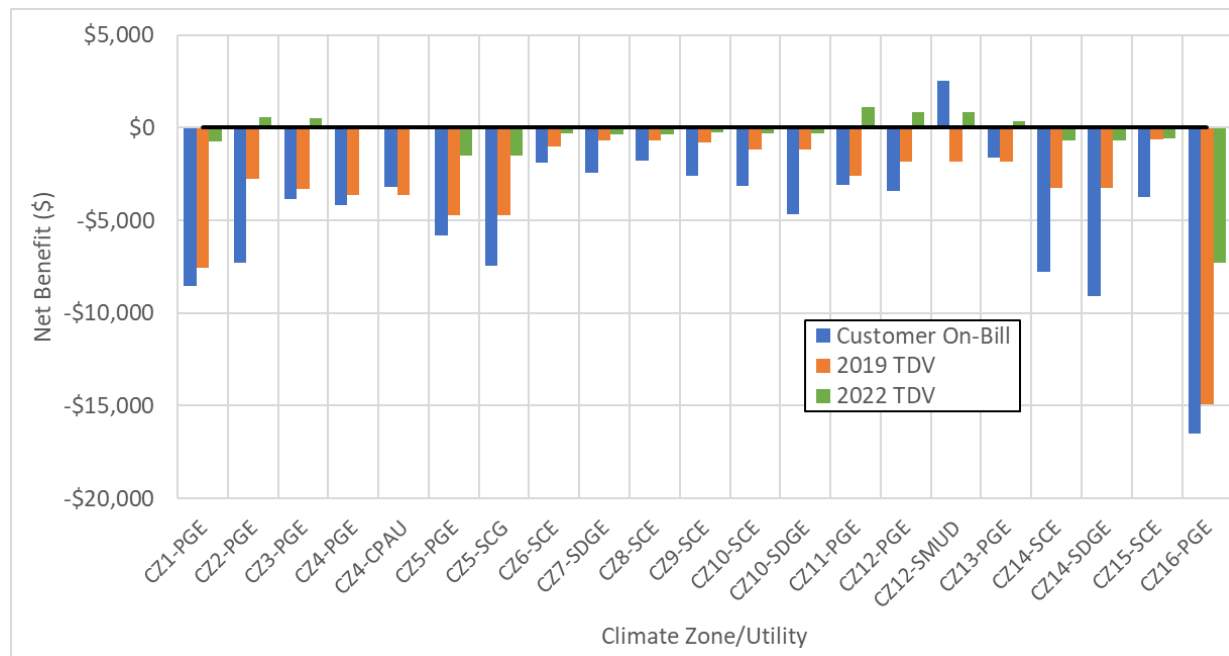


Figure 4: Net benefit – minimum efficiency heat pump at HVAC replacement: 1992-2010.

High-Efficiency Heat Pump at HVAC Replacement: Cost-effectiveness of replacing a ducted furnace and air conditioner with a high-efficiency, 21 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. In 1992-2010 vintage homes it is cost-effective On-Bill in Climate Zones 13, and 15, and in 12 with SMUD rates.

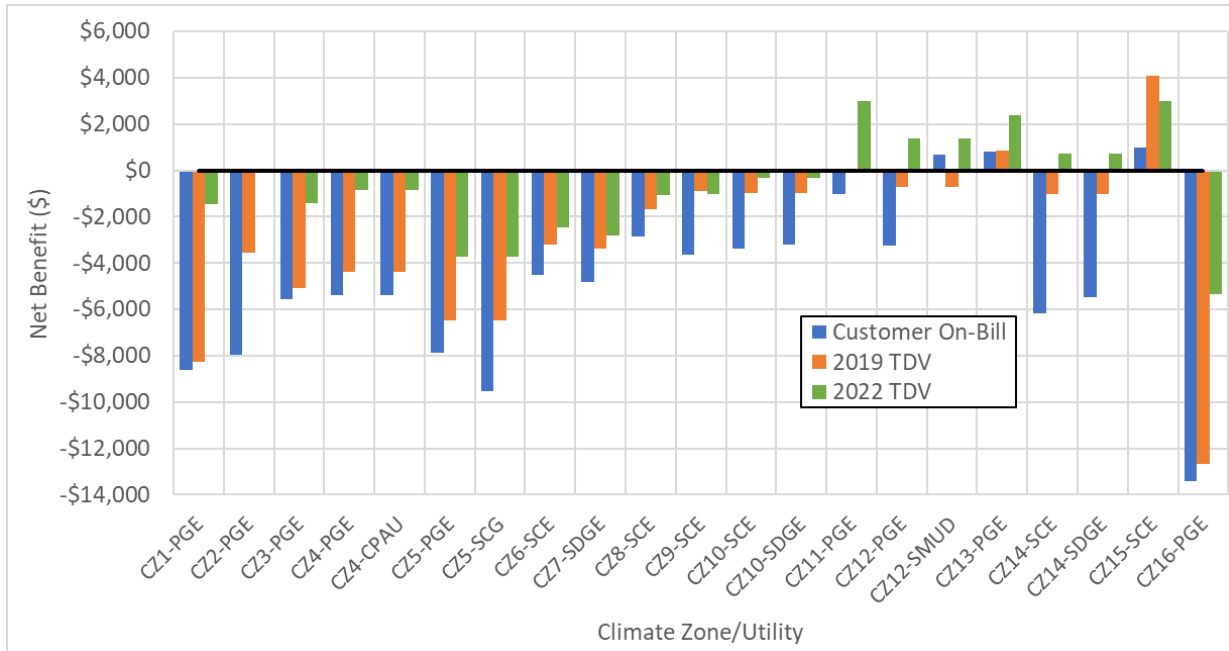


Figure 5: Net benefit – high-efficiency heat pump at HVAC replacement: 1992-2010.

HVAC Heat Pump + PV: Combining heat pump installation with a new PV system when replacing a natural gas furnace/AC increases first costs but improves cost effectiveness (see Figure 6 and Table 15). PV offsets additional electricity used by the heat pump, resulting in net energy cost savings and On-Bill cost effectiveness in all cases except homes in Climate Zone 1 (older vintage homes only), 16 and 4 in CPAU territory. 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).

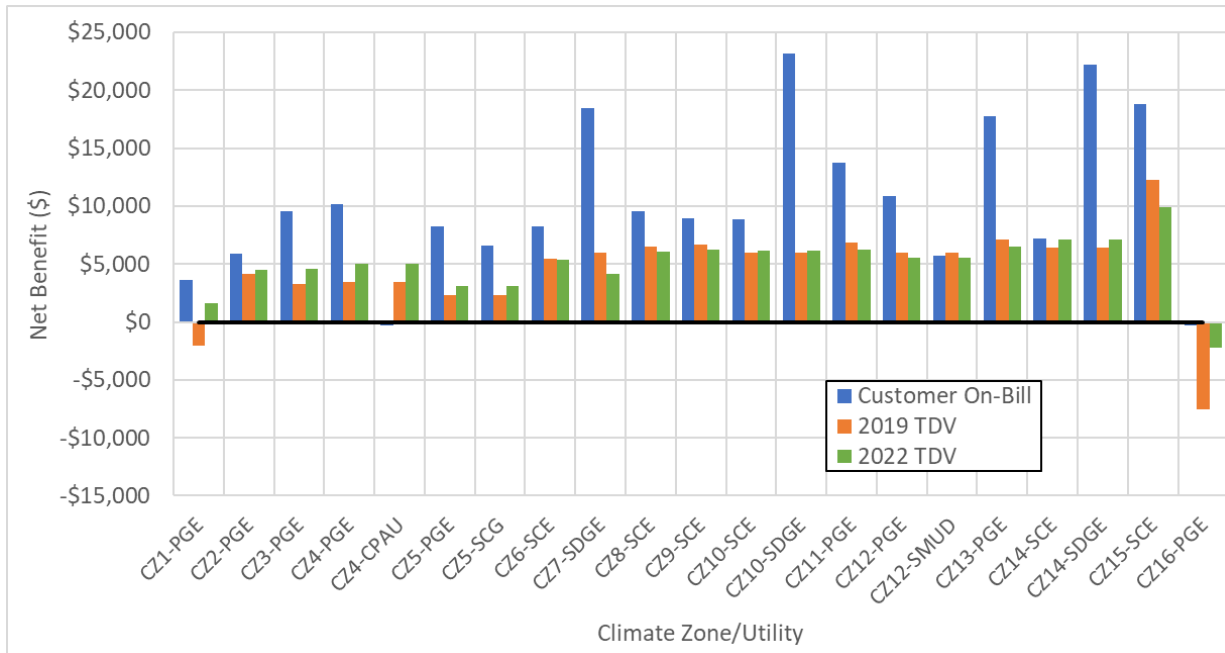


Figure 6: Net benefit – min efficiency heat pump at HVAC replacement + PV: 1992-2010.

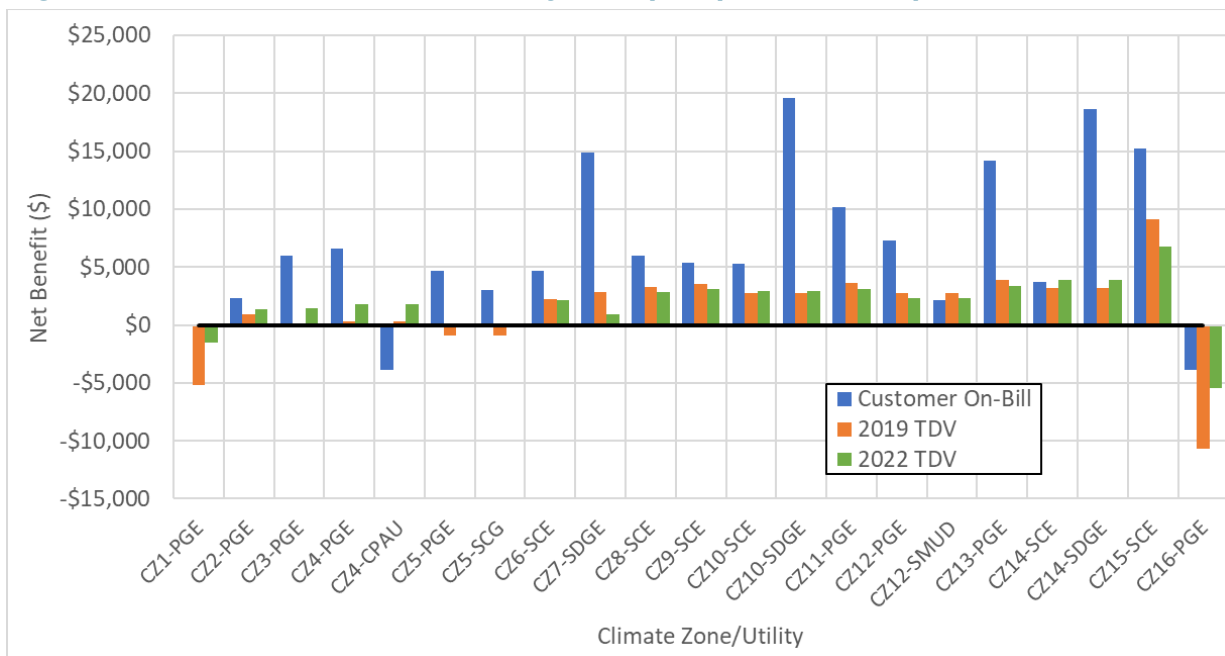


Figure 7: Net benefit – min efficiency heat pump at HVAC replacement + PV + panel upgrade: 1992-2010.

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.

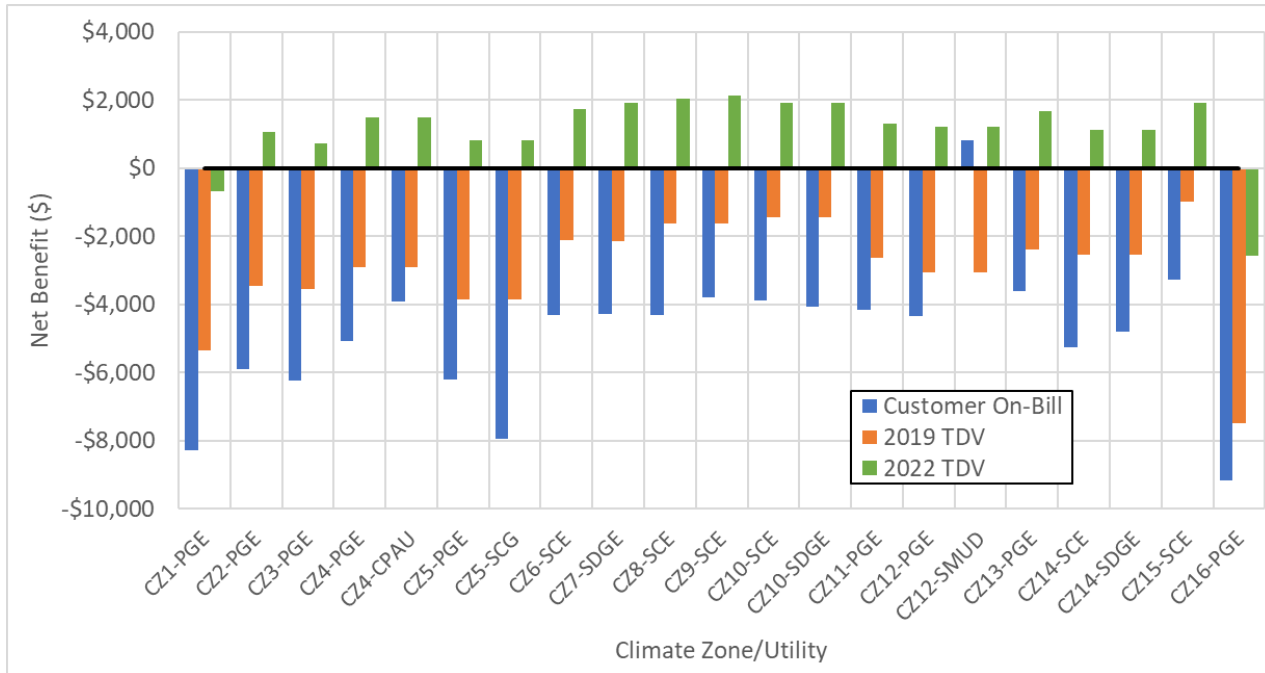


Figure 8: Net benefit – minimum efficiency HPWH at DHW replacement: 1992-2010.

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 many climate zones, but due to higher incremental costs it is still 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.

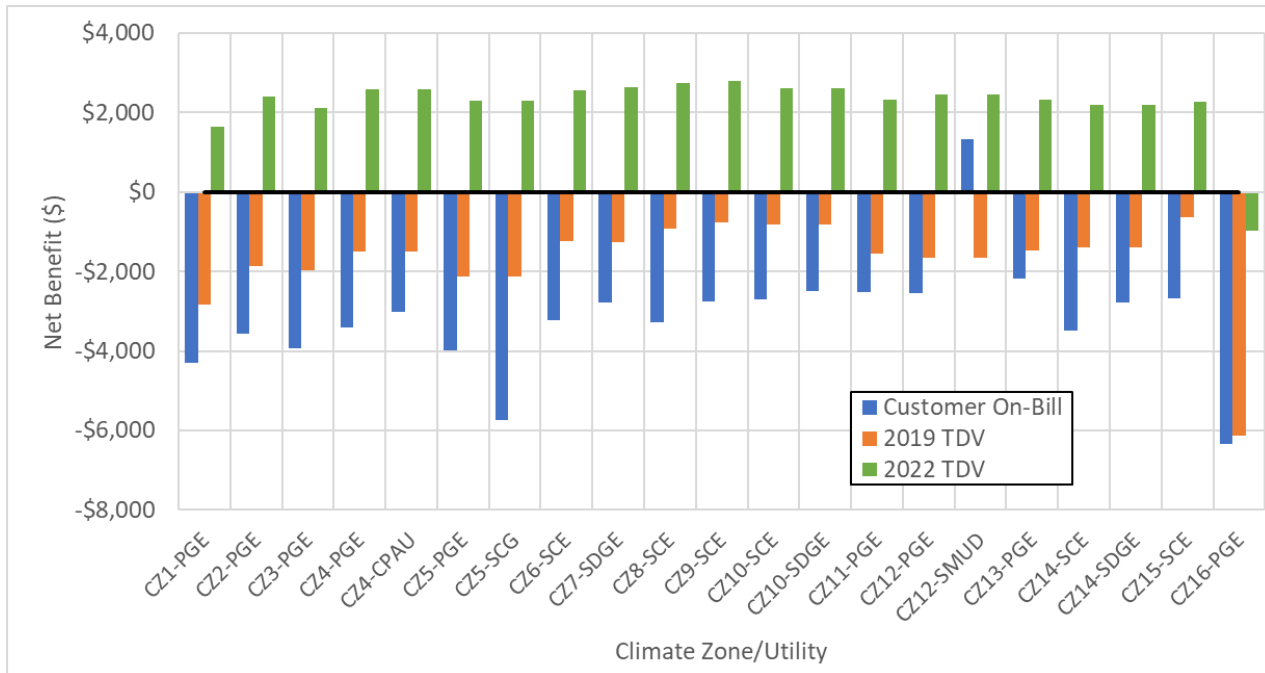


Figure 9: Net benefit – high-efficiency HPWH at DHW replacement: 1992-2010.

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 15). PV offsets additional electricity used by the HPWH, resulting in net energy cost savings and positive customer On-Bill cost effectiveness in all cases except Climate Zone 4 with CPAU rates. 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).

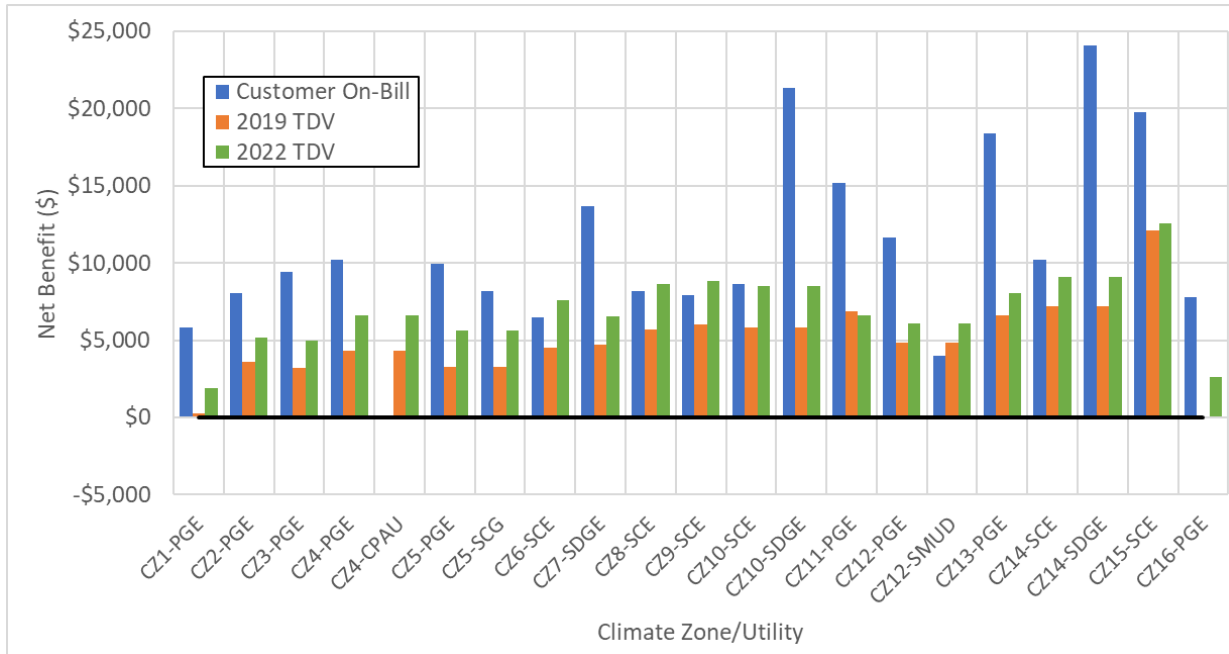


Figure 10: Net benefit – min efficiency HPWH at DHW replacement + PV: 1992-2010.

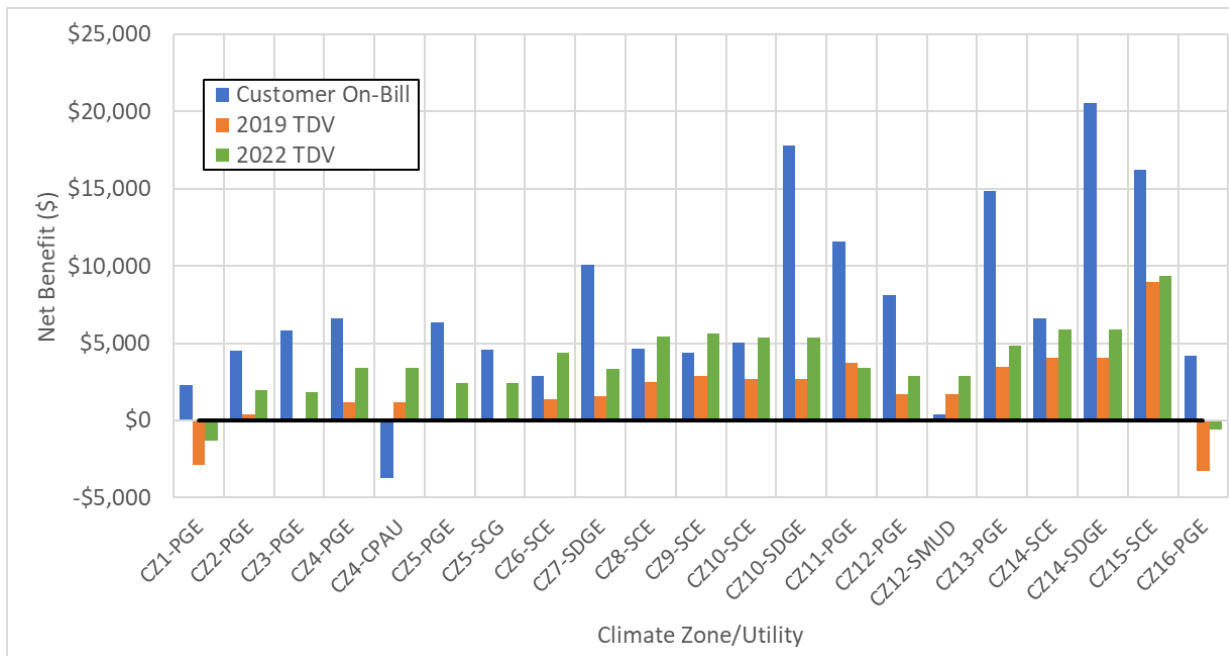


Figure 11: Net benefit – min efficiency HPWH at DHW replacement + PV + Panel Upgrade: 1992-2010.

Table 14: Summary of Single Family 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	N/A	N/A
2022 TDV	Pre-1978	TDV	TDV	TDV	TDV	N/A	N/A	N/A	N/A	TDV	N/A	TDV	TDV Both	TDV	N/A	N/A	N/A
	1978-1991	TDV	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
	1992-2010	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
		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 15: Summary of Single Family 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	N/A	Both	Both	Both TDV	Both	Both	Both	Both	Both	Both	Both	Both	Both	Both	Both	N/A
	1978-1991	N/A	Both	Both	Both TDV	Both	Both	Both	Both	Both	Both	Both	Both	Both	Both	Both	N/A
	1992-2010	On-Bill	Both	Both	Both TDV	Both	Both	Both	Both	Both	Both	Both	Both	Both	Both	Both	N/A
2022 TDV	Pre-1978	TDV	Both	Both	Both TDV	Both	Both	Both	Both	Both	Both	Both	Both	Both	Both	Both	N/A
	1978-1991	TDV	Both	Both	Both TDV	Both	Both	Both	Both	Both	Both	Both	Both	Both	Both	Both	N/A
	1992-2010	Both	Both	Both	Both TDV	Both	Both	Both	Both	Both	Both	Both	Both	Both	Both	Both	N/A
		HPWH + PV at DHW Replacement															
2019 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	On-Bill
	1992-2010	Both	Both	Both	Both TDV	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 TDV	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 rewiring and service panel upgrades and reduce fuel substitution costs when appliances are replaced at end of useful life (see Figure 12 and Table 16). 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.

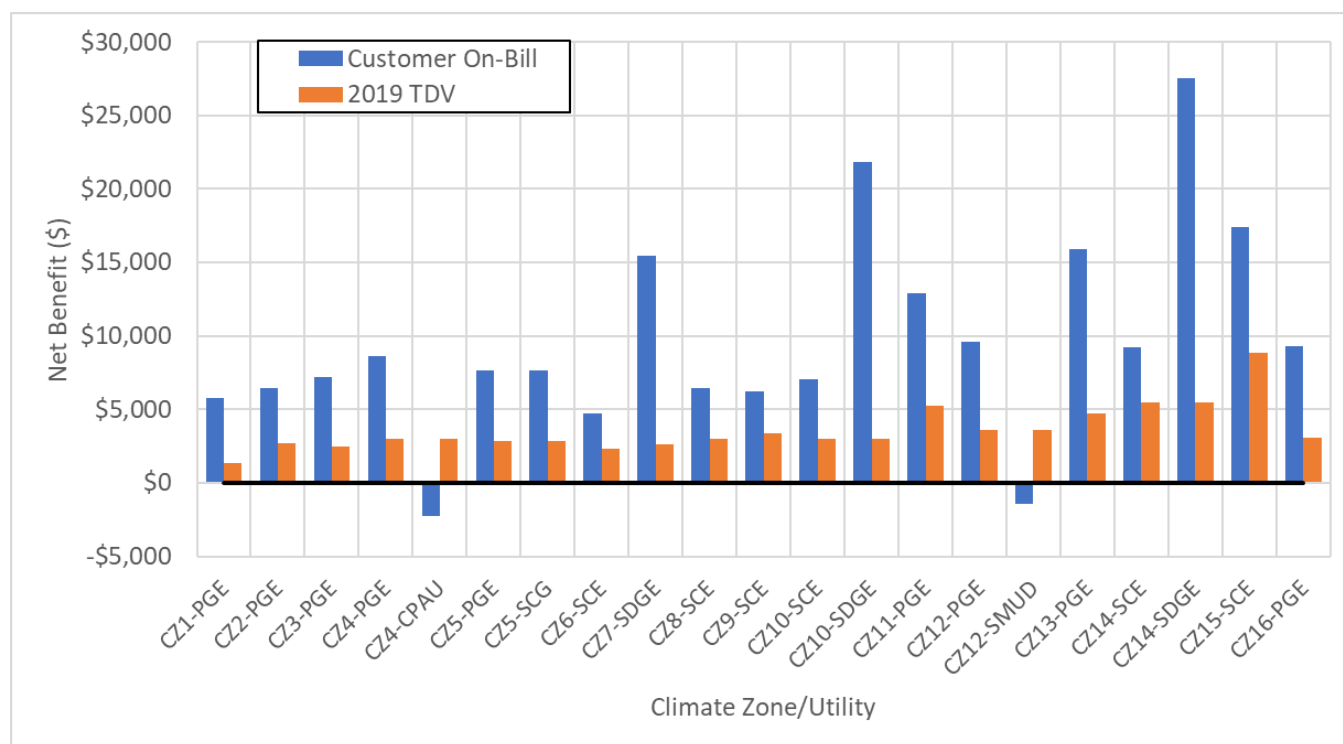


Figure 12: Net benefit – PV and Electric Readiness: 1992-2010.

Table 16: Summary of Single Family 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

5 Energy Performance Equivalency

For jurisdictions looking to provide flexibility in their reach codes for existing buildings, an approach to energy performance equivalency for retrofit measures and packages was completed. The metric for evaluating equivalency is based on the 2022 Title 24 source energy metric (EDR1). A summary of the results and how this can be applied is described below. Appendix E – Details on Energy Performance Equivalency provides additional background and the point score for all retrofit measures and packages by climate zone.

The results of this analysis presented in Section 4 demonstrate different sets of cost-effective measures based on home vintage. The energy performance equivalency defines value for the building characteristics that are applied in each of the three vintage prototypes and evaluated as upgrades. The values are relative to a typical worst-case scenario (i.e., uninsulated or minimally insulated assemblies, very leaky ducts, old mechanical equipment).

Table 17 presents the energy performance equivalency for the three vintage homes. The pre-1978 vintage generally represents the worst-case scenario and therefore has zero points. These values reflect the assumptions presented in Table 2.

Table 17: Energy Performance Equivalency for Each Vintage by Climate Zone

Climate Zone	Pre-1978	1978-1991	1992-2010
1	0	8.8	25.5
2	0	5.3	9.3
3	0	4.1	6.1
4	0	3.7	6.9
5	0	3.9	5.5
6	0	2.1	3.4
7	0	1.6	2.7
8	0	1.8	3.8
9	0	2.3	4.8
10	0	3.0	6.2
11	0	6.0	13.1
12	0	5.1	10.5
13	0	4.3	10.3
14	0	5.8	11.3
15	0	2.3	8.3
16	0	9.9	29.9

If a jurisdiction adopts an ordinance with different sets of requirements based on home vintage, an applicant could either conform with the requirements based on their home's year of construction or value existing upgrades to the home according to a points menu. A sample points menu for Climate Zone 12 is presented in Table 18. Measures are valued differently according to each of the three prototype vintages evaluated.

As an example, consider a home built in the 1950s in Climate Zone 12 that recently replaced their HVAC system with an 80 AFUE furnace (0.4 points) and 14 SEER air conditioner (1.4 points) and testing confirmed duct leakage of no more than 15 percent (2.1 points). In addition, the home has replaced windows with a U-factor less than or

equal to 0.32 (2.5 points). This combination results in a total of 6.4 points which is greater than the 1978-1991 vintage points of 5.1 but less than the 10.5 points for the 1992-2010 vintage. In this instance the project could be subject to the ordinance retrofit requirements for a 1978-1991 vintage home instead of a pre-1978 vintage home. The existing home characteristics should be verified by a HERS Rater, the building department, or another third party.

Table 18: Energy Performance Equivalency by Measure for Climate Zone 12

Component	Pre-1978	1978-1991	1992-2010
<u>Walls</u>			
R-11 (≤ 0.110 U-factor)	2.9	0.4	n/a
R-19 (≤ 0.074 U-factor)	4.2	1.7	1.1
<u>Attic Ceiling Insulation</u>			
R-19	1.4	n/a	n/a
R-30	2.3	0.9	n/a
R-38	2.6	1.2	0.3
$\geq$ R-49	2.9	1.5	0.6
<u>Roof</u>			
Cool roof (aged solar reflectance ≥ 0.25)	0.1	0.1	0.0
<u>Floors</u>			
$\geq$ R-19 raised floor	3.5	1.3	n/a
<u>Windows</u>			
Double non-metal	1.8	1.4	n/a
U-factor ≤ 0.32	2.5	2.1	1.3
<u>Infiltration</u>			
≤ 10 ACH50	0.8	n/a	n/a
≤ 7 ACH50	1.3	0.5	n/a
≤ 5 ACH50	1.7	0.9	0.3
<u>Duct Leakage</u>			
$\leq 15\%$ leakage	2.1	1.1	n/a
$\leq 10\%$ leakage	2.7	1.6	n/a
New ducts ^a	4.5	3.3	1.1
<u>Heating</u>			
80% AFUE	0.4	0.3	0.3
90% AFUE	2.3	1.7	1.3
Heat Pump: 8.2 HSPF	7.8	5.8	4.9
Heat Pump: 9 HSPF	8.4	6.3	5.5
<u>Cooling</u>			

Component	Pre-1978	1978-1991	1992-2010
13 SEER	0.9	0.8	n/a
14 SEER	1.4	1.2	0.2
16+ SEER	1.7	1.4	0.4
<u>Water Heater</u>			
Gas tankless	3.0	3.0	3.0
Condensing gas water heater	3.8	3.8	3.8
2.0 UEF HPWH	7.1	7.2	7.2
NEEA Tier 3 HPWH	7.6	7.7	7.7
<u>PV+Battery</u>			
Solar PV	1.2	1.2	1.2
10 kWh Battery	3.2	3.3	3.4

^a ≥R-6+ and ≤5% leakage, ducts in conditioned space, or ductless distribution.

The energy performance equivalency approach also provides additional flexibility in allowing applicants the ability to choose upgrades from the points menu that result in equivalent performance to the applicable reach code requirement. Table 19 and Table 20 demonstrate how this could be implemented. As an example, consider a jurisdiction with an ordinance that requires attic insulation, air sealing, and duct sealing package. While not cost-effective in all climate zones and vintages, where cost-effective and if this package was part of an ordinance, there are other measures that provide equal or greater energy performance that could be used as equivalent to the required ordinance. For a pre-1978 home (Table 19), the value for this package is 6.2 in Climate Zone 12. Based on the menu of options (Table 18) there are several alternative individual or packages of measures that provide equal or greater energy performance. For the 1992-2010 home (Table 20) almost all the mechanical packages provide equivalent or greater performance than the package. This is because the impact of those insulation and air sealing measures is reduced in a newer home with a better building envelope. Measures like water heating upgrades have a similar impact across vintages because the loads are primarily occupant driven.

Table 19: Performance Equivalency Options – Pre-1978 Home

Climate Zone	R-49, Air & Duct Sealing Package	80 AFUE/14 SEER	90 AFUE/16 SEER/New Ducts	8.2 HSPF/14 SEER	Condensing Water Heater	NEEA Tier 3 HPWH	NEEA Tier 3 HPWH & PV/Battery	R-13 Wall Insulation & R-49 Attic Insulation
1	9.7	No	No	Yes	No	No	Yes	No
2	5.8	No	No	Yes	No	Yes	Yes	No
3	4.2	No	No	Yes	No	Yes	Yes	Yes
4	4.2	No	No	Yes	No	Yes	Yes	No
5	3.9	No	No	Yes	Yes	Yes	Yes	Yes
6	2.2	No	No	No	Yes	Yes	Yes	Yes
7	1.8	No	No	No	Yes	Yes	Yes	Yes
8	2.1	No	Yes	Yes	Yes	Yes	Yes	Yes
9	2.8	No	Yes	Yes	Yes	Yes	Yes	No
10	3.4	No	Yes	Yes	Yes	Yes	Yes	No
11	7.1	No	Yes	Yes	No	Yes	Yes	No
12	6.2	No	Yes	Yes	No	Yes	Yes	No
13	5.5	No	Yes	Yes	No	Yes	Yes	No
14	6.7	No	Yes	Yes	No	Yes	Yes	No
15	3.5	Yes	Yes	Yes	No	Yes	Yes	No
16	12.8	No	No	Yes	No	No	No	No

Table 20: Performance Equivalency Options – 1992-2010 Home

Climate Zone	R-49, Air & Duct Sealing Package	80 AFUE/14 SEER	90 AFUE/16 SEER/New Ducts	8.2 HSPF/14 SEER	Condensing Water Heater	Minimum Efficiency HPWH	New Construction PV System
1	1.9	No	Yes	Yes	Yes	Yes	No
2	1.2	No	Yes	Yes	Yes	Yes	No
3	0.9	No	Yes	Yes	Yes	Yes	Yes
4	0.9	No	Yes	Yes	Yes	Yes	Yes
5	0.8	No	Yes	Yes	Yes	Yes	Yes
6	0.4	No	Yes	Yes	Yes	Yes	Yes
7	0.3	No	Yes	Yes	Yes	Yes	Yes
8	0.4	No	Yes	Yes	Yes	Yes	Yes
9	0.6	No	Yes	Yes	Yes	Yes	Yes
10	0.7	No	Yes	Yes	Yes	Yes	Yes
11	1.5	No	Yes	Yes	Yes	Yes	No
12	1.3	No	Yes	Yes	Yes	Yes	No
13	1.2	No	Yes	Yes	Yes	Yes	Yes
14	1.4	No	Yes	Yes	Yes	Yes	Yes
15	0.6	Yes	Yes	Yes	Yes	Yes	Yes
16	2.5	No	Yes	Yes	Yes	Yes	No

6 Recommendations and Discussion

This analysis evaluated the feasibility and cost effectiveness of retrofit measures in California existing homes built before 2010. The Statewide Reach Codes 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.

6.1 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 4. Descriptions of each measure or package and the relevant 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. Recessed downlight luminaires in the ceiling shall be covered with insulation to the same depth as the rest of the ceiling. Luminaires not rated for insulation contact must be replaced or fitted with a fire-proof cover that allows for insulation to be installed directly over the cover. This measure applies to homes according to vintage and climate zone as defined in Table 2.

Exception 1: Buildings with at least R-38 existing insulation installed at the ceiling level. Buildings with at least R-30 existing insulation installed at the ceiling level are exempt from the recessed downlight luminaire requirements.

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, recessed can light luminaires, and windows. Weather-strip doors if not already present. Verification shall be conducted following a prescriptive checklist (to be developed) 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 homes according to vintage, building type and climate zone as defined in Table 11.

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 Section 150.2(b)1E, with the exception that the duct sealing requirements be reduced from the current code requirement of 15 percent to ten percent in alignment with the 2022 Title 24 code change proposal. 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. See Appendix C – Standards Sections for additional details on the requirements per Title 24. This measure applies to homes according to vintage, building type and climate zone as defined in Table 11.

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

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 Section 150.0(m)11.

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 Section 150.1(c)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 10-15 for the pre-1992 vintage homes and as part of the Advanced Envelope Package in pre-1978 vintage homes. 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 homes 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.

Cool Roof: When replacing a roof, install a roofing product rated by the Cool Roof Rating Council to have an aged solar reflectance equal to or greater than 0.25, and a thermal emittance equal to or greater than 0.75, regardless of the compliance approach (prescriptive or performance). This measure only applies to steep slope roofs (ratio of rise to run greater than 2:12) and to buildings that are installing a new roof as part of the scope of the remodel and where more than 50 percent of the roof is being replaced. This applies only to certain homes according to vintage, building type, and climate zone as defined in Table 11. 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.

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

Exception 2: All exceptions as stated in the 2019 Title 24 Section 150.2(b)1ii for steep slope roofs and 150.2(b)1iii for low slope roofs are allowed.

Envelope and Duct Packages: 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. When the building shell is being improved, 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 where cost-effective. Detailed requirements and relevant exceptions are listed above for the individual measures.

Attic Insulation, Air Sealing, and Duct Packages: These requirements can be triggered when an entirely new or complete replacement duct system is installed in a vented attic space in alignment with the 2022 Title 24 code change proposal. 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. Other benefits to addressing air sealing and ceiling insulation when HVAC systems and ductwork are being replaced is the potential ability to downsize equipment by reducing heating and cooling loads.

Advanced Envelope Package: This package only applies to older vintage homes with single-pane windows and no exterior wall insulation where cost-effective as defined in Table 12. 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 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 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 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 Section 150.1(c)14 and a battery system that meets the requirements of 2019 Title 24 Joint Appendix 12. Combining PV with a battery system is cost-effective both On-Bill and TDV as shown in Table 13; 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 Section 150.1(c)14 are allowed.

6.2 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 homes according to climate zone as defined in Table 14, and summarized in Figure 4, Figure 5, and Figure 6. 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 homes according to climate zone as defined in Table 15, and summarized in Figure 8, Figure 9, and Figure 10. 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.

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 except the newest vintage case in Climate Zone 4 and CPAU territory.

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

1. Electric resistance water heater located in a garage or vented closet with adequate space and ventilation,
2. Natural gas or propane water heater located in a garage or vented closet with adequate space and ventilation, and
 - a. 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 located 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 RA4.20 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. Install a dedicated 240 V, 50 A or greater electrical circuit that terminates within three feet of the existing furnace or designated future location of an electric replacement heater with no obstructions into a listed cabinet, box, enclosure, or receptacle labelled "For Future Heat Pump Space Heater".

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. Install a dedicated 240 V, 30 A or greater electrical circuit that terminates within three feet of the existing water heater or designated future location of an electric replacement water heater with no obstructions into a listed cabinet, box, enclosure, or receptacle labelled "For Future Heat Pump Water Heater".

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 HPWH equivalent in size and one-hour capacity rating to the existing water heater or the next nominal size available.

Exception 3: The building already has a HPWH.

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.

6.3 Other Considerations

Measure Tradeoffs for Energy Performance Equivalency: Jurisdictions looking to provide flexibility in their reach codes for existing buildings can use the energy performance equivalency results to allow projects to select alternative measures or packages to meet the energy performance of the ordinance. This approach also allows an applicant to value previous upgrades made to the building in determining which ordinance requirements should apply. If tradeoffs are adopted by a jurisdiction, it can also provide flexibility to applicants to choose upgrades from the points menu that result in equivalent performance to the applicable reach code requirement or allow a jurisdiction to encourage installation of fuel substitution measures, such as space conditioning heat pumps or HPWHs as an equivalent alternative path to the adopted reach code measure or package.

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

Required Measures Included in Title 24 Performance Simulation: If any of the measures above are included in a performance Title 24 compliance report, it's suggested that trade-offs be allowed as long as all minimum code requirements are met. For example, if a project is installing new windows, a new roof, and insulating the attic and is demonstrating Title 24 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. 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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8 Appendices

8.1 Appendix A: Map of California Climate Zones

Climate zone geographical boundaries are depicted in Figure 13. The map in Figure 13 along with a zip-code search directory is available at: https://ww2.energy.ca.gov/maps/renewable/building_climate_zones.html

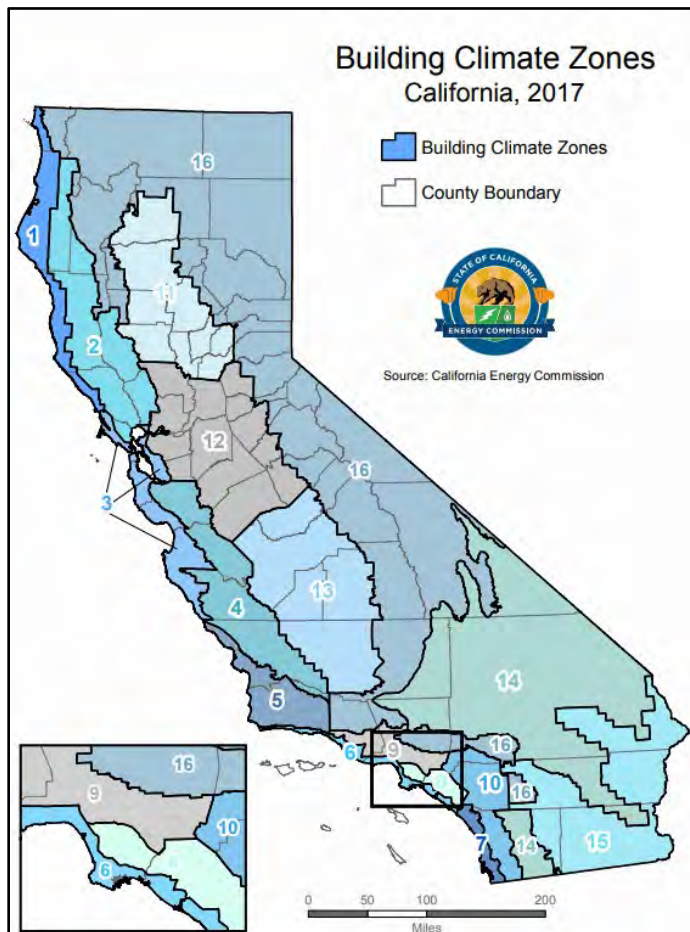


Figure 13: Map of California Climate Zones.

Source: California Energy Commission

8.2 Appendix B: Utility Rate Schedules

PG&E

The following pages provide details on the PG&E electricity and natural gas tariffs applied in this study. Table 21 describes the baseline territories that were assumed for each climate zone.

Table 21: PG&E Baseline Territory by Climate Zone

	<u>Baseline Territory</u>
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 March 2021 according to the rates shown in Table 22.

Table 22: PG&E Monthly Gas Rate (\$/therm)

<u>Month</u>	<u>Procurement Charge</u>	<u>Transportation Charge</u>		<u>Total Charge</u>	
		<u>Baseline</u>	<u>Excess</u>	<u>Baseline</u>	<u>Excess</u>
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	\$2.1035
Apr 2020	\$0.23856	\$1.13126	\$1.64861	\$1.36982	\$1.88717
May 2020	\$0.23187	\$1.13126	\$1.64861	\$1.36313	\$1.88048
June 2020	\$0.24614	\$1.13126	\$1.64861	\$1.3774	\$1.89475
July 2020	\$0.23892	\$1.13126	\$1.64861	\$1.37018	\$1.88753
Aug 2020	\$0.28328	\$1.13126	\$1.64861	\$1.41454	\$1.93189
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



**Pacific Gas and
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Cal. P.U.C. Sheet No. 35436-G
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.

<u>Baseline Territories</u>	BASELINE QUANTITIES (Therms Per Day Per Dwelling Unit)						(T)
	Summer		Winter Off-Peak		Winter On-Peak		
	(April-October)		(Nov, Feb, Mar)		(Dec, Jan)		(T)
	Effective Apr. 1, 2020		Effective Nov. 1, 2019		Effective Dec. 1, 2019		

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.



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Cal. P.U.C. Sheet No. 49113-E
Cal. P.U.C. Sheet No. 48199-E

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

Sheet 2

RATES:
(Cont'd.)

E-TOU-C TOTAL RATES

Total Energy Rates (\$ per kWh)	PEAK		OFF-PEAK	
<i>Summer</i>				
Total Usage	\$0.41813	(I)	\$0.35469	(I)
Baseline Credit (Applied to Baseline Usage Only)	(\$0.07584)	(R)	(\$0.07584)	(R)
<i>Winter</i>				
Total Usage	\$0.32104	(I)	\$0.30372	(I)
Baseline Credit (Applied to Baseline Usage Only)	(\$0.07584)	(R)	(\$0.07584)	(R)
Delivery Minimum Bill Amount (\$ per meter per day)	\$0.32854			
California Climate Credit (per household, per semi-annual payment occurring in the April and October bill cycles)	(\$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)

Advice	6090-E-A	Issued by	Submitted	February 26, 2021
Decision		Robert S. Kenney	Effective	March 1, 2021
		Vice President, Regulatory Affairs	Resolution	



**Pacific Gas and
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U 39

San Francisco, California

Cancelling Revised
Revised

Cal. P.U.C. Sheet No. 46190-E
Cal. P.U.C. Sheet No. 43414-E

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

Sheet 4 (T)

**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	Winter	Summer	Winter
	Tier I	Tier I	Tier I	Tier I
P	14.2	12.0	16.0	27.4
Q	10.3	12.0	8.9	27.4
R	18.8	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	8.2	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)

Advice	5759-E	Issued by	Submitted	February 14, 2020
Decision	D.19-07-004	Robert S. Kenney	Effective	March 1, 2020
		Vice President, Regulatory Affairs	Resolution	

SCE

The following pages provide details on are the SCE electricity tariffs applied in this study. Table 23 describes the baseline territories that were assumed for each climate zone.

Table 23: 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 :

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



Southern California Edison
Rosemead, California (U 338-E)

Revised Cal. PUC Sheet No. 70277-E
Cancelling Revised Cal. PUC Sheet No. 69597-E

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:

Option 4-9 PM / Option 4-9 PM-CPP	Delivery Service Total ¹	Generation ²	
		UG***	DWREC ⁴
Energy Charge - \$/kWh			
Summer Season - On-Peak	0.24845 (I)	0.18143 (R)	0.00000 (I)
Mid-Peak	0.24845 (I)	0.10036 (R)	0.00000 (I)
Off-Peak	0.19495 (I)	0.07403 (R)	0.00000 (I)
Winter Season - Mid-Peak	0.24845 (I)	0.12593 (R)	0.00000 (I)
Off-Peak	0.19495 (I)	0.08893 (R)	0.00000 (I)
Super-Off-Peak	0.18859 (I)	0.06926 (R)	0.00000 (I)
Baseline Credit**** - \$/kWh	(0.07228) (R)	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 ⁶	(29.00) (R)		
California Alternate Rates for			
Energy Discount - %	100.00 ¹		
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		(0.58115) (I)	

¹ Represents 100% of the discount percentage as shown in the applicable Special Condition of this Schedule.

² The Minimum Charge is applicable when the Delivery Service Energy Charge, plus the applicable Basic Charge is less than the Minimum Charge.

³ The ongoing Competition Transition Charge CTC of (\$0.00002) per kWh is recovered in the UG component of Generation.

⁴ 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. (R)

⁵ The Maximum Available Credit is the capped credit amount for CPP Customers dual participating in other demand response programs.

⁶ 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.

⁷ Generation = The Gen rates are applicable only to Bundled Service Customers.

⁸ DWREG = Department of Water Resources (DWR) Energy Credit - For more information on the DWR Energy Credit, see the Billing Calculation Special Condition of this Schedule.

⁹ Applied on an equal basis, per household, semi-annually. See the Special Conditions of this Schedule for more information.

(Continued)

(To be inserted by utility)

Advice 4377-E-A

Decision

2011

Issued by

Carla Peterman

Senior Vice President

(To be inserted by Cal. PUC)

Date Submitted Jan 11, 2021

Effective Feb 1, 2021

Resolution

SoCalGas

Following are the SoCalGas natural gas tariffs applied in this study. Table 24 describes the baseline territories that were assumed for each climate zone.

Table 24: 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 March 2021 according to the rates shown in Table 25. Historical natural gas rate data was only available for SoCalGas' procurement charges.⁵ To estimate total costs by month, the baseline and excess transmission charges were assumed to be relatively consistent and applied for the entire year based on January 2021 costs.

Table 25: 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	\$1.19340	\$1.58364
Apr 2020	\$0.20307	\$0.82358	\$1.21382	\$1.02665	\$1.41689
May 2020	\$0.25654	\$0.82358	\$1.21382	\$1.08012	\$1.47036
June 2020	\$0.2758	\$0.82358	\$1.21382	\$1.09938	\$1.48962
July 2020	\$0.26816	\$0.82358	\$1.21382	\$1.09174	\$1.48198
Aug 2020	\$0.26239	\$0.82358	\$1.21382	\$1.08597	\$1.47621
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

⁵ The SoCalGas procurement and transmission charges were obtained from the following site: <https://www.socalgas.com/for-your-business/energy-market-services/gas-prices>

SOUTHERN CALIFORNIA GAS COMPANY Revised CAL P.U.C. SHEET NO. 57456-G
 LOS ANGELES, CALIFORNIA CANCELING Revised CAL P.U.C. SHEET NO. 57430-G

Schedule No. GR
RESIDENTIAL SERVICE
(Includes GR, GR-C and GT-R Rates)

Sheet 1

APPLICABILITY

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

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

The GT-R rate is applicable to Core Aggregation Transportation (CAT) service to individually metered residential customers, as set forth in Special Condition 11.

The California Alternate Rates for Energy (CARE) discount of 20%, reflected as a separate line item on the bill, is applicable to income-qualified households that meet the requirements for the CARE program as set forth in Schedule No. G-CARE.

TERRITORY

Applicable throughout the service territory.

RATES

	<u>GR</u>	<u>GR-C</u>	<u>GT-R</u>
<u>Customer Charge</u> , 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 ^{1/2} :	33.149¢	33.149¢	33.149¢

SDG&E

Following are the SDG&E electricity and natural gas tariffs applied in this study. Table 26 describes the baseline territories that were assumed for each climate zone.

Table 26: SDG&E Baseline Territory by Climate Zone

	<u>Baseline Territory</u>
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 March 2021 according to the rates shown in Table 27. Historical natural gas rate data from SDG&E was reviewed to identify the procurement and transmission charges⁶ used to calculate the monthly total gas rate.

Table 27: SDG&E Monthly Gas Rate (\$/therm)

<u>Month</u>	<u>Procurement Charge</u>	<u>Transportation Charge</u>		<u>Total Charge</u>	
		<u>Baseline</u>	<u>Excess</u>	<u>Baseline</u>	<u>Excess</u>
Jan 2021	\$0.39803	\$1.44464	\$1.70732	\$1.84267	\$2.10535
Feb 2021	\$0.28035	\$1.36166	\$1.59166	\$1.64201	\$1.87201
Mar 2021	\$0.22130	\$1.36166	\$1.59166	\$1.58296	\$1.81296
Apr 2020	\$0.20327	\$1.35946	\$1.59125	\$1.56273	\$1.79452
May 2020	\$0.25676	\$1.39202	\$1.62888	\$1.64878	\$1.88564
June 2020	\$0.27605	\$1.39202	\$1.62888	\$1.66807	\$1.90493
July 2020	\$0.2684	\$1.39202	\$1.62888	\$1.66042	\$1.89728
Aug 2020	\$0.26263	\$1.39202	\$1.62888	\$1.65465	\$1.89151
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

⁶ The SDG&E procurement and transmission charges were obtained from the following sets of documents:

http://regarchive.sdge.com/tm2/pdf/GAS_GAS-SCHEDS_GM_2020.pdf

http://regarchive.sdge.com/tm2/pdf/GAS_GAS-SCHEDS_GM_2019.pdf

<u>RATES</u>		<u>GR</u>	<u>GR-C</u>	<u>GTC/GTCA^{1/}</u>
Minimum Bill, per day: ^{3/}				
Non-CARE customers:		\$0.13151	\$0.13151	\$0.13151
CARE customers:		\$0.10521	\$0.10521	\$0.10521

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

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



San Diego Gas & Electric Company
San Diego, California

Revised Cal. P.U.C. Sheet No. 33144-E

Canceling Revised Cal. P.U.C. Sheet No. 32930-E

SCHEDULE TOU-DR1

Sheet 2

RESIDENTIAL TIME-OF-USE

RATES

Total Rates:

Description – TOU DR1	UDC Total Rate	DWR-BC Rate	EECC Rate + DWR Credit	Total Rate
Summer:				
On-Peak	0.22374	I 0.00580	0.29042 R	0.51996 R
Off-Peak	0.22374	I 0.00580	0.09305 R	0.32259 R
Super Off-Peak	0.22374	I 0.00580	0.04743 R	0.27697 R
Winter:				
On-Peak	0.25734	R 0.00580	0.07844 R	0.34158 R
Off-Peak	0.25734	R 0.00580	0.06961 R	0.33275 R
Super Off-Peak	0.25734	R 0.00580	0.05981 R	0.32295 R
Summer Baseline Adjustment Credit up to 130% of Baseline	(0.07506)	I		(0.07506) I
Winter Baseline Adjustment Credit up to 130% of Baseline	(0.06833)	I		(0.06833) I
Minimum Bill (\$/day)	0.338			0.338

Note:

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

(Continued)

2C6

Advice Ltr. No. 3514-E

Decision No. D.20-01-021

Issued by
Dan Skopec
Vice President
Regulatory Affairs

Submitted Mar 26, 2020

Effective Apr 1, 2020

Resolution No.

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.

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 .

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 February 2021 according to the rates shown in Table 28. 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 28: CPAU Monthly Gas Rate (\$/therm)

<u>Effective Date</u>	<u>Commodity Rate</u>	<u>Cap and Trade Compliance Charge</u>	<u>Transportation Charge</u>	<u>Carbon Offset Charge</u>	<u>G1 Tier 1 Volumetric Totals</u>	<u>G1 Tier 2 Volumetric Totals</u>
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 2020	\$0.2416	\$0.033	\$0.09891	\$0.040	\$0.89701	\$1.45611
Apr 2020	\$0.2066	\$0.033	\$0.09891	\$0.040	\$0.86201	\$1.42111
May 2020	\$0.2258	\$0.033	\$0.09891	\$0.040	\$0.88121	\$1.44031
June 2020	\$0.2279	\$0.033	\$0.09891	\$0.040	\$0.88331	\$1.44241
July 2020	\$0.2186	\$0.033	\$0.09862	\$0.040	\$0.89402	\$1.67842
Aug 2020	\$0.2257	\$0.033	\$0.09862	\$0.040	\$0.90112	\$1.68552
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:

<u>Per kilowatt-hour (kWh)</u>	<u>Commodity</u>	<u>Distribution</u>	<u>Public Benefits</u>	<u>Total</u>
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
<u>Minimum Bill (\$/day)</u>				0.3283

Escalation Assumptions

The average annual escalation rates in the following table were used in this study and are from E3's 2019 study Residential Building Electrification in California (Energy & Environmental Economics, 2019). These rates are applied to the 2019 rate schedules over a 30-year period beginning in 2020. SDG&E was not covered in the E3 study. The Statewide Reach Code Team reviewed SDG&E's GRC filing and applied the same approach that E3 applied for PG&E and SoCalGas to arrive at average escalation rates between 2020 and 2022.

Table 29: Real Utility Rate Escalation Rate Assumptions

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

8.3 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.

8.4 Appendix D – Measure Cost-Effectiveness Tables

Detailed cost-effectiveness analysis results are summarized by vintage and climate zone in Table 30 through Table 113. 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.

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 30: CZ 1 - Single Family Efficiency Upgrade Cost-Effectiveness Results

Measure	Vintage	Measure Cost (\$)	Electricity Savings (kWh)	Gas Savings (therm)	GHG Savings (lb CO ₂ e)	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	\$3,332	103	57	593	\$149	\$124	1.00	-\$14	0.91	-\$312	1.19	\$620
	1978-1991	\$2,874	78	29	301	\$82	\$68	0.64	-\$1,173	0.57	-\$1,245	0.74	-\$751
	1992-2010	\$1,852	11	13	131	\$30	\$25	0.36	-\$1,330	0.32	-\$1,259	0.44	-\$1,037
Reduced Infiltration	Pre-1978	\$1,474	29	34	345	\$77	\$65	1.17	\$283	0.93	-\$100	1.42	\$614
	1978-1991		17	20	209	\$47	\$39	0.71	-\$481	0.57	-\$636	0.86	-\$209
	1992-2010		11	13	131	\$29	\$24	0.44	-\$920	0.37	-\$927	0.54	-\$676
Duct Sealing	Pre-1978	\$683	77	90	920	\$206	\$173	6.78	\$4,432	6.02	\$3,430	8.29	\$4,977
	1978-1991	\$683	47	55	562	\$126	\$106	4.14	\$2,410	3.68	\$1,832	5.07	\$2,779
	1992-2010	\$423	9	10	105	\$24	\$20	1.25	\$121	1.13	\$55	1.54	\$228
New Ducts	Pre-1978	\$3,986	127	147	1,510	\$339	\$285	1.91	\$4,060	1.71	\$2,812	2.33	\$5,309
	1978-1991		92	107	1,099	\$247	\$207	1.39	\$1,740	1.25	\$1,009	1.70	\$2,789
	1992-2010		28	32	328	\$74	\$62	0.42	-\$2,613	0.38	-\$2,454	0.51	-\$1,947
Cool Roof	Pre-1978	\$778	-14	-18	-186	-\$41	-\$34	0	-\$1,874	0	-\$1,446	0	-\$1,861
	1978-1991		-10	-14	-139	-\$30	-\$25	0	-\$1,611	0	-\$1,273	0	-\$1,584
	1992-2010		-6	-9	-91	-\$20	-\$17	0	-\$1,345	0	-\$1,121	0	-\$1,305
R-13 Wall Insulation	Pre-1978	\$3,360	86	99	1,019	\$228	\$192	1.52	\$1,973	1.29	\$961	1.84	\$2,836
Windows	Pre-1978	\$9,810	68	77	804	\$180	\$151	0.41	-\$6,481	0.38	-\$6,117	0.51	-\$4,804
	1978-1991		60	69	712	\$159	\$134	0.36	-\$7,002	0.33	-\$6,587	0.45	-\$5,389
LED lamp vs CFL	All	\$2.26	1.2	0	n/a	\$0.33	\$0.26	3.47	\$5.56	n/a	n/a	n/a	n/a
Exterior Photosensor	All	\$42.58	12.1	0	n/a	\$2.88	\$2.27	1.60	\$25.62	n/a	n/a	n/a	n/a

Table 31: CZ 1 - Single Family Efficiency Packages Cost-Effectiveness Results

Measure	Vintage	Measure Cost (\$)	Electricity Savings (kWh)	Gas Savings (therm)	GHG Savings (lb CO ₂ e)	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	\$4,806	133	93	954	\$229	\$192	1.07	\$359	0.93	-\$343	1.28	\$1,335
	1978-1991	\$4,348	96	50	514	\$130	\$109	0.67	-\$1,627	0.58	-\$1,821	0.79	-\$929
	1992-2010	\$3,326	22	26	264	\$59	\$50	0.40	-\$2,242	0.34	-\$2,186	0.49	-\$1,702
R49 Attic & Duct Sealing Package	Pre-1978	\$4,015	180	147	1,515	\$356	\$298	1.98	\$4,428	1.75	\$3,006	2.40	\$5,603
	1978-1991	\$3,557	124	83	849	\$205	\$172	1.29	\$1,159	1.15	\$523	1.55	\$1,942
	1992-2010	\$2,275	20	23	233	\$53	\$44	0.52	-\$1,229	0.47	-\$1,215	0.64	-\$829
R49 Attic, Air Sealing & Duct Sealing Package	Pre-1978	\$5,489	206	178	1,831	\$426	\$357	1.74	\$4,553	1.51	\$2,822	2.10	\$6,050
	1978-1991	\$5,031	140	102	1,048	\$250	\$209	1.11	\$627	0.97	-\$145	1.33	\$1,681
	1992-2010	\$3,749	30	35	362	\$81	\$68	0.49	-\$2,161	0.43	-\$2,154	0.60	-\$1,517
R49 Attic, Air Sealing & New Ducts Package	Pre-1978	\$8,792	255	235	2,412	\$557	\$467	1.42	\$4,129	1.25	\$2,204	1.72	\$6,322
	1978-1991	\$8,334	184	153	1,572	\$368	\$308	0.99	-\$119	0.88	-\$1,022	1.19	\$1,604
	1992-2010	\$7,312	48	56	575	\$129	\$108	0.40	-\$4,956	0.36	-\$4,708	0.49	-\$3,758
Advanced Envelope Package	Pre-1978	\$18,659	337	328	3,373	\$772	\$647	0.93	-\$1,530	0.81	-\$3,544	1.13	\$2,380
Water Heating Package	All Vintages	\$208	0	15	n/a	\$28	\$26	1.64	\$150	n/a	n/a	n/a	n/a

Table 32: CZ 1 - Single Family PV & Battery Cost-Effectiveness Results

Measure	Vintage	Measure Cost (\$)	Electricity Savings (kWh)	Gas Savings (therm)	GHG Savings (lb CO ₂ e)	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	\$8,236	3,394	0	208	\$895	\$707	2.33	\$12,094	1.66	\$5,443	1.29	\$2,381
	1978-1991		3,394		208	\$874	\$690	2.27	\$11,577	1.66	\$5,431	1.29	\$2,372
	1992-2010		3,394		208	\$822	\$649	2.14	\$10,366	1.66	\$5,414	1.29	\$2,358
PV + Battery	Pre-1978	\$19,609	3,221	0	787	\$920	\$726	1.03	\$625	1.00	-\$27	0.75	-\$4,965
	1978-1991		3,222		786	\$889	\$702	0.99	-\$109	1.00	-\$59	0.74	-\$5,022
	1992-2010		3,224		767	\$838	\$662	0.94	-\$1,312	0.99	-\$140	0.73	-\$5,232

Table 33: CZ 1 - Single Family Equipment Fuel Substitution Cost-Effectiveness Results

Measure	Vintage	Measure Cost (\$)	Electricity Savings (kWh)	Gas Savings (therm)	GHG Savings (lb CO ₂ e)	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	\$501	-7,493	705	4,052	-\$780	-\$538	0	-\$16,682	0	-\$12,787	3.58	\$1,296
	1978-1991		-6,202	568	3,193	-\$658	-\$457	0	-\$14,266	0	-\$11,444	1.24	\$121
	1992-2010		-3,675	322	1,734	-\$379	-\$266	0	-\$8,530	0	-\$7,550	0	-\$738
High-Effic. Heat Pump at HVAC Replacement	Pre-1978	\$3,749	-6,395	705	4,464	-\$438	-\$268	0	-\$12,105	0	-\$10,343	2.00	\$3,731
	1978-1991		-5,308	568	3,529	-\$380	-\$238	0	-\$11,210	0	-\$10,043	1.40	\$1,499
	1992-2010		-3,190	322	1,917	-\$235	-\$152	0	-\$8,624	0	-\$8,277	0.61	-\$1,474
Heat Pump at HVAC Replacement + PV	Pre-1978	\$8,738	-4,115	705	4,255	\$206	\$240	0.75	-\$2,452	0.18	-\$7,188	1.43	\$3,714
	1978-1991		-2,818	568	3,398	\$304	\$302	0.94	-\$607	0.33	-\$5,875	1.29	\$2,551
	1992-2010		-281	322	1,938	\$519	\$443	1.38	\$3,634	0.87	-\$2,029	1.19	\$1,629
HVAC HP Replacement w/ Panel Upgrade + PV	Pre-1978	\$11,919	-4,115	705	4,255	\$206	\$240	0.54	-\$6,024	0.13	-\$10,369	1.04	\$533
	1978-1991		-2,818	568	3,398	\$304	\$302	0.68	-\$4,179	0.24	-\$9,056	0.95	-\$630
	1992-2010		-281	322	1,938	\$519	\$443	1.00	\$62	0.56	-\$5,210	0.87	-\$1,552
HPWH at Water Heater Replacement	Pre-1978	\$2,594	-1,769	175	1,286	-\$229	-\$161	0	-\$7,728	0	-\$5,359	0.69	-\$802
	1978-1991		-1,776	176	1,301	-\$233	-\$164	0	-\$7,813	0	-\$5,356	0.72	-\$736
	1992-2010		-1,776	177	1,311	-\$251	-\$180	0	-\$8,285	0	-\$5,342	0.74	-\$681
NEEA Tier 3 HPWH at Replacement	Pre-1978	\$2,775	-1,221	172	1,417	-\$54	-\$23	0	-\$3,788	0	-\$2,830	1.55	\$1,537
	1978-1991		-1,228	174	1,436	-\$56	-\$25	0	-\$3,835	0	-\$2,864	1.57	\$1,586
	1992-2010		-1,231	175	1,449	-\$75	-\$40	0	-\$4,301	0	-\$2,827	1.59	\$1,647
HPWH at Water Heater Replacement + PV	Pre-1978	\$10,830	1,625	175	1,495	\$767	\$625	1.56	\$6,751	1.03	\$277	1.16	\$1,778
	1978-1991		1,618	176	1,509	\$758	\$618	1.55	\$6,546	1.03	\$271	1.17	\$1,838
	1992-2010		1,618	177	1,519	\$730	\$595	1.49	\$5,855	1.03	\$274	1.17	\$1,881
HPWH Replacement w/ Panel Upgrade + PV	Pre-1978	\$14,011	1,625	175	1,495	\$767	\$625	1.20	\$3,179	0.79	-\$2,904	0.90	-\$1,403
	1978-1991		1,618	176	1,509	\$758	\$618	1.19	\$2,974	0.79	-\$2,910	0.90	-\$1,343
	1992-2010		1,618	177	1,519	\$730	\$595	1.15	\$2,283	0.79	-\$2,907	0.91	-\$1,300

Measure	Vintage	Measure Cost (\$)	Electricity Savings (kWh)	Gas Savings (therm)	GHG Savings (lb CO ₂ e)	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
PV + Electric Ready Pre-Wire	Pre-1978	\$12,327	3,394	0	208	\$895	\$707	1.55	\$7,500	1.11	\$1,352	0.86	-\$1,710
	1978-1991		3,394	0	208	\$874	\$690	1.51	\$6,984	1.11	\$1,340	0.86	-\$1,719
	1992-2010		3,394	0	208	\$822	\$649	1.42	\$5,772	1.11	\$1,323	0.86	-\$1,733

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 34: CZ 2 - Single Family Efficiency Upgrade Cost-Effectiveness Results

Measure	Vintage	Measure Cost (\$)	Electricity Savings (kWh)	Gas Savings (therm)	GHG Savings (lb CO ₂ e)	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	\$3,332	505	38	484	\$269	\$217	1.74	\$2,758	1.93	\$3,093	2.12	\$3,743
	1978-1991	\$2,874	254	19	247	\$131	\$105	0.98	-\$69	1.28	\$803	1.39	\$1,122
	1992-2010	\$1,852	34	7	85	\$26	\$22	0.31	-\$1,433	0.61	-\$720	0.58	-\$772
Reduced Infiltration	Pre-1978	\$1,474	21	17	173	\$41	\$35	0.63	-\$616	0.62	-\$555	0.91	-\$135
	1978-1991		12	11	110	\$25	\$21	0.38	-\$1,031	0.41	-\$866	0.66	-\$503
	1992-2010		9	7	73	\$16	\$14	0.25	-\$1,246	0.29	-\$1,053	0.36	-\$938
Duct Sealing	Pre-1978	\$683	184	42	466	\$157	\$129	5.03	\$3,090	6.17	\$3,528	8.63	\$5,213
	1978-1991	\$683	85	24	269	\$80	\$66	2.58	\$1,209	3.59	\$1,768	5.14	\$2,825
	1992-2010	\$423	11	7	74	\$17	\$15	0.92	-\$38	1.19	\$81	1.83	\$352
New Ducts	Pre-1978	\$3,986	345	72	806	\$280	\$230	1.54	\$2,410	1.89	\$3,529	2.71	\$6,801
	1978-1991		205	51	575	\$178	\$147	0.98	-\$78	1.34	\$1,366	2.02	\$4,059
	1992-2010		41	22	232	\$56	\$46	0.31	-\$3,084	0.41	-\$2,356	0.64	-\$1,422
Cool Roof	Pre-1978	\$778	177	-8	-48	\$54	\$42	1.48	\$407	1.76	\$593	2.01	\$786
	1978-1991		101	-6	-37	\$28	\$21	0.76	-\$204	1.37	\$291	1.58	\$452
	1992-2010		23	-5	-41	-\$1	-\$1	0	-\$878	0.54	-\$354	0.46	-\$418
R-13 Wall Insulation	Pre-1978	\$3,360	118	56	589	\$156	\$129	1.03	\$109	1.11	\$359	1.47	\$1,563
Windows	Pre-1978	\$9,810	563	21	347	\$260	\$208	0.57	-\$4,776	0.76	-\$2,309	0.82	-\$1,733
	1978-1991		359	16	270	\$174	\$139	0.38	-\$6,839	0.66	-\$3,369	0.66	-\$3,335
LED lamp vs CFL	All	\$2.26	1.2	0	n/a	\$0.37	\$0.29	3.84	\$6.40	n/a	n/a	n/a	n/a
Exterior Photosensor	All	\$42.58	12.1	0	n/a	\$2.88	\$2.27	1.60	\$25.62	n/a	n/a	n/a	n/a

Table 35: CZ 2 - Single Family Efficiency Packages Cost-Effectiveness Results

Measure	Vintage	Measure Cost (\$)	Electricity Savings (kWh)	Gas Savings (therm)	GHG Savings (lb CO ₂ e)	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	\$4,806	533	56	675	\$315	\$256	1.42	\$2,270	1.56	\$2,702	1.77	\$3,686
	1978-1991	\$4,348	270	31	362	\$157	\$127	0.78	-\$1,062	1.00	\$15	1.11	\$498
	1992-2010	\$3,326	42	14	157	\$42	\$35	0.28	-\$2,687	0.48	-\$1,739	0.48	-\$1,716
R49 Attic & Duct Sealing Package	Pre-1978	\$4,015	626	79	931	\$398	\$323	2.15	\$5,196	2.55	\$6,239	3.07	\$8,291
	1978-1991	\$3,557	316	43	499	\$199	\$162	1.22	\$859	1.65	\$2,301	1.97	\$3,449
	1992-2010	\$2,275	44	14	156	\$43	\$35	0.41	-\$1,497	0.70	-\$685	0.78	-\$501
R49 Attic, Air Sealing & Duct Sealing Package	Pre-1978	\$5,489	647	94	1,092	\$436	\$356	1.73	\$4,501	2.04	\$5,709	2.47	\$8,079
	1978-1991	\$5,031	330	53	603	\$223	\$182	0.96	-\$202	1.28	\$1,409	1.55	\$2,767
	1992-2010	\$3,749	52	21	225	\$58	\$48	0.34	-\$2,776	0.54	-\$1,727	0.61	-\$1,448
R49 Attic, Air Sealing & New Ducts Package	Pre-1978	\$8,792	764	123	1,415	\$536	\$438	1.33	\$3,258	1.62	\$5,439	2.08	\$9,454
	1978-1991	\$8,334	422	78	893	\$308	\$252	0.81	-\$1,796	1.09	\$773	1.44	\$3,675
	1992-2010	\$7,312	78	35	377	\$92	\$76	0.28	-\$5,920	0.42	-\$4,276	0.55	-\$3,294
Advanced Envelope Package	Pre-1978	\$18,659	1,000	178	2,048	\$730	\$596	0.85	-\$3,066	1.12	\$2,264	1.29	\$5,503
Water Heating Package	All Vintages	\$208	0	16	n/a	\$31	\$28	1.82	\$192	n/a	n/a	n/a	n/a

Table 36: CZ 2 - Single Family PV & Battery Cost-Effectiveness Results

Measure	Vintage	Measure Cost (\$)	Electricity Savings (kWh)	Gas Savings (therm)	GHG Savings (lb CO ₂ e)	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	\$7,167	3,442	0	216	\$896	\$707	2.68	\$13,295	1.95	\$6,844	1.55	\$3,946
	1978-1991		3,442		216	\$863	\$681	2.58	\$12,505	1.95	\$6,829	1.55	\$3,932
	1992-2010		3,442		216	\$801	\$632	2.39	\$11,030	1.95	\$6,824	1.55	\$3,923
PV + Battery	Pre-1978	\$18,539	3,252	0	818	\$937	\$739	1.11	\$2,207	0.79	-\$3,814	0.83	-\$3,071
	1978-1991		3,265		827	\$875	\$690	1.04	\$733	0.81	-\$3,607	0.88	-\$2,279
	1992-2010		3,256		836	\$823	\$649	0.97	-\$500	0.82	-\$3,299	0.96	-\$816

Table 37: CZ 2 - Single Family Equipment Fuel Substitution Cost-Effectiveness Results

Measure	Vintage	Measure Cost (\$)	Electricity Savings (kWh)	Gas Savings (therm)	GHG Savings (lb CO ₂ e)	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	\$501	-3,567	322	1,601	-\$443	-\$317	0	-\$10,046	0	-\$3,874	3.90	\$1,454
	1978-1991		-2,772	246	1,188	-\$357	-\$258	0	-\$8,279	0	-\$3,189	2.42	\$711
	1992-2010		-2,400	211	1,035	-\$311	-\$225	0	-\$7,287	0	-\$2,757	2.10	\$550
High-Effic. Heat Pump at HVAC Replacement	Pre-1978	\$3,749	-2,885	322	1,889	-\$227	-\$146	0	-\$8,438	0.34	-\$2,473	1.81	\$3,046
	1978-1991		-2,263	246	1,410	-\$199	-\$133	0	-\$8,034	0.21	-\$2,960	1.32	\$1,193
	1992-2010		-2,009	211	1,206	-\$192	-\$131	0	-\$7,981	0.05	-\$3,571	0.99	-\$54
Heat Pump at HVAC Replacement + PV	Pre-1978	\$7,668	-125	322	1,817	\$497	\$425	1.51	\$4,280	1.40	\$3,036	1.71	\$5,438
	1978-1991		671	246	1,404	\$556	\$463	1.64	\$5,419	1.48	\$3,695	1.61	\$4,675
	1992-2010		1,042	211	1,251	\$581	\$479	1.70	\$5,901	1.54	\$4,136	1.59	\$4,513
HVAC HP Replacement w/ Panel Upgrade + PV	Pre-1978	\$10,849	-125	322	1,817	\$497	\$425	1.06	\$708	0.99	-\$145	1.21	\$2,257
	1978-1991		671	246	1,404	\$556	\$463	1.15	\$1,847	1.05	\$514	1.14	\$1,494
	1992-2010		1,042	211	1,251	\$581	\$479	1.19	\$2,329	1.09	\$955	1.12	\$1,332
HPWH at Water Heater Replacement	Pre-1978	\$2,594	-1,330	164	1,282	-\$132	-\$88	0	-\$5,516	0	-\$3,366	1.42	\$1,087
	1978-1991		-1,345	165	1,288	-\$144	-\$97	0	-\$5,813	0	-\$3,400	1.45	\$1,174
	1992-2010		-1,349	165	1,291	-\$147	-\$101	0	-\$5,911	0	-\$3,452	1.41	\$1,059
NEEA Tier 3 HPWH at Replacement	Pre-1978	\$2,775	-983	163	1,391	-\$23	-\$1	0	-\$3,126	0.34	-\$1,844	1.89	\$2,465
	1978-1991		-1,000	164	1,397	-\$35	-\$11	0	-\$3,430	0.33	-\$1,850	1.89	\$2,473
	1992-2010		-1,010	165	1,400	-\$40	-\$16	0	-\$3,556	0.32	-\$1,876	1.87	\$2,416
HPWH at Water Heater Replacement + PV	Pre-1978	\$9,761	2,112	164	1,498	\$859	\$695	1.93	\$10,021	1.38	\$3,677	1.53	\$5,221
	1978-1991		2,098	165	1,504	\$814	\$659	1.83	\$8,942	1.37	\$3,628	1.54	\$5,295
	1992-2010		2,093	165	1,507	\$778	\$630	1.75	\$8,079	1.37	\$3,573	1.53	\$5,174
HPWH Replacement w/ Panel Upgrade + PV	Pre-1978	\$12,942	2,112	164	1,498	\$859	\$695	1.45	\$6,449	1.04	\$496	1.16	\$2,040
	1978-1991		2,098	165	1,504	\$814	\$659	1.37	\$5,370	1.03	\$447	1.16	\$2,114
	1992-2010		2,093	165	1,507	\$778	\$630	1.31	\$4,507	1.03	\$392	1.15	\$1,993

Measure	Vintage	Measure Cost (\$)	Electricity Savings (kWh)	Gas Savings (therm)	GHG Savings (lb CO ₂ e)	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
PV + Electric Ready Pre-Wire	Pre-1978	\$11,258	3,442	0	216	\$896	\$707	1.70	\$8,701	1.24	\$2,753	0.99	-\$145
	1978-1991		3,442	0	216	\$863	\$681	1.63	\$7,911	1.24	\$2,738	0.99	-\$159
	1992-2010		3,442	0	216	\$801	\$632	1.51	\$6,436	1.24	\$2,733	0.99	-\$168

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 38: CZ 3 - Single Family Efficiency Upgrade Cost-Effectiveness Results

Measure	Vintage	Measure Cost (\$)	Electricity Savings (kWh)	Gas Savings (therm)	GHG Savings (lb CO ₂ e)	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	\$3,332	151	33	359	\$115	\$95	0.76	-\$901	0.65	-\$1,182	1.27	\$902
	1978-1991	\$2,874	90	17	184	\$61	\$50	0.47	-\$1,717	0.42	-\$1,672	0.95	-\$138
	1992-2010	\$1,852	6	6	65	\$14	\$12	0.17	-\$1,725	0.19	-\$1,504	0.22	-\$1,438
Reduced Infiltration	Pre-1978	\$1,474	10	14	143	\$31	\$26	0.47	-\$883	0.47	-\$783	0.63	-\$552
	1978-1991		7	9	90	\$19	\$16	0.29	-\$1,177	0.30	-\$1,030	0.41	-\$869
	1992-2010		4	6	57	\$12	\$10	0.18	-\$1,349	0.20	-\$1,186	0.24	-\$1,114
Duct Sealing	Pre-1978	\$683	40	30	315	\$73	\$61	2.40	\$1,070	2.59	\$1,086	3.68	\$1,832
	1978-1991	\$683	18	17	175	\$39	\$33	1.29	\$220	1.51	\$348	1.97	\$659
	1992-2010	\$423	4	5	48	\$10	\$9	0.56	-\$211	0.69	-\$129	0.72	-\$118
New Ducts	Pre-1978	\$3,986	77	54	567	\$133	\$111	0.75	-\$1,136	0.81	-\$754	1.20	\$781
	1978-1991		43	38	392	\$89	\$74	0.50	-\$2,246	0.58	-\$1,659	0.79	-\$826
	1992-2010		14	16	164	\$35	\$30	0.20	-\$3,585	0.24	-\$3,010	0.26	-\$2,952
Cool Roof	Pre-1978	\$778	25	-8	-69	-\$5	-\$5	0	-\$984	0	-\$1,089	0.25	-\$582
	1978-1991		11	-5	-50	-\$6	-\$5	0	-\$997	0	-\$1,014	0.41	-\$461
	1992-2010		-1	-4	-45	-\$9	-\$7	0	-\$1,068	0	-\$971	0	-\$1,040
R-13 Wall Insulation	Pre-1978	\$3,360	49	44	458	\$102	\$85	0.68	-\$1,221	0.72	-\$955	1.00	\$10
Windows	Pre-1978	\$9,810	100	27	309	\$92	\$76	0.21	-\$8,740	0.20	-\$7,843	0.50	-\$4,916
	1978-1991		57	25	276	\$71	\$59	0.16	-\$9,257	0.17	-\$8,131	0.38	-\$6,071
LED lamp vs CFL	All	\$2.26	1.2	0	n/a	\$0.34	\$0.27	3.55	\$5.76	n/a	n/a	n/a	n/a
Exterior Photosensor	All	\$42.58	12.1	0	n/a	\$2.88	\$2.27	1.60	\$25.62	n/a	n/a	n/a	n/a

Table 39: CZ 3 - Single Family Efficiency Packages Cost-Effectiveness Results

Measure	Vintage	Measure Cost (\$)	Electricity Savings (kWh)	Gas Savings (therm)	GHG Savings (lb CO ₂ e)	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	\$4,806	163	47	511	\$148	\$122	0.68	-\$1,743	0.60	-\$1,902	1.09	\$453
	1978-1991	\$4,348	97	26	276	\$81	\$67	0.41	-\$2,881	0.38	-\$2,691	0.77	-\$987
	1992-2010	\$3,326	11	12	123	\$27	\$22	0.18	-\$3,066	0.19	-\$2,690	0.23	-\$2,549
R49 Attic & Duct Sealing Package	Pre-1978	\$4,015	179	61	651	\$180	\$149	0.99	-\$45	0.96	-\$163	1.60	\$2,405
	1978-1991	\$3,557	104	33	346	\$97	\$80	0.60	-\$1,587	0.61	-\$1,379	1.08	\$299
	1992-2010	\$2,275	10	11	113	\$24	\$21	0.24	-\$1,938	0.28	-\$1,642	0.31	-\$1,561
R49 Attic, Air Sealing & Duct Sealing Package	Pre-1978	\$5,489	190	74	788	\$209	\$173	0.84	-\$966	0.82	-\$963	1.34	\$1,856
	1978-1991	\$5,031	111	41	430	\$115	\$95	0.51	-\$2,793	0.52	-\$2,435	0.88	-\$604
	1992-2010	\$3,749	15	16	169	\$36	\$30	0.22	-\$3,297	0.24	-\$2,836	0.29	-\$2,681
R49 Attic, Air Sealing & New Ducts Package	Pre-1978	\$8,792	216	97	1,029	\$263	\$219	0.66	-\$3,313	0.68	-\$2,837	1.07	\$598
	1978-1991	\$8,334	131	60	632	\$159	\$132	0.42	-\$5,389	0.46	-\$4,505	0.71	-\$2,427
	1992-2010	\$7,312	24	27	279	\$59	\$49	0.18	-\$6,733	0.22	-\$5,740	0.24	-\$5,552
Advanced Envelope Package	Pre-1978	\$18,659	274	137	1,451	\$359	\$299	0.43	-\$11,982	0.45	-\$10,354	0.74	-\$4,911
Water Heating Package	All Vintages	\$208	0	16	n/a	\$30	\$28	1.78	\$183	n/a	n/a	n/a	n/a

Table 40: CZ 3 - Single Family PV & Battery Cost-Effectiveness Results

Measure	Vintage	Measure Cost (\$)	Electricity Savings (kWh)	Gas Savings (therm)	GHG Savings (lb CO ₂ e)	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	\$6,886	3,464	0	226	\$866	\$684	2.69	\$12,900	1.95	\$6,551	1.59	\$4,080
	1978-1991		3,464		226	\$837	\$661	2.60	\$12,212	1.95	\$6,546	1.59	\$4,074
	1992-2010		3,464		226	\$821	\$648	2.55	\$11,829	1.95	\$6,546	1.59	\$4,074
PV + Battery	Pre-1978	\$18,258	3,276	0	875	\$885	\$698	1.07	\$1,280	1.16	\$2,997	0.92	-\$1,523
	1978-1991		3,277		877	\$855	\$675	1.03	\$579	1.16	\$2,991	0.96	-\$806
	1992-2010		3,278		875	\$838	\$662	1.01	\$183	1.16	\$2,991	0.91	-\$1,719

Table 41: CZ 3 - Single Family Equipment Fuel Substitution Cost-Effectiveness Results

Measure	Vintage	Measure Cost (\$)	Electricity Savings (kWh)	Gas Savings (therm)	GHG Savings (lb CO ₂ e)	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	\$501	-2,496	241	1,220	-\$238	-\$163	0	-\$5,443	0	-\$5,127	4.10	\$1,555
	1978-1991		-1,895	178	861	-\$181	-\$125	0	-\$4,306	0	-\$4,727	2.42	\$714
	1992-2010		-1,660	154	753	-\$158	-\$110	0	-\$3,846	0	-\$3,321	2.02	\$510
High-Effic. Heat Pump at HVAC Replacement	Pre-1978	\$3,749	-2,063	241	1,418	-\$106	-\$59	0	-\$5,824	0	-\$5,956	1.26	\$989
	1978-1991		-1,573	178	1,011	-\$86	-\$50	0	-\$5,564	0	-\$6,224	0.83	-\$627
	1992-2010		-1,398	154	872	-\$82	-\$50	0	-\$5,544	0	-\$5,092	0.62	-\$1,433
Heat Pump at HVAC Replacement + PV	Pre-1978	\$7,387	968	241	1,446	\$670	\$554	2.03	\$8,445	1.20	\$1,467	1.77	\$5,661
	1978-1991		1,569	178	1,086	\$710	\$578	2.13	\$9,191	1.25	\$1,850	1.65	\$4,806
	1992-2010		1,804	154	979	\$730	\$591	2.17	\$9,572	1.44	\$3,270	1.62	\$4,610
HVAC HP Replacement w/ Panel Upgrade + PV	Pre-1978	\$10,568	968	241	1,446	\$670	\$554	1.42	\$4,873	0.84	-\$1,714	1.23	\$2,480
	1978-1991		1,569	178	1,086	\$710	\$578	1.48	\$5,619	0.87	-\$1,331	1.15	\$1,625
	1992-2010		1,804	154	979	\$730	\$591	1.51	\$6,000	1.01	\$89	1.14	\$1,429
HPWH at Water Heater Replacement	Pre-1978	\$2,594	-1,308	164	1,288	-\$148	-\$101	0	-\$5,927	0	-\$3,565	1.31	\$808
	1978-1991		-1,317	165	1,295	-\$151	-\$103	0	-\$5,990	0	-\$3,542	1.33	\$845
	1992-2010		-1,320	165	1,296	-\$160	-\$111	0	-\$6,229	0	-\$3,539	1.28	\$727
NEEA Tier 3 HPWH at Replacement	Pre-1978	\$2,775	-986	163	1,397	-\$45	-\$20	0	-\$3,681	0.28	-\$1,991	1.81	\$2,249
	1978-1991		-990	164	1,409	-\$45	-\$20	0	-\$3,697	0.28	-\$1,986	1.81	\$2,249
	1992-2010		-993	164	1,410	-\$55	-\$28	0	-\$3,934	0.29	-\$1,963	1.76	\$2,119
HPWH at Water Heater Replacement + PV	Pre-1978	\$9,480	2,155	164	1,513	\$844	\$682	1.95	\$9,952	1.34	\$3,186	1.54	\$5,087
	1978-1991		2,146	165	1,521	\$834	\$674	1.93	\$9,719	1.34	\$3,206	1.54	\$5,118
	1992-2010		2,143	165	1,522	\$821	\$663	1.89	\$9,394	1.34	\$3,209	1.53	\$5,000
HPWH Replacement w/ Panel Upgrade + PV	Pre-1978	\$12,661	2,155	164	1,513	\$844	\$682	1.45	\$6,380	1.00	\$5	1.15	\$1,906
	1978-1991		2,146	165	1,521	\$834	\$674	1.44	\$6,147	1.00	\$25	1.15	\$1,937
	1992-2010		2,143	165	1,522	\$821	\$663	1.41	\$5,822	1.00	\$28	1.14	\$1,819

Measure	Vintage	Measure Cost (\$)	Electricity Savings (kWh)	Gas Savings (therm)	GHG Savings (lb CO ₂ e)	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
PV + Electric Ready Pre-Wire	Pre-1978	\$10,977	3,464	0	226	\$866	\$684	1.68	\$8,306	1.22	\$2,460	1.00	-\$11
	1978-1991		3,464	0	226	\$837	\$661	1.62	\$7,618	1.22	\$2,455	1.00	-\$17
	1992-2010		3,464	0	226	\$821	\$648	1.59	\$7,235	1.22	\$2,455	1.00	-\$17

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 42: CZ 4 (PG&E) - Single Family Efficiency Upgrade Cost-Effectiveness Results

Measure	Vintage	Measure Cost (\$)	Electricity Savings (kWh)	Gas Savings (therm)	GHG Savings (lb CO ₂ e)	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	\$3,332	654	29	409	\$305	\$244	1.96	\$3,579	1.95	\$3,168	1.92	\$3,075
	1978-1991	\$2,874	340	15	218	\$156	\$125	1.16	\$511	1.23	\$674	1.18	\$517
	1992-2010	\$1,852	79	6	79	\$39	\$31	0.45	-\$1,138	0.63	-\$691	0.60	-\$740
Reduced Infiltration	Pre-1978	\$1,474	20	11	111	\$28	\$24	0.43	-\$946	0.59	-\$598	0.84	-\$233
	1978-1991		9	7	74	\$15	\$13	0.23	-\$1,274	0.36	-\$944	0.29	-\$1,051
	1992-2010		8	5	48	\$11	\$9	0.16	-\$1,393	0.23	-\$1,140	0.29	-\$1,051
Duct Sealing	Pre-1978	\$683	299	24	314	\$164	\$132	5.17	\$3,201	6.90	\$4,027	7.62	\$4,522
	1978-1991	\$683	160	13	179	\$88	\$71	2.77	\$1,354	3.79	\$1,904	4.48	\$2,379
	1992-2010	\$423	23	4	45	\$15	\$12	0.79	-\$101	1.17	\$72	1.50	\$214
New Ducts	Pre-1978	\$3,986	611	43	586	\$324	\$261	1.75	\$3,339	2.38	\$5,482	2.55	\$6,165
	1978-1991		430	30	425	\$222	\$178	1.19	\$862	1.79	\$3,140	1.88	\$3,492
	1992-2010		97	12	159	\$59	\$48	0.32	-\$3,050	0.54	-\$1,849	0.58	-\$1,673
Cool Roof	Pre-1978	\$778	272	-5	-3	\$96	\$76	2.67	\$1,418	2.80	\$1,403	2.98	\$1,544
	1978-1991		185	-4	6	\$66	\$52	1.83	\$705	2.09	\$847	2.02	\$792
	1992-2010		75	-3	-8	\$24	\$18	0.65	-\$298	0.99	-\$6	0.89	-\$87
R-13 Wall Insulation	Pre-1978	\$3,360	123	36	394	\$116	\$96	0.76	-\$901	0.90	-\$330	1.07	\$241
Windows	Pre-1978	\$9,810	873	6	243	\$354	\$280	0.76	-\$2,601	0.83	-\$1,627	0.87	-\$1,321
	1978-1991		674	5	220	\$273	\$216	0.59	-\$4,534	0.71	-\$2,811	0.67	-\$3,240
LED lamp vs CFL	All	\$2.26	1.2	0	n/a	\$0.40	\$0.31	4.16	\$7.13	n/a	n/a	n/a	n/a
Exterior Photosensor	All	\$42.58	12.1	0	n/a	\$2.88	\$2.27	1.60	\$25.62	n/a	n/a	n/a	n/a

Table 43: CZ 4 (PG&E) - Single Family Efficiency Packages Cost-Effectiveness Results

Measure	Vintage	Measure Cost (\$)	Electricity Savings (kWh)	Gas Savings (therm)	GHG Savings (lb CO ₂ e)	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	\$4,806	673	41	532	\$335	\$269	1.50	\$2,673	1.54	\$2,582	1.56	\$2,705
	1978-1991	\$4,348	352	22	292	\$172	\$138	0.85	-\$737	0.93	-\$319	0.93	-\$320
	1992-2010	\$3,326	86	10	128	\$50	\$40	0.32	-\$2,530	0.46	-\$1,797	0.46	-\$1,805
R49 Attic & Duct Sealing Package	Pre-1978	\$4,015	879	52	699	\$437	\$351	2.34	\$6,022	2.65	\$6,619	2.78	\$7,157
	1978-1991	\$3,557	473	27	383	\$229	\$184	1.38	\$1,512	1.67	\$2,367	1.67	\$2,389
	1992-2010	\$2,275	98	9	122	\$53	\$43	0.50	-\$1,278	0.74	-\$596	0.71	-\$665
R49 Attic, Air Sealing & Duct Sealing Package	Pre-1978	\$5,489	893	62	807	\$461	\$371	1.80	\$4,959	2.05	\$5,741	2.21	\$6,624
	1978-1991	\$5,031	482	34	449	\$243	\$195	1.04	\$209	1.27	\$1,371	1.30	\$1,503
	1992-2010	\$3,749	105	14	168	\$62	\$50	0.36	-\$2,697	0.54	-\$1,724	0.52	-\$1,799
R49 Attic, Air Sealing & New Ducts Package	Pre-1978	\$8,792	1,158	80	1,070	\$598	\$481	1.46	\$4,549	1.79	\$6,929	1.90	\$7,942
	1978-1991	\$8,334	724	49	676	\$363	\$291	0.93	-\$629	1.26	\$2,193	1.31	\$2,572
	1992-2010	\$7,312	171	22	276	\$101	\$82	0.30	-\$5,752	0.48	-\$3,795	0.48	-\$3,792
Advanced Envelope Package	Pre-1978	\$18,659	1,501	115	1,502	\$783	\$630	0.90	-\$2,049	1.09	\$1,633	1.13	\$2,418
Water Heating Package	All Vintages	\$208	0	16	n/a	\$32	\$29	1.88	\$205	n/a	n/a	n/a	n/a

Table 44: CZ 4 (PG&E) - Single Family PV & Battery Cost-Effectiveness Results

Measure	Vintage	Measure Cost (\$)	Electricity Savings (kWh)	Gas Savings (therm)	GHG Savings (lb CO ₂ e)	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	\$6,950	3,562	0	232	\$980	\$773	3.02	\$15,511	2.02	\$7,090	1.72	\$4,984
	1978-1991		3,562		232	\$946	\$746	2.91	\$14,704	2.02	\$7,072	1.71	\$4,958
	1992-2010		3,562		232	\$883	\$697	2.72	\$13,223	2.02	\$7,061	1.71	\$4,932
PV + Battery	Pre-1978	\$18,322	3,368	0	822	\$1,020	\$805	1.22	\$4,414	1.20	\$3,650	0.86	-\$2,534
	1978-1991		3,366		842	\$987	\$779	1.18	\$3,642	1.24	\$4,310	0.89	-\$2,079
	1992-2010		3,367		870	\$920	\$726	1.10	\$2,045	1.29	\$5,246	0.96	-\$786

Table 45: CZ 4 (PG&E) - Single Family Equipment Fuel Substitution Cost-Effectiveness Results

Measure	Vintage	Measure Cost (\$)	Electricity Savings (kWh)	Gas Savings (therm)	GHG Savings (lb CO ₂ e)	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	\$501	-2,034	190	917	-\$240	-\$171	0	-\$5,666	0	-\$4,436	2.49	\$749
	1978-1991		-1,520	138	633	-\$195	-\$141	0	-\$4,771	0	-\$3,774	1.26	\$132
	1992-2010		-1,290	117	543	-\$167	-\$121	0	-\$4,167	0	-\$3,647	1.11	\$54
High-Effic. Heat Pump at HVAC Replacement	Pre-1978	\$3,749	-1,446	190	1,150	-\$43	-\$16	0	-\$4,530	0.22	-\$2,908	1.51	\$1,916
	1978-1991		-1,084	138	813	-\$50	-\$26	0	-\$4,848	0.13	-\$3,248	1.09	\$329
	1992-2010		-993	117	675	-\$70	-\$45	0	-\$5,403	0	-\$4,389	0.77	-\$846
Heat Pump at HVAC Replacement + PV	Pre-1978	\$7,451	1,528	190	1,149	\$746	\$608	2.21	\$9,995	1.36	\$2,691	1.77	\$5,753
	1978-1991		2,042	138	865	\$771	\$622	2.27	\$10,414	1.45	\$3,330	1.69	\$5,105
	1992-2010		2,272	117	775	\$763	\$613	2.23	\$10,159	1.46	\$3,457	1.67	\$5,010
HVAC HP Replacement w/ Panel Upgrade + PV	Pre-1978	\$10,632	1,528	190	1,149	\$746	\$608	1.54	\$6,423	0.95	-\$490	1.24	\$2,572
	1978-1991		2,042	138	865	\$771	\$622	1.58	\$6,842	1.01	\$149	1.18	\$1,924
	1992-2010		2,272	117	775	\$763	\$613	1.56	\$6,587	1.03	\$276	1.17	\$1,829
HPWH at Water Heater Replacement	Pre-1978	\$2,594	-1,103	157	1,265	-\$84	-\$51	0	-\$4,427	0	-\$2,761	1.63	\$1,643
	1978-1991		-1,118	157	1,271	-\$104	-\$68	0	-\$4,927	0	-\$2,893	1.52	\$1,338
	1992-2010		-1,128	158	1,270	-\$110	-\$73	0	-\$5,069	0	-\$2,911	1.57	\$1,473
NEEA Tier 3 HPWH at Replacement	Pre-1978	\$2,775	-862	156	1,360	-\$8	\$9	0.09	-\$2,815	0.47	-\$1,461	1.99	\$2,756
	1978-1991		-873	157	1,369	-\$26	-\$7	0	-\$3,287	0.49	-\$1,410	1.86	\$2,378
	1992-2010		-881	157	1,370	-\$31	-\$10	0	-\$3,403	0.46	-\$1,493	1.93	\$2,583
HPWH at Water Heater Replacement + PV	Pre-1978	\$9,544	2,459	157	1,497	\$968	\$779	2.21	\$12,793	1.47	\$4,522	1.71	\$6,812
	1978-1991		2,444	157	1,503	\$924	\$743	2.11	\$11,729	1.46	\$4,375	1.68	\$6,483
	1992-2010		2,434	158	1,502	\$859	\$692	1.96	\$10,188	1.46	\$4,349	1.69	\$6,596
HPWH Replacement w/ Panel Upgrade + PV	Pre-1978	\$12,725	2,459	157	1,497	\$968	\$779	1.65	\$9,221	1.11	\$1,341	1.29	\$3,631
	1978-1991		2,444	157	1,503	\$924	\$743	1.58	\$8,157	1.09	\$1,194	1.26	\$3,302
	1992-2010		2,434	158	1,502	\$859	\$692	1.47	\$6,616	1.09	\$1,168	1.27	\$3,415

Measure	Vintage	Measure Cost (\$)	Electricity Savings (kWh)	Gas Savings (therm)	GHG Savings (lb CO ₂ e)	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
PV + Electric Ready Pre-Wire	Pre-1978	\$11,041	3,562	0	232	\$980	\$773	1.89	\$10,917	1.27	\$2,999	1.08	\$893
	1978-1991		3,562	0	232	\$946	\$746	1.82	\$10,110	1.27	\$2,981	1.08	\$867
	1992-2010		3,562	0	232	\$883	\$697	1.70	\$8,629	1.27	\$2,970	1.08	\$841

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 46: CZ 4 (CPAU) - Single Family Efficiency Upgrade Cost-Effectiveness Results

Measure	Vintage	Measure Cost (\$)	Electricity Savings (kWh)	Gas Savings (therm)	GHG Savings (lb CO ₂ e)	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	\$3,332	654	29	409	\$172	\$138	1.11	\$404	1.95	\$3,168	1.92	\$3,075
	1978-1991	\$2,874	340	15	218	\$83	\$66	0.62	-\$1,234	1.23	\$674	1.18	\$517
	1992-2010	\$1,852	79	6	79	\$20	\$16	0.23	-\$1,599	0.63	-\$691	0.60	-\$740
Reduced Infiltration	Pre-1978	\$1,474	20	11	111	\$22	\$18	0.33	-\$1,114	0.59	-\$598	0.84	-\$233
	1978-1991		9	7	74	\$11	\$9	0.17	-\$1,381	0.36	-\$944	0.29	-\$1,051
	1992-2010		8	5	48	\$6	\$5	0.09	-\$1,498	0.23	-\$1,140	0.29	-\$1,051
Duct Sealing	Pre-1978	\$683	299	24	314	\$98	\$80	3.13	\$1,631	6.90	\$4,027	7.62	\$4,522
	1978-1991	\$683	160	13	179	\$49	\$40	1.55	\$419	3.79	\$1,904	4.48	\$2,379
	1992-2010	\$423	23	4	45	\$8	\$7	0.42	-\$274	1.17	\$72	1.50	\$214
New Ducts	Pre-1978	\$3,986	611	43	586	\$191	\$155	1.04	\$168	2.38	\$5,482	2.55	\$6,165
	1978-1991		430	30	425	\$122	\$99	0.66	-\$1,514	1.79	\$3,140	1.88	\$3,492
	1992-2010		97	12	159	\$31	\$25	0.17	-\$3,716	0.54	-\$1,849	0.58	-\$1,673
Cool Roof	Pre-1978	\$778	272	-5	-3	\$44	\$35	1.22	\$191	2.80	\$1,403	2.98	\$1,544
	1978-1991		185	-4	6	\$31	\$24	0.84	-\$135	2.09	\$847	2.02	\$792
	1992-2010		75	-3	-8	\$10	\$8	0.27	-\$615	0.99	-\$6	0.89	-\$87
R-13 Wall Insulation	Pre-1978	\$3,360	123	36	394	\$83	\$69	0.55	-\$1,713	0.90	-\$330	1.07	\$241
Windows	Pre-1978	\$9,810	873	6	243	\$183	\$145	0.39	-\$6,666	0.83	-\$1,627	0.87	-\$1,321
	1978-1991		674	5	220	\$137	\$109	0.30	-\$7,758	0.71	-\$2,811	0.67	-\$3,240
LED lamp vs CFL	All	\$2.26	1.2	0	n/a	\$0.18	\$0.14	1.90	\$2.03	n/a	n/a	n/a	n/a
Exterior Photosensor	All	\$42.58	12.1	0	n/a	\$1.66	\$1.31	0.93	-\$3.17	n/a	n/a	n/a	n/a

Table 47: CZ 4 (CPAU) - Single Family Efficiency Packages Cost-Effectiveness Results

Measure	Vintage	Measure Cost (\$)	Electricity Savings (kWh)	Gas Savings (therm)	GHG Savings (lb CO ₂ e)	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	\$4,806	673	41	532	\$195	\$157	0.88	-\$673	1.54	\$2,582	1.56	\$2,705
	1978-1991	\$4,348	352	22	292	\$94	\$76	0.47	-\$2,612	0.93	-\$319	0.93	-\$320
	1992-2010	\$3,326	86	10	128	\$26	\$21	0.17	-\$3,095	0.46	-\$1,797	0.46	-\$1,805
R49 Attic & Duct Sealing Package	Pre-1978	\$4,015	879	52	699	\$252	\$204	1.36	\$1,612	2.65	\$6,619	2.78	\$7,157
	1978-1991	\$3,557	473	27	383	\$124	\$100	0.75	-\$997	1.67	\$2,367	1.67	\$2,389
	1992-2010	\$2,275	98	9	122	\$27	\$22	0.26	-\$1,891	0.74	-\$596	0.71	-\$665
R49 Attic, Air Sealing & Duct Sealing Package	Pre-1978	\$5,489	893	62	807	\$270	\$219	1.07	\$405	2.05	\$5,741	2.21	\$6,624
	1978-1991	\$5,031	482	34	449	\$134	\$108	0.57	-\$2,414	1.27	\$1,371	1.30	\$1,503
	1992-2010	\$3,749	105	14	168	\$33	\$27	0.19	-\$3,398	0.54	-\$1,724	0.52	-\$1,799
R49 Attic, Air Sealing & New Ducts Package	Pre-1978	\$8,792	1,158	80	1,070	\$345	\$279	0.85	-\$1,489	1.79	\$6,929	1.90	\$7,942
	1978-1991	\$8,334	724	49	676	\$195	\$157	0.50	-\$4,635	1.26	\$2,193	1.31	\$2,572
	1992-2010	\$7,312	171	22	276	\$54	\$44	0.16	-\$6,888	0.48	-\$3,795	0.48	-\$3,792
Advanced Envelope Package	Pre-1978	\$18,659	1,501	115	1,502	\$448	\$363	0.52	-\$10,070	1.09	\$1,633	1.13	\$2,418
Water Heating Package	All Vintages	\$208	0	16	n/a	\$23	\$21	1.36	\$85	n/a	n/a	n/a	n/a

Table 48: CZ 4 (CPAU) - Single Family PV & Battery Cost-Effectiveness Results

Measure	Vintage	Measure Cost (\$)	Electricity Savings (kWh)	Gas Savings (therm)	GHG Savings (lb CO ₂ e)	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	\$6,950	3,562	0	232	\$459	\$362	1.41	\$3,171	2.02	\$7,090	1.72	\$4,984
	1978-1991		3,562		232	\$448	\$353	1.38	\$2,918	2.02	\$7,072	1.71	\$4,958
	1992-2010		3,562		232	\$424	\$335	1.31	\$2,355	2.02	\$7,061	1.71	\$4,932
PV + Battery	Pre-1978	\$18,322	3,368	0	822	\$512	\$404	0.61	-\$7,606	1.20	\$3,650	0.86	-\$2,534
	1978-1991		3,366		842	\$491	\$387	0.59	-\$8,118	1.24	\$4,310	0.89	-\$2,079
	1992-2010		3,367		870	\$434	\$342	0.52	-\$9,467	1.29	\$5,246	0.96	-\$786

Table 49: CZ 4 (CPAU) - Single Family Equipment Fuel Substitution Cost-Effectiveness Results

Measure	Vintage	Measure Cost (\$)	Electricity Savings (kWh)	Gas Savings (therm)	GHG Savings (lb CO ₂ e)	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	\$501	-2,034	190	917	-\$161	-\$114	0	-\$3,969	0	-\$4,436	2.49	\$749
	1978-1991		-1,520	138	633	-\$140	-\$102	0	-\$3,598	0	-\$3,774	1.26	\$132
	1992-2010		-1,290	117	543	-\$121	-\$88	0	-\$3,197	0	-\$2,014	1.11	\$54
High-Effic. Heat Pump at HVAC Replacement	Pre-1978	\$3,749	-1,446	190	1,150	-\$47	-\$24	0	-\$4,781	0.22	-\$2,908	1.51	\$1,916
	1978-1991		-1,084	138	813	-\$56	-\$35	0	-\$5,121	0.13	-\$3,248	1.09	\$329
	1992-2010		-993	117	675	-\$64	-\$44	0	-\$5,370	0.27	-\$2,756	0.77	-\$846
Heat Pump at HVAC Replacement + PV	Pre-1978	\$7,451	1,528	190	1,149	\$318	\$264	0.96	-\$316	1.36	\$2,691	1.77	\$5,753
	1978-1991		2,042	138	865	\$325	\$265	0.97	-\$273	1.45	\$3,330	1.69	\$5,105
	1992-2010		2,272	117	775	\$325	\$264	0.96	-\$318	1.46	\$3,457	1.67	\$5,010
HVAC HP Replacement w/ Panel Upgrade + PV	Pre-1978	\$10,632	1,528	190	1,149	\$318	\$264	0.67	-\$3,888	0.95	-\$490	1.24	\$2,572
	1978-1991		2,042	138	865	\$325	\$265	0.67	-\$3,845	1.01	\$149	1.18	\$1,924
	1992-2010		2,272	117	775	\$325	\$264	0.67	-\$3,890	1.03	\$276	1.17	\$1,829
HPWH at Water Heater Replacement	Pre-1978	\$2,594	-1,103	157	1,265	-\$23	-\$8	0	-\$3,125	0	-\$2,761	1.63	\$1,643
	1978-1991		-1,118	157	1,271	-\$50	-\$30	0	-\$3,790	0	-\$2,893	1.52	\$1,338
	1992-2010		-1,128	158	1,270	-\$55	-\$35	0	-\$3,931	0	-\$2,911	1.57	\$1,473
NEEA Tier 3 HPWH at Replacement	Pre-1978	\$2,775	-862	156	1,360	\$22	\$28	0.27	-\$2,241	0.47	-\$1,461	1.99	\$2,756
	1978-1991		-873	157	1,369	-\$3	\$7	0.07	-\$2,881	0.49	-\$1,410	1.86	\$2,378
	1992-2010		-881	157	1,370	-\$8	\$3	0.03	-\$3,006	0.46	-\$1,493	1.93	\$2,583
HPWH at Water Heater Replacement + PV	Pre-1978	\$9,544	2,459	157	1,497	\$488	\$395	1.12	\$1,287	1.47	\$4,522	1.71	\$6,812
	1978-1991		2,444	157	1,503	\$455	\$368	1.04	\$463	1.46	\$4,375	1.68	\$6,483
	1992-2010		2,434	158	1,502	\$430	\$348	0.99	-\$138	1.46	\$4,349	1.69	\$6,596
HPWH Replacement w/ Panel Upgrade + PV	Pre-1978	\$12,725	2,459	157	1,497	\$488	\$395	0.84	-\$2,285	1.11	\$1,341	1.29	\$3,631
	1978-1991		2,444	157	1,503	\$455	\$368	0.78	-\$3,109	1.09	\$1,194	1.26	\$3,302
	1992-2010		2,434	158	1,502	\$430	\$348	0.74	-\$3,710	1.09	\$1,168	1.27	\$3,415

Measure	Vintage	Measure Cost (\$)	Electricity Savings (kWh)	Gas Savings (therm)	GHG Savings (lb CO ₂ e)	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
PV + Electric Ready Pre-Wire	Pre-1978	\$11,041	3,562	0	232	\$459	\$362	0.88	-\$1,423	1.27	\$2,999	1.08	\$893
	1978-1991		3,562	0	232	\$448	\$353	0.86	-\$1,676	1.27	\$2,981	1.08	\$867
	1992-2010		3,562	0	232	\$424	\$335	0.82	-\$2,239	1.27	\$2,970	1.08	\$841

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 50: CZ 5 (PG&E) - Single Family Efficiency Upgrade Cost-Effectiveness Results

Measure	Vintage	Measure Cost (\$)	Electricity Savings (kWh)	Gas Savings (therm)	GHG Savings (lb CO ₂ e)	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	\$3,332	141	31	339	\$106	\$87	0.70	-\$1,125	0.57	-\$1,430	0.97	-\$100
	1978-1991	\$2,874	84	16	169	\$56	\$46	0.43	-\$1,853	0.39	-\$1,765	0.60	-\$1,145
	1992-2010	\$1,852	6	6	60	\$13	\$10	0.15	-\$1,766	0.17	-\$1,538	0.22	-\$1,449
Reduced Infiltration	Pre-1978	\$1,474	10	14	141	\$30	\$25	0.45	-\$908	0.55	-\$670	0.59	-\$607
	1978-1991		6	9	87	\$19	\$16	0.28	-\$1,188	0.33	-\$981	0.37	-\$932
	1992-2010		4	6	57	\$12	\$10	0.18	-\$1,365	0.22	-\$1,149	0.24	-\$1,123
Duct Sealing	Pre-1978	\$683	32	28	293	\$66	\$55	2.16	\$892	2.70	\$1,160	2.81	\$1,238
	1978-1991	\$683	15	15	160	\$35	\$30	1.16	\$120	1.55	\$374	1.52	\$354
	1992-2010	\$423	4	5	47	\$10	\$8	0.51	-\$235	0.73	-\$115	0.69	-\$132
New Ducts	Pre-1978	\$3,986	63	49	517	\$119	\$99	0.66	-\$1,502	0.81	-\$769	0.87	-\$504
	1978-1991		35	34	351	\$78	\$65	0.44	-\$2,515	0.57	-\$1,702	0.59	-\$1,647
	1992-2010		13	15	152	\$31	\$26	0.17	-\$3,693	0.25	-\$2,986	0.24	-\$3,035
Cool Roof	Pre-1978	\$778	19	-8	-77	-\$8	-\$7	0	-\$1,067	0	-\$1,282	0	-\$1,077
	1978-1991		5	-6	-56	-\$9	-\$8	0	-\$1,084	0	-\$1,132	0	-\$1,017
	1992-2010		-1	-5	-48	-\$9	-\$8	0	-\$1,080	0	-\$1,072	0	-\$1,043
R-13 Wall Insulation	Pre-1978	\$3,360	44	43	445	\$98	\$82	0.65	-\$1,311	0.79	-\$719	0.85	-\$491
Windows	Pre-1978	\$9,810	72	21	236	\$68	\$56	0.15	-\$9,341	0.15	-\$8,315	0.21	-\$7,759
	1978-1991		38	20	213	\$52	\$43	0.12	-\$9,727	0.14	-\$8,407	0.18	-\$8,018
LED lamp vs CFL	All	\$2.26	1.2	0	n/a	\$0.34	\$0.27	3.54	\$5.72	n/a	n/a	n/a	n/a
Exterior Photosensor	All	\$42.58	12.1	0	n/a	\$2.88	\$2.27	1.60	\$25.62	n/a	n/a	n/a	n/a

Table 51: CZ 5 (PG&E) - Single Family Efficiency Packages Cost-Effectiveness Results

Measure	Vintage	Measure Cost (\$)	Electricity Savings (kWh)	Gas Savings (therm)	GHG Savings (lb CO ₂ e)	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	\$4,806	152	45	484	\$137	\$113	0.63	-\$1,999	0.58	-\$2,032	0.86	-\$675
	1978-1991	\$4,348	91	24	259	\$75	\$62	0.38	-\$3,021	0.38	-\$2,714	0.53	-\$2,061
	1992-2010	\$3,326	11	11	117	\$24	\$20	0.16	-\$3,129	0.19	-\$2,678	0.23	-\$2,569
R49 Attic & Duct Sealing Package	Pre-1978	\$4,015	163	56	603	\$164	\$136	0.90	-\$441	0.91	-\$368	1.22	\$874
	1978-1991	\$3,557	96	30	316	\$88	\$73	0.55	-\$1,806	0.59	-\$1,442	0.75	-\$904
	1992-2010	\$2,275	10	10	105	\$22	\$18	0.21	-\$2,010	0.27	-\$1,656	0.30	-\$1,593
R49 Attic, Air Sealing & Duct Sealing Package	Pre-1978	\$5,489	173	69	736	\$192	\$160	0.78	-\$1,377	0.80	-\$1,073	1.04	\$226
	1978-1991	\$5,031	103	38	398	\$105	\$87	0.46	-\$3,038	0.51	-\$2,447	0.63	-\$1,868
	1992-2010	\$3,749	14	15	160	\$33	\$28	0.20	-\$3,385	0.25	-\$2,813	0.27	-\$2,727
R49 Attic, Air Sealing & New Ducts Package	Pre-1978	\$8,792	190	89	945	\$238	\$198	0.60	-\$3,940	0.66	-\$3,008	0.80	-\$1,769
	1978-1991	\$8,334	117	55	575	\$141	\$117	0.38	-\$5,836	0.45	-\$4,566	0.51	-\$4,065
	1992-2010	\$7,312	23	25	260	\$53	\$44	0.16	-\$6,880	0.22	-\$5,711	0.23	-\$5,662
Advanced Envelope Package	Pre-1978	\$18,659	226	124	1,302	\$313	\$261	0.37	-\$13,126	0.42	-\$10,731	0.50	-\$9,309
Water Heating Package	All Vintages	\$208	0	16	0	\$30	\$28	1.79	\$186	n/a	n/a	n/a	n/a

Table 52: CZ 5 (PG&E) - Single Family PV & Battery Cost-Effectiveness Results

Measure	Vintage	Measure Cost (\$)	Electricity Savings (kWh)	Gas Savings (therm)	GHG Savings (lb CO ₂ e)	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	\$6,467	3,463	0	259	\$851	\$672	2.82	\$13,000	2.08	\$6,961	1.71	\$4,619
	1978-1991		3,463		259	\$828	\$654	2.74	\$12,459	2.08	\$6,955	1.71	\$4,617
	1992-2010		3,463		259	\$818	\$646	2.71	\$12,219	2.08	\$6,955	1.71	\$4,617
PV + Battery	Pre-1978	\$17,840	3,268	0	921	\$868	\$685	1.07	\$1,350	1.14	\$2,519	0.90	-\$1,802
	1978-1991		3,269		923	\$845	\$667	1.04	\$797	1.14	\$2,502	0.91	-\$1,554
	1992-2010		3,270		923	\$834	\$659	1.03	\$554	1.14	\$2,505	0.92	-\$1,358

Table 53: CZ 5 (PG&E) - Single Family Equipment Fuel Substitution Cost-Effectiveness Results

Measure	Vintage	Measure Cost (\$)	Electricity Savings (kWh)	Gas Savings (therm)	GHG Savings (lb CO ₂ e)	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	\$501	-2,800	213	797	-\$379	-\$277	0	-\$8,861	0	-\$6,740	0	-\$1,959
	1978-1991		-2,205	154	479	-\$319	-\$236	0	-\$7,639	0	-\$6,282	0	-\$2,495
	1992-2010		-1,828	138	514	-\$238	-\$175	0	-\$5,788	0	-\$4,710	0	-\$1,512
High-Effic. Heat Pump at HVAC Replacement	Pre-1978	\$3,749	-2,469	213	945	-\$280	-\$199	0	-\$10,036	0	-\$7,696	0.08	-\$3,435
	1978-1991		-1,968	154	587	-\$248	-\$181	0	-\$9,482	0	-\$7,851	0	-\$4,478
	1992-2010		-1,624	138	604	-\$177	-\$127	0	-\$7,864	0	-\$6,463	0	-\$3,732
Heat Pump at HVAC Replacement + PV	Pre-1978	\$6,969	663	213	1,056	\$534	\$443	1.73	\$5,599	1.04	\$264	1.38	\$2,678
	1978-1991		1,258	154	738	\$582	\$474	1.85	\$6,524	1.10	\$705	1.31	\$2,133
	1992-2010		1,634	138	773	\$658	\$532	2.07	\$8,271	1.33	\$2,298	1.45	\$3,121
HVAC HP Replacement w/ Panel Upgrade + PV	Pre-1978	\$10,150			1,056	\$534	\$443	1.18	\$2,027	0.71	-\$2,917	0.95	-\$503
	1978-1991				738	\$582	\$474	1.26	\$2,952	0.76	-\$2,476	0.90	-\$1,048
	1992-2010				773	\$658	\$532	1.42	\$4,699	0.91	-\$883	0.99	-\$60
HPWH at Water Heater Replacement	Pre-1978	\$2,594	-1,304	164	1,292	-\$143	-\$97	0	-\$5,796	0	-\$3,945	1.31	\$802
	1978-1991		-1,308	165	1,299	-\$149	-\$102	0	-\$5,942	0	-\$3,879	1.32	\$831
	1992-2010		-1,309	165	1,301	-\$159	-\$111	0	-\$6,213	0	-\$3,870	1.32	\$819
NEEA Tier 3 HPWH at Replacement	Pre-1978	\$2,775	-987	163	1,405	-\$41	-\$17	0	-\$3,586	0.21	-\$2,181	1.81	\$2,254
	1978-1991		-990	164	1,415	-\$46	-\$21	0	-\$3,705	0.23	-\$2,147	1.83	\$2,312
	1992-2010		-992	165	1,416	-\$57	-\$30	0	-\$3,983	0.23	-\$2,124	1.82	\$2,289
HPWH at Water Heater Replacement + PV	Pre-1978	\$9,061	2,158	164	1,551	\$849	\$686	2.05	\$10,534	1.36	\$3,227	1.62	\$5,620
	1978-1991		2,154	165	1,559	\$838	\$677	2.02	\$10,261	1.36	\$3,290	1.62	\$5,646
	1992-2010		2,153	165	1,561	\$825	\$666	1.99	\$9,936	1.36	\$3,302	1.62	\$5,635
HPWH Replacement w/ Panel Upgrade + PV	Pre-1978	\$12,242	2,158	164	1,551	\$849	\$686	1.51	\$6,962	1.00	\$46	1.20	\$2,439
	1978-1991		2,154	165	1,559	\$838	\$677	1.49	\$6,689	1.01	\$109	1.20	\$2,465
	1992-2010		2,153	165	1,561	\$825	\$666	1.47	\$6,364	1.01	\$121	1.20	\$2,454

Measure	Vintage	Measure Cost (\$)	Electricity Savings (kWh)	Gas Savings (therm)	GHG Savings (lb CO ₂ e)	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
PV + Electric Ready Pre-Wire	Pre-1978	\$10,558	3,463	0	259	\$851	\$672	1.72	\$8,406	1.27	\$2,870	1.05	\$528
	1978-1991		3,463	0	259	\$828	\$654	1.67	\$7,865	1.27	\$2,864	1.05	\$526
	1992-2010		3,463	0	259	\$818	\$646	1.65	\$7,625	1.27	\$2,864	1.05	\$526

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 54: CZ 5 (PG&E/SoCalGas) - Single Family Efficiency Upgrade Cost-Effectiveness Results

Measure	Vintage	Measure Cost (\$)	Electricity Savings (kWh)	Gas Savings (therm)	GHG Savings (lb CO ₂ e)	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	\$3,332	141	31	339	\$89	\$73	0.58	-\$1,565	0.57	-\$1,430	0.97	-\$100
	1978-1991	\$2,874	84	16	169	\$45	\$37	0.34	-\$2,127	0.39	-\$1,765	0.60	-\$1,145
	1992-2010	\$1,852	6	6	60	\$9	\$8	0.11	-\$1,843	0.17	-\$1,538	0.22	-\$1,449
Reduced Infiltration	Pre-1978	\$1,474	10	14	141	\$23	\$19	0.34	-\$1,087	0.55	-\$670	0.59	-\$607
	1978-1991		6	9	87	\$14	\$12	0.21	-\$1,310	0.33	-\$981	0.37	-\$932
	1992-2010		4	6	57	\$8	\$7	0.13	-\$1,443	0.22	-\$1,149	0.24	-\$1,123
Duct Sealing	Pre-1978	\$683	32	28	293	\$52	\$43	1.69	\$531	2.70	\$1,160	2.81	\$1,238
	1978-1991	\$683	15	15	160	\$26	\$22	0.87	-\$102	1.55	\$374	1.52	\$354
	1992-2010	\$423	4	5	47	\$7	\$6	0.37	-\$298	0.73	-\$115	0.69	-\$132
New Ducts	Pre-1978	\$3,986	63	49	517	\$94	\$78	0.52	-\$2,134	0.81	-\$769	0.87	-\$504
	1978-1991		35	34	351	\$58	\$49	0.33	-\$3,011	0.57	-\$1,702	0.59	-\$1,647
	1992-2010		13	15	152	\$23	\$19	0.13	-\$3,898	0.25	-\$2,986	0.24	-\$3,035
Cool Roof	Pre-1978	\$778	19	-8	-77	-\$4	-\$4	0	-\$956	0	-\$1,282	0	-\$1,077
	1978-1991		5	-6	-56	-\$6	-\$5	0	-\$1,003	0	-\$1,132	0	-\$1,017
	1992-2010		-1	-5	-48	-\$6	-\$5	0	-\$1,009	0	-\$1,072	0	-\$1,043
R-13 Wall Insulation	Pre-1978	\$3,360	44	43	445	\$76	\$63	0.50	-\$1,868	0.79	-\$719	0.85	-\$491
Windows	Pre-1978	\$9,810	72	21	236	\$57	\$47	0.13	-\$9,605	0.15	-\$8,315	0.21	-\$7,759
	1978-1991		38	20	213	\$41	\$34	0.09	-\$10,007	0.14	-\$8,407	0.18	-\$8,018
LED lamp vs CFL	All	\$2.26	1.2	0	n/a	\$0.28	\$0.22	2.96	\$4.42	n/a	n/a	n/a	n/a
Exterior Photosensor	All	\$42.58	12.1	0	n/a	\$2.88	\$2.27	1.60	\$25.62	n/a	n/a	n/a	n/a

Table 55: CZ 5 (PG&E/SoCalGas) - Single Family Efficiency Packages Cost-Effectiveness Results

Measure	Vintage	Measure Cost (\$)	Electricity Savings (kWh)	Gas Savings (therm)	GHG Savings (lb CO ₂ e)	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	\$4,806	152	45	484	\$112	\$92	0.51	-\$2,623	0.58	-\$2,032	0.86	-\$675
	1978-1991	\$4,348	91	24	259	\$59	\$49	0.30	-\$3,426	0.38	-\$2,714	0.53	-\$2,061
	1992-2010	\$3,326	11	11	117	\$18	\$15	0.12	-\$3,284	0.19	-\$2,678	0.23	-\$2,569
R49 Attic & Duct Sealing Package	Pre-1978	\$4,015	163	56	603	\$133	\$110	0.73	-\$1,211	0.91	-\$368	1.22	\$874
	1978-1991	\$3,557	96	30	316	\$69	\$57	0.43	-\$2,293	0.59	-\$1,442	0.75	-\$904
	1992-2010	\$2,275	10	10	105	\$16	\$14	0.16	-\$2,148	0.27	-\$1,656	0.30	-\$1,593
R49 Attic, Air Sealing & Duct Sealing Package	Pre-1978	\$5,489	173	69	736	\$155	\$128	0.62	-\$2,316	0.80	-\$1,073	1.04	\$226
	1978-1991	\$5,031	103	38	398	\$81	\$67	0.36	-\$3,643	0.51	-\$2,447	0.63	-\$1,868
	1992-2010	\$3,749	14	15	160	\$24	\$20	0.15	-\$3,597	0.25	-\$2,813	0.27	-\$2,727
R49 Attic, Air Sealing & New Ducts Package	Pre-1978	\$8,792	190	89	945	\$189	\$157	0.48	-\$5,173	0.66	-\$3,008	0.80	-\$1,769
	1978-1991	\$8,334	117	55	575	\$108	\$89	0.29	-\$6,682	0.45	-\$4,566	0.51	-\$4,065
	1992-2010	\$7,312	23	25	260	\$39	\$33	0.12	-\$7,231	0.22	-\$5,711	0.23	-\$5,662
Advanced Envelope Package	Pre-1978	\$18,659	226	124	1,302	\$245	\$204	0.29	-\$14,840	0.42	-\$10,731	0.50	-\$9,309
Water Heating Package	All Vintages	\$208	0	16	n/a	\$24	\$22	1.41	\$96	n/a	n/a	n/a	n/a

Table 56: CZ 5 (PG&E/SoCalGas) - Single Family PV & Battery Cost-Effectiveness Results

Measure	Vintage	Measure Cost (\$)	Electricity Savings (kWh)	Gas Savings (therm)	GHG Savings (lb CO ₂ e)	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	\$6,467	3,463	0	259	\$851	\$672	2.82	\$13,000	2.08	\$6,961	1.71	\$4,619
	1978-1991		3,463		259	\$828	\$654	2.74	\$12,459	2.08	\$6,955	1.71	\$4,617
	1992-2010		3,463		259	\$818	\$646	2.71	\$12,219	2.08	\$6,955	1.71	\$4,617
PV + Battery	Pre-1978	\$17,840	3,268	0	921	\$868	\$685	1.07	\$1,350	1.14	\$2,519	0.90	-\$1,802
	1978-1991		3,269		923	\$845	\$667	1.04	\$797	1.14	\$2,502	0.91	-\$1,554
	1992-2010		3,270		923	\$834	\$659	1.03	\$554	1.14	\$2,505	0.92	-\$1,358

Table 57: CZ 5 (PG&E/SoCalGas) - Single Family Equipment Fuel Substitution Cost-Effectiveness Results

Measure	Vintage	Measure Cost (\$)	Electricity Savings (kWh)	Gas Savings (therm)	GHG Savings (lb CO ₂ e)	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	\$501	-2,800	213	797	-\$484	-\$366	0	-\$11,529	0	-\$6,740	0	-\$1,959
	1978-1991		-2,205	154	479	-\$393	-\$299	0	-\$9,525	0	-\$6,282	0	-\$2,495
	1992-2010		-1,828	138	514	-\$303	-\$230	0	-\$7,438	0	-\$4,710	0	-\$1,512
High-Effic. Heat Pump at HVAC Replacement	Pre-1978	\$3,749	-2,469	213	945	-\$385	-\$288	0	-\$12,704	0	-\$7,696	0.08	-\$3,435
	1978-1991		-1,968	154	587	-\$322	-\$244	0	-\$11,369	0	-\$7,851	0	-\$4,478
	1992-2010		-1,624	138	604	-\$242	-\$182	0	-\$9,514	0	-\$6,463	0	-\$3,732
Heat Pump at HVAC Replacement + PV	Pre-1978	\$6,969	663	213	1,056	\$429	\$354	1.38	\$2,931	1.04	\$264	1.38	\$2,678
	1978-1991		1,258	154	738	\$507	\$411	1.60	\$4,637	1.10	\$705	1.31	\$2,133
	1992-2010		1,634	138	773	\$593	\$477	1.86	\$6,621	1.33	\$2,298	0.99	-\$60
HVAC HP Replacement w/ Panel Upgrade + PV	Pre-1978	\$10,150	663	213	1,056	\$429	\$354	0.94	-\$641	0.71	-\$2,917	0.95	-\$503
	1978-1991		1,258	154	738	\$507	\$411	1.09	\$1,065	0.76	-\$2,476	0.90	-\$1,048
	1992-2010		1,634	138	773	\$593	\$477	1.27	\$3,049	0.91	-\$883	0.99	-\$60
HPWH at Water Heater Replacement	Pre-1978	\$2,594	-1,304	164	1,292	-\$212	-\$155	0	-\$7,548	0	-\$3,945	1.31	\$802
	1978-1991		-1,308	165	1,299	-\$222	-\$163	0	-\$7,793	0	-\$3,879	1.32	\$831
	1992-2010		-1,309	165	1,301	-\$228	-\$169	0	-\$7,962	0	-\$3,870	1.32	\$819
NEEA Tier 3 HPWH at Replacement	Pre-1978	\$2,775	-987	163	1,405	-\$110	-\$75	0	-\$5,324	0.21	-\$2,181	1.81	\$2,254
	1978-1991		-990	164	1,415	-\$118	-\$82	0	-\$5,548	0.23	-\$2,147	1.83	\$2,312
	1992-2010		-992	165	1,416	-\$125	-\$88	0	-\$5,725	0.23	-\$2,124	1.82	\$2,289
HPWH at Water Heater Replacement + PV	Pre-1978	\$9,061	2,158	164	1,551	\$780	\$628	1.87	\$8,783	1.36	\$3,227	1.62	\$5,620
	1978-1991		2,154	165	1,559	\$765	\$615	1.84	\$8,410	1.36	\$3,290	1.62	\$5,646
	1992-2010		2,153	165	1,561	\$756	\$608	1.82	\$8,187	1.36	\$3,302	1.62	\$5,635
HPWH Replacement w/ Panel Upgrade + PV	Pre-1978	\$12,242	2,158	164	1,551	\$780	\$628	1.38	\$5,211	1.00	\$46	1.20	\$2,439
	1978-1991		2,154	165	1,559	\$765	\$615	1.36	\$4,838	1.01	\$109	1.20	\$2,465
	1992-2010		2,153	165	1,561	\$756	\$608	1.34	\$4,615	1.01	\$121	1.20	\$2,454

Measure	Vintage	Measure Cost (\$)	Electricity Savings (kWh)	Gas Savings (therm)	GHG Savings (lb CO ₂ e)	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
PV + Electric Ready Pre-Wire	Pre-1978	\$10,558	3,463	0	259	\$851	\$672	1.72	\$8,406	1.27	\$2,870	1.05	\$528
	1978-1991		3,463	0	259	\$828	\$654	1.67	\$7,865	1.27	\$2,864	1.05	\$526
	1992-2010		3,463	0	259	\$818	\$646	1.65	\$7,625	1.27	\$2,864	1.05	\$526

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 58: CZ 6 - Single Family Efficiency Upgrade Cost-Effectiveness Results

Measure	Vintage	Measure Cost (\$)	Electricity Savings (kWh)	Gas Savings (therm)	GHG Savings (lb CO ₂ e)	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	\$3,332	547	18	273	\$218	\$174	1.40	\$1,489	1.60	\$1,987	1.32	\$1,050
	1978-1991	\$2,874	254	7	112	\$97	\$77	0.72	-\$909	0.82	-\$505	0.72	-\$808
	1992-2010	\$1,852	54	3	43	\$21	\$17	0.25	-\$1,567	0.34	-\$1,227	0.36	-\$1,193
Reduced Infiltration	Pre-1978	\$1,474	-12	5	50	\$1	\$1	0.02	-\$1,614	0.23	-\$1,131	0.22	-\$1,146
	1978-1991		-7	3	32	\$1	\$1	0.02	-\$1,625	0.13	-\$1,275	0.15	-\$1,246
	1992-2010		-3	2	20	\$1	\$1	0.03	-\$1,613	0.10	-\$1,324	0.09	-\$1,347
Duct Sealing	Pre-1978	\$683	182	8	121	\$78	\$63	2.46	\$1,123	3.30	\$1,572	3.18	\$1,486
	1978-1991	\$683	98	4	63	\$41	\$33	1.29	\$224	1.72	\$492	1.89	\$610
	1992-2010	\$423	12	1	14	\$5	\$4	0.27	-\$348	0.52	-\$201	0.55	-\$190
New Ducts	Pre-1978	\$3,986	340	16	229	\$147	\$118	0.79	-\$933	1.08	\$309	1.03	\$133
	1978-1991		227	9	147	\$96	\$77	0.52	-\$2,161	0.73	-\$1,083	0.76	-\$944
	1992-2010		41	4	52	\$19	\$15	0.10	-\$4,019	0.20	-\$3,200	0.21	-\$3,145
Cool Roof	Pre-1978	\$778	277	0	52	\$104	\$82	2.90	\$1,611	3.71	\$1,566	2.32	\$1,025
	1978-1991		132	-2	5	\$47	\$37	1.30	\$251	1.51	\$293	1.12	\$92
	1992-2010		54	-2	-2	\$16	\$13	0.45	-\$470	0.50	-\$286	0.54	-\$360
R-13 Wall Insulation	Pre-1978	\$3,360	41	18	185	\$34	\$29	0.23	-\$2,908	0.51	-\$1,643	0.44	-\$1,877
Windows	Pre-1978	\$9,810	643	-3	76	\$235	\$185	0.50	-\$5,459	0.48	-\$5,089	0.45	-\$5,440
	1978-1991		521	-3	83	\$192	\$151	0.41	-\$6,472	0.39	-\$5,953	0.44	-\$5,515
LED lamp vs CFL	All	\$2.26	1.2	0	n/a	\$0.31	\$0.25	3.27	\$5.11	n/a	n/a	n/a	n/a
Exterior Photosensor	All	\$42.58	12.1	0	n/a	\$2.00	\$1.58	1.11	\$4.84	n/a	n/a	n/a	n/a

Table 59: CZ 6 - Single Family Efficiency Packages Cost-Effectiveness Results

Measure	Vintage	Measure Cost (\$)	Electricity Savings (kWh)	Gas Savings (therm)	GHG Savings (lb CO ₂ e)	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	\$4,806	536	24	327	\$220	\$176	0.98	-\$104	1.18	\$876	0.99	-\$64
	1978-1991	\$4,348	245	10	142	\$97	\$78	0.48	-\$2,551	0.59	-\$1,771	0.52	-\$2,083
	1992-2010	\$3,326	52	5	64	\$23	\$19	0.15	-\$3,174	0.24	-\$2,540	0.24	-\$2,540
R49 Attic & Duct Sealing Package	Pre-1978	\$4,015	668	25	373	\$272	\$218	1.45	\$2,019	1.75	\$3,029	1.54	\$2,176
	1978-1991	\$3,557	327	11	165	\$128	\$103	0.77	-\$914	0.94	-\$208	0.88	-\$411
	1992-2010	\$2,275	63	4	56	\$25	\$21	0.24	-\$1,938	0.36	-\$1,460	0.38	-\$1,411
R49 Attic, Air Sealing & Duct Sealing Package	Pre-1978	\$5,489	657	30	419	\$272	\$219	1.06	\$398	1.34	\$1,875	1.18	\$993
	1978-1991	\$5,031	317	13	191	\$127	\$102	0.54	-\$2,580	0.70	-\$1,507	0.66	-\$1,735
	1992-2010	\$3,749	61	6	76	\$27	\$22	0.16	-\$3,546	0.26	-\$2,781	0.26	-\$2,764
R49 Attic, Air Sealing & New Ducts Package	Pre-1978	\$8,792	777	36	511	\$325	\$261	0.79	-\$2,044	1.04	\$346	0.94	-\$510
	1978-1991	\$8,334	428	18	265	\$175	\$140	0.45	-\$5,151	0.61	-\$3,266	0.59	-\$3,396
	1992-2010	\$7,312	86	8	109	\$38	\$31	0.11	-\$7,273	0.20	-\$5,840	0.21	-\$5,777
Advanced Envelope Package	Pre-1978	\$18,659	1,056	52	731	\$445	\$358	0.51	-\$10,204	0.67	-\$6,243	0.62	-\$7,131
Water Heating Package	All Vintages	\$208	0	17	n/a	\$23	\$21	1.38	\$88	n/a	n/a	n/a	n/a

Table 60: CZ 6 - Single Family PV & Battery Cost-Effectiveness Results

Measure	Vintage	Measure Cost (\$)	Electricity Savings (kWh)	Gas Savings (therm)	GHG Savings (lb CO ₂ e)	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	\$7,056	3,858	0	306	\$800	\$631	2.43	\$11,140	1.92	\$6,468	1.81	\$5,708
	1978-1991		3,858		306	\$771	\$609	2.34	\$10,455	1.91	\$6,454	1.81	\$5,687
	1992-2010	\$6,963 ^a	3,806		302	\$724	\$571	2.23	\$9,436	1.91	\$6,445	1.80	\$5,592
PV + Battery	Pre-1978	\$18,428	3,643	0	992	\$969	\$765	1.16	\$3,099	1.11	\$2,084	0.97	-\$578
	1978-1991		3,641		1,016	\$938	\$740	1.12	\$2,356	1.12	\$2,150	0.98	-\$414
	1992-2010		3,640		1,054	\$788	\$622	0.94	-\$1,198	1.10	\$1,853	1.03	\$612

^aThe 1992-2010 vintage was evaluated with a 2.18kW PV system instead of a 2.22kW system in the other vintages to avoid over-generation of PV electricity on an annual basis.

Table 61: CZ 6 - Single Family Equipment Fuel Substitution Cost-Effectiveness Results

Measure	Vintage	Measure Cost (\$)	Electricity Savings (kWh)	Gas Savings (therm)	GHG Savings (lb CO ₂ e)	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	\$501	-700	67	311	-\$121	-\$87	0	-\$3,158	0	-\$1,377	0.97	-\$18
	1978-1991		-435	40	171	-\$76	-\$55	0	-\$2,195	0	-\$1,216	0.33	-\$334
	1992-2010		-365	34	149	-\$61	-\$44	0	-\$1,865	0	-\$1,034	0.34	-\$329
High-Effic. Heat Pump at HVAC Replacement	Pre-1978	\$3,749	-402	67	417	-\$21	-\$7	0	-\$4,281	0.44	-\$2,087	0.77	-\$852
	1978-1991		-240	40	243	-\$9	-\$2	0	-\$4,112	0.28	-\$2,718	0.52	-\$1,802
	1992-2010		-250	34	198	-\$24	-\$15	0	-\$4,504	0.15	-\$3,185	0.35	-\$2,450
Heat Pump at HVAC Replacement + PV	Pre-1978	\$7,557	3,158	67	617	\$702	\$563	2.02	\$8,529	1.68	\$5,108	1.75	\$5,693
	1978-1991		3,423	40	478	\$708	\$564	2.03	\$8,582	1.69	\$5,247	1.71	\$5,353
	1992-2010		3,493	34	455	\$696	\$554	1.99	\$8,261	1.72	\$5,425	1.71	\$5,336
HVAC HP Replacement w/ Panel Upgrade + PV	Pre-1978	\$10,738	3,158	67	617	\$702	\$563	1.42	\$4,957	1.18	\$1,927	1.23	\$2,512
	1978-1991		3,423	40	478	\$708	\$564	1.42	\$5,010	1.19	\$2,066	1.20	\$2,172
	1992-2010		3,493	34	455	\$696	\$554	1.39	\$4,689	1.21	\$2,244	1.20	\$2,155
HPWH at Water Heater Replacement	Pre-1978	\$2,594	-971	153	1,264	-\$90	-\$52	0	-\$4,451	0.21	-\$2,041	1.68	\$1,764
	1978-1991		-975	153	1,267	-\$88	-\$50	0	-\$4,390	0.20	-\$2,073	1.68	\$1,758
	1992-2010		-984	154	1,267	-\$84	-\$47	0	-\$4,311	0.18	-\$2,121	1.66	\$1,724
NEEA Tier 3 HPWH at Replacement	Pre-1978	\$2,775	-798	153	1,347	-\$34	-\$8	0	-\$3,329	0.59	-\$1,150	1.94	\$2,609
	1978-1991		-803	153	1,350	-\$32	-\$6	0	-\$3,272	0.58	-\$1,176	1.94	\$2,612
	1992-2010		-813	153	1,350	-\$30	-\$4	0	-\$3,223	0.56	-\$1,234	1.93	\$2,568
HPWH at Water Heater Replacement + PV	Pre-1978	\$9,650	2,887	153	1,570	\$771	\$627	1.76	\$8,125	1.48	\$4,626	1.79	\$7,656
	1978-1991		2,883	153	1,573	\$741	\$604	1.69	\$7,425	1.47	\$4,583	1.79	\$7,630
	1992-2010		2,874	154	1,573	\$701	\$572	1.61	\$6,478	1.47	\$4,525	1.79	\$7,576
HPWH Replacement w/ Panel Upgrade + PV	Pre-1978	\$12,831	2,887	153	1,570	\$771	\$627	1.32	\$4,553	1.11	\$1,445	1.35	\$4,475
	1978-1991		2,883	153	1,573	\$741	\$604	1.27	\$3,853	1.11	\$1,402	1.35	\$4,449
	1992-2010		2,874	154	1,573	\$701	\$572	1.20	\$2,906	1.10	\$1,344	1.34	\$4,395

Measure	Vintage	Measure Cost (\$)	Electricity Savings (kWh)	Gas Savings (therm)	GHG Savings (lb CO ₂ e)	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
PV + Electric Ready Pre-Wire	Pre-1978	\$11,147	3,858	0	306	\$800	\$631	1.53	\$6,546	1.21	\$2,377	1.15	\$1,617
	1978-1991		3,858	0	306	\$771	\$609	1.47	\$5,861	1.21	\$2,363	1.14	\$1,596
	1992-2010		3,806	0	302	\$724	\$571	1.38	\$4,740	1.21	\$2,354	1.13	\$1,409

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 62: CZ 7 - Single Family Efficiency Upgrade Cost-Effectiveness Results

Measure	Vintage	Measure Cost (\$)	Electricity Savings (kWh)	Gas Savings (therm)	GHG Savings (lb CO ₂ e)	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	\$3,332	515	14	241	\$286	\$228	1.83	\$3,098	1.26	\$856	1.11	\$351
	1978-1991	\$2,874	227	5	94	\$124	\$99	0.92	-\$266	0.69	-\$898	0.56	-\$1,277
	1992-2010	\$1,852	49	2	37	\$30	\$24	0.34	-\$1,367	0.36	-\$1,190	0.28	-\$1,337
Reduced Infiltration	Pre-1978	\$1,474	-23	4	30	-\$5	-\$4	0	-\$1,768	0.05	-\$1,393	0.02	-\$1,439
	1978-1991		-12	2	18	-\$3	-\$2	0	-\$1,711	0.02	-\$1,445	0.04	-\$1,422
	1992-2010		-4	2	13	\$0	\$0	0.01	-\$1,642	0.03	-\$1,437	0.04	-\$1,419
Duct Sealing	Pre-1978	\$683	149	5	86	\$93	\$74	2.89	\$1,449	1.85	\$579	1.87	\$596
	1978-1991	\$683	76	2	41	\$48	\$38	1.50	\$381	0.94	-\$41	0.99	-\$9
	1992-2010	\$423	10	1	9	\$7	\$5	0.33	-\$318	0.21	-\$334	0.30	-\$296
New Ducts	Pre-1978	\$3,986	318	11	176	\$196	\$156	1.05	\$213	0.67	-\$1,324	0.67	-\$1,307
	1978-1991		218	6	114	\$136	\$108	0.72	-\$1,241	0.46	-\$2,168	0.49	-\$2,033
	1992-2010		44	2	38	\$28	\$23	0.15	-\$3,796	0.10	-\$3,600	0.14	-\$3,442
Cool Roof	Pre-1978	\$778	278	0	57	\$146	\$115	4.07	\$2,607	2.97	\$1,137	2.01	\$783
	1978-1991		119	-2	11	\$63	\$49	1.74	\$625	1.40	\$232	0.83	-\$136
	1992-2010		51	-1	3	\$25	\$19	0.68	-\$274	0.72	-\$162	0.43	-\$447
R-13 Wall Insulation	Pre-1978	\$3,360	26	14	137	\$35	\$30	0.23	-\$2,887	0.27	-\$2,447	0.28	-\$2,418
Windows	Pre-1978	\$9,810	541	-6	43	\$279	\$219	0.60	-\$4,439	0.34	-\$6,483	0.29	-\$6,984
	1978-1991		416	-4	63	\$226	\$178	0.49	-\$5,670	0.35	-\$6,328	0.27	-\$7,195
LED lamp vs CFL	All	\$2.26	1.2	0	n/a	\$0.44	\$0.35	4.63	\$8.20	n/a	n/a	n/a	n/a
Exterior Photosensor	All	\$42.58	12.1	0	n/a	\$2.76	\$2.18	1.54	\$22.81	n/a	n/a	n/a	n/a

Table 63: CZ 7 - Single Family Efficiency Packages Cost-Effectiveness Results

Measure	Vintage	Measure Cost (\$)	Electricity Savings (kWh)	Gas Savings (therm)	GHG Savings (lb CO ₂ e)	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	\$4,806	500	18	274	\$284	\$227	1.26	\$1,402	0.89	-\$531	0.79	-\$999
	1978-1991	\$4,348	215	8	112	\$121	\$96	0.59	-\$1,993	0.46	-\$2,349	0.38	-\$2,708
	1992-2010	\$3,326	45	4	50	\$30	\$24	0.19	-\$3,008	0.21	-\$2,615	0.17	-\$2,759
R49 Attic & Duct Sealing Package	Pre-1978	\$4,015	615	19	310	\$351	\$279	1.86	\$3,869	1.27	\$1,086	1.17	\$702
	1978-1991	\$3,557	288	7	130	\$162	\$129	0.97	-\$122	0.71	-\$1,045	0.62	-\$1,355
	1992-2010	\$2,275	57	3	45	\$35	\$28	0.33	-\$1,712	0.32	-\$1,547	0.28	-\$1,644
R49 Attic, Air Sealing & Duct Sealing Package	Pre-1978	\$5,489	600	22	339	\$348	\$278	1.35	\$2,168	0.94	-\$304	0.88	-\$674
	1978-1991	\$5,031	277	9	146	\$159	\$127	0.68	-\$1,835	0.50	-\$2,496	0.45	-\$2,786
	1992-2010	\$3,749	54	4	59	\$36	\$29	0.20	-\$3,349	0.21	-\$2,977	0.18	-\$3,064
R49 Attic, Air Sealing & New Ducts Package	Pre-1978	\$8,792	735	26	414	\$433	\$345	1.05	\$489	0.72	-\$2,461	0.69	-\$2,713
	1978-1991	\$8,334	401	12	209	\$237	\$189	0.61	-\$3,694	0.42	-\$4,820	0.41	-\$4,919
	1992-2010	\$7,312	83	6	84	\$55	\$44	0.16	-\$6,893	0.14	-\$6,304	0.15	-\$6,247
Advanced Envelope Package	Pre-1978	\$18,659	922	37	565	\$552	\$441	0.63	-\$7,734	0.48	-\$9,611	0.43	-\$10,707
Water Heating Package	All Vintages	\$208	0	17	n/a	\$31	\$29	1.86	\$200	n/a	n/a	n/a	n/a

Table 64: CZ 7 - Single Family PV & Battery Cost-Effectiveness Results

Measure	Vintage	Measure Cost (\$)	Electricity Savings (kWh)	Gas Savings (therm)	GHG Savings (lb CO ₂ e)	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	\$6,685	3,425	0	289	\$1,151	\$909	3.69	\$19,872	2.00	\$6,692	1.67	\$4,494
	1978-1991		3,425		289	\$1,192	\$941	3.82	\$20,837	2.00	\$6,683	1.67	\$4,474
	1992-2010		3,425		289	\$1,158	\$914	3.71	\$20,029	2.00	\$6,680	1.67	\$4,457
PV + Battery	Pre-1978	\$18,057	3,237	0	871	\$1,230	\$971	1.50	\$9,690	1.12	\$2,169	0.88	-\$2,189
	1978-1991		3,237		892	\$1,270	\$1,003	1.55	\$10,633	1.13	\$2,302	0.90	-\$1,794
	1992-2010		3,235		923	\$1,174	\$927	1.43	\$8,352	1.12	\$2,100	0.95	-\$844

Table 65: CZ 7 - Single Family Equipment Fuel Substitution Cost-Effectiveness Results

Measure	Vintage	Measure Cost (\$)	Electricity Savings (kWh)	Gas Savings (therm)	GHG Savings (lb CO ₂ e)	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	\$501	-441	44	212	-\$142	-\$106	0	-\$3,716	0	-\$715	0.91	-\$43
	1978-1991		-258	24	106	-\$100	-\$75	0	-\$2,803	0	-\$703	0.34	-\$331
	1992-2010		-217	21	93	-\$83	-\$63	0	-\$2,428	0	-\$674	0.33	-\$334
High-Effic. Heat Pump at HVAC Replacement	Pre-1978	\$3,749	-194	44	301	-\$16	-\$6	0	-\$4,250	0.39	-\$2,303	0.58	-\$1,580
	1978-1991		-96	24	167	-\$14	-\$8	0	-\$4,300	0.24	-\$2,845	0.38	-\$2,335
	1992-2010		-122	21	134	-\$35	-\$25	0	-\$4,801	0.10	-\$3,363	0.25	-\$2,796
Heat Pump at HVAC Replacement + PV	Pre-1978	\$7,186	2,984	44	501	\$1,058	\$841	3.18	\$17,298	1.83	\$5,983	1.62	\$4,451
	1978-1991		3,168	24	395	\$1,119	\$887	3.35	\$18,661	1.83	\$5,983	1.58	\$4,143
	1992-2010		3,209	21	382	\$1,110	\$879	3.32	\$18,425	1.84	\$6,009	1.57	\$4,125
HVAC HP Replacement w/ Panel Upgrade + PV	Pre-1978	\$10,367	2,984	44	501	\$1,058	\$841	2.19	\$13,726	1.27	\$2,802	1.12	\$1,270
	1978-1991		3,168	24	395	\$1,119	\$887	2.31	\$15,089	1.27	\$2,802	1.09	\$962
	1992-2010		3,209	21	382	\$1,110	\$879	2.29	\$14,853	1.27	\$2,828	1.09	\$944
HPWH at Water Heater Replacement	Pre-1978	\$2,594	-953	153	1,267	-\$92	-\$52	0	-\$4,445	0.18	-\$2,116	1.73	\$1,897
	1978-1991		-961	153	1,274	-\$87	-\$48	0	-\$4,327	0.18	-\$2,121	1.76	\$1,966
	1992-2010		-969	153	1,272	-\$85	-\$46	0	-\$4,273	0.17	-\$2,142	1.74	\$1,917
NEEA Tier 3 HPWH at Replacement	Pre-1978	\$2,775	-777	153	1,352	-\$18	\$7	0.07	-\$2,878	0.56	-\$1,228	1.97	\$2,698
	1978-1991		-786	153	1,355	-\$14	\$10	0.10	-\$2,791	0.55	-\$1,242	1.97	\$2,686
	1992-2010		-796	153	1,353	-\$14	\$10	0.10	-\$2,792	0.54	-\$1,265	1.95	\$2,638
HPWH at Water Heater Replacement + PV	Pre-1978	\$9,279	2,472	153	1,556	\$1,047	\$847	2.47	\$15,138	1.51	\$4,766	1.71	\$6,561
	1978-1991		2,464	153	1,562	\$1,026	\$831	2.42	\$14,639	1.51	\$4,755	1.71	\$6,613
	1992-2010		2,456	153	1,561	\$985	\$798	2.33	\$13,665	1.51	\$4,732	1.71	\$6,549
HPWH Replacement w/ Panel Upgrade + PV	Pre-1978	\$12,460	2,472	153	1,556	\$1,047	\$847	1.83	\$11,566	1.13	\$1,585	1.27	\$3,380
	1978-1991		2,464	153	1,562	\$1,026	\$831	1.80	\$11,067	1.13	\$1,574	1.28	\$3,432
	1992-2010		2,456	153	1,561	\$985	\$798	1.73	\$10,093	1.12	\$1,551	1.27	\$3,368

Measure	Vintage	Measure Cost (\$)	Electricity Savings (kWh)	Gas Savings (therm)	GHG Savings (lb CO ₂ e)	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
PV + Electric Ready Pre-Wire	Pre-1978	\$10,776	3,425	0	289	\$1,151	\$909	2.27	\$15,279	1.24	\$2,601	1.04	\$403
	1978-1991		3,425	0	289	\$1,192	\$941	2.36	\$16,243	1.24	\$2,592	1.04	\$383
	1992-2010		3,425	0	289	\$1,158	\$914	2.29	\$15,435	1.24	\$2,589	1.03	\$366

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 66: CZ 8 - Single Family Efficiency Upgrade Cost-Effectiveness Results

Measure	Vintage	Measure Cost (\$)	Electricity Savings (kWh)	Gas Savings (therm)	GHG Savings (lb CO ₂ e)	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	\$3,332	913	15	246	\$328	\$261	2.09	\$4,075	1.84	\$2,796	2.06	\$3,541
	1978-1991	\$2,874	487	7	119	\$176	\$140	1.30	\$973	1.19	\$555	1.38	\$1,099
	1992-2010	\$1,852	124	3	45	\$48	\$39	0.56	-\$921	0.63	-\$694	0.69	-\$568
Reduced Infiltration	Pre-1978	\$1,474	9	4	42	\$7	\$6	0.12	-\$1,463	0.29	-\$1,045	0.34	-\$976
	1978-1991		-1	3	20	\$2	\$2	0.04	-\$1,596	0.22	-\$1,143	0.30	-\$1,030
	1992-2010		1	2	14	\$2	\$2	0.03	-\$1,599	0.15	-\$1,252	0.20	-\$1,174
Duct Sealing	Pre-1978	\$683	575	7	151	\$217	\$172	6.74	\$4,402	7.33	\$4,326	9.09	\$5,527
	1978-1991	\$683	340	3	87	\$130	\$103	4.04	\$2,330	4.55	\$2,422	5.75	\$3,243
	1992-2010	\$423	58	1	21	\$23	\$18	1.16	\$77	1.42	\$179	1.82	\$346
New Ducts	Pre-1978	\$3,986	1,040	14	280	\$394	\$313	2.09	\$4,901	2.32	\$5,257	2.89	\$7,516
	1978-1991		775	8	201	\$298	\$236	1.58	\$2,603	1.82	\$3,276	2.29	\$5,134
	1992-2010		202	3	75	\$82	\$65	0.43	-\$2,533	0.55	-\$1,785	0.67	-\$1,304
Cool Roof	Pre-1978	\$778	422	-2	27	\$144	\$113	3.99	\$2,541	4.09	\$1,782	3.94	\$2,284
	1978-1991		303	-2	28	\$106	\$83	2.95	\$1,656	3.35	\$1,358	2.99	\$1,550
	1992-2010		135	-1	12	\$48	\$38	1.34	\$288	1.68	\$394	1.59	\$461
R-13 Wall Insulation	Pre-1978	\$3,360	151	16	181	\$71	\$58	0.46	-\$2,038	0.69	-\$1,053	0.77	-\$776
Windows	Pre-1978	\$9,810	1,105	-2	91	\$375	\$296	0.81	-\$2,147	0.71	-\$2,851	0.82	-\$1,791
	1978-1991		891	-1	94	\$313	\$247	0.67	-\$3,611	0.65	-\$3,479	0.73	-\$2,675
LED lamp vs CFL	All	\$2.26	1.2	0	n/a	\$0.35	\$0.28	3.68	\$6.04	n/a	n/a	n/a	n/a
Exterior Photosensor	All	\$42.58	12.1	0	n/a	\$2.00	\$1.58	1.11	\$4.84	n/a	n/a	n/a	n/a

Table 67: CZ 8 - Single Family Efficiency Packages Cost-Effectiveness Results

Measure	Vintage	Measure Cost (\$)	Electricity Savings (kWh)	Gas Savings (therm)	GHG Savings (lb CO ₂ e)	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	\$4,806	916	19	284	\$333	\$265	1.48	\$2,564	1.38	\$1,829	1.58	\$2,810
	1978-1991	\$4,348	485	10	139	\$178	\$142	0.87	-\$624	0.85	-\$639	1.02	\$97
	1992-2010	\$3,326	125	4	59	\$51	\$41	0.33	-\$2,520	0.41	-\$1,961	0.47	-\$1,759
R49 Attic & Duct Sealing Package	Pre-1978	\$4,015	1,382	20	385	\$508	\$404	2.69	\$7,605	2.63	\$6,529	3.09	\$8,403
	1978-1991	\$3,557	772	10	195	\$287	\$228	1.71	\$2,840	1.75	\$2,655	2.13	\$4,025
	1992-2010	\$2,275	175	3	63	\$69	\$55	0.64	-\$908	0.74	-\$587	0.89	-\$242
R49 Attic, Air Sealing & Duct Sealing Package	Pre-1978	\$5,489	1,377	24	416	\$510	\$406	1.98	\$6,011	2.01	\$5,533	2.38	\$7,597
	1978-1991	\$5,031	779	12	222	\$292	\$232	1.23	\$1,300	1.28	\$1,403	1.55	\$2,767
	1992-2010	\$3,749	177	5	79	\$71	\$57	0.41	-\$2,498	0.51	-\$1,854	0.59	-\$1,523
R49 Attic, Air Sealing & New Ducts Package	Pre-1978	\$8,792	1,820	29	548	\$681	\$542	1.65	\$6,373	1.73	\$6,410	2.08	\$9,462
	1978-1991	\$8,334	1,186	16	330	\$450	\$357	1.15	\$1,360	1.26	\$2,129	1.54	\$4,522
	1992-2010	\$7,312	314	7	131	\$127	\$101	0.37	-\$5,172	0.46	-\$3,928	0.55	-\$3,262
Advanced Envelope Package	Pre-1978	\$18,659	2,129	44	706	\$799	\$636	0.91	-\$1,862	0.98	-\$355	1.13	\$2,444
Water Heating Package	All Vintages	\$208	0	17	n/a	\$23	\$22	1.39	\$90	n/a	n/a	n/a	n/a

Table 68: CZ 8 - Single Family PV & Battery Cost-Effectiveness Results

Measure	Vintage	Measure Cost (\$)	Electricity Savings (kWh)	Gas Savings (therm)	GHG Savings (lb CO ₂ e)	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	\$7,458	3,929	0	312	\$895	\$706	2.57	\$12,934	1.96	\$7,166	1.87	\$6,506
	1978-1991		3,929		312	\$886	\$699	2.54	\$12,728	1.96	\$7,140	1.87	\$6,466
	1992-2010		3,929		312	\$813	\$642	2.34	\$11,013	1.95	\$7,111	1.86	\$6,414
PV + Battery	Pre-1978	\$18,831	3,719	0	873	\$1,070	\$845	1.25	\$5,041	1.09	\$1,787	0.98	-\$284
	1978-1991		3,714		906	\$1,067	\$842	1.25	\$4,974	1.12	\$2,294	1.00	-\$42
	1992-2010		3,710		976	\$1,001	\$790	1.17	\$3,391	1.15	\$2,773	1.01	\$238

Table 69: CZ 8 - Single Family Equipment Fuel Substitution Cost-Effectiveness Results

Measure	Vintage	Measure Cost (\$)	Electricity Savings (kWh)	Gas Savings (therm)	GHG Savings (lb CO ₂ e)	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	\$501	-568	55	250	-\$96	-\$69	0	-\$2,607	0	-\$692	0.81	-\$95
	1978-1991		-362	33	145	-\$66	-\$47	0	-\$1,967	0	-\$700	0.33	-\$334
	1992-2010		-296	27	120	-\$56	-\$40	0.00	-\$1,756	0	-\$660	0.29	-\$355
High-Effic. Heat Pump at HVAC Replacement	Pre-1978	\$3,749	-15	55	401	\$97	\$83	0.62	-\$1,556	1.03	\$108	1.30	\$1,124
	1978-1991		66	33	264	\$87	\$73	0.54	-\$1,863	0.81	-\$719	1.01	\$33
	1992-2010		-9	27	215	\$47	\$40	0.30	-\$2,843	0.56	-\$1,658	0.71	-\$1,079
Heat Pump at HVAC Replacement + PV	Pre-1978	\$7,960	3,361	55	562	\$807	\$644	2.20	\$10,520	1.81	\$6,486	1.81	\$6,408
	1978-1991		3,567	33	457	\$806	\$640	2.18	\$10,412	1.81	\$6,448	1.77	\$6,128
	1992-2010		3,633	27	432	\$771	\$612	2.09	\$9,579	1.81	\$6,465	1.76	\$6,059
HVAC HP Replacement w/ Panel Upgrade + PV	Pre-1978	\$11,141	3,361	55	562	\$807	\$644	1.56	\$6,948	1.30	\$3,305	1.29	\$3,227
	1978-1991		3,567	33	457	\$806	\$640	1.55	\$6,840	1.29	\$3,267	1.26	\$2,947
	1992-2010		3,633	27	432	\$771	\$612	1.49	\$6,007	1.29	\$3,284	1.26	\$2,878
HPWH at Water Heater Replacement	Pre-1978	\$2,594	-888	149	1,239	-\$85	-\$48	0	-\$4,343	0.39	-\$1,580	1.81	\$2,093
	1978-1991		-900	149	1,239	-\$85	-\$49	0	-\$4,347	0.39	-\$1,577	1.83	\$2,147
	1992-2010		-908	149	1,241	-\$84	-\$48	0	-\$4,326	0.38	-\$1,620	1.78	\$2,032
NEEA Tier 3 HPWH at Replacement	Pre-1978	\$2,775	-717	149	1,318	-\$31	-\$6	0	-\$3,260	0.68	-\$882	2.01	\$2,793
	1978-1991		-732	149	1,317	-\$32	-\$7	0	-\$3,289	0.69	-\$871	2.04	\$2,894
	1992-2010		-740	149	1,320	-\$31	-\$6	0	-\$3,264	0.67	-\$926	1.99	\$2,735
HPWH at Water Heater Replacement + PV	Pre-1978	\$10,052	3,041	149	1,551	\$861	\$698	1.88	\$9,793	1.57	\$5,776	1.87	\$8,769
	1978-1991		3,029	149	1,551	\$850	\$689	1.86	\$9,541	1.57	\$5,758	1.87	\$8,786
	1992-2010		3,021	149	1,553	\$794	\$645	1.74	\$8,208	1.57	\$5,689	1.86	\$8,622
HPWH Replacement w/ Panel Upgrade + PV	Pre-1978	\$13,233	3,041	149	1,551	\$861	\$698	1.42	\$6,221	1.20	\$2,595	1.42	\$5,588
	1978-1991		3,029	149	1,551	\$850	\$689	1.41	\$5,969	1.19	\$2,577	1.42	\$5,605
	1992-2010		3,021	149	1,553	\$794	\$645	1.32	\$4,636	1.19	\$2,508	1.41	\$5,441

Measure	Vintage	Measure Cost (\$)	Electricity Savings (kWh)	Gas Savings (therm)	GHG Savings (lb CO ₂ e)	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
PV + Electric Ready Pre-Wire	Pre-1978	\$11,549	3,929	0	312	\$895	\$706	1.65	\$8,340	1.27	\$3,075	1.21	\$2,415
	1978-1991		3,929	0	312	\$886	\$699	1.63	\$8,135	1.26	\$3,049	1.21	\$2,375
	1992-2010		3,929	0	312	\$813	\$642	1.50	\$6,420	1.26	\$3,020	1.20	\$2,323

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 70: CZ 9 - Single Family Efficiency Upgrade Cost-Effectiveness Results

Measure	Vintage	Measure Cost (\$)	Electricity Savings (kWh)	Gas Savings (therm)	GHG Savings (lb CO ₂ e)	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	\$3,332	840	19	289	\$311	\$248	1.99	\$3,702	2.22	\$4,054	2.04	\$3,463
	1978-1991	\$2,874	455	9	152	\$167	\$133	1.24	\$762	1.36	\$1,021	1.21	\$603
	1992-2010	\$1,852	115	3	58	\$44	\$36	0.51	-\$1,015	0.73	-\$507	0.66	-\$631
Reduced Infiltration	Pre-1978	\$1,474	25	6	62	\$15	\$12	0.22	-\$1,283	0.55	-\$665	0.44	-\$826
	1978-1991		12	3	33	\$8	\$7	0.12	-\$1,455	0.29	-\$1,042	0.35	-\$956
	1992-2010		7	2	23	\$5	\$4	0.07	-\$1,534	0.26	-\$1,094	0.21	-\$1,169
Duct Sealing	Pre-1978	\$683	544	11	206	\$212	\$168	6.59	\$4,287	10.65	\$6,593	8.86	\$5,372
	1978-1991	\$683	322	6	123	\$126	\$100	3.91	\$2,230	6.75	\$3,929	5.26	\$2,909
	1992-2010	\$423	54	2	30	\$22	\$17	1.10	\$47	2.38	\$582	1.76	\$320
New Ducts	Pre-1978	\$3,986	1,018	21	393	\$395	\$315	2.11	\$4,972	3.28	\$9,068	2.79	\$7,144
	1978-1991		764	13	290	\$298	\$237	1.59	\$2,633	2.55	\$6,165	2.17	\$4,670
	1992-2010		198	5	109	\$79	\$63	0.42	-\$2,586	0.86	-\$573	0.64	-\$1,437
Cool Roof	Pre-1978	\$778	396	-3	20	\$136	\$107	3.77	\$2,350	5.57	\$2,637	3.75	\$2,137
	1978-1991		284	-2	26	\$100	\$78	2.77	\$1,499	3.92	\$1,687	2.68	\$1,305
	1992-2010		128	-2	13	\$44	\$34	1.21	\$175	2.20	\$690	1.29	\$225
R-13 Wall Insulation	Pre-1978	\$3,360	170	21	238	\$82	\$68	0.54	-\$1,744	1.02	\$62	0.88	-\$393
Windows	Pre-1978	\$9,810	1,141	0	137	\$396	\$313	0.85	-\$1,637	0.94	-\$621	0.82	-\$1,719
	1978-1991		929	0	140	\$330	\$260	0.71	-\$3,210	0.78	-\$2,122	0.70	-\$2,897
LED lamp vs CFL	All	\$2.26	1.2	0	n/a	\$0.34	\$0.27	3.57	\$5.80	n/a	n/a	n/a	n/a
Exterior Photosensor	All	\$42.58	12.1	0	n/a	\$2.00	\$1.58	1.11	\$4.84	n/a	n/a	n/a	n/a

Table 71: CZ 9 - Single Family Efficiency Packages Cost-Effectiveness Results

Measure	Vintage	Measure Cost (\$)	Electricity Savings (kWh)	Gas Savings (therm)	GHG Savings (lb CO ₂ e)	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	\$4,806	864	25	353	\$325	\$260	1.44	\$2,394	1.70	\$3,358	1.54	\$2,580
	1978-1991	\$4,348	464	13	183	\$174	\$139	0.85	-\$712	1.06	\$244	0.94	-\$243
	1992-2010	\$3,326	121	6	81	\$49	\$39	0.32	-\$2,551	0.55	-\$1,494	0.46	-\$1,808
R49 Attic & Duct Sealing Package	Pre-1978	\$4,015	1,294	28	484	\$488	\$389	2.59	\$7,170	3.45	\$9,841	2.96	\$7,887
	1978-1991	\$3,557	735	14	266	\$277	\$220	1.65	\$2,612	2.26	\$4,497	1.89	\$3,163
	1992-2010	\$2,275	165	5	88	\$64	\$51	0.60	-\$1,010	1.03	\$58	0.81	-\$438
R49 Attic, Air Sealing & Duct Sealing Package	Pre-1978	\$5,489	1,303	34	532	\$497	\$397	1.93	\$5,739	2.70	\$9,352	2.31	\$7,188
	1978-1991	\$5,031	739	17	295	\$282	\$225	1.19	\$1,086	1.72	\$3,599	1.43	\$2,167
	1992-2010	\$3,749	171	7	110	\$69	\$55	0.39	-\$2,557	0.72	-\$1,062	0.56	-\$1,647
R49 Attic, Air Sealing & New Ducts Package	Pre-1978	\$8,792	1,747	42	719	\$670	\$535	1.62	\$6,166	2.34	\$11,812	2.00	\$8,828
	1978-1991	\$8,334	1,153	24	459	\$444	\$353	1.13	\$1,243	1.71	\$5,939	1.44	\$3,657
	1992-2010	\$7,312	305	11	183	\$122	\$98	0.36	-\$5,270	0.68	-\$2,306	0.54	-\$3,378
Advanced Envelope Package	Pre-1978	\$18,659	2,105	62	932	\$813	\$649	0.93	-\$1,469	1.32	\$5,955	1.15	\$2,881
Water Heating Package	All Vintages	\$208	0	17	n/a	\$23	\$21	1.38	\$88	n/a	n/a	n/a	n/a

Table 72: CZ 9 - Single Family PV & Battery Cost-Effectiveness Results

Measure	Vintage	Measure Cost (\$)	Electricity Savings (kWh)	Gas Savings (therm)	GHG Savings (lb CO ₂ e)	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	\$7,570	4,154	0	326	\$927	\$732	2.62	\$13,591	1.99	\$7,507	1.87	\$6,599
	1978-1991		4,154		326	\$902	\$712	2.55	\$12,979	1.99	\$7,475	1.87	\$6,568
	1992-2010		4,154		326	\$811	\$640	2.29	\$10,840	1.98	\$7,440	1.86	\$6,513
PV + Battery	Pre-1978	\$18,942	3,931	0	950	\$1,118	\$883	1.30	\$6,055	1.12	\$2,244	0.97	-\$631
	1978-1991		3,928		978	\$1,096	\$865	1.27	\$5,531	1.14	\$2,687	1.00	\$92
	1992-2010		3,926		1,040	\$1,000	\$789	1.16	\$3,247	1.17	\$3,186	1.06	\$1,051

Table 73: CZ 9 - Single Family Equipment Fuel Substitution Cost-Effectiveness Results

Measure	Vintage	Measure Cost (\$)	Electricity Savings (kWh)	Gas Savings (therm)	GHG Savings (lb CO ₂ e)	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	\$501	-921	86	387	-\$164	-\$118	0	-\$4,092	0	-\$902	1.15	\$78
	1978-1991		-638	57	243	-\$118	-\$85	0	-\$3,108	0	-\$861	0.49	-\$257
	1992-2010		-525	48	207	-\$93	-\$68	0	-\$2,572	0	-\$778	0.49	-\$257
High-Effic. Heat Pump at HVAC Replacement	Pre-1978	\$3,749	-341	86	567	\$34	\$38	0.28	-\$2,920	1.32	\$1,208	1.33	\$1,240
	1978-1991		-189	57	387	\$38	\$38	0.28	-\$2,930	1.05	\$180	1.01	\$50
	1992-2010		-223	48	319	\$10	\$14	0.10	-\$3,639	0.76	-\$901	0.73	-\$1,004
Heat Pump at HVAC Replacement + PV	Pre-1978	\$8,071	3,233	86	713	\$772	\$620	2.09	\$9,693	1.82	\$6,625	1.83	\$6,683
	1978-1991		3,516	57	569	\$775	\$619	2.08	\$9,666	1.82	\$6,628	1.78	\$6,311
	1992-2010		3,629	48	533	\$747	\$596	2.01	\$8,963	1.83	\$6,683	1.78	\$6,262
HVAC HP Replacement w/ Panel Upgrade + PV	Pre-1978	\$11,252	3,233	86	713	\$772	\$620	1.49	\$6,121	1.31	\$3,444	1.31	\$3,502
	1978-1991		3,516	57	569	\$775	\$619	1.49	\$6,094	1.31	\$3,447	1.28	\$3,130
	1992-2010		3,629	48	533	\$747	\$596	1.43	\$5,391	1.31	\$3,502	1.27	\$3,081
HPWH at Water Heater Replacement	Pre-1978	\$2,594	-913	150	1,246	-\$72	-\$38	0	-\$4,040	0.37	-\$1,626	1.83	\$2,142
	1978-1991		-921	150	1,250	-\$70	-\$36	0	-\$3,984	0.36	-\$1,672	1.82	\$2,121
	1992-2010		-932	150	1,249	-\$62	-\$30	0	-\$3,796	0.38	-\$1,612	1.82	\$2,136
NEEA Tier 3 HPWH at Replacement	Pre-1978	\$2,775	-744	150	1,323	-\$18	\$4	0.04	-\$2,955	0.70	-\$819	2.01	\$2,816
	1978-1991		-755	150	1,321	-\$17	\$5	0.05	-\$2,926	0.68	-\$888	2.09	\$3,018
	1992-2010		-764	150	1,326	-\$10	\$11	0.11	-\$2,762	0.72	-\$767	2.01	\$2,802
HPWH at Water Heater Replacement + PV	Pre-1978	\$10,163	3,242	150	1,572	\$893	\$724	1.93	\$10,447	1.60	\$6,077	1.88	\$8,931
	1978-1991		3,233	150	1,577	\$872	\$707	1.88	\$9,959	1.59	\$6,005	1.87	\$8,879
	1992-2010		3,222	150	1,576	\$788	\$640	1.71	\$7,947	1.59	\$6,030	1.87	\$8,842
HPWH Replacement w/ Panel Upgrade + PV	Pre-1978	\$13,344	3,242	150	1,572	\$893	\$724	1.46	\$6,875	1.22	\$2,896	1.43	\$5,750
	1978-1991		3,233	150	1,577	\$872	\$707	1.43	\$6,387	1.21	\$2,824	1.43	\$5,698
	1992-2010		3,222	150	1,576	\$788	\$640	1.29	\$4,375	1.21	\$2,849	1.42	\$5,661

Measure	Vintage	Measure Cost (\$)	Electricity Savings (kWh)	Gas Savings (therm)	GHG Savings (lb CO ₂ e)	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
PV + Electric Ready Pre-Wire	Pre-1978	\$11,661	4,154	0	326	\$927	\$732	1.69	\$8,997	1.29	\$3,416	1.22	\$2,508
	1978-1991		4,154	0	326	\$902	\$712	1.65	\$8,385	1.29	\$3,384	1.21	\$2,477
	1992-2010		4,154	0	326	\$811	\$640	1.48	\$6,246	1.29	\$3,349	1.21	\$2,422

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 74: CZ 10 (SCE/SoCalGas) - Single Family Efficiency Upgrade Cost-Effectiveness Results

Measure	Vintage	Measure Cost (\$)	Electricity Savings (kWh)	Gas Savings (therm)	GHG Savings (lb CO ₂ e)	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	\$3,332	1,013	23	333	\$369	\$295	2.37	\$5,109	2.27	\$4,236	2.01	\$3,357
	1978-1991	\$2,874	529	11	148	\$193	\$154	1.43	\$1,397	1.43	\$1,228	1.32	\$920
	1992-2010	\$1,852	143	4	61	\$54	\$44	0.63	-\$773	0.77	-\$421	0.68	-\$591
Reduced Infiltration	Pre-1978	\$1,474	62	8	88	\$31	\$26	0.47	-\$882	0.63	-\$546	0.62	-\$555
	1978-1991		34	5	47	\$17	\$14	0.26	-\$1,228	0.49	-\$754	0.43	-\$843
	1992-2010		18	3	32	\$10	\$8	0.15	-\$1,401	0.27	-\$1,082	0.27	-\$1,076
Duct Sealing	Pre-1978	\$683	796	16	266	\$303	\$242	9.46	\$6,485	11.56	\$7,209	10.04	\$6,175
	1978-1991	\$683	471	8	154	\$181	\$144	5.64	\$3,558	7.08	\$4,150	6.41	\$3,698
	1992-2010	\$423	82	2	37	\$33	\$27	1.68	\$325	2.61	\$683	2.32	\$559
New Ducts	Pre-1978	\$3,986	1,400	30	489	\$535	\$427	2.86	\$8,341	3.59	\$10,321	3.09	\$8,334
	1978-1991		1,035	20	351	\$400	\$319	2.13	\$5,079	2.78	\$7,107	2.45	\$5,782
	1992-2010		281	8	137	\$113	\$90	0.60	-\$1,778	0.91	-\$377	0.81	-\$751
Cool Roof	Pre-1978	\$778	480	-4	14	\$157	\$124	4.37	\$2,861	5.17	\$2,404	3.13	\$1,653
	1978-1991		337	-3	14	\$114	\$90	3.18	\$1,849	4.05	\$1,762	2.50	\$1,164
	1992-2010		153	-2	5	\$51	\$40	1.41	\$347	2.23	\$707	1.28	\$222
R-13 Wall Insulation	Pre-1978	\$3,360	271	27	311	\$127	\$105	0.83	-\$631	1.21	\$701	1.09	\$295
Windows	Pre-1978	\$9,810	1,443	3	185	\$491	\$388	1.06	\$623	1.10	\$992	0.86	-\$1,399
	1978-1991		1,141	2	145	\$394	\$312	0.85	-\$1,670	0.90	-\$967	0.71	-\$2,796
LED lamp vs CFL	All	\$2.26	1.2	0	n/a	\$0.35	\$0.27	3.64	\$5.95	n/a	n/a	n/a	n/a
Exterior Photosensor	All	\$42.58	12.1	0	n/a	\$2.00	\$1.58	1.11	\$4.84	n/a	n/a	n/a	n/a

Table 75: CZ 10 (SCE/SoCalGas) - Single Family Efficiency Packages Cost-Effectiveness Results

Measure	Vintage	Measure Cost (\$)	Electricity Savings (kWh)	Gas Savings (therm)	GHG Savings (lb CO ₂ e)	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	\$4,806	1,072	31	419	\$399	\$320	1.78	\$4,196	1.76	\$3,649	1.61	\$2,908
	1978-1991	\$4,348	564	16	199	\$211	\$169	1.04	\$180	1.11	\$475	1.02	\$82
	1992-2010	\$3,326	160	7	93	\$64	\$52	0.42	-\$2,183	0.56	-\$1,457	0.50	-\$1,661
R49 Attic & Duct Sealing Package	Pre-1978	\$4,015	1,682	37	574	\$629	\$502	3.34	\$10,545	3.65	\$10,650	3.28	\$9,149
	1978-1991	\$3,557	944	19	300	\$354	\$282	2.12	\$4,461	2.42	\$5,065	2.18	\$4,200
	1992-2010	\$2,275	219	6	99	\$85	\$68	0.80	-\$507	1.09	\$196	0.95	-\$106
R49 Attic, Air Sealing & Duct Sealing Package	Pre-1978	\$5,489	1,729	45	655	\$653	\$523	2.54	\$9,513	2.83	\$10,052	2.55	\$8,527
	1978-1991	\$5,031	970	23	346	\$368	\$294	1.56	\$3,162	1.82	\$4,115	1.65	\$3,279
	1992-2010	\$3,749	234	10	128	\$94	\$76	0.54	-\$1,942	0.76	-\$909	0.68	-\$1,186
R49 Attic, Air Sealing & New Ducts Package	Pre-1978	\$8,792	2,308	57	876	\$878	\$702	2.13	\$11,183	2.51	\$13,313	2.24	\$10,870
	1978-1991	\$8,334	1,511	33	535	\$579	\$462	1.48	\$4,490	1.86	\$7,126	1.65	\$5,426
	1992-2010	\$7,312	423	15	222	\$169	\$136	0.50	-\$4,145	0.72	-\$2,067	0.66	-\$2,513
Advanced Envelope Package	Pre-1978	\$18,659	2,797	82	1,159	\$1,065	\$853	1.22	\$4,641	1.45	\$8,398	1.27	\$5,050
Water Heating Package	All Vintages	\$208	0	17	n/a	\$24	\$22	1.40	\$93	n/a	n/a	n/a	n/a

Table 76: CZ 10 (SCE/SoCalGas) - Single Family PV & Battery Cost-Effectiveness Results

Measure	Vintage	Measure Cost (\$)	Electricity Savings (kWh)	Gas Savings (therm)	GHG Savings (lb CO ₂ e)	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	\$7,803	4,272	0	340	\$965	\$762	2.65	\$14,223	1.92	\$7,176	1.84	\$6,530
	1978-1991		4,272		340	\$940	\$742	2.58	\$13,634	1.92	\$7,141	1.83	\$6,487
	1992-2010		4,272		340	\$855	\$675	2.35	\$11,611	1.91	\$7,101	1.82	\$6,421
PV + Battery	Pre-1978	\$19,175	4,048	0	939	\$1,151	\$908	1.32	\$6,564	1.17	\$3,192	0.99	-\$236
	1978-1991		4,045		972	\$1,135	\$896	1.30	\$6,193	1.19	\$3,667	1.00	-\$23
	1992-2010		4,041		1,046	\$1,048	\$827	1.20	\$4,142	1.22	\$4,200	1.04	\$781

Table 77: CZ 10 (SCE/SoCalGas) - Single Family Equipment Fuel Substitution Cost-Effectiveness Results

Measure	Vintage	Measure Cost (\$)	Electricity Savings (kWh)	Gas Savings (therm)	GHG Savings (lb CO ₂ e)	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	\$501	-1,398	123	504	-\$214	-\$152	0	-\$5,105	0	-\$1,469	0.93	-\$35
	1978-1991		-986	85	335	-\$151	-\$107	0	-\$3,771	0	-\$1,271	0.41	-\$294
	1992-2010		-823	71	286	-\$121	-\$86	0	-\$3,122	0	-\$1,150	0.40	-\$303
High-Effic. Heat Pump at HVAC Replacement	Pre-1978	\$3,749	-625	123	739	\$45	\$52	0.39	-\$2,491	1.30	\$1,113	1.53	\$1,994
	1978-1991		-385	85	524	\$53	\$53	0.39	-\$2,467	1.05	\$197	1.20	\$750
	1992-2010		-397	71	440	\$17	\$23	0.17	-\$3,369	0.74	-\$990	0.91	-\$348
Heat Pump at HVAC Replacement + PV	Pre-1978	\$8,304	2,874	123	843	\$751	\$610	1.99	\$9,118	1.69	\$5,729	1.78	\$6,501
	1978-1991		3,286	85	675	\$776	\$624	2.04	\$9,543	1.71	\$5,888	1.75	\$6,196
	1992-2010		3,449	71	625	\$751	\$602	1.97	\$8,890	1.72	\$5,974	1.74	\$6,127
HVAC HP Replacement w/ Panel Upgrade + PV	Pre-1978	\$11,485	2,874	123	843	\$751	\$610	1.44	\$5,546	1.22	\$2,548	1.29	\$3,320
	1978-1991		3,286	85	675	\$776	\$624	1.47	\$5,971	1.24	\$2,707	1.26	\$3,015
	1992-2010		3,449	71	625	\$751	\$602	1.42	\$5,318	1.24	\$2,793	1.26	\$2,946
HPWH at Water Heater Replacement	Pre-1978	\$2,594	-922	149	1,233	-\$69	-\$35	0	-\$3,946	0.41	-\$1,543	1.75	\$1,951
	1978-1991		-935	150	1,232	-\$71	-\$37	0	-\$3,996	0.45	-\$1,427	1.74	\$1,911
	1992-2010		-946	150	1,232	-\$65	-\$33	0	-\$3,874	0.44	-\$1,456	1.74	\$1,920
NEEA Tier 3 HPWH at Replacement	Pre-1978	\$2,775	-734	149	1,319	-\$8	\$13	0.12	-\$2,704	0.70	-\$828	1.95	\$2,623
	1978-1991		-752	150	1,310	-\$12	\$10	0.09	-\$2,803	0.74	-\$710	1.95	\$2,643
	1992-2010		-761	150	1,314	-\$8	\$13	0.12	-\$2,713	0.71	-\$807	1.94	\$2,614
HPWH at Water Heater Replacement + PV	Pre-1978	\$10,397	3,350	149	1,572	\$932	\$755	1.97	\$11,140	1.56	\$5,832	1.83	\$8,663
	1978-1991		3,337	150	1,572	\$910	\$737	1.92	\$10,605	1.57	\$5,918	1.83	\$8,586
	1992-2010		3,326	150	1,571	\$827	\$672	1.75	\$8,634	1.56	\$5,849	1.82	\$8,531
HPWH Replacement w/ Panel Upgrade + PV	Pre-1978	\$13,578	3,350	149	1,572	\$932	\$755	1.50	\$7,568	1.20	\$2,651	1.40	\$5,482
	1978-1991		3,337	150	1,572	\$910	\$737	1.47	\$7,033	1.20	\$2,737	1.40	\$5,405
	1992-2010		3,326	150	1,571	\$827	\$672	1.34	\$5,062	1.20	\$2,668	1.39	\$5,350

Measure	Vintage	Measure Cost (\$)	Electricity Savings (kWh)	Gas Savings (therm)	GHG Savings (lb CO ₂ e)	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
PV + Electric Ready Pre-Wire	Pre-1978	\$11,894	4,272	0	340	\$965	\$762	1.73	\$9,630	1.26	\$3,085	1.21	\$2,439
	1978-1991		4,272	0	340	\$940	\$742	1.68	\$9,040	1.26	\$3,050	1.20	\$2,396
	1992-2010		4,272	0	340	\$855	\$675	1.53	\$7,017	1.25	\$3,010	1.20	\$2,330

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 78: CZ 10 (SDG&E) - Single Family Efficiency Upgrade Cost-Effectiveness Results

Measure	Vintage	Measure Cost (\$)	Electricity Savings (kWh)	Gas Savings (therm)	GHG Savings (lb CO ₂ e)	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	\$3,332	1,013	23	333	\$514	\$410	3.29	\$8,569	2.27	\$4,236	2.01	\$3,357
	1978-1991	\$2,874	529	11	148	\$272	\$217	2.02	\$3,277	1.43	\$1,228	1.32	\$920
	1992-2010	\$1,852	143	4	61	\$82	\$65	0.94	-\$117	0.77	-\$421	0.68	-\$591
Reduced Infiltration	Pre-1978	\$1,474	62	8	88	\$42	\$35	0.64	-\$599	0.63	-\$546	0.62	-\$555
	1978-1991		34	5	47	\$24	\$20	0.35	-\$1,068	0.49	-\$754	0.43	-\$843
	1992-2010		18	3	32	\$14	\$12	0.22	-\$1,295	0.27	-\$1,082	0.27	-\$1,076
Duct Sealing	Pre-1978	\$683	796	16	266	\$432	\$344	13.47	\$9,564	11.56	\$7,209	10.04	\$6,175
	1978-1991	\$683	471	8	154	\$261	\$208	8.12	\$5,462	7.08	\$4,150	6.41	\$3,698
	1992-2010	\$423	82	2	37	\$50	\$40	2.53	\$725	2.61	\$683	2.32	\$559
New Ducts	Pre-1978	\$3,986	1,400	30	489	\$764	\$610	4.09	\$13,810	3.59	\$10,321	3.09	\$8,334
	1978-1991		1,035	20	351	\$577	\$459	3.08	\$9,304	2.78	\$7,107	2.45	\$5,782
	1992-2010		281	8	137	\$170	\$136	0.91	-\$402	0.91	-\$377	0.81	-\$751
Cool Roof	Pre-1978	\$778	480	-4	14	\$221	\$174	6.14	\$4,363	5.17	\$2,404	3.13	\$1,653
	1978-1991		337	-3	14	\$162	\$127	4.51	\$2,976	4.05	\$1,762	2.50	\$1,164
	1992-2010		153	-2	5	\$77	\$61	2.14	\$967	2.23	\$707	1.28	\$222
R-13 Wall Insulation	Pre-1978	\$3,360	271	27	311	\$178	\$146	1.16	\$613	1.21	\$701	1.09	\$295
Windows	Pre-1978	\$9,810	1,443	3	185	\$686	\$542	1.48	\$5,258	1.10	\$992	0.86	-\$1,399
	1978-1991		1,141	2	145	\$558	\$441	1.20	\$2,215	0.90	-\$967	0.71	-\$2,796
LED lamp vs CFL	All	\$2.26	1.2	0	n/a	\$0.51	\$0.40	5.33	\$9.76	n/a	n/a	n/a	n/a
Exterior Photosensor	All	\$42.58	12.1	0	n/a	\$2.76	\$2.18	1.54	\$22.81	n/a	n/a	n/a	n/a

Table 79: CZ 10 (SDG&E) - Single Family Efficiency Packages Cost-Effectiveness Results

Measure	Vintage	Measure Cost (\$)	Electricity Savings (kWh)	Gas Savings (therm)	GHG Savings (lb CO ₂ e)	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	\$4,806	1,072	31	419	\$555	\$445	2.47	\$7,948	1.76	\$3,649	1.61	\$2,908
	1978-1991	\$4,348	564	16	199	\$296	\$237	1.46	\$2,226	1.11	\$475	1.02	\$82
	1992-2010	\$3,326	160	7	93	\$96	\$77	0.62	-\$1,414	0.56	-\$1,457	0.50	-\$1,661
R49 Attic & Duct Sealing Package	Pre-1978	\$4,015	1,682	37	574	\$888	\$709	4.72	\$16,754	3.65	\$10,650	3.28	\$9,149
	1978-1991	\$3,557	944	19	300	\$504	\$402	3.02	\$8,062	2.42	\$5,065	2.18	\$4,200
	1992-2010	\$2,275	219	6	99	\$128	\$103	1.20	\$522	1.09	\$196	0.95	-\$106
R49 Attic, Air Sealing & Duct Sealing Package	Pre-1978	\$5,489	1,729	45	655	\$922	\$737	3.59	\$15,957	2.83	\$10,052	2.55	\$8,527
	1978-1991	\$5,031	970	23	346	\$524	\$418	2.22	\$6,899	1.82	\$4,115	1.65	\$3,279
	1992-2010	\$3,749	234	10	128	\$142	\$114	0.81	-\$797	0.76	-\$909	0.68	-\$1,186
R49 Attic, Air Sealing & New Ducts Package	Pre-1978	\$8,792	2,308	57	876	\$1,248	\$996	3.03	\$20,022	2.51	\$13,313	2.24	\$10,870
	1978-1991	\$8,334	1,511	33	535	\$833	\$664	2.13	\$10,576	1.86	\$7,126	1.65	\$5,426
	1992-2010	\$7,312	423	15	222	\$258	\$207	0.76	-\$2,004	0.72	-\$2,067	0.66	-\$2,513
Advanced Envelope Package	Pre-1978	\$18,659	2,797	82	1,159	\$1,512	\$1,210	1.73	\$15,344	1.45	\$8,398	1.27	\$5,050
Water Heating Package	All Vintages	\$208	0	17	n/a	\$32	\$29	1.88	\$206	n/a	n/a	n/a	n/a

Table 80: CZ 10 (SDG&E) - Single Family PV & Battery Cost-Effectiveness Results

Measure	Vintage	Measure Cost (\$)	Electricity Savings (kWh)	Gas Savings (therm)	GHG Savings (lb CO ₂ e)	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	\$7,803	4,272	0	340	\$1,520	\$1,199	4.17	\$27,356	1.92	\$7,176	1.84	\$6,530
	1978-1991		4,272		340	\$1,507	\$1,190	4.14	\$27,064	1.92	\$7,141	1.83	\$6,487
	1992-2010		4,272		340	\$1,479	\$1,168	4.06	\$26,402	1.91	\$7,101	1.82	\$6,421
PV + Battery	Pre-1978	\$19,175	4,048	0	939	\$1,702	\$1,343	1.95	\$19,620	1.17	\$3,192	0.99	-\$236
	1978-1991		4,045		972	\$1,706	\$1,346	1.95	\$19,708	1.19	\$3,667	1.00	-\$23
	1992-2010		4,041		1,046	\$1,682	\$1,328	1.93	\$19,152	1.22	\$4,200	1.04	\$781

Table 81: CZ 10 (SDG&E) - Single Family Equipment Fuel Substitution Cost-Effectiveness Results

Measure	Vintage	Measure Cost (\$)	Electricity Savings (kWh)	Gas Savings (therm)	GHG Savings (lb CO ₂ e)	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	\$501	-1,398	123	504	-\$323	-\$231	0	-\$7,467	0	-\$1,469	0.93	-\$35
	1978-1991		-986	85	335	-\$232	-\$167	0	-\$5,544	0	-\$1,271	0.41	-\$294
	1992-2010		-823	71	286	-\$191	-\$137	0.00	-\$4,665	0	-\$1,150	0.40	-\$303
High-Effic. Heat Pump at HVAC Replacement	Pre-1978	\$3,749	-625	123	739	\$49	\$63	0.46	-\$2,178	1.30	\$1,113	1.53	\$1,994
	1978-1991		-385	85	524	\$64	\$67	0.49	-\$2,052	1.05	\$197	1.20	\$750
	1992-2010		-397	71	440	\$20	\$29	0.21	-\$3,187	0.74	-\$990	0.91	-\$348
Heat Pump at HVAC Replacement + PV	Pre-1978	\$8,304	2,874	123	843	\$1,251	\$1,012	3.31	\$21,173	1.69	\$5,729	1.78	\$6,501
	1978-1991		3,286	85	675	\$1,352	\$1,083	3.54	\$23,321	1.71	\$5,888	1.75	\$6,196
	1992-2010		3,449	71	625	\$1,348	\$1,078	3.52	\$23,157	1.72	\$5,974	1.74	\$6,127
HVAC HP Replacement w/ Panel Upgrade + PV	Pre-1978	\$11,485	2,874	123	843	\$1,251	\$1,012	2.38	\$17,601	1.22	\$2,548	1.29	\$3,320
	1978-1991		3,286	85	675	\$1,352	\$1,083	2.55	\$19,749	1.24	\$2,707	1.26	\$3,015
	1992-2010		3,449	71	625	\$1,348	\$1,078	2.54	\$19,585	1.24	\$2,793	1.26	\$2,946
HPWH at Water Heater Replacement	Pre-1978	\$2,594	-922	149	1,233	-\$87	-\$40	0	-\$4,083	0.41	-\$1,543	1.75	\$1,951
	1978-1991		-935	150	1,232	-\$88	-\$42	0	-\$4,139	0.45	-\$1,427	1.74	\$1,911
	1992-2010		-946	150	1,232	-\$85	-\$39	0	-\$4,069	0.44	-\$1,456	1.74	\$1,920
NEEA Tier 3 HPWH at Replacement	Pre-1978	\$2,775	-734	149	1,319	-\$9	\$22	0.21	-\$2,444	0.70	-\$828	1.95	\$2,623
	1978-1991		-752	150	1,310	-\$13	\$18	0.17	-\$2,553	0.74	-\$710	1.95	\$2,643
	1992-2010		-761	150	1,314	-\$10	\$20	0.20	-\$2,485	0.71	-\$807	1.94	\$2,614
HPWH at Water Heater Replacement + PV	Pre-1978	\$10,397	3,350	149	1,572	\$1,402	\$1,135	2.96	\$22,534	1.56	\$5,832	1.83	\$8,663
	1978-1991		3,337	150	1,572	\$1,382	\$1,119	2.91	\$22,046	1.57	\$5,918	1.83	\$8,586
	1992-2010		3,326	150	1,571	\$1,352	\$1,095	2.85	\$21,341	1.56	\$5,849	1.82	\$8,531
HPWH Replacement w/ Panel Upgrade + PV	Pre-1978	\$13,578	3,350	149	1,572	\$1,402	\$1,135	2.26	\$18,962	1.20	\$2,651	1.40	\$5,482
	1978-1991		3,337	150	1,572	\$1,382	\$1,119	2.22	\$18,475	1.20	\$2,737	1.40	\$5,405
	1992-2010		3,326	150	1,571	\$1,352	\$1,095	2.18	\$17,769	1.20	\$2,668	1.39	\$5,350

Measure	Vintage	Measure Cost (\$)	Electricity Savings (kWh)	Gas Savings (therm)	GHG Savings (lb CO ₂ e)	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
PV + Electric Ready Pre-Wire	Pre-1978	\$11,894	4,272	0	340	\$1,520	\$1,199	2.72	\$22,762	1.26	\$3,085	1.21	\$2,439
	1978-1991		4,272	0	340	\$1,507	\$1,190	2.70	\$22,470	1.26	\$3,050	1.20	\$2,396
	1992-2010		4,272	0	340	\$1,479	\$1,168	2.65	\$21,808	1.25	\$3,010	1.20	\$2,330

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 82: CZ 11 - Single Family Efficiency Upgrade Cost-Effectiveness Results

Measure	Vintage	Measure Cost (\$)	Electricity Savings (kWh)	Gas Savings (therm)	GHG Savings (lb CO ₂ e)	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	\$3,332	1,031	47	610	\$479	\$384	3.08	\$7,766	3.13	\$7,085	2.73	\$5,757
	1978-1991	\$2,874	559	23	293	\$256	\$205	1.90	\$2,908	2.10	\$3,165	1.71	\$2,053
	1992-2010	\$1,852	161	9	116	\$78	\$63	0.90	-\$199	1.08	\$152	0.91	-\$176
Reduced Infiltration	Pre-1978	\$1,474	100	17	194	\$73	\$60	1.08	\$132	1.11	\$168	1.21	\$306
	1978-1991		63	11	117	\$45	\$36	0.66	-\$562	1.04	\$56	0.76	-\$356
	1992-2010		35	7	73	\$27	\$22	0.40	-\$1,000	0.40	-\$881	0.51	-\$719
Duct Sealing	Pre-1978	\$683	1,087	43	608	\$506	\$405	15.83	\$11,373	19.66	\$12,746	16.28	\$10,438
	1978-1991	\$683	669	24	357	\$308	\$246	9.61	\$6,607	12.99	\$8,189	10.24	\$6,311
	1992-2010	\$423	129	7	94	\$64	\$51	3.23	\$1,060	4.28	\$1,386	3.90	\$1,227
New Ducts	Pre-1978	\$3,986	1,837	74	1,052	\$858	\$686	4.60	\$16,105	5.71	\$18,793	4.79	\$15,103
	1978-1991		1,387	52	774	\$643	\$513	3.44	\$10,926	4.39	\$13,530	3.72	\$10,837
	1992-2010		406	21	304	\$201	\$161	1.08	\$350	1.41	\$1,640	1.28	\$1,135
Cool Roof	Pre-1978	\$778	475	-5	6	\$170	\$133	4.71	\$3,148	6.76	\$3,323	3.37	\$1,843
	1978-1991		343	-4	6	\$124	\$98	3.46	\$2,086	6.04	\$2,911	2.63	\$1,270
	1992-2010		164	-3	3	\$59	\$46	1.62	\$529	2.52	\$875	1.35	\$273
R-13 Wall Insulation	Pre-1978	\$3,360	448	55	647	\$281	\$228	1.81	\$3,067	2.03	\$3,472	2.05	\$3,516
Windows	Pre-1978	\$9,810	1,779	34	605	\$738	\$586	1.60	\$6,574	1.61	\$5,960	1.39	\$3,838
	1978-1991		1,453	26	480	\$601	\$477	1.30	\$3,299	1.32	\$3,161	1.13	\$1,237
LED lamp vs CFL	All	\$2.26	1.2	0	n/a	\$0.44	\$0.35	4.65	\$8.23	n/a	n/a	n/a	n/a
Exterior Photosensor	All	\$42.58	12.1	0	n/a	\$2.88	\$2.27	1.60	\$25.62	n/a	n/a	n/a	n/a

Table 83: CZ 11 - Single Family Efficiency Packages Cost-Effectiveness Results

Measure	Vintage	Measure Cost (\$)	Electricity Savings (kWh)	Gas Savings (therm)	GHG Savings (lb CO ₂ e)	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	\$4,806	1,135	65	805	\$554	\$445	2.47	\$7,956	2.55	\$7,458	2.28	\$6,155
	1978-1991	\$4,348	626	35	420	\$302	\$243	1.49	\$2,397	1.59	\$2,558	1.39	\$1,696
	1992-2010	\$3,326	196	16	189	\$105	\$85	0.68	-\$1,187	0.74	-\$878	0.75	-\$835
R49 Attic & Duct Sealing Package	Pre-1978	\$4,015	2,012	87	1,182	\$938	\$751	5.00	\$18,017	5.77	\$19,166	4.86	\$15,501
	1978-1991	\$3,557	1,172	46	643	\$540	\$431	3.24	\$8,943	3.92	\$10,374	3.23	\$7,917
	1992-2010	\$2,275	281	15	205	\$138	\$111	1.30	\$772	1.57	\$1,302	1.46	\$1,037
R49 Attic, Air Sealing & Duct Sealing Package	Pre-1978	\$5,489	2,095	103	1,355	\$1,002	\$803	3.91	\$17,922	4.47	\$19,071	3.87	\$15,741
	1978-1991	\$5,031	1,228	56	755	\$580	\$464	2.47	\$8,282	2.92	\$9,667	2.49	\$7,486
	1992-2010	\$3,749	316	22	282	\$164	\$132	0.94	-\$244	1.16	\$612	1.05	\$185
R49 Attic, Air Sealing & New Ducts Package	Pre-1978	\$8,792	2,851	133	1,811	\$1,356	\$1,086	3.30	\$22,705	3.85	\$25,061	3.37	\$20,806
	1978-1991	\$8,334	1,928	82	1,157	\$906	\$724	2.32	\$12,371	2.81	\$15,114	2.46	\$12,156
	1992-2010	\$7,312	581	36	479	\$296	\$238	0.87	-\$1,078	1.08	\$592	1.03	\$185
Advanced Envelope Package	Pre-1978	\$18,659	3,636	197	2,570	\$1,768	\$1,418	2.03	\$21,602	2.27	\$23,651	2.05	\$19,546
Water Heating Package	All Vintages	\$208	0	16	n/a	\$32	\$29	1.88	\$207	n/a	n/a	n/a	n/a

Table 84: CZ 11 - Single Family PV & Battery Cost-Effectiveness Results

Measure	Vintage	Measure Cost (\$)	Electricity Savings (kWh)	Gas Savings (therm)	GHG Savings (lb CO ₂ e)	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	\$9,005	4,408	0	283	\$1,260	\$995	3.00	\$19,886	2.05	\$9,439	1.58	\$5,236
	1978-1991		4,408		283	\$1,235	\$975	2.94	\$19,296	2.04	\$9,390	1.58	\$5,190
	1992-2010		4,408		283	\$1,159	\$915	2.76	\$17,493	2.04	\$9,324	1.57	\$5,113
PV + Battery	Pre-1978	\$20,377	4,191	0	901	\$1,304	\$1,029	1.40	\$8,869	1.42	\$8,612	0.92	-\$1,562
	1978-1991		4,187		926	\$1,284	\$1,014	1.38	\$8,395	1.43	\$8,822	0.93	-\$1,389
	1992-2010		4,184		973	\$1,215	\$959	1.31	\$6,748	1.45	\$9,254	0.95	-\$1,046

Table 85: CZ 11 - Single Family Equipment Fuel Substitution Cost-Effectiveness Results

Measure	Vintage	Measure Cost (\$)	Electricity Savings (kWh)	Gas Savings (therm)	GHG Savings (lb CO ₂ e)	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	\$501	-3,496	328	1,615	-\$237	-\$152	0	-\$5,114	0	-\$3,889	5.15	\$2,079
	1978-1991		-2,597	244	1,186	-\$162	-\$102	0	-\$3,621	0	-\$3,128	3.73	\$1,371
	1992-2010		-2,122	199	986	-\$132	-\$84	0	-\$3,064	0	-\$2,581	3.19	\$1,097
High-Effic. Heat Pump at HVAC Replacement	Pre-1978	\$3,749	-2,236	328	2,046	\$187	\$182	1.35	\$1,408	1.66	\$2,487	2.92	\$7,185
	1978-1991		-1,610	244	1,528	\$172	\$161	1.19	\$771	1.37	\$1,384	2.30	\$4,872
	1992-2010		-1,389	199	1,258	\$104	\$102	0.75	-\$1,004	1.01	\$56	1.79	\$2,974
Heat Pump at HVAC Replacement + PV	Pre-1978	\$9,506	912	328	1,898	\$997	\$821	2.35	\$14,141	1.59	\$5,622	1.77	\$7,362
	1978-1991		1,811	244	1,469	\$1,037	\$843	2.41	\$14,796	1.66	\$6,313	1.69	\$6,593
	1992-2010		2,285	199	1,270	\$1,000	\$809	2.31	\$13,774	1.72	\$6,815	1.66	\$6,259
HVAC HP Replacement w/ Panel Upgrade + PV	Pre-1978	\$12,687	912	328	1,898	\$997	\$821	1.75	\$10,569	1.19	\$2,441	1.33	\$4,181
	1978-1991		1,811	244	1,469	\$1,037	\$843	1.80	\$11,224	1.25	\$3,132	1.27	\$3,412
	1992-2010		2,285	199	1,270	\$1,000	\$809	1.72	\$10,202	1.29	\$3,634	1.24	\$3,078
HPWH at Water Heater Replacement	Pre-1978	\$2,594	-1,079	151	1,207	-\$61	-\$32	0	-\$3,855	0.03	-\$2,510	1.50	\$1,306
	1978-1991		-1,092	152	1,213	-\$66	-\$37	0	-\$3,997	0.04	-\$2,487	1.50	\$1,300
	1992-2010		-1,101	152	1,214	-\$73	-\$42	0	-\$4,154	0	-\$2,634	1.50	\$1,303
NEEA Tier 3 HPWH at Replacement	Pre-1978	\$2,775	-829	150	1,292	\$17	\$29	0.28	-\$2,210	0.45	-\$1,516	1.85	\$2,361
	1978-1991		-844	151	1,298	\$11	\$24	0.24	-\$2,361	0.48	-\$1,438	1.85	\$2,349
	1992-2010		-855	152	1,301	\$5	\$19	0.18	-\$2,522	0.44	-\$1,548	1.84	\$2,329
HPWH at Water Heater Replacement + PV	Pre-1978	\$11,598	3,328	151	1,490	\$1,263	\$1,012	2.36	\$17,525	1.61	\$7,116	1.58	\$6,727
	1978-1991		3,316	152	1,496	\$1,240	\$994	2.32	\$16,983	1.61	\$7,096	1.58	\$6,678
	1992-2010		3,306	152	1,497	\$1,165	\$934	2.18	\$15,184	1.59	\$6,885	1.57	\$6,609
HPWH Replacement w/ Panel Upgrade + PV	Pre-1978	\$14,779	3,328	151	1,490	\$1,263	\$1,012	1.85	\$13,953	1.27	\$3,935	1.24	\$3,546
	1978-1991		3,316	152	1,496	\$1,240	\$994	1.82	\$13,411	1.26	\$3,915	1.24	\$3,497
	1992-2010		3,306	152	1,497	\$1,165	\$934	1.71	\$11,612	1.25	\$3,704	1.23	\$3,428

Measure	Vintage	Measure Cost (\$)	Electricity Savings (kWh)	Gas Savings (therm)	GHG Savings (lb CO ₂ e)	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
PV + Electric Ready Pre-Wire	Pre-1978	\$13,096	4,408	0	283	\$1,260	\$995	2.05	\$15,292	1.41	\$5,348	1.09	\$1,145
	1978-1991		4,408	0	283	\$1,235	\$975	2.01	\$14,702	1.40	\$5,299	1.08	\$1,099
	1992-2010		4,408	0	283	\$1,159	\$915	1.89	\$12,899	1.40	\$5,233	1.08	\$1,022

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 86: CZ 12 (PG&E) - Single Family Efficiency Upgrade Cost-Effectiveness Results

Measure	Vintage	Measure Cost (\$)	Electricity Savings (kWh)	Gas Savings (therm)	GHG Savings (lb CO ₂ e)	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	\$3,332	886	41	545	\$421	\$337	2.70	\$6,372	2.61	\$5,372	2.55	\$5,152
	1978-1991	\$2,874	482	20	282	\$224	\$179	1.66	\$2,144	1.61	\$1,745	1.57	\$1,644
	1992-2010	\$1,852	126	8	106	\$60	\$48	0.69	-\$643	0.84	-\$291	0.84	-\$294
Reduced Infiltration	Pre-1978	\$1,474	52	14	146	\$48	\$40	0.72	-\$468	0.76	-\$359	0.97	-\$42
	1978-1991		31	9	97	\$29	\$24	0.43	-\$938	0.50	-\$739	0.58	-\$616
	1992-2010		18	6	60	\$18	\$15	0.27	-\$1,212	0.23	-\$1,131	0.44	-\$820
Duct Sealing	Pre-1978	\$683	619	38	509	\$321	\$258	10.07	\$6,958	13.77	\$8,719	12.40	\$7,788
	1978-1991	\$683	358	22	299	\$185	\$148	5.80	\$3,679	8.59	\$5,182	7.73	\$4,597
	1992-2010	\$423	60	6	77	\$34	\$28	1.75	\$355	2.57	\$663	2.83	\$775
New Ducts	Pre-1978	\$3,986	1,094	66	888	\$562	\$451	3.03	\$9,068	4.19	\$12,715	3.77	\$11,030
	1978-1991		795	47	662	\$407	\$326	2.19	\$5,316	3.23	\$8,898	2.91	\$7,605
	1992-2010		203	19	251	\$114	\$92	0.62	-\$1,708	1.02	\$84	1.01	\$38
Cool Roof	Pre-1978	\$778	389	-5	14	\$142	\$111	3.93	\$2,486	5.48	\$2,588	3.28	\$1,771
	1978-1991		276	-3	18	\$101	\$80	2.82	\$1,542	4.41	\$1,969	2.51	\$1,172
	1992-2010		121	-3	2	\$39	\$30	1.07	\$62	1.88	\$509	1.30	\$233
R-13 Wall Insulation	Pre-1978	\$3,360	247	49	550	\$192	\$157	1.25	\$934	1.55	\$1,859	1.58	\$1,940
Windows	Pre-1978	\$9,810	1,242	25	473	\$532	\$423	1.15	\$1,680	1.27	\$2,662	1.05	\$499
	1978-1991		1,011	21	408	\$435	\$346	0.94	-\$647	1.05	\$456	0.89	-\$1,094
LED lamp vs CFL	All	\$2.26	1.2	0	n/a	\$0.43	\$0.34	4.48	\$7.85	n/a	n/a	n/a	n/a
Exterior Photosensor	All	\$42.58	12.1	0	n/a	\$2.88	\$2.27	1.60	\$25.62	n/a	n/a	n/a	n/a

Table 87: CZ 12 (PG&E) - Single Family Efficiency Packages Cost-Effectiveness Results

Measure	Vintage	Measure Cost (\$)	Electricity Savings (kWh)	Gas Savings (therm)	GHG Savings (lb CO ₂ e)	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	\$4,806	938	57	713	\$471	\$378	2.10	\$5,956	2.16	\$5,571	2.05	\$5,046
	1978-1991	\$4,348	513	30	377	\$254	\$204	1.25	\$1,225	1.27	\$1,181	1.27	\$1,175
	1992-2010	\$3,326	145	14	170	\$78	\$63	0.51	-\$1,842	0.60	-\$1,319	0.64	-\$1,212
R49 Attic & Duct Sealing Package	Pre-1978	\$4,015	1,396	77	1,026	\$694	\$557	3.71	\$12,205	4.34	\$13,393	4.04	\$12,223
	1978-1991	\$3,557	789	41	563	\$386	\$310	2.32	\$5,291	2.85	\$6,578	2.65	\$5,863
	1992-2010	\$2,275	179	14	181	\$91	\$74	0.87	-\$343	1.22	\$493	1.17	\$398
R49 Attic, Air Sealing & Duct Sealing Package	Pre-1978	\$5,489	1,439	90	1,169	\$736	\$591	2.88	\$11,568	3.38	\$13,089	3.17	\$11,899
	1978-1991	\$5,031	817	49	655	\$413	\$331	1.76	\$4,294	2.20	\$6,020	2.02	\$5,141
	1992-2010	\$3,749	197	19	241	\$109	\$88	0.63	-\$1,568	0.88	-\$460	0.88	-\$466
R49 Attic, Air Sealing & New Ducts Package	Pre-1978	\$8,792	1,884	117	1,548	\$964	\$774	2.35	\$13,357	2.96	\$17,240	2.74	\$15,342
	1978-1991	\$8,334	1,222	73	1,005	\$621	\$498	1.60	\$5,591	2.15	\$9,587	1.97	\$8,083
	1992-2010	\$7,312	330	32	411	\$184	\$149	0.54	-\$3,753	0.83	-\$1,275	0.80	-\$1,482
Advanced Envelope Package	Pre-1978	\$18,659	2,410	169	2,174	\$1,262	\$1,015	1.45	\$9,508	1.76	\$14,200	1.63	\$11,725
Water Heating Package	All Vintages	\$208	0	16	n/a	\$32	\$29	1.89	\$208	n/a	n/a	n/a	n/a

Table 88: CZ 12 (PG&E) - Single Family PV & Battery Cost-Effectiveness Results

Measure	Vintage	Measure Cost (\$)	Electricity Savings (kWh)	Gas Savings (therm)	GHG Savings (lb CO ₂ e)	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	\$7,697	3,876	0	237	\$1,077	\$850	2.99	\$16,979	2.01	\$7,783	1.62	\$4,738
	1978-1991		3,876		237	\$1,046	\$826	2.91	\$16,264	2.01	\$7,754	1.61	\$4,704
	1992-2010		3,876		237	\$958	\$756	2.66	\$14,167	2.00	\$7,719	1.61	\$4,666
PV + Battery	Pre-1978	\$19,069	3,673	0	854	\$1,123	\$887	1.29	\$6,038	1.28	\$5,337	0.87	-\$2,389
	1978-1991		3,670		878	\$1,095	\$864	1.26	\$5,368	1.30	\$5,789	0.88	-\$2,236
	1992-2010		3,671		908	\$1,006	\$794	1.16	\$3,254	1.33	\$6,342	0.90	-\$1,864

Table 89: CZ 12 (PG&E) - Single Family Equipment Fuel Substitution Cost-Effectiveness Results

Measure	Vintage	Measure Cost (\$)	Electricity Savings (kWh)	Gas Savings (therm)	GHG Savings (lb CO ₂ e)	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	\$501	-3,101	293	1,419	-\$236	-\$156	0	-\$5,224	0	-\$2,541	4.12	\$1,567
	1978-1991		-2,361	222	1,058	-\$177	-\$117	0	-\$4,068	0	-\$2,083	2.93	\$968
	1992-2010		-1,955	184	899	-\$145	-\$96	0	-\$3,427	0	-\$1,841	2.63	\$815
High-Effic. Heat Pump at HVAC Replacement	Pre-1978	\$3,749	-2,198	293	1,769	\$59	\$78	0.57	-\$1,729	1.44	\$1,666	2.28	\$4,794
	1978-1991		-1,669	222	1,334	\$50	\$62	0.46	-\$2,198	1.17	\$632	1.78	\$2,907
	1992-2010		-1,459	184	1,110	\$11	\$27	0.20	-\$3,262	0.81	-\$725	1.37	\$1,395
Heat Pump at HVAC Replacement + PV	Pre-1978	\$8,198	776	293	1,657	\$800	\$662	2.19	\$10,809	1.65	\$5,302	1.77	\$6,334
	1978-1991		1,515	222	1,295	\$823	\$672	2.23	\$11,116	1.70	\$5,720	1.69	\$5,697
	1992-2010		1,921	184	1,136	\$818	\$664	2.20	\$10,859	1.73	\$5,945	1.67	\$5,516
HVAC HP Replacement w/ Panel Upgrade + PV	Pre-1978	\$11,379	776	293	1,657	\$800	\$662	1.57	\$7,237	1.19	\$2,121	1.28	\$3,153
	1978-1991		1,515	222	1,295	\$823	\$672	1.60	\$7,544	1.22	\$2,539	1.22	\$2,516
	1992-2010		1,921	184	1,136	\$818	\$664	1.58	\$7,287	1.24	\$2,764	1.21	\$2,335
HPWH at Water Heater Replacement	Pre-1978	\$2,594	-1,146	157	1,243	-\$79	-\$46	0	-\$4,279	0	-\$2,957	1.48	\$1,257
	1978-1991		-1,154	158	1,248	-\$85	-\$51	0	-\$4,423	0	-\$3,009	1.48	\$1,252
	1992-2010		-1,161	158	1,250	-\$81	-\$48	0	-\$4,335	0	-\$3,061	1.47	\$1,211
NEEA Tier 3 HPWH at Replacement	Pre-1978	\$2,775	-868	156	1,340	\$8	\$22	0.21	-\$2,428	0.43	-\$1,571	1.90	\$2,508
	1978-1991		-881	157	1,346	\$1	\$17	0.16	-\$2,593	0.45	-\$1,530	1.90	\$2,511
	1992-2010		-892	157	1,348	\$3	\$18	0.17	-\$2,553	0.41	-\$1,649	1.88	\$2,445
HPWH at Water Heater Replacement + PV	Pre-1978	\$10,291	2,731	157	1,481	\$1,065	\$857	2.25	\$14,302	1.49	\$5,016	1.60	\$6,186
	1978-1991		2,722	158	1,485	\$1,036	\$833	2.19	\$13,602	1.48	\$4,938	1.60	\$6,151
	1992-2010		2,716	158	1,488	\$954	\$769	2.02	\$11,660	1.47	\$4,855	1.59	\$6,076
HPWH Replacement w/ Panel Upgrade + PV	Pre-1978	\$13,472	2,731	157	1,481	\$1,065	\$857	1.72	\$10,730	1.14	\$1,835	1.22	\$3,005
	1978-1991		2,722	158	1,485	\$1,036	\$833	1.67	\$10,030	1.13	\$1,757	1.22	\$2,970
	1992-2010		2,716	158	1,488	\$954	\$769	1.54	\$8,088	1.12	\$1,674	1.21	\$2,895

Measure	Vintage	Measure Cost (\$)	Electricity Savings (kWh)	Gas Savings (therm)	GHG Savings (lb CO ₂ e)	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
PV + Electric Ready Pre-Wire	Pre-1978	\$11,788	3,876	0	237	\$1,077	\$850	1.95	\$12,385	1.31	\$3,692	1.05	\$647
	1978-1991		3,876	0	237	\$1,046	\$826	1.89	\$11,670	1.31	\$3,663	1.05	\$613
	1992-2010		3,876	0	237	\$958	\$756	1.73	\$9,574	1.31	\$3,628	1.05	\$575

Climate Zone 12 SMUD/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 90: CZ 12 (SMUD/PG&E) - Single Family Efficiency Upgrade Cost-Effectiveness Results

Measure	Vintage	Measure Cost (\$)	Electricity Savings (kWh)	Gas Savings (therm)	GHG Savings (lb CO ₂ e)	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	\$3,332	886	41	545	\$249	\$201	1.61	\$2,295	2.61	\$5,372	2.55	\$5,152
	1978-1991	\$2,874	482	20	282	\$131	\$106	0.99	-\$47	1.61	\$1,745	1.57	\$1,644
	1992-2010	\$1,852	126	8	106	\$39	\$32	0.46	-\$1,124	0.84	-\$291	0.84	-\$294
Reduced Infiltration	Pre-1978	\$1,474	52	14	146	\$38	\$32	0.57	-\$706	0.76	-\$359	0.97	-\$42
	1978-1991		31	9	97	\$23	\$19	0.34	-\$1,084	0.50	-\$739	0.58	-\$616
	1992-2010		18	6	60	\$15	\$13	0.23	-\$1,280	0.23	-\$1,131	0.44	-\$820
Duct Sealing	Pre-1978	\$683	619	38	509	\$199	\$162	6.33	\$4,091	13.77	\$8,719	12.40	\$7,788
	1978-1991	\$683	358	22	299	\$115	\$93	3.65	\$2,034	8.59	\$5,182	7.73	\$4,597
	1992-2010	\$423	60	6	77	\$24	\$20	1.25	\$120	2.57	\$663	2.83	\$775
New Ducts	Pre-1978	\$3,986	1,094	66	888	\$348	\$283	1.90	\$4,006	4.19	\$12,715	3.77	\$11,030
	1978-1991		795	47	662	\$252	\$205	1.37	\$1,660	3.23	\$8,898	2.91	\$7,605
	1992-2010		203	19	251	\$80	\$66	0.44	-\$2,510	1.02	\$84	1.01	\$38
Cool Roof	Pre-1978	\$778	389	-5	14	\$65	\$51	1.79	\$668	5.48	\$2,588	3.28	\$1,771
	1978-1991		276	-3	18	\$47	\$37	1.30	\$254	4.41	\$1,969	2.51	\$1,172
	1992-2010		121	-3	2	\$19	\$15	0.52	-\$408	1.88	\$509	1.30	\$233
R-13 Wall Insulation	Pre-1978	\$3,360	247	49	550	\$144	\$119	0.95	-\$202	1.55	\$1,859	1.58	\$1,940
Windows	Pre-1978	\$9,810	1,242	25	473	\$289	\$231	0.63	-\$4,084	1.27	\$2,662	1.05	\$499
	1978-1991		1,011	21	408	\$239	\$191	0.52	-\$5,282	1.05	\$456	0.89	-\$1,094
LED lamp vs CFL	All	\$2.26	1.2	0	n/a	\$0.24	\$0.19	2.54	\$3.48	n/a	n/a	n/a	n/a
Exterior Photosensor	All	\$42.58	12.1	0	n/a	\$1.44	\$1.14	0.80	-\$8.38	n/a	n/a	n/a	n/a

Table 91: CZ 12 (SMUD/PG&E) - Single Family Efficiency Packages Cost-Effectiveness Results

Measure	Vintage	Measure Cost (\$)	Electricity Savings (kWh)	Gas Savings (therm)	GHG Savings (lb CO ₂ e)	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	\$4,806	938	57	713	\$289	\$234	1.30	\$1,635	2.16	\$5,571	2.05	\$5,046
	1978-1991	\$4,348	513	30	377	\$155	\$126	0.77	-\$1,103	1.27	\$1,181	1.27	\$1,175
	1992-2010	\$3,326	145	14	170	\$54	\$45	0.36	-\$2,399	0.60	-\$1,319	0.64	-\$1,212
R49 Attic & Duct Sealing Package	Pre-1978	\$4,015	1,396	77	1,026	\$423	\$343	2.28	\$5,779	4.34	\$13,393	4.04	\$12,223
	1978-1991	\$3,557	789	41	563	\$235	\$190	1.43	\$1,701	2.85	\$6,578	2.65	\$5,863
	1992-2010	\$2,275	179	14	181	\$62	\$51	0.59	-\$1,039	1.22	\$493	1.17	\$398
R49 Attic, Air Sealing & Duct Sealing Package	Pre-1978	\$5,489	1,439	90	1,169	\$456	\$370	1.80	\$4,938	3.38	\$13,089	3.17	\$11,899
	1978-1991	\$5,031	817	49	655	\$256	\$207	1.10	\$573	2.20	\$6,020	2.02	\$5,141
	1992-2010	\$3,749	197	19	241	\$77	\$63	0.45	-\$2,329	0.88	-\$460	0.88	-\$466
R49 Attic, Air Sealing & New Ducts Package	Pre-1978	\$8,792	1,884	117	1,548	\$598	\$485	1.47	\$4,682	2.96	\$17,240	2.74	\$15,342
	1978-1991	\$8,334	1,222	73	1,005	\$385	\$312	1.00	\$12	2.15	\$9,587	1.97	\$8,083
	1992-2010	\$7,312	330	32	411	\$129	\$105	0.39	-\$5,050	0.83	-\$1,275	0.80	-\$1,482
Advanced Envelope Package	Pre-1978	\$18,659	2,410	169	2,174	\$797	\$649	0.93	-\$1,489	1.76	\$14,200	1.63	\$11,725
Water Heating Package	All Vintages	\$208	0	16	n/a	\$32	\$29	1.89	\$208	n/a	n/a	n/a	n/a

Table 92: CZ 12 (SMUD/PG&E) - Single Family PV & Battery Cost-Effectiveness Results

Measure	Vintage	Measure Cost (\$)	Electricity Savings (kWh)	Gas Savings (therm)	GHG Savings (lb CO ₂ e)	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	\$7,697	3,876	0	237	\$493	\$389	1.37	\$3,157	2.01	\$7,783	1.62	\$4,738
	1978-1991		3,876		237	\$493	\$389	1.37	\$3,157	2.01	\$7,754	1.61	\$4,704
	1992-2010		3,876		237	\$493	\$389	1.37	\$3,157	2.00	\$7,719	1.61	\$4,666
PV + Battery	Pre-1978	\$19,069	3,673	0	854	\$559	\$441	0.64	-\$7,321	1.28	\$5,337	0.87	-\$2,389
	1978-1991		3,670		878	\$562	\$444	0.65	-\$7,252	1.30	\$5,789	0.88	-\$2,236
	1992-2010		3,671		908	\$557	\$440	0.64	-\$7,363	1.33	\$6,342	0.90	-\$1,864

Table 93: CZ 12 (SMUD/PG&E) - Single Family Equipment Fuel Substitution Cost-Effectiveness Results

Measure	Vintage	Measure Cost (\$)	Electricity Savings (kWh)	Gas Savings (therm)	GHG Savings (lb CO ₂ e)	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	\$501	-3,101	293	1,419	\$202	\$190	10.45	\$5,158	0	-\$2,541	4.12	\$1,567
	1978-1991		-2,361	222	1,058	\$138	\$132	7.24	\$3,406	0	-\$2,083	2.93	\$968
	1992-2010		-1,955	184	899	\$107	\$103	5.65	\$2,537	0	-\$1,841	2.63	\$815
High-Effic. Heat Pump at HVAC Replacement	Pre-1978	\$3,749	-2,198	293	1,769	\$334	\$295	2.18	\$4,780	1.44	\$1,666	2.28	\$4,794
	1978-1991		-1,669	222	1,334	\$241	\$213	1.57	\$2,327	1.17	\$632	1.78	\$2,907
	1992-2010		-1,459	184	1,110	\$178	\$159	1.17	\$699	0.81	-\$725	1.37	\$1,395
Heat Pump at HVAC Replacement + PV	Pre-1978	\$8,198	776	293	1,657	\$695	\$579	1.92	\$8,315	1.65	\$5,302	1.77	\$6,334
	1978-1991		1,515	222	1,295	\$631	\$521	1.72	\$6,563	1.70	\$5,720	1.69	\$5,697
	1992-2010		1,921	184	1,136	\$600	\$492	1.63	\$5,694	1.73	\$5,945	1.67	\$5,516
HVAC HP Replacement w/ Panel Upgrade + PV	Pre-1978	\$11,379	776	293	1,657	\$695	\$579	1.38	\$4,743	1.19	\$2,121	1.28	\$3,153
	1978-1991		1,515	222	1,295	\$631	\$521	1.24	\$2,991	1.22	\$2,539	1.22	\$2,516
	1992-2010		1,921	184	1,136	\$600	\$492	1.17	\$2,122	1.24	\$2,764	1.21	\$2,335
HPWH at Water Heater Replacement	Pre-1978	\$2,594	-1,146	157	1,243	\$145	\$130	1.35	\$1,009	0	-\$2,957	1.48	\$1,257
	1978-1991		-1,154	158	1,248	\$139	\$126	1.30	\$879	0	-\$3,009	1.48	\$1,252
	1992-2010		-1,161	158	1,250	\$136	\$123	1.28	\$805	0	-\$3,061	1.47	\$1,211
NEEA Tier 3 HPWH at Replacement	Pre-1978	\$2,775	-868	156	1,340	\$176	\$154	1.50	\$1,541	0.43	-\$1,571	1.90	\$2,508
	1978-1991		-881	157	1,346	\$170	\$150	1.46	\$1,408	0.45	-\$1,530	1.90	\$2,511
	1992-2010		-892	157	1,348	\$167	\$147	1.43	\$1,329	0.41	-\$1,649	1.88	\$2,445
HPWH at Water Heater Replacement + PV	Pre-1978	\$10,291	2,731	157	1,481	\$637	\$519	1.37	\$4,165	1.49	\$5,016	1.60	\$6,186
	1978-1991		2,722	158	1,485	\$632	\$515	1.35	\$4,036	1.48	\$4,938	1.60	\$6,151
	1992-2010		2,716	158	1,488	\$629	\$512	1.35	\$3,962	1.47	\$4,855	1.59	\$6,076
HPWH Replacement w/ Panel Upgrade + PV	Pre-1978	\$13,472	2,731	157	1,481	\$637	\$519	1.04	\$594	1.14	\$1,835	1.22	\$3,005
	1978-1991		2,722	158	1,485	\$632	\$515	1.03	\$464	1.13	\$1,757	1.22	\$2,970
	1992-2010		2,716	158	1,488	\$629	\$512	1.03	\$390	1.12	\$1,674	1.21	\$2,895

Measure	Vintage	Measure Cost (\$)	Electricity Savings (kWh)	Gas Savings (therm)	GHG Savings (lb CO ₂ e)	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
PV + Electric Ready Pre-Wire	Pre-1978	\$11,788	3,876	0	237	\$493	\$389	0.89	-\$1,437	1.31	\$3,692	1.05	\$647
	1978-1991		3,876	0	237	\$493	\$389	0.89	-\$1,437	1.31	\$3,663	1.05	\$613
	1992-2010		3,876	0	237	\$493	\$389	0.89	-\$1,437	1.31	\$3,628	1.05	\$575

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 94: CZ 13 - Single Family Efficiency Upgrade Cost-Effectiveness Results

Measure	Vintage	Measure Cost (\$)	Electricity Savings (kWh)	Gas Savings (therm)	GHG Savings (lb CO ₂ e)	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	\$3,332	1,329	29	454	\$545	\$434	3.48	\$9,266	2.80	\$6,001	3.09	\$6,969
	1978-1991	\$2,874	714	15	223	\$294	\$234	2.18	\$3,796	1.86	\$2,458	2.01	\$2,907
	1992-2010	\$1,852	207	5	86	\$90	\$71	1.03	\$59	0.97	-\$58	1.01	\$23
Reduced Infiltration	Pre-1978	\$1,474	107	12	132	\$64	\$52	0.94	-\$104	0.99	-\$19	1.12	\$171
	1978-1991		70	7	72	\$42	\$34	0.62	-\$636	0.71	-\$428	0.92	-\$112
	1992-2010		41	5	60	\$24	\$20	0.36	-\$1,064	0.37	-\$932	0.29	-\$1,051
Duct Sealing	Pre-1978	\$683	1,409	27	475	\$593	\$471	18.42	\$13,362	17.50	\$11,271	19.77	\$12,821
	1978-1991	\$683	873	15	299	\$368	\$292	11.43	\$8,001	11.78	\$7,365	12.43	\$7,806
	1992-2010	\$423	174	4	79	\$77	\$61	3.86	\$1,357	4.37	\$1,426	4.39	\$1,435
New Ducts	Pre-1978	\$3,986	2,409	47	853	\$1,016	\$808	5.41	\$19,752	5.20	\$16,745	5.68	\$18,660
	1978-1991		1,839	34	679	\$777	\$617	4.13	\$14,030	4.23	\$12,876	4.29	\$13,127
	1992-2010		551	13	266	\$242	\$193	1.29	\$1,313	1.43	\$1,706	1.38	\$1,524
Cool Roof	Pre-1978	\$778	631	-5	26	\$225	\$177	6.27	\$4,472	4.23	\$2,512	5.29	\$3,338
	1978-1991		460	-3	31	\$167	\$131	4.64	\$3,087	3.69	\$2,094	3.95	\$2,293
	1992-2010		220	-3	18	\$79	\$62	2.19	\$1,007	1.86	\$671	1.79	\$613
R-13 Wall Insulation	Pre-1978	\$3,360	550	38	464	\$281	\$226	1.80	\$3,012	1.82	\$2,758	2.02	\$3,429
Windows	Pre-1978	\$9,810	1,991	21	451	\$781	\$619	1.68	\$7,542	1.41	\$4,048	1.52	\$5,116
	1978-1991		1,617	18	388	\$640	\$507	1.38	\$4,203	1.21	\$2,063	1.24	\$2,357
LED lamp vs CFL	All	\$2.26	1.2	0	n/a	\$0.44	\$0.35	4.67	\$8.27	n/a	n/a	n/a	n/a
Exterior Photosensor	All	\$42.58	12.1	0	n/a	\$2.88	\$2.27	1.60	\$25.62	n/a	n/a	n/a	n/a

Table 95: CZ 13 - Single Family Efficiency Packages Cost-Effectiveness Results

Measure	Vintage	Measure Cost (\$)	Electricity Savings (kWh)	Gas Savings (therm)	GHG Savings (lb CO ₂ e)	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	\$4,806	1,444	42	598	\$613	\$489	2.72	\$9,271	2.26	\$6,048	2.50	\$7,195
	1978-1991	\$4,348	785	22	318	\$336	\$268	1.64	\$3,146	1.46	\$2,006	1.51	\$2,200
	1992-2010	\$3,326	248	10	149	\$114	\$91	0.73	-\$995	0.71	-\$973	0.69	-\$1,042
R49 Attic & Duct Sealing Package	Pre-1978	\$4,015	2,592	55	932	\$1,082	\$860	5.73	\$21,304	5.19	\$16,820	5.57	\$18,341
	1978-1991	\$3,557	1,508	29	527	\$631	\$501	3.76	\$11,043	3.62	\$9,316	3.72	\$9,685
	1992-2010	\$2,275	370	10	166	\$162	\$129	1.51	\$1,312	1.56	\$1,273	1.58	\$1,314
R49 Attic, Air Sealing & Duct Sealing Package	Pre-1978	\$5,489	2,686	66	1,055	\$1,141	\$908	4.42	\$21,080	4.07	\$16,832	4.40	\$18,641
	1978-1991	\$5,031	1,574	36	616	\$669	\$532	2.83	\$10,316	2.75	\$8,792	2.77	\$8,908
	1992-2010	\$3,749	409	14	226	\$185	\$148	1.05	\$227	1.10	\$358	1.06	\$214
R49 Attic, Air Sealing & New Ducts Package	Pre-1978	\$8,792	3,687	86	1,451	\$1,567	\$1,246	3.79	\$27,518	3.60	\$22,815	3.80	\$24,651
	1978-1991	\$8,334	2,512	53	973	\$1,068	\$849	2.72	\$16,119	2.72	\$14,335	2.77	\$14,736
	1992-2010	\$7,312	772	23	402	\$345	\$275	1.00	\$38	1.11	\$793	1.06	\$407
Advanced Envelope Package	Pre-1978	\$18,659	4,436	128	1,955	\$1,924	\$1,533	2.20	\$25,042	2.09	\$20,426	2.17	\$21,881
Water Heating Package	All Vintages	\$208	0	16	n/a	\$33	\$30	1.94	\$220	n/a	n/a	n/a	n/a

Table 96: CZ 13 - Single Family PV & Battery Cost-Effectiveness Results

Measure	Vintage	Measure Cost (\$)	Electricity Savings (kWh)	Gas Savings (therm)	GHG Savings (lb CO ₂ e)	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	\$9,534	4,855	0	309	\$1,394	\$1,101	3.13	\$22,473	1.94	\$8,973	1.66	\$6,326
	1978-1991		4,855		309	\$1,376	\$1,086	3.09	\$22,042	1.94	\$8,921	1.66	\$6,262
	1992-2010		4,855		309	\$1,312	\$1,035	2.95	\$20,511	1.93	\$8,843	1.65	\$6,167
PV + Battery	Pre-1978	\$20,907	4,634	0	911	\$1,432	\$1,131	1.50	\$11,321	1.31	\$6,412	0.94	-\$1,201
	1978-1991		4,629		942	\$1,422	\$1,122	1.49	\$11,067	1.35	\$7,333	0.96	-\$913
	1992-2010		4,622		1,002	\$1,367	\$1,079	1.43	\$9,771	1.42	\$8,802	0.97	-\$556

Table 97: CZ 13 - Single Family Equipment Fuel Substitution Cost-Effectiveness Results

Measure	Vintage	Measure Cost (\$)	Electricity Savings (kWh)	Gas Savings (therm)	GHG Savings (lb CO ₂ e)	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	\$501	-2,305	214	991	-\$120	-\$72	0	-\$2,717	0	-\$2,757	2.65	\$826
	1978-1991		-1,711	159	730	-\$75	-\$43	0	-\$1,846	0	-\$2,163	1.93	\$466
	1992-2010		-1,396	130	605	-\$60	-\$35	0	-\$1,598	0.97	-\$58	1.65	\$325
High-Effic. Heat Pump at HVAC Replacement	Pre-1978	\$3,749	-1,039	214	1,388	\$316	\$272	2.01	\$4,099	1.90	\$3,362	2.63	\$6,102
	1978-1991		-700	159	1,054	\$278	\$235	1.74	\$2,996	1.60	\$2,265	2.12	\$4,186
	1992-2010		-647	130	865	\$190	\$162	1.20	\$808	0.37	-\$932	1.63	\$2,357
Heat Pump at HVAC Replacement + PV	Pre-1978	\$10,036	2,550	214	1,300	\$1,224	\$988	2.67	\$18,562	1.63	\$6,279	1.72	\$7,181
	1978-1991		3,144	159	1,039	\$1,247	\$1,000	2.71	\$18,924	1.68	\$6,806	1.67	\$6,746
	1992-2010		3,459	130	914	\$1,203	\$962	2.60	\$17,775	4.37	\$1,426	1.65	\$6,527
HVAC HP Replacement w/ Panel Upgrade + PV	Pre-1978	\$13,217	2,550	214	1,300	\$1,224	\$988	2.02	\$14,990	1.23	\$3,098	1.30	\$4,000
	1978-1991		3,144	159	1,039	\$1,247	\$1,000	2.05	\$15,352	1.27	\$3,625	1.27	\$3,565
	1992-2010		3,459	130	914	\$1,203	\$962	1.97	\$14,203	1.43	\$1,706	1.25	\$3,346
HPWH at Water Heater Replacement	Pre-1978	\$2,594	-952	148	1,205	-\$36	-\$14	0	-\$3,297	0.12	-\$2,286	1.67	\$1,735
	1978-1991		-964	149	1,205	-\$36	-\$14	0	-\$3,311	0.10	-\$2,338	1.72	\$1,871
	1992-2010		-976	149	1,210	-\$48	-\$24	0	-\$3,605	0.07	-\$2,401	1.64	\$1,663
NEEA Tier 3 HPWH at Replacement	Pre-1978	\$2,775	-736	147	1,295	\$32	\$40	0.39	-\$1,884	0.54	-\$1,283	1.90	\$2,494
	1978-1991		-747	148	1,293	\$32	\$40	0.39	-\$1,881	0.55	-\$1,260	1.97	\$2,704
	1992-2010		-759	148	1,306	\$21	\$30	0.30	-\$2,176	0.47	-\$1,458	1.83	\$2,315
HPWH at Water Heater Replacement + PV	Pre-1978	\$12,128	3,904	148	1,514	\$1,406	\$1,125	2.51	\$20,306	1.57	\$6,874	1.68	\$8,243
	1978-1991		3,891	149	1,514	\$1,396	\$1,117	2.49	\$20,066	1.56	\$6,776	1.69	\$8,320
	1992-2010		3,879	149	1,519	\$1,326	\$1,061	2.37	\$18,400	1.55	\$6,635	1.66	\$8,024
HPWH Replacement w/ Panel Upgrade + PV	Pre-1978	\$15,309	3,904	148	1,514	\$1,406	\$1,125	1.98	\$16,734	1.24	\$3,693	1.33	\$5,062
	1978-1991		3,891	149	1,514	\$1,396	\$1,117	1.97	\$16,494	1.23	\$3,595	1.34	\$5,139
	1992-2010		3,879	149	1,519	\$1,326	\$1,061	1.87	\$14,828	1.23	\$3,454	1.32	\$4,843

Measure	Vintage	Measure Cost (\$)	Electricity Savings (kWh)	Gas Savings (therm)	GHG Savings (lb CO ₂ e)	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
PV + Electric Ready Pre-Wire	Pre-1978	\$13,625	4,855	0	309	\$1,394	\$1,101	2.18	\$17,880	1.36	\$4,882	1.16	\$2,235
	1978-1991		4,855	0	309	\$1,376	\$1,086	2.15	\$17,448	1.35	\$4,830	1.16	\$2,171
	1992-2010		4,855	0	309	\$1,312	\$1,035	2.05	\$15,917	1.35	\$4,752	1.15	\$2,076

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 98: CZ 14 (SCE/SoCalGas) - Single Family Efficiency Upgrade Cost-Effectiveness Results

Measure	Vintage	Measure Cost (\$)	Electricity Savings (kWh)	Gas Savings (therm)	GHG Savings (lb CO ₂ e)	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	\$3,332	936	48	564	\$374	\$303	2.43	\$5,358	2.75	\$5,816	2.83	\$6,086
	1978-1991	\$2,874	504	23	274	\$201	\$162	1.51	\$1,634	1.76	\$2,180	1.75	\$2,154
	1992-2010	\$1,852	139	9	105	\$61	\$50	0.72	-\$588	0.96	-\$75	0.92	-\$141
Reduced Infiltration	Pre-1978	\$1,474	111	19	201	\$63	\$52	0.95	-\$86	1.26	\$378	1.30	\$444
	1978-1991		69	11	120	\$38	\$31	0.57	-\$714	0.80	-\$290	0.72	-\$420
	1992-2010		36	7	74	\$22	\$19	0.34	-\$1,100	0.40	-\$889	0.51	-\$728
Duct Sealing	Pre-1978	\$683	939	44	567	\$388	\$314	12.27	\$8,641	17.18	\$11,049	15.61	\$9,980
	1978-1991	\$683	560	24	321	\$233	\$188	7.36	\$4,876	10.91	\$6,766	9.68	\$5,928
	1992-2010	\$423	104	7	88	\$47	\$38	2.43	\$679	3.74	\$1,158	3.40	\$1,017
New Ducts	Pre-1978	\$3,986	1,650	73	960	\$681	\$550	3.68	\$12,009	5.01	\$15,981	4.76	\$14,976
	1978-1991		1,230	50	692	\$511	\$411	2.76	\$7,865	3.91	\$11,586	3.60	\$10,382
	1992-2010		349	21	279	\$157	\$128	0.86	-\$647	1.27	\$1,092	1.21	\$839
Cool Roof	Pre-1978	\$778	432	-7	-43	\$136	\$106	3.75	\$2,335	3.97	\$2,307	4.06	\$2,382
	1978-1991		306	-5	-14	\$99	\$78	2.74	\$1,478	3.17	\$1,685	2.75	\$1,362
	1992-2010		141	-4	-17	\$46	\$35	1.25	\$216	1.49	\$383	1.34	\$268
R-13 Wall Insulation	Pre-1978	\$3,360	389	57	641	\$210	\$175	1.39	\$1,482	1.84	\$2,810	1.90	\$3,032
Windows	Pre-1978	\$9,810	1,571	17	363	\$554	\$440	1.20	\$2,183	1.38	\$3,725	1.12	\$1,150
	1978-1991		1,281	9	272	\$452	\$358	0.98	-\$269	1.11	\$1,116	0.89	-\$1,125
LED lamp vs CFL	All	\$2.26	1.2	0	n/a	\$0.35	\$0.28	3.66	\$6.01	n/a	n/a	n/a	n/a
Exterior Photosensor	All	\$42.58	12.1	0	n/a	\$2.00	\$1.58	1.11	\$4.84	n/a	n/a	n/a	n/a

Table 99: CZ 14 (SCE/SoCalGas) - Single Family Efficiency Packages Cost-Effectiveness Results

Measure	Vintage	Measure Cost (\$)	Electricity Savings (kWh)	Gas Savings (therm)	GHG Savings (lb CO ₂ e)	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	\$4,806	1,051	67	761	\$439	\$357	1.99	\$5,326	2.35	\$6,467	2.40	\$6,726
	1978-1991	\$4,348	573	35	397	\$240	\$195	1.20	\$964	1.43	\$1,864	1.44	\$1,913
	1992-2010	\$3,326	173	16	183	\$83	\$68	0.54	-\$1,704	0.70	-\$993	0.73	-\$904
R49 Attic & Duct Sealing Package	Pre-1978	\$4,015	1,764	88	1,094	\$726	\$587	3.91	\$13,105	5.04	\$16,222	4.83	\$15,366
	1978-1991	\$3,557	1,006	45	579	\$413	\$334	2.51	\$6,017	3.39	\$8,517	3.12	\$7,554
	1992-2010	\$2,275	235	15	191	\$106	\$86	1.01	\$21	1.39	\$887	1.34	\$778
R49 Attic, Air Sealing & Duct Sealing Package	Pre-1978	\$5,489	1,851	105	1,277	\$777	\$630	3.07	\$12,751	4.01	\$16,508	3.80	\$15,373
	1978-1991	\$5,031	1,063	56	698	\$446	\$361	1.92	\$5,183	2.59	\$8,019	2.39	\$6,976
	1992-2010	\$3,749	267	22	265	\$126	\$103	0.73	-\$1,120	1.04	\$157	1.01	\$21
R49 Attic, Air Sealing & New Ducts Package	Pre-1978	\$8,792	2,558	132	1,671	\$1,072	\$868	2.64	\$16,165	3.45	\$21,550	3.33	\$20,481
	1978-1991	\$8,334	1,711	80	1,054	\$716	\$579	1.85	\$7,997	2.55	\$12,880	2.37	\$11,425
	1992-2010	\$7,312	502	35	447	\$232	\$189	0.69	-\$2,538	1.00	\$16	0.98	-\$180
Advanced Envelope Package	Pre-1978	\$18,659	3,187	188	2,319	\$1,350	\$1,096	1.57	\$11,940	2.04	\$19,495	1.90	\$16,726
Water Heating Package	All Vintages	\$208	0	16	n/a	\$24	\$22	1.43	\$100	n/a	n/a	n/a	n/a

Table 100: CZ 14 (SCE/SoCalGas) - Single Family PV & Battery Cost-Effectiveness Results

Measure	Vintage	Measure Cost (\$)	Electricity Savings (kWh)	Gas Savings (therm)	GHG Savings (lb CO ₂ e)	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	\$7,929	4,697	0	377	\$1,043	\$823	2.82	\$15,923	2.22	\$9,650	1.99	\$7,867
	1978-1991		4,697		377	\$1,022	\$806	2.76	\$15,421	2.21	\$9,610	1.99	\$7,821
	1992-2010		4,697		377	\$954	\$753	2.58	\$13,814	2.20	\$9,546	1.98	\$7,746
PV + Battery	Pre-1978	\$19,302	4,467	0	1,019	\$1,218	\$962	1.39	\$8,029	1.27	\$5,234	1.09	\$1,705
	1978-1991		4,463		1,041	\$1,209	\$954	1.37	\$7,795	1.28	\$5,404	1.10	\$1,968
	1992-2010		4,456		1,105	\$1,154	\$911	1.31	\$6,509	1.31	\$6,009	1.16	\$3,166

Table 101: CZ 14 (SCE/SoCalGas) - Single Family Equipment Fuel Substitution Cost-Effectiveness Results

Measure	Vintage	Measure Cost (\$)	Electricity Savings (kWh)	Gas Savings (therm)	GHG Savings (lb CO2e)	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	\$501	-3,788	306	1,144	-\$549	-\$387	0	-\$12,159	0	-\$4,914	0	-\$729
	1978-1991		-2,810	222	785	-\$409	-\$291	0	-\$9,269	0	-\$3,895	0	-\$1,011
	1992-2010		-2,358	189	701	-\$338	-\$240	0	-\$7,756	0	-\$3,246	0	-\$712
High-Effic. Heat Pump at HVAC Replacement	Pre-1978	\$3,749	-2,606	306	1,569	-\$178	-\$94	0	-\$6,890	1.21	\$776	1.99	\$3,717
	1978-1991		-1,884	222	1,124	-\$118	-\$61	0	-\$5,873	1.02	\$64	1.52	\$1,942
	1992-2010		-1,662	189	976	-\$123	-\$70	0	-\$6,157	0.73	-\$1,022	1.19	\$718
Heat Pump at HVAC Replacement + PV	Pre-1978	\$8,431	909	306	1,522	\$521	\$457	1.47	\$4,401	1.57	\$4,840	1.85	\$7,187
	1978-1991		1,887	222	1,162	\$639	\$536	1.73	\$6,776	1.69	\$5,790	1.81	\$6,841
	1992-2010		2,339	189	1,078	\$665	\$552	1.78	\$7,243	1.76	\$6,404	1.84	\$7,089
HVAC HP Replacement w/ Panel Upgrade + PV	Pre-1978	\$11,612	909	306	1,522	\$521	\$457	1.06	\$829	1.14	\$1,659	1.35	\$4,006
	1978-1991		1,887	222	1,162	\$639	\$536	1.25	\$3,204	1.22	\$2,609	1.32	\$3,660
	1992-2010		2,339	189	1,078	\$665	\$552	1.28	\$3,671	1.28	\$3,223	1.34	\$3,908
HPWH at Water Heater Replacement	Pre-1978	\$2,594	-1,144	153	1,195	-\$127	-\$79	0	-\$5,271	0.06	-\$2,441	1.47	\$1,217
	1978-1991		-1,160	153	1,193	-\$128	-\$80	0	-\$5,290	0.05	-\$2,453	1.48	\$1,243
	1992-2010		-1,168	154	1,198	-\$127	-\$79	0	-\$5,266	0.02	-\$2,545	1.43	\$1,110
NEEA Tier 3 HPWH at Replacement	Pre-1978	\$2,775	-873	152	1,288	-\$43	-\$13	0	-\$3,477	0.53	-\$1,312	1.83	\$2,306
	1978-1991		-891	153	1,287	-\$44	-\$14	0	-\$3,500	0.54	-\$1,289	1.84	\$2,324
	1992-2010		-902	153	1,292	-\$43	-\$13	0	-\$3,487	0.50	-\$1,392	1.79	\$2,203
HPWH at Water Heater Replacement + PV	Pre-1978	\$10,523	3,553	153	1,572	\$982	\$796	2.05	\$12,218	1.71	\$7,425	1.88	\$9,300
	1978-1991		3,537	153	1,571	\$961	\$780	2.01	\$11,738	1.70	\$7,376	1.88	\$9,286
	1992-2010		3,529	154	1,576	\$897	\$729	1.88	\$10,205	1.69	\$7,223	1.86	\$9,081
HPWH Replacement w/ Panel Upgrade + PV	Pre-1978	\$13,704	3,553	153	1,572	\$982	\$796	1.57	\$8,646	1.31	\$4,244	1.45	\$6,119
	1978-1991		3,537	153	1,571	\$961	\$780	1.54	\$8,166	1.31	\$4,195	1.45	\$6,105
	1992-2010		3,529	154	1,576	\$897	\$729	1.44	\$6,633	1.29	\$4,042	1.43	\$5,900

Measure	Vintage	Measure Cost (\$)	Electricity Savings (kWh)	Gas Savings (therm)	GHG Savings (lb CO2e)	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
PV + Electric Ready Pre-Wire	Pre-1978	\$12,020	4,697	0	377	\$1,043	\$823	1.85	\$11,329	1.46	\$5,559	1.31	\$3,776
	1978-1991		4,697	0	377	\$1,022	\$806	1.81	\$10,827	1.46	\$5,519	1.31	\$3,730
	1992-2010		4,697	0	377	\$954	\$753	1.69	\$9,221	1.45	\$5,455	1.30	\$3,655

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 102: CZ 14 (SDG&E) - Single Family Efficiency Upgrade Cost-Effectiveness Results

Measure	Vintage	Measure Cost (\$)	Electricity Savings (kWh)	Gas Savings (therm)	GHG Savings (lb CO ₂ e)	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	\$3,332	936	48	564	\$506	\$409	3.28	\$8,541	2.75	\$5,816	2.83	\$6,086
	1978-1991	\$2,874	504	23	274	\$272	\$219	2.04	\$3,354	1.76	\$2,180	1.75	\$2,154
	1992-2010	\$1,852	139	9	105	\$86	\$70	1.01	\$17	0.96	-\$75	0.92	-\$141
Reduced Infiltration	Pre-1978	\$1,474	111	19	201	\$85	\$71	1.28	\$467	1.26	\$378	1.30	\$444
	1978-1991		69	11	120	\$50	\$42	0.76	-\$397	0.80	-\$290	0.72	-\$420
	1992-2010		36	7	74	\$30	\$25	0.46	-\$892	0.40	-\$889	0.51	-\$728
Duct Sealing	Pre-1978	\$683	939	44	567	\$540	\$436	17.05	\$12,306	17.18	\$11,049	15.61	\$9,980
	1978-1991	\$683	560	24	321	\$326	\$263	10.27	\$7,112	10.91	\$6,766	9.68	\$5,928
	1992-2010	\$423	104	7	88	\$68	\$55	3.45	\$1,166	3.74	\$1,158	3.40	\$1,017
New Ducts	Pre-1978	\$3,986	1,650	73	960	\$948	\$764	5.12	\$18,435	5.01	\$15,981	4.76	\$14,976
	1978-1991		1,230	50	692	\$717	\$576	3.86	\$12,814	3.91	\$11,586	3.60	\$10,382
	1992-2010		349	21	279	\$226	\$183	1.23	\$1,007	1.27	\$1,092	1.21	\$839
Cool Roof	Pre-1978	\$778	432	-7	-43	\$189	\$148	5.22	\$3,585	3.97	\$2,307	4.06	\$2,382
	1978-1991		306	-5	-14	\$137	\$107	3.80	\$2,375	3.17	\$1,685	2.75	\$1,362
	1992-2010		141	-4	-17	\$66	\$51	1.81	\$690	1.49	\$383	1.34	\$268
R-13 Wall Insulation	Pre-1978	\$3,360	389	57	641	\$285	\$237	1.89	\$3,352	1.84	\$2,810	1.90	\$3,032
Windows	Pre-1978	\$9,810	1,571	17	363	\$752	\$597	1.63	\$6,901	1.38	\$3,725	1.12	\$1,150
	1978-1991		1,281	9	272	\$618	\$490	1.33	\$3,673	1.11	\$1,116	0.89	-\$1,125
LED lamp vs CFL	All	\$2.26	1.2	0	n/a	\$0.50	\$0.39	5.23	\$9.55	n/a	n/a	n/a	n/a
Exterior Photosensor	All	\$42.58	12.1	0	n/a	\$2.76	\$2.18	1.54	\$22.81	n/a	n/a	n/a	n/a

Table 103: CZ 14 (SDG&E) - Single Family Efficiency Packages Cost-Effectiveness Results

Measure	Vintage	Measure Cost (\$)	Electricity Savings (kWh)	Gas Savings (therm)	GHG Savings (lb CO ₂ e)	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	\$4,806	1,051	67	761	\$593	\$482	2.68	\$9,064	2.35	\$6,467	2.40	\$6,726
	1978-1991	\$4,348	573	35	397	\$324	\$263	1.62	\$3,021	1.43	\$1,864	1.44	\$1,913
	1992-2010	\$3,326	173	16	183	\$115	\$94	0.76	-\$901	0.70	-\$993	0.73	-\$904
R49 Attic & Duct Sealing Package	Pre-1978	\$4,015	1,764	88	1,094	\$995	\$804	5.35	\$19,623	5.04	\$16,222	4.83	\$15,366
	1978-1991	\$3,557	1,006	45	579	\$571	\$461	3.46	\$9,823	3.39	\$8,517	3.12	\$7,554
	1992-2010	\$2,275	235	15	191	\$150	\$121	1.42	\$1,083	1.39	\$887	1.34	\$778
R49 Attic, Air Sealing & Duct Sealing Package	Pre-1978	\$5,489	1,851	105	1,277	\$1,064	\$862	4.20	\$19,699	4.01	\$16,508	3.80	\$15,373
	1978-1991	\$5,031	1,063	56	698	\$615	\$497	2.64	\$9,267	2.59	\$8,019	2.39	\$6,976
	1992-2010	\$3,749	267	22	265	\$177	\$145	1.03	\$133	1.04	\$157	1.01	\$21
R49 Attic, Air Sealing & New Ducts Package	Pre-1978	\$8,792	2,558	132	1,671	\$1,479	\$1,196	3.63	\$26,004	3.45	\$21,550	3.33	\$20,481
	1978-1991	\$8,334	1,711	80	1,054	\$1,000	\$806	2.58	\$14,825	2.55	\$12,880	2.37	\$11,425
	1992-2010	\$7,312	502	35	447	\$333	\$271	0.99	-\$92	1.00	\$16	0.98	-\$180
Advanced Envelope Package	Pre-1978	\$18,659	3,187	188	2,319	\$1,851	\$1,501	2.15	\$24,087	2.04	\$19,495	1.90	\$16,726
Water Heating Package	All Vintages	\$208	0	16	n/a	\$31	\$29	1.85	\$198	n/a	n/a	n/a	n/a

Table 104: CZ 14 (SDG&E) - Single Family PV & Battery Cost-Effectiveness Results

Measure	Vintage	Measure Cost (\$)	Electricity Savings (kWh)	Gas Savings (therm)	GHG Savings (lb CO ₂ e)	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	\$7,929	4,697	0	377	\$1,651	\$1,303	4.46	\$30,316	2.22	\$9,650	1.99	\$7,867
	1978-1991		4,697		377	\$1,771	\$1,398	4.78	\$33,158	2.21	\$9,610	1.99	\$7,821
	1992-2010		4,697		377	\$1,726	\$1,362	4.66	\$32,106	2.20	\$9,546	1.98	\$7,746
PV + Battery	Pre-1978	\$19,302	4,467	0	1,019	\$1,810	\$1,429	2.06	\$22,037	1.27	\$5,234	1.09	\$1,705
	1978-1991		4,463		1,041	\$1,822	\$1,438	2.07	\$22,311	1.28	\$5,404	1.10	\$1,968
	1992-2010		4,456		1,105	\$1,846	\$1,457	2.10	\$22,892	1.31	\$6,009	1.16	\$3,166

Table 105: CZ 14 (SDG&E) - Single Family Equipment Fuel Substitution Cost-Effectiveness Results

Measure	Vintage	Measure Cost (\$)	Electricity Savings (kWh)	Gas Savings (therm)	GHG Savings (lb CO ₂ e)	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	\$501	-3,788	306	1,144	-\$733	-\$515	0	-\$15,998	0	-\$4,914	0	-\$729
	1978-1991		-2,810	222	785	-\$519	-\$364	0	-\$11,456	0	-\$3,895	0	-\$1,011
	1992-2010		-2,358	189	701	-\$410	-\$285	0	-\$9,110	0	-\$3,246	0	-\$712
High-Effic. Heat Pump at HVAC Replacement	Pre-1978	\$3,749	-2,606	306	1,569	-\$210	-\$102	0	-\$7,128	1.21	\$776	1.99	\$3,717
	1978-1991		-1,884	222	1,124	-\$102	-\$34	0	-\$5,091	1.02	\$64	1.52	\$1,942
	1992-2010		-1,662	189	976	-\$108	-\$47	0	-\$5,471	0.73	-\$1,022	1.19	\$718
Heat Pump at HVAC Replacement + PV	Pre-1978	\$8,431	909	306	1,522	\$1,009	\$860	2.77	\$16,491	1.57	\$4,840	1.85	\$7,187
	1978-1991		1,887	222	1,162	\$1,195	\$989	3.19	\$20,356	1.69	\$5,790	1.81	\$6,841
	1992-2010		2,339	189	1,078	\$1,282	\$1,050	3.38	\$22,193	1.76	\$6,404	1.84	\$7,089
HVAC HP Replacement w/ Panel Upgrade + PV	Pre-1978	\$11,612	909	306	1,522	\$1,009	\$860	2.00	\$12,919	1.14	\$1,659	1.35	\$4,006
	1978-1991		1,887	222	1,162	\$1,195	\$989	2.30	\$16,784	1.22	\$2,609	1.32	\$3,660
	1992-2010		2,339	189	1,078	\$1,282	\$1,050	2.45	\$18,621	1.28	\$3,223	1.34	\$3,908
HPWH at Water Heater Replacement	Pre-1978	\$2,594	-1,144	153	1,195	-\$130	-\$73	0	-\$5,075	0.06	-\$2,441	1.47	\$1,217
	1978-1991		-1,160	153	1,193	-\$121	-\$66	0	-\$4,870	0.05	-\$2,453	1.48	\$1,243
	1992-2010		-1,168	154	1,198	-\$118	-\$63	0	-\$4,791	0.02	-\$2,545	1.43	\$1,110
NEEA Tier 3 HPWH at Replacement	Pre-1978	\$2,775	-873	152	1,288	-\$27	\$8	0.08	-\$2,851	0.53	-\$1,312	1.83	\$2,306
	1978-1991		-891	153	1,287	-\$22	\$12	0.12	-\$2,727	0.54	-\$1,289	1.84	\$2,324
	1992-2010		-902	153	1,292	-\$25	\$10	0.10	-\$2,777	0.50	-\$1,392	1.79	\$2,203
HPWH at Water Heater Replacement + PV	Pre-1978	\$10,523	3,553	153	1,572	\$1,487	\$1,203	3.10	\$24,444	1.71	\$7,425	1.88	\$9,300
	1978-1991		3,537	153	1,571	\$1,478	\$1,197	3.08	\$24,239	1.70	\$7,376	1.88	\$9,286
	1992-2010		3,529	154	1,576	\$1,472	\$1,192	3.07	\$24,096	1.69	\$7,223	1.86	\$9,081
HPWH Replacement w/ Panel Upgrade + PV	Pre-1978	\$13,704	3,553	153	1,572	\$1,487	\$1,203	2.37	\$20,872	1.31	\$4,244	1.45	\$6,119
	1978-1991		3,537	153	1,571	\$1,478	\$1,197	2.36	\$20,667	1.31	\$4,195	1.45	\$6,105
	1992-2010		3,529	154	1,576	\$1,472	\$1,192	2.35	\$20,524	1.29	\$4,042	1.43	\$5,900

Measure	Vintage	Measure Cost (\$)	Electricity Savings (kWh)	Gas Savings (therm)	GHG Savings (lb CO ₂ e)	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
PV + Electric Ready Pre-Wire	Pre-1978	\$12,020	4,697	0	377	\$1,651	\$1,303	2.92	\$25,722	1.46	\$5,559	1.31	\$3,776
	1978-1991		4,697	0	377	\$1,771	\$1,398	3.14	\$28,564	1.46	\$5,519	1.31	\$3,730
	1992-2010		4,697	0	377	\$1,726	\$1,362	3.06	\$27,512	1.45	\$5,455	1.30	\$3,655

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 106: CZ 15 - Single Family Efficiency Upgrade Cost-Effectiveness Results

Measure	Vintage	Measure Cost (\$)	Electricity Savings (kWh)	Gas Savings (therm)	GHG Savings (lb CO ₂ e)	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	\$3,332	1,824	10	257	\$584	\$463	3.71	\$10,135	3.33	\$7,766	3.26	\$7,518
	1978-1991	\$2,874	996	5	140	\$320	\$253	2.35	\$4,368	2.12	\$3,206	1.98	\$2,803
	1992-2010	\$1,852	296	2	44	\$97	\$77	1.10	\$218	1.09	\$167	1.03	\$60
Reduced Infiltration	Pre-1978	\$1,474	219	3	38	\$71	\$57	1.02	\$40	1.15	\$214	1.12	\$179
	1978-1991		142	2	42	\$47	\$37	0.67	-\$546	0.79	-\$313	0.56	-\$642
	1992-2010		84	1	22	\$27	\$22	0.39	-\$1,006	0.51	-\$728	0.38	-\$918
Duct Sealing	Pre-1978	\$683	2,634	4	325	\$866	\$684	26.77	\$19,763	27.36	\$18,002	25.02	\$16,407
	1978-1991	\$683	1,696	1	243	\$566	\$447	17.49	\$12,645	18.21	\$11,758	16.21	\$10,389
	1992-2010	\$423	356	0	63	\$119	\$94	5.95	\$2,352	6.99	\$2,532	5.97	\$2,100
New Ducts	Pre-1978	\$3,986	4,230	7	577	\$1,401	\$1,107	7.42	\$28,727	7.53	\$26,043	6.90	\$23,514
	1978-1991		3,252	4	486	\$1,093	\$863	5.78	\$21,413	6.01	\$19,985	5.40	\$17,537
	1992-2010		1,016	1	178	\$342	\$270	1.81	\$3,633	2.08	\$4,324	1.84	\$3,356
Cool Roof	Pre-1978	\$778	883	-1	56	\$280	\$221	7.82	\$5,788	6.20	\$4,044	6.13	\$3,992
	1978-1991		659	-1	65	\$214	\$169	5.96	\$4,209	4.85	\$2,996	4.58	\$2,785
	1992-2010		311	0	26	\$102	\$81	2.85	\$1,568	2.52	\$1,184	2.61	\$1,250
R-13 Wall Insulation	Pre-1978	\$3,360	1,020	10	259	\$337	\$267	2.13	\$4,245	2.40	\$4,717	2.02	\$3,432
Windows	Pre-1978	\$9,810	3,358	2	347	\$1,067	\$842	2.29	\$14,248	2.15	\$11,315	1.88	\$8,668
	1978-1991		2,702	2	284	\$864	\$682	1.86	\$9,453	1.71	\$6,989	1.52	\$5,108
LED lamp vs CFL	All	\$2.26	1.2	0	n/a	\$0.36	\$0.28	3.73	\$6.17	n/a	n/a	n/a	n/a
Exterior Photosensor	All	\$42.58	12.1	0	n/a	\$2.00	\$1.58	1.11	\$4.84	n/a	n/a	n/a	n/a

Table 107: CZ 15 - Single Family Efficiency Packages Cost-Effectiveness Results

Measure	Vintage	Measure Cost (\$)	Electricity Savings (kWh)	Gas Savings (therm)	GHG Savings (lb CO ₂ e)	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	\$4,806	2,056	13	322	\$660	\$523	2.91	\$10,289	2.70	\$8,167	2.55	\$7,450
	1978-1991	\$4,348	1,133	6	154	\$365	\$289	1.77	\$3,777	1.64	\$2,764	1.57	\$2,469
	1992-2010	\$3,326	379	3	67	\$124	\$98	0.79	-\$795	0.83	-\$564	0.74	-\$881
R49 Attic & Duct Sealing Package	Pre-1978	\$4,015	4,283	13	617	\$1,401	\$1,107	7.37	\$28,712	7.23	\$25,008	6.65	\$22,669
	1978-1991	\$3,557	2,574	6	374	\$850	\$672	5.05	\$16,159	5.06	\$14,449	4.54	\$12,581
	1992-2010	\$2,275	636	2	108	\$211	\$167	1.96	\$2,450	2.15	\$2,627	1.89	\$2,019
R49 Attic, Air Sealing & Duct Sealing Package	Pre-1978	\$5,489	4,496	15	676	\$1,471	\$1,163	5.66	\$28,734	5.64	\$25,467	5.12	\$22,592
	1978-1991	\$5,031	2,706	7	408	\$894	\$706	3.75	\$15,536	3.81	\$14,138	3.38	\$11,986
	1992-2010	\$3,749	710	3	123	\$236	\$186	1.33	\$1,383	1.50	\$1,862	1.31	\$1,159
R49 Attic, Air Sealing & New Ducts Package	Pre-1978	\$8,792	6,122	18	920	\$2,023	\$1,599	4.86	\$38,098	4.90	\$34,297	4.49	\$30,658
	1978-1991	\$8,334	4,241	8	648	\$1,417	\$1,120	3.59	\$24,236	3.71	\$22,585	3.32	\$19,312
	1992-2010	\$7,312	1,353	3	242	\$450	\$356	1.30	\$2,464	1.49	\$3,607	1.31	\$2,285
Advanced Envelope Package	Pre-1978	\$18,659	7,579	28	1,156	\$2,482	\$1,963	2.81	\$37,936	2.87	\$34,978	2.55	\$28,977
Water Heating Package	All Vintages	\$208	0	17	n/a	\$24	\$22	1.43	\$101	n/a	n/a	n/a	n/a

Table 108: CZ 15 - Single Family PV & Battery Cost-Effectiveness Results

Measure	Vintage	Measure Cost (\$)	Electricity Savings (kWh)	Gas Savings (therm)	GHG Savings (lb CO ₂ e)	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	\$12,933	7,104	0	584	\$1,705	\$1,346	2.82	\$26,069	2.03	\$13,265	1.84	\$10,897
	1978-1991		7,104		584	\$1,683	\$1,328	2.79	\$25,539	2.01	\$13,124	1.83	\$10,736
	1992-2010		7,104		584	\$1,533	\$1,210	2.54	\$21,996	2.00	\$12,942	1.81	\$10,494
PV + Battery	Pre-1978	\$24,305	6,850	0	1,082	\$1,885	\$1,487	1.69	\$18,268	1.34	\$8,172	1.11	\$2,564
	1978-1991		6,832		1,157	\$1,882	\$1,485	1.69	\$18,199	1.38	\$9,324	1.13	\$3,085
	1992-2010		6,821		1,273	\$1,769	\$1,396	1.59	\$15,539	1.43	\$10,341	1.17	\$4,102

Table 109: CZ 15 - Single Family Equipment Fuel Substitution Cost-Effectiveness Results

Measure	Vintage	Measure Cost (\$)	Electricity Savings (kWh)	Gas Savings (therm)	GHG Savings (lb CO ₂ e)	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	\$501	-308	28	120	-\$150	-\$115	0	-\$3,985	0	-\$709	0.21	-\$398
	1978-1991		-163	14	52	-\$140	-\$109	0	-\$3,813	0	-\$668	0	-\$524
	1992-2010		-112	9	29	-\$137	-\$107	0	-\$3,753	0	-\$643	0	-\$553
High-Effic. Heat Pump at HVAC Replacement	Pre-1978	\$3,749	1,349	28	466	\$394	\$315	2.33	\$5,379	3.14	\$8,029	2.80	\$6,753
	1978-1991		1,212	14	350	\$314	\$250	1.85	\$3,441	2.64	\$6,165	2.32	\$4,950
	1992-2010		929	9	284	\$212	\$169	1.25	\$1,004	2.08	\$4,065	1.80	\$3,011
Heat Pump at HVAC Replacement + PV	Pre-1978	\$13,434	6,796	28	704	\$1,479	\$1,171	2.37	\$20,288	1.93	\$12,516	1.78	\$10,433
	1978-1991		6,941	14	636	\$1,460	\$1,154	2.33	\$19,787	1.92	\$12,426	1.76	\$10,159
	1992-2010		6,992	9	613	\$1,420	\$1,122	2.27	\$18,814	1.92	\$12,300	1.74	\$9,932
HVAC HP Replacement w/ Panel Upgrade + PV	Pre-1978	\$16,615	6,796	28	704	\$1,479	\$1,171	1.91	\$16,716	1.56	\$9,335	1.44	\$7,252
	1978-1991		6,941	14	636	\$1,460	\$1,154	1.88	\$16,215	1.56	\$9,245	1.42	\$6,978
	1992-2010		6,992	9	613	\$1,420	\$1,122	1.83	\$15,242	1.55	\$9,119	1.41	\$6,751
HPWH at Water Heater Replacement	Pre-1978	\$2,594	-613	127	1,086	-\$33	-\$10	0	-\$3,189	0.64	-\$926	1.77	\$2,006
	1978-1991		-622	127	1,089	-\$35	-\$12	0	-\$3,243	0.65	-\$917	1.75	\$1,943
	1992-2010		-633	127	1,089	-\$36	-\$13	0	-\$3,273	0.62	-\$981	1.73	\$1,903
NEEA Tier 3 HPWH at Replacement	Pre-1978	\$2,775	-504	127	1,131	\$1	\$17	0.16	-\$2,589	0.81	-\$531	1.85	\$2,358
	1978-1991		-513	127	1,134	-\$1	\$15	0.15	-\$2,640	0.80	-\$566	1.84	\$2,324
	1992-2010		-524	127	1,132	-\$3	\$13	0.13	-\$2,687	0.77	-\$626	1.82	\$2,272
HPWH at Water Heater Replacement + PV	Pre-1978	\$15,527	6,491	127	1,670	\$1,708	\$1,364	2.38	\$23,723	1.81	\$12,503	1.84	\$13,047
	1978-1991		6,482	127	1,673	\$1,684	\$1,345	2.35	\$23,150	1.80	\$12,376	1.83	\$12,828
	1992-2010		6,471	127	1,672	\$1,541	\$1,232	2.15	\$19,781	1.78	\$12,137	1.81	\$12,552
HPWH Replacement w/ Panel Upgrade + PV	Pre-1978	\$18,708	6,491	127	1,670	\$1,708	\$1,364	1.97	\$20,151	1.50	\$9,322	1.53	\$9,866
	1978-1991		6,482	127	1,673	\$1,684	\$1,345	1.94	\$19,578	1.49	\$9,195	1.52	\$9,647
	1992-2010		6,471	127	1,672	\$1,541	\$1,232	1.78	\$16,209	1.48	\$8,956	1.50	\$9,371

Measure	Vintage	Measure Cost (\$)	Electricity Savings (kWh)	Gas Savings (therm)	GHG Savings (lb CO ₂ e)	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
PV + Electric Ready Pre-Wire	Pre-1978	\$17,024	7,104	0	584	\$1,705	\$1,346	2.14	\$21,475	1.54	\$9,174	1.40	\$6,806
	1978-1991		7,104	0	584	\$1,683	\$1,328	2.11	\$20,945	1.53	\$9,033	1.39	\$6,645
	1992-2010		7,104	0	584	\$1,533	\$1,210	1.92	\$17,402	1.52	\$8,851	1.38	\$6,403

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 110: CZ 16 - Single Family Efficiency Upgrade Cost-Effectiveness Results

Measure	Vintage	Measure Cost (\$)	Electricity Savings (kWh)	Gas Savings (therm)	GHG Savings (lb CO ₂ e)	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	\$3,332	470	79	891	\$338	\$276	2.21	\$4,545	1.83	\$2,757	2.06	\$3,532
	1978-1991	\$2,874	261	40	450	\$178	\$145	1.35	\$1,127	1.12	\$346	1.25	\$715
	1992-2010	\$1,852	68	16	182	\$59	\$48	0.70	-\$630	0.61	-\$729	0.71	-\$545
Reduced Infiltration	Pre-1978	\$1,474	29	33	342	\$76	\$64	1.16	\$271	1.02	\$30	1.46	\$683
	1978-1991		17	20	208	\$46	\$39	0.71	-\$487	0.64	-\$538	0.89	-\$166
	1992-2010		10	13	137	\$30	\$25	0.45	-\$908	0.42	-\$858	0.58	-\$621
Duct Sealing	Pre-1978	\$683	263	121	1,277	\$343	\$285	11.15	\$7,787	9.74	\$5,968	12.45	\$7,820
	1978-1991	\$683	151	76	799	\$209	\$174	6.80	\$4,446	6.02	\$3,427	7.72	\$4,591
	1992-2010	\$423	34	16	167	\$44	\$36	2.29	\$612	2.12	\$473	2.63	\$689
New Ducts	Pre-1978	\$3,986	505	192	2,053	\$581	\$481	3.22	\$9,953	2.83	\$7,277	3.49	\$9,918
	1978-1991		367	142	1,521	\$425	\$352	2.36	\$6,095	2.10	\$4,370	2.58	\$6,294
	1992-2010		123	46	499	\$139	\$115	0.77	-\$1,020	0.72	-\$1,114	0.85	-\$593
Cool Roof	Pre-1978	\$778	165	-12	-86	\$42	\$32	1.12	\$106	0.69	-\$239	0	-\$792
	1978-1991		114	-9	-64	\$28	\$21	0.75	-\$211	0.49	-\$401	0	-\$815
	1992-2010		63	-7	-48	\$13	\$9	0.33	-\$572	0.24	-\$594	0	-\$873
R-13 Wall Insulation	Pre-1978	\$3,360	139	108	1,121	\$267	\$223	1.77	\$2,919	1.56	\$1,880	2.13	\$3,795
Windows	Pre-1978	\$9,810	416	114	1,235	\$388	\$319	0.87	-\$1,436	0.73	-\$2,618	0.89	-\$1,071
	1978-1991		311	93	1,018	\$307	\$253	0.69	-\$3,417	0.59	-\$4,017	0.72	-\$2,710
LED lamp vs CFL	All	\$2.26	1.2	0	n/a	\$0.37	\$0.30	3.93	\$6.61	n/a	n/a	n/a	n/a
Exterior Photosensor	All	\$42.58	12.1	0	n/a	\$2.88	\$2.27	1.60	\$25.62	n/a	n/a	n/a	n/a

Table 111: CZ 16 - Single Family Efficiency Packages Cost-Effectiveness Results

Measure	Vintage	Measure Cost (\$)	Electricity Savings (kWh)	Gas Savings (therm)	GHG Savings (lb CO ₂ e)	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	\$4,806	501	114	1,248	\$419	\$344	1.91	\$4,922	1.61	\$2,931	1.90	\$4,314
	1978-1991	\$4,348	277	61	662	\$225	\$185	1.14	\$660	0.97	-\$151	1.13	\$566
	1992-2010	\$3,326	78	30	321	\$89	\$74	0.59	-\$1,526	0.53	-\$1,566	0.65	-\$1,154
R49 Attic & Duct Sealing Package	Pre-1978	\$4,015	691	198	2,140	\$660	\$544	3.62	\$11,813	3.11	\$8,486	3.75	\$11,059
	1978-1991	\$3,557	392	113	1,223	\$375	\$309	2.32	\$5,272	2.01	\$3,595	2.43	\$5,090
	1992-2010	\$2,275	99	31	343	\$100	\$83	0.97	-\$66	0.88	-\$271	1.04	\$92
R49 Attic, Air Sealing & Duct Sealing Package	Pre-1978	\$5,489	715	229	2,457	\$730	\$603	2.93	\$11,923	2.54	\$8,473	3.11	\$11,566
	1978-1991	\$5,031	408	132	1,418	\$418	\$345	1.83	\$4,703	1.60	\$2,997	1.96	\$4,837
	1992-2010	\$3,749	108	44	475	\$129	\$107	0.76	-\$1,000	0.69	-\$1,148	0.85	-\$555
R49 Attic, Air Sealing & New Ducts Package	Pre-1978	\$8,792	933	301	3,240	\$959	\$792	2.41	\$13,894	2.09	\$9,600	2.55	\$13,641
	1978-1991	\$8,334	606	197	2,127	\$625	\$516	1.65	\$6,128	1.46	\$3,813	1.77	\$6,414
	1992-2010	\$7,312	194	74	798	\$220	\$182	0.66	-\$2,752	0.61	-\$2,825	0.74	-\$1,900
Advanced Envelope Package	Pre-1978	\$18,659	1,189	418	4,487	\$1,288	\$1,065	1.53	\$11,008	1.33	\$6,171	1.65	\$12,076
Water Heating Package	All Vintages	\$208	0	15	n/a	\$28	\$26	1.68	\$159	n/a	n/a	n/a	n/a

Table 112: CZ 16 - Single Family PV & Battery Cost-Effectiveness Results

Measure	Vintage	Measure Cost (\$)	Electricity Savings (kWh)	Gas Savings (therm)	GHG Savings (lb CO ₂ e)	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	\$7,003	3,694	0	260	\$988	\$780	3.02	\$15,645	2.03	\$7,235	1.71	\$4,986
	1978-1991		3,694		260	\$952	\$751	2.91	\$14,793	2.03	\$7,209	1.71	\$4,963
	1992-2010		3,694		260	\$915	\$722	2.80	\$13,917	2.03	\$7,186	1.71	\$4,940
PV + Battery	Pre-1978	\$18,375	3,500	0	922	\$1,024	\$808	1.23	\$4,457	1.10	\$1,872	0.90	-\$1,908
	1978-1991		3,499		933	\$990	\$782	1.18	\$3,653	1.11	\$1,993	0.90	-\$1,882
	1992-2010		3,498		930	\$954	\$753	1.14	\$2,783	1.11	\$2,010	0.89	-\$1,985

Table 113: CZ 16 - Single Family Equipment Fuel Substitution Cost-Effectiveness Results

Measure	Vintage	Measure Cost (\$)	Electricity Savings (kWh)	Gas Savings (therm)	GHG Savings (lb CO ₂ e)	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	\$501	-10,697	878	4,463	-\$1,361	-\$979	0	-\$29,912	0	-\$28,001	0	-\$11,165
	1978-1991		-8,906	715	3,546	-\$1,154	-\$835	0	-\$25,586	0	-\$23,948	0	-\$10,272
	1992-2010		-5,719	448	2,155	-\$731	-\$532	0	-\$16,498	0	-\$14,907	0	-\$7,270
High-Effic. Heat Pump at HVAC Replacement	Pre-1978	\$3,749	-9,151	878	5,042	-\$879	-\$598	0	-\$22,010	0	-\$21,556	0	-\$5,639
	1978-1991		-7,682	715	4,007	-\$774	-\$534	0	-\$20,088	0	-\$18,854	0	-\$6,572
	1992-2010		-4,830	448	2,502	-\$453	-\$312	0	-\$13,416	0	-\$12,690	0	-\$5,342
Heat Pump at HVAC Replacement + PV	Pre-1978	\$7,504	-7,016	878	4,718	-\$328	-\$164	0	-\$13,209	0	-\$20,538	0.19	-\$6,081
	1978-1991		-5,221	715	3,802	-\$136	-\$32	0	-\$9,235	0	-\$16,520	0.31	-\$5,197
	1992-2010		-2,025	448	2,411	\$281	\$267	0.97	-\$277	0	-\$7,530	0.70	-\$2,250
HVAC HP Replacement w/ Panel Upgrade + PV	Pre-1978	\$10,685	-7,016	878	4,718	-\$328	-\$164	0	-\$16,781	0	-\$23,719	0.13	-\$9,262
	1978-1991		-5,221	715	3,802	-\$136	-\$32	0	-\$12,807	0	-\$19,701	0.22	-\$8,378
	1992-2010		-2,025	448	2,411	\$281	\$267	0.68	-\$3,849	0	-\$10,711	0.49	-\$5,431
HPWH at Water Heater Replacement	Pre-1978	\$2,594	-1,925	176	1,219	-\$276	-\$199	0	-\$8,870	0	-\$7,338	0.10	-\$2,326
	1978-1991		-1,959	177	1,211	-\$284	-\$205	0	-\$9,055	0	-\$7,447	0.02	-\$2,531
	1992-2010		-1,973	177	1,209	-\$288	-\$209	0	-\$9,171	0	-\$7,485	0.01	-\$2,579
NEEA Tier 3 HPWH at Replacement	Pre-1978	\$2,775	-1,501	174	1,310	-\$144	-\$95	0	-\$5,939	0	-\$5,817	0.79	-\$586
	1978-1991		-1,559	176	1,302	-\$157	-\$106	0	-\$6,260	0	-\$6,067	0.67	-\$903
	1992-2010		-1,572	176	1,304	-\$161	-\$109	0	-\$6,351	0	-\$6,125	0.65	-\$966
HPWH at Water Heater Replacement + PV	Pre-1978	\$9,597	1,769	176	1,479	\$825	\$670	1.89	\$9,458	1.01	\$111	1.30	\$2,882
	1978-1991		1,735	177	1,470	\$792	\$644	1.82	\$8,689	1.00	-\$19	1.28	\$2,657
	1992-2010		1,721	177	1,469	\$754	\$614	1.73	\$7,772	0.99	-\$77	1.27	\$2,588
HPWH Replacement w/ Panel Upgrade + PV	Pre-1978	\$12,778	1,769	176	1,479	\$825	\$670	1.41	\$5,886	0.76	-\$3,070	0.98	-\$299
	1978-1991		1,735	177	1,470	\$792	\$644	1.36	\$5,117	0.75	-\$3,200	0.96	-\$524
	1992-2010		1,721	177	1,469	\$754	\$614	1.30	\$4,200	0.75	-\$3,258	0.95	-\$593

Measure	Vintage	Measure Cost (\$)	Electricity Savings (kWh)	Gas Savings (therm)	GHG Savings (lb CO ₂ e)	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
PV + Electric Ready Pre-Wire	Pre-1978	\$11,094	3,694	0	260	\$988	\$780	1.90	\$11,051	1.28	\$3,144	1.08	\$895
	1978-1991		3,694	0	260	\$952	\$751	1.83	\$10,199	1.28	\$3,118	1.08	\$872
	1992-2010		3,694	0	260	\$915	\$722	1.76	\$9,323	1.28	\$3,095	1.08	\$849

8.5 Appendix E – Details on Energy Performance Equivalency

Jurisdictions adopting a retrofit reach code that want flexibility in implementation can apply all or portions of the following approach.

1. Identify the appropriate home vintage based on one of the following two methods.
 - a. Year of construction.
 - b. Appraisal of existing conditions of home using the points menu for a pre-1978 home (Table 114) and the relevant climate zone. The sum of the eligible points is compared to the energy performance value for each vintage (Table 17). If the sum is greater than the threshold for any vintage, the requirements for that vintage may be applied in place of those based on the year of construction. Verification should be conducted by a third party such as a HERS Rater or the building department.
2. Identify the relevant reach code requirements per the ordinance.
3. Demonstrate compliance with the reach code in one of the following ways.
 - a. Install the prescriptive reach code requirements.
 - b. Install individual measures or a package of measures that result in equivalent energy performance as the prescriptive reach code requirement.
 - i. Determine the value for the reach code requirement. For individual measures refer to Table 114, Table 115, or Table 116. For packages of measures refer to Table 117. Use the values for the appropriate vintage home determined in Step 1.
 - ii. Determine the value for the proposed upgrades using Table 114, Table 115, or Table 116 for the appropriate vintage home determined in Step 1.
 - iii. If the sum of the value for the proposed upgrades is greater than or equal to the value of the reach code requirement then the proposed upgrades are an acceptable alternative.

Table 114: Energy Performance Equivalency by Measure for the Pre-1978 Vintage Home

Component	CZ1	CZ2	CZ3	CZ4	CZ5	CZ6	CZ7	CZ8	CZ9	CZ10	CZ11	CZ12	CZ13	CZ14	CZ15	CZ16
Walls																
R-11 to R-13	5.4	3.1	2.4	2.1	2.3	1.0	0.7	0.9	1.2	1.6	3.4	2.9	2.4	3.3	1.3	5.9
R-19	7.7	4.5	3.5	3.0	3.4	1.4	1.0	1.4	1.8	2.4	4.9	4.2	3.6	4.7	1.9	8.3
Ceiling																
R-19	1.6	1.3	0.9	1.1	0.8	0.8	0.7	0.6	0.7	0.9	1.6	1.4	1.1	1.5	0.8	2.3
R-30	2.5	2.0	1.5	1.7	1.3	1.2	1.0	1.0	1.2	1.4	2.5	2.3	1.9	2.3	1.2	3.6
R-38	2.8	2.3	1.7	1.9	1.6	1.3	1.1	1.1	1.4	1.5	2.9	2.6	2.1	2.7	1.3	4.2
>R-38	3.2	2.6	1.9	2.2	1.8	1.4	1.2	1.3	1.5	1.7	3.2	2.9	2.4	2.9	1.3	4.6
Roof																
Cool roof	0.0	0.0	0.0	0.0	0.0	0.3	0.3	0.1	0.1	0.1	0.0	0.1	0.1	0.0	0.3	0.0
Floors																
R-19+ insulation in raised floor	10.9	4.1	4.7	2.8	4.0	1.0	0.5	0.5	1.0	1.7	5.1	3.5	2.8	5.2	1.4	10.0
Windows																
Double non-metal	2.6	1.6	1.0	1.1	0.8	0.4	0.2	0.4	0.6	0.8	2.3	1.8	1.5	1.8	1.0	3.8
<=0.32 U-factor	4.3	1.8	1.6	1.3	1.2	0.4	0.2	0.5	0.7	0.9	3.2	2.5	2.3	1.9	1.8	6.4
Infiltration																
<=10 ACH50	1.8	0.9	0.8	0.6	0.7	0.3	0.1	0.2	0.3	0.5	1.0	0.8	0.7	1.1	0.2	1.8
<=7 ACH50	3.0	1.5	1.2	1.0	1.2	0.4	0.3	0.3	0.5	0.8	1.7	1.3	1.1	1.7	0.4	2.9
<=5 ACH50	3.7	1.9	1.6	1.3	1.6	0.6	0.3	0.4	0.6	0.9	2.1	1.7	1.4	2.1	0.5	3.6
Duct Leakage																
<=15% leakage	3.7	1.9	1.3	1.3	1.2	0.5	0.3	0.6	0.8	1.1	2.5	2.1	1.9	2.2	1.3	5.1
<=10% leakage	4.9	2.5	1.7	1.7	1.5	0.6	0.4	0.8	1.1	1.4	3.2	2.7	2.5	3.0	1.7	6.7
R-6+ & <=5% leakage (or ductless)	7.7	4.1	2.9	2.9	2.6	1.1	0.9	1.4	1.9	2.4	5.3	4.5	4.2	4.8	2.9	10.4
Heating																
80% AFUE	1.0	0.5	0.4	0.3	0.3	0.1	0.1	0.1	0.1	0.2	0.5	0.4	0.3	0.5	0.0	1.3
90% AFUE	5.6	2.6	1.9	1.5	1.7	0.5	0.3	0.4	0.7	1.0	2.6	2.3	1.7	2.4	0.2	6.9
8.2 HSPF	21.9	8.7	6.6	5.0	4.4	1.7	1.1	1.3	2.1	2.7	8.8	7.8	5.4	6.1	0.6	23.7
9 HSPF	23.0	9.3	7.3	5.5	5.6	1.8	1.3	1.4	2.2	2.8	9.2	8.3	5.7	6.8	0.6	25.9

Component	CZ1	CZ2	CZ3	CZ4	CZ5	CZ6	CZ7	CZ8	CZ9	CZ10	CZ11	CZ12	CZ13	CZ14	CZ15	CZ16
Cooling																
13 SEER	0.0	0.3	0.0	0.6	0.0	0.3	0.4	0.8	0.9	1.1	1.5	0.9	1.9	1.2	3.0	0.4
14 SEER	0.0	0.4	0.0	0.8	0.0	0.4	0.4	1.2	1.3	1.6	2.2	1.4	2.9	1.8	4.5	0.5
16+ SEER	0.0	0.5	0.1	1.0	0.0	0.5	0.6	1.5	1.6	2.0	2.8	1.7	3.5	2.2	5.6	0.6
Water Heater																
Tankless	3.1	3.0	3.0	3.0	3.0	2.9	2.9	2.9	2.9	2.9	2.9	3.0	2.9	2.9	2.7	3.1
Condensing water heater	4.1	3.9	3.9	3.8	3.9	3.7	3.7	3.6	3.6	3.6	3.7	3.8	3.7	3.7	3.3	4.0
HPWH	7.4	7.3	7.4	7.2	7.4	7.1	7.1	6.9	7.0	6.9	6.9	7.1	6.9	6.7	6.1	6.9
NEEA HPWH	8.0	7.9	7.9	7.7	8.0	7.5	7.5	7.3	7.4	7.4	7.3	7.6	7.3	7.2	6.4	7.4
PV+Battery																
NC PV	1.1	1.1	1.2	1.2	1.3	1.6	1.5	1.6	1.7	1.7	1.5	1.2	1.6	1.9	3.0	1.3
10kWh Battery	3.0	3.1	3.3	3.0	3.4	3.5	3.0	2.9	3.2	3.1	3.2	3.2	3.1	3.3	2.6	3.4

Table 115: Energy Performance Equivalency by Measure for the 1978-1991 Vintage Home

Component	CZ1	CZ2	CZ3	CZ4	CZ5	CZ6	CZ7	CZ8	CZ9	CZ10	CZ11	CZ12	CZ13	CZ14	CZ15	CZ16
Walls																
R-11 to R-13	0.8	0.4	0.3	0.3	0.3	0.1	0.1	0.1	0.2	0.2	0.4	0.4	0.3	0.4	0.2	0.8
R-19	3.0	1.8	1.4	1.2	1.3	0.6	0.4	0.6	0.7	0.9	1.9	1.7	1.5	1.9	0.8	3.2
Ceiling																
R-19	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-30	0.9	0.8	0.6	0.7	0.5	0.3	0.3	0.3	0.4	0.5	0.9	0.9	0.7	0.8	0.5	1.4
R-38	1.3	1.1	0.8	0.9	0.7	0.5	0.4	0.5	0.6	0.6	1.2	1.2	1.0	1.2	0.6	1.9
>R-38	1.6	1.3	1.0	1.2	0.9	0.6	0.5	0.6	0.8	0.8	1.5	1.5	1.2	1.4	0.7	2.3
Roof																
Cool roof	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.2	0.1	0.1	0.0	0.1	0.2	0.0	0.3	0.0
Floors																
R-19+ insulation in raised floor	4.0	1.5	1.8	1.1	1.5	0.3	0.2	0.2	0.4	0.6	1.8	1.3	1.0	1.9	0.6	3.7
Windows																
Double non-metal	2.2	1.4	0.9	0.9	0.7	0.3	0.2	0.3	0.5	0.6	1.6	1.4	1.2	1.4	0.7	2.8
<=0.32 U-factor	3.8	1.4	1.5	1.1	1.1	0.4	0.3	0.5	0.7	0.8	2.5	2.1	2.0	1.4	1.5	5.3
Infiltration																
<=10 ACH50	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
<=7 ACH50	1.1	0.6	0.5	0.4	0.5	0.2	0.1	0.1	0.2	0.3	0.6	0.5	0.4	0.6	0.2	1.1
<=5 ACH50	1.8	1.0	0.8	0.7	0.8	0.3	0.2	0.2	0.3	0.4	1.0	0.9	0.8	1.1	0.3	1.8
Duct Leakage																
<=15% leakage	2.0	1.0	0.6	0.6	0.6	0.2	0.1	0.3	0.4	0.5	1.2	1.1	1.1	1.1	0.9	2.9
<=10% leakage	3.0	1.4	0.9	0.9	0.8	0.3	0.2	0.5	0.6	0.8	1.9	1.6	1.6	1.7	1.3	4.2
R-6+ & <=5% leakage (or ductless)	5.5	2.9	2.0	2.1	1.8	0.7	0.5	1.0	1.4	1.7	3.8	3.3	3.3	3.4	2.4	7.6
Heating																
80% AFUE	0.8	0.4	0.3	0.2	0.2	0.1	0.0	0.0	0.1	0.1	0.4	0.3	0.2	0.3	0.0	1.0
90% AFUE	4.3	1.9	1.4	1.1	1.2	0.3	0.2	0.3	0.4	0.7	1.9	1.7	1.2	1.7	0.1	5.4
8.2 HSPF	17.3	6.5	4.7	3.5	2.7	0.9	0.6	0.8	1.3	1.8	6.5	5.8	4.0	4.2	0.3	18.8
9 HSPF	18.6	7.1	5.3	4.0	4.0	1.1	0.7	0.8	1.4	1.9	6.9	6.3	4.3	4.9	0.2	21.2

Component	CZ1	CZ2	CZ3	CZ4	CZ5	CZ6	CZ7	CZ8	CZ9	CZ10	CZ11	CZ12	CZ13	CZ14	CZ15	CZ16
Cooling																
13 SEER	0.0	0.2	0.0	0.5	0.0	0.3	0.3	0.7	0.8	0.9	1.3	0.8	1.7	1.1	2.7	0.3
14 SEER	0.0	0.3	0.0	0.6	0.0	0.3	0.3	1.0	1.1	1.3	1.9	1.2	2.4	1.6	4.0	0.4
16+ SEER	0.0	0.3	0.0	0.8	0.0	0.4	0.5	1.3	1.4	1.7	2.3	1.4	3.0	1.9	4.9	0.5
Water Heater																
Tankless	3.1	3.0	3.0	3.0	3.0	2.9	2.9	2.9	2.9	2.9	2.9	3.0	2.9	2.9	2.7	3.1
Condensing water heater	4.1	3.9	3.9	3.8	3.9	3.7	3.7	3.6	3.6	3.6	3.7	3.8	3.7	3.7	3.3	4.0
HPWH	7.4	7.4	7.4	7.3	7.4	7.1	7.1	7.0	7.0	6.9	6.9	7.2	6.9	6.7	6.2	6.9
NEEA HPWH	8.1	7.9	8.0	7.8	8.0	7.5	7.5	7.4	7.4	7.3	7.4	7.7	7.3	7.2	6.4	7.3
PV+Battery																
NC PV	1.1	1.1	1.2	1.2	1.3	1.6	1.5	1.6	1.7	1.7	1.5	1.2	1.6	1.9	3.0	1.3
10kWh Battery	3.0	3.1	3.3	3.1	3.4	3.6	3.1	3.1	3.3	3.2	3.3	3.3	3.3	3.4	2.9	3.5

Table 116: Energy Performance Equivalency by Measure for the 1992-2010 Vintage Home

Component	CZ1	CZ2	CZ3	CZ4	CZ5	CZ6	CZ7	CZ8	CZ9	CZ10	CZ11	CZ12	CZ13	CZ14	CZ15	CZ16
Walls																
R-11 to R-13	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-19	2.0	1.2	0.9	0.8	0.9	0.4	0.3	0.4	0.5	0.6	1.3	1.1	1.0	1.3	0.4	2.2
Ceiling																
R-19	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-30	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-38	0.4	0.3	0.2	0.2	0.2	0.1	0.1	0.1	0.2	0.2	0.3	0.3	0.2	0.3	0.1	0.5
>R-38	0.7	0.4	0.3	0.4	0.3	0.2	0.2	0.2	0.3	0.3	0.6	0.6	0.4	0.6	0.2	1.0
Roof																
Cool roof	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.0	0.0	0.0	0.1	0.0	0.1	0.0
Floors																
R-19+ insulation in raised floor	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
Windows																
Double non-metal	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
<=0.32 U-factor	3.6	1.1	1.7	0.8	1.7	0.3	0.2	0.3	0.5	0.6	1.4	1.3	1.1	1.1	0.6	2.5
Infiltration																
<=10 ACH50	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
<=7 ACH50	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
<=5 ACH50	0.7	0.4	0.3	0.3	0.3	0.1	0.1	0.1	0.1	0.2	0.4	0.3	0.3	0.4	0.1	0.7
Duct Leakage																
<=15% leakage	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
<=10% leakage	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-6+ & <=5% leakage (or ductless)	1.5	1.1	0.7	0.7	0.7	0.2	0.2	0.3	0.5	0.6	1.4	1.1	1.2	1.3	0.8	2.3
Heating																
80% AFUE	0.4	0.3	0.2	0.2	0.2	0.0	0.0	0.0	0.1	0.1	0.3	0.3	0.2	0.3	0.0	0.6
90% AFUE	2.3	1.5	1.1	0.8	1.0	0.2	0.1	0.2	0.3	0.5	1.4	1.3	0.9	1.3	0.1	3.2
8.2 HSPF	9.4	5.7	4.1	3.0	2.9	0.8	0.5	0.6	1.1	1.5	5.4	4.9	3.3	3.8	0.2	11.5
9 HSPF	10.7	6.5	4.9	3.6	3.9	0.9	0.6	0.7	1.3	1.8	5.9	5.5	3.7	4.5	0.2	13.5

Component	CZ1	CZ2	CZ3	CZ4	CZ5	CZ6	CZ7	CZ8	CZ9	CZ10	CZ11	CZ12	CZ13	CZ14	CZ15	CZ16
Cooling																
13 SEER	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
14 SEER	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.3	0.3	0.3	0.4	0.2	0.6	0.4	1.1	0.1
16+ SEER	0.0	0.1	0.0	0.2	0.0	0.1	0.1	0.4	0.4	0.6	0.8	0.4	1.1	0.7	1.8	0.2
Water Heater																
Tankless	3.1	3.0	3.0	3.0	3.0	2.9	2.9	2.9	2.9	2.9	2.9	3.0	2.9	2.9	2.7	3.1
Condensing water heater	4.1	3.9	3.9	3.8	3.9	3.7	3.7	3.6	3.6	3.6	3.7	3.8	3.7	3.7	3.3	4.0
HPWH	7.5	7.4	7.4	7.2	7.4	7.1	7.1	7.0	7.0	6.9	6.9	7.2	6.9	6.7	6.1	6.8
NEEA HPWH	8.2	7.9	8.0	7.8	8.0	7.5	7.5	7.4	7.4	7.4	7.4	7.7	7.4	7.2	6.4	7.3
PV+Battery																
NC PV	1.1	1.1	1.2	1.2	1.3	1.6	1.5	1.6	1.7	1.7	1.5	1.2	1.6	1.9	3.0	1.3
5kWh Battery	2.9	3.2	3.3	3.3	3.4	3.9	3.3	3.4	3.7	3.6	3.5	3.4	3.6	3.7	3.5	3.4

Table 117: Energy Performance Equivalency for Packages for all Vintages

Component	Vintage	CZ1	CZ2	CZ3	CZ4	CZ5	CZ6	CZ7	CZ8	CZ9	CZ10	CZ11	CZ12	CZ13	CZ14	CZ15	CZ16
R-49 & Air Sealing	Pre-1978	5.1	3.6	2.7	2.8	2.5	1.7	1.4	1.5	1.8	2.2	4.2	3.8	3.1	4.0	1.7	6.5
	1978-1991	2.7	1.9	1.4	1.5	1.4	0.7	0.6	0.7	0.9	1.0	2.2	2.0	1.7	2.1	0.8	3.5
	1992-2010	1.4	0.8	0.7	0.7	0.6	0.3	0.3	0.3	0.4	0.5	1.0	0.9	0.8	1.0	0.3	1.7
R-49 & Duct Sealing	Pre-1978	8.0	4.9	3.4	3.7	3.2	1.9	1.6	2.0	2.5	3.0	6.2	5.4	4.9	5.7	3.2	11.2
	1978-1991	4.5	2.6	1.8	2.0	1.7	0.9	0.7	1.0	1.4	1.6	3.4	3.0	2.8	3.0	1.9	6.4
	1992-2010	1.2	0.8	0.6	0.6	0.6	0.3	0.2	0.3	0.5	0.5	1.1	0.9	0.9	1.0	0.6	1.8
R-49, Air & Duct Sealing	Pre-1978	9.7	5.8	4.2	4.2	3.9	2.2	1.8	2.1	2.8	3.4	7.1	6.2	5.5	6.7	3.5	12.8
	1978-1991	5.5	3.2	2.3	2.4	2.1	1.0	0.8	1.2	1.5	1.8	4.0	3.4	3.2	3.6	2.1	7.4
	1992-2010	1.9	1.2	0.9	0.9	0.8	0.4	0.3	0.4	0.6	0.7	1.5	1.3	1.2	1.4	0.6	2.5
R-49, Air Sealing & New Ducts	Pre-1978	12.8	7.5	5.4	5.6	5.0	2.7	2.1	2.8	3.7	4.6	9.5	8.1	7.6	8.7	4.7	16.9
	1978-1991	8.3	4.7	3.3	3.6	3.0	1.4	1.1	1.7	2.4	2.8	6.1	5.3	5.1	5.5	3.3	11.1
	1992-2010	3.0	2.0	1.5	1.5	1.4	0.6	0.4	0.7	0.9	1.2	2.5	2.2	2.1	2.3	1.3	4.2
Advanced Envelope	Pre-1978	17.8	10.8	7.7	7.9	6.9	3.8	2.9	3.6	4.8	6.0	13.5	11.4	10.2	12.1	5.9	23.4



Application of the 2022 Studies to the 2025 Energy Code: Existing Single Family Building Upgrades

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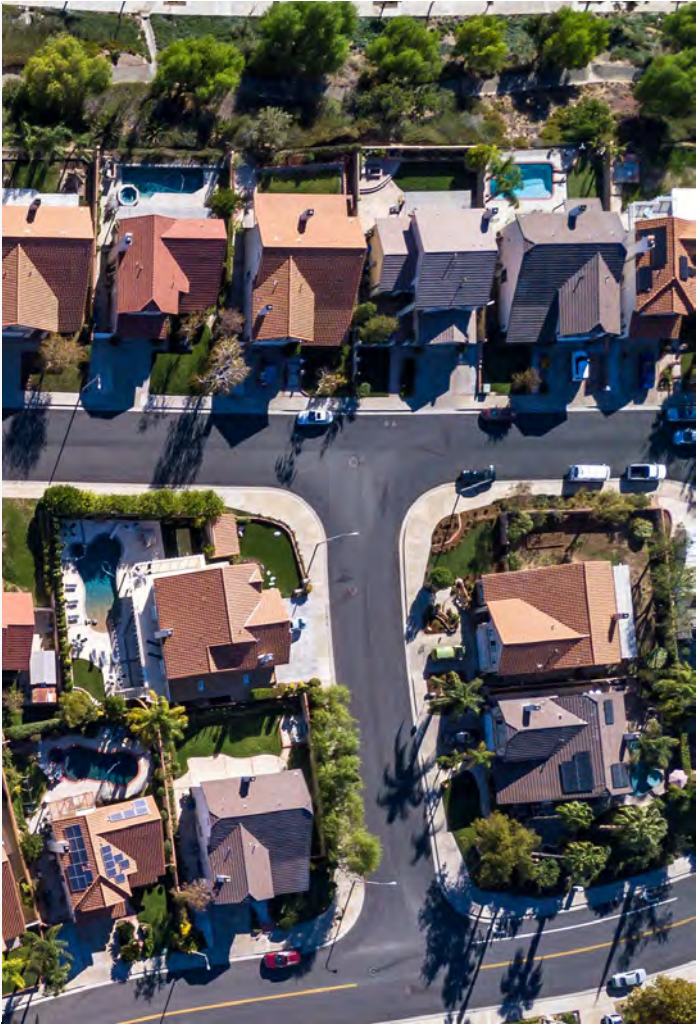


Table 1 Summary of Revisions

Date	Description	Reference (page or section)
8/15/2025	Original Release	N/A
9/18/2025	Minor updates to text, no change to results	Various

Acronym List

B/C – Lifecycle Benefit-to-Cost Ratio

CASE – Codes and Standards Enhancement

CFL – Compact Fluorescent Lamps

CPAU – City of Palo Alto Utilities

CPUC – California Public Utilities Commission

CZ – California Climate Zone

kWh – Kilowatt Hour

NPV – Net Present Value

PG&E – Pacific Gas and Electric Company

PV – Photovoltaic

SCE – Southern California Edison

SDG&E – San Diego Gas and Electric

SMUD – Sacramento Municipal Utility District

SoCalGas – Southern California Gas Company

Therm – Unit for quantity of heat that equals 100,000 British thermal units

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1 Summary

The California Codes and Standards (C&S) 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 efficiency 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.

In April 2024, the Statewide Reach Codes Team published the [2022 Cost-Effectiveness Study: Existing Single Family Building Upgrades](#). This study focuses on existing single family buildings (including duplexes and townhomes) identifying cost-effective measures and measure package upgrades in all 16 California climate zones. The study was conducted to complement Part 6 of the California Building Code (the Energy Code) for the 2022 code cycle, effective January 1, 2023. In the 2019 code cycle the [2019 Cost-Effectiveness Study: Existing Single Family Residential Building Upgrades](#) study included outdoor lighting and a water heater package that was discontinued in the 2022 study but has been brought back in this memo by request from jurisdictions. The studies document the estimated costs, benefits, energy impacts and greenhouse gas emission reductions that may result from implementing an ordinance to help local leadership, residents, and other stakeholders make informed policy decisions.

The Statewide Reach Codes Team reviewed the cost-effectiveness study for impacts of code changes implemented in the 2025 Energy Code. Measures that are now required by code may alter the results presented in the 2022 study. Below is a summary of the changes to the additions and alterations for residential buildings sections of the 2025 Energy Code.

- Mandatory wall insulation R-value has been increased from R-13 to R-15. [Section 150.2(a) of the Energy Code]
- Prescriptive window U-factor has decreased from 0.30 to 0.27 in Climate Zones 1-5, 11-14, and 16. [Section 150.2(b)1B of the Energy Code]

The wall insulation measure has been re-evaluated with R-15 instead of R-13. There is generally a slight increase in utility cost savings as expected with the increase in efficiency. However, there is not a substantial impact on the cost-effectiveness results.

For the prescriptive window U-factor, the original study modeled U-0.28 in all climate zones. This updated memo drops the U-factor from 0.28 to 0.27 in all climate zones. The SHGC is maintained at 0.23 for climate zone 2, 4, and 6-15 and 0.35 for CZ 1, 3, 5, 16. There is minimal impact on the cost-effectiveness results due to this update. However, there are two instances in the 1978-1991 vintage where cost-effectiveness flips from cost-effective to not cost-effective. Climate zone 4 in PGE territory utilizing standard rates and the modest gas escalation is no longer cost-effective on-bill by the smallest margin. Climate zone 10 in SDGE territory utilizing CARE rates and the modest gas escalation has also become no longer cost-effective on-bill.

The 2022 study included a whole building air sealing measure defined as a 30% reduction in air leakage. A new measure – air sealing of the ceiling floor, representing a 14% reduction in air leakage – is added in this memo. Further details and cost-effectiveness results are provided in Section 2.

Lighting measures were previously presented in the [2019 Cost-Effectiveness Study: Existing Single Family Residential Building Upgrades](#) study but were not analyzed in the 2022 study. Updated cost-effectiveness analysis for this measure is presented in Section 3.

The water heating package measure was previously presented in [2019 Cost-Effectiveness Study: Existing Single Family Residential Building Upgrades](#) study. Updated cost-effectiveness analysis for this measure is presented in Section 4.

The 3 kW PV measure from the 2022 study is revised here with an updated cost-effectiveness analysis that accounts for the elimination of the Federal Solar tax credit December 31, 2025. Additional details and analysis are provided in Section 5.

The 2022 report, model ordinance language and other resources are posted on the C&S Reach Codes Program website at LocalEnergyCodes.com. Local jurisdictions that are considering adopting an ordinance may contact the program for further technical support at info@localenergycodes.com.

2 Air Sealing at the Ceiling

Unlike full air sealing, which has previously been presented, air sealing of the ceiling floor may be an attractive measure for an attic remodel project. The whole building air sealing measure estimated a 30% reduction in air leakage, while air sealing at the ceiling measure results in a 14% reduction in air leakage.

Table 2 through Table 7 present the cost-effectiveness results for the air sealing at the ceiling plane measure. The estimated incremental cost for air sealing at the ceiling plane is \$1,963 which is from the 2022 Residential Additions and Alterations CASE Report (Statewide CASE Team, 2020).

Table 2. [Pre-1978] Air Sealing at the Ceiling (Std)

Climate Zone	Electric/ Gas Utility	First Incremental Cost	First-year Utility Savings	Lifecycle NPV Savings		
				2025 LSC NPV	On-Bill NPV Modest Gas Escalation	On-Bill NPV High Gas Escalation
CZ01	PGE	\$1,963	\$33	(\$465)	(\$997)	(\$432)
CZ02	PGE	\$1,963	\$18	(\$1,114)	(\$1,433)	(\$1,118)
CZ03	PGE	\$1,963	\$17	(\$1,180)	(\$1,463)	(\$1,171)
CZ04	PGE	\$1,963	\$25	(\$1,081)	(\$1,290)	(\$979)
CZ04	CPAU	\$1,963	\$21	(\$1,081)	(\$1,379)	(\$1,069)
CZ05	PGE	\$1,963	\$16	(\$1,230)	(\$1,500)	(\$1,235)
CZ05	PGE/SCG	\$1,963	\$14	(\$1,230)	(\$1,555)	(\$1,325)
CZ06	SCE/SCG	\$1,963	(\$2)	(\$1,797)	(\$1,987)	(\$1,937)
CZ07	SDGE	\$1,963	(\$3)	(\$1,813)	(\$2,008)	(\$1,934)
CZ08	SCE/SCG	\$1,963	\$7	(\$1,680)	(\$1,775)	(\$1,703)
CZ09	SCE/SCG	\$1,963	\$10	(\$1,597)	(\$1,693)	(\$1,592)
CZ10	SCE/SCG	\$1,963	\$17	(\$1,497)	(\$1,540)	(\$1,420)
CZ10	SDGE	\$1,963	\$23	(\$1,497)	(\$1,366)	(\$1,237)
CZ11	PGE	\$1,963	\$32	(\$1,014)	(\$1,120)	(\$816)
CZ12	PGE	\$1,963	\$22	(\$1,147)	(\$1,348)	(\$1,064)
CZ12	SMUD/PGE	\$1,963	\$17	(\$1,147)	(\$1,468)	(\$1,190)
CZ13	PGE	\$1,963	\$31	(\$1,114)	(\$1,162)	(\$918)
CZ14	SCE/SCG	\$1,963	\$32	(\$897)	(\$1,130)	(\$832)
CZ14	SDGE	\$1,963	\$42	(\$897)	(\$845)	(\$519)
CZ15	SCE/SCG	\$1,963	\$40	(\$1,297)	(\$1,041)	(\$946)
CZ16	PGE	\$1,963	\$30	(\$581)	(\$1,071)	(\$551)

Table 3. [1978-1991] Air Sealing at the Ceiling (Std)

Climate Zone	Electric/ Gas Utility	First Incremental Cost	First-year Utility Savings	Lifecycle NPV Savings		
				2025 LSC NPV	On-Bill NPV Modest Gas Escalation	On-Bill NPV High Gas Escalation
CZ01	PGE	\$1,963	\$23	(\$931)	(\$1,292)	(\$903)
CZ02	PGE	\$1,963	\$13	(\$1,364)	(\$1,570)	(\$1,341)
CZ03	PGE	\$1,963	\$10	(\$1,480)	(\$1,668)	(\$1,496)
CZ04	PGE	\$1,963	\$16	(\$1,330)	(\$1,522)	(\$1,292)
CZ04	CPAU	\$1,963	\$13	(\$1,330)	(\$1,575)	(\$1,356)
CZ05	PGE	\$1,963	\$11	(\$1,447)	(\$1,649)	(\$1,466)
CZ05	PGE/SCG	\$1,963	\$10	(\$1,447)	(\$1,684)	(\$1,522)
CZ06	SCE/SCG	\$1,963	(\$1)	(\$1,830)	(\$1,967)	(\$1,934)
CZ07	SDGE	\$1,963	(\$4)	(\$1,896)	(\$2,040)	(\$1,991)
CZ08	SCE/SCG	\$1,963	\$4	(\$1,797)	(\$1,860)	(\$1,813)
CZ09	SCE/SCG	\$1,963	\$5	(\$1,747)	(\$1,823)	(\$1,764)
CZ10	SCE/SCG	\$1,963	\$10	(\$1,663)	(\$1,722)	(\$1,652)
CZ10	SDGE	\$1,963	\$14	(\$1,663)	(\$1,603)	(\$1,517)
CZ11	PGE	\$1,963	\$25	(\$1,264)	(\$1,320)	(\$1,096)
CZ12	PGE	\$1,963	\$16	(\$1,380)	(\$1,520)	(\$1,314)
CZ12	SMUD/PGE	\$1,963	\$12	(\$1,380)	(\$1,604)	(\$1,402)
CZ13	PGE	\$1,963	\$23	(\$1,364)	(\$1,373)	(\$1,199)
CZ14	SCE/SCG	\$1,963	\$22	(\$1,230)	(\$1,397)	(\$1,182)
CZ14	SDGE	\$1,963	\$28	(\$1,230)	(\$1,212)	(\$974)
CZ15	SCE/SCG	\$1,963	\$32	(\$1,463)	(\$1,225)	(\$1,154)
CZ16	PGE	\$1,963	\$21	(\$1,014)	(\$1,357)	(\$1,001)

Table 4. [1992-2010] Air Sealing at the Ceiling (Std)

Climate Zone	Electric/ Gas Utility	First Incremental Cost	First-year Utility Savings	Lifecycle NPV Savings		
				2025 LSC NPV	On-Bill NPV Modest Gas Escalation	On-Bill NPV High Gas Escalation
CZ01	PGE	\$1,963	\$14	(\$1,314)	(\$1,550)	(\$1,309)
CZ02	PGE	\$1,963	\$9	(\$1,530)	(\$1,687)	(\$1,529)
CZ03	PGE	\$1,963	\$7	(\$1,613)	(\$1,744)	(\$1,618)
CZ04	PGE	\$1,963	\$11	(\$1,530)	(\$1,653)	(\$1,501)
CZ04	CPAU	\$1,963	\$9	(\$1,530)	(\$1,701)	(\$1,557)
CZ05	PGE	\$1,963	\$7	(\$1,613)	(\$1,759)	(\$1,637)
CZ05	PGE/SCG	\$1,963	\$6	(\$1,613)	(\$1,788)	(\$1,686)
CZ06	SCE/SCG	\$1,963	\$1	(\$1,863)	(\$1,936)	(\$1,911)
CZ07	SDGE	\$1,963	\$0	(\$1,896)	(\$1,944)	(\$1,911)
CZ08	SCE/SCG	\$1,963	\$3	(\$1,830)	(\$1,885)	(\$1,851)
CZ09	SCE/SCG	\$1,963	\$3	(\$1,780)	(\$1,892)	(\$1,853)
CZ10	SCE/SCG	\$1,963	\$6	(\$1,763)	(\$1,814)	(\$1,767)
CZ10	SDGE	\$1,963	\$8	(\$1,763)	(\$1,741)	(\$1,681)
CZ11	PGE	\$1,963	\$14	(\$1,530)	(\$1,581)	(\$1,437)
CZ12	PGE	\$1,963	\$10	(\$1,580)	(\$1,693)	(\$1,560)
CZ12	SMUD/PGE	\$1,963	\$8	(\$1,580)	(\$1,737)	(\$1,606)
CZ13	PGE	\$1,963	\$12	(\$1,580)	(\$1,643)	(\$1,531)
CZ14	SCE/SCG	\$1,963	\$12	(\$1,530)	(\$1,639)	(\$1,503)
CZ14	SDGE	\$1,963	\$16	(\$1,530)	(\$1,537)	(\$1,382)
CZ15	SCE/SCG	\$1,963	\$17	(\$1,680)	(\$1,572)	(\$1,532)
CZ16	PGE	\$1,963	\$14	(\$1,314)	(\$1,556)	(\$1,314)

Table 5. [Pre-1978] Air Sealing at the Ceiling (CARE)

Climate Zone	Electric/ Gas Utility	First Incremental Cost	First-year Utility Savings	Lifecycle NPV Savings		
				2025 LSC NPV	On-Bill NPV Modest Gas Escalation	On-Bill NPV High Gas Escalation
CZ01	PGE	\$1,963	\$26	(\$465)	(\$1,212)	(\$766)
CZ02	PGE	\$1,963	\$14	(\$1,114)	(\$1,550)	(\$1,302)
CZ03	PGE	\$1,963	\$13	(\$1,180)	(\$1,574)	(\$1,343)
CZ04	PGE	\$1,963	\$18	(\$1,081)	(\$1,459)	(\$1,216)
CZ04	CPAU	\$1,963	\$0	(\$1,081)	(\$1,963)	(\$1,963)
CZ05	PGE	\$1,963	\$12	(\$1,230)	(\$1,604)	(\$1,395)
CZ05	PGE/SCG	\$1,963	\$11	(\$1,230)	(\$1,648)	(\$1,467)
CZ06	SCE/SCG	\$1,963	(\$1)	(\$1,797)	(\$1,969)	(\$1,928)
CZ07	SDGE	\$1,963	(\$1)	(\$1,813)	(\$1,976)	(\$1,918)
CZ08	SCE/SCG	\$1,963	\$5	(\$1,680)	(\$1,824)	(\$1,768)
CZ09	SCE/SCG	\$1,963	\$8	(\$1,597)	(\$1,764)	(\$1,686)
CZ10	SCE/SCG	\$1,963	\$12	(\$1,497)	(\$1,659)	(\$1,566)
CZ10	SDGE	\$1,963	\$16	(\$1,497)	(\$1,546)	(\$1,443)
CZ11	PGE	\$1,963	\$23	(\$1,014)	(\$1,353)	(\$1,116)
CZ12	PGE	\$1,963	\$17	(\$1,147)	(\$1,503)	(\$1,279)
CZ12	SMUD/PGE	\$1,963	\$11	(\$1,147)	(\$1,623)	(\$1,406)
CZ13	PGE	\$1,963	\$22	(\$1,114)	(\$1,394)	(\$1,205)
CZ14	SCE/SCG	\$1,963	\$23	(\$897)	(\$1,352)	(\$1,120)
CZ14	SDGE	\$1,963	\$30	(\$897)	(\$1,163)	(\$905)
CZ15	SCE/SCG	\$1,963	\$27	(\$1,297)	(\$1,334)	(\$1,266)
CZ16	PGE	\$1,963	\$24	(\$581)	(\$1,270)	(\$859)

Table 6. [1978-1991] Air Sealing at the Ceiling (CARE)

Climate Zone	Electric/ Gas Utility	First Incremental Cost	First-year Utility Savings	Lifecycle NPV Savings		
				2025 LSC NPV	On-Bill NPV Modest Gas Escalation	On-Bill NPV High Gas Escalation
CZ01	PGE	\$1,963	\$18	(\$931)	(\$1,442)	(\$1,135)
CZ02	PGE	\$1,963	\$10	(\$1,364)	(\$1,658)	(\$1,477)
CZ03	PGE	\$1,963	\$8	(\$1,480)	(\$1,734)	(\$1,598)
CZ04	PGE	\$1,963	\$12	(\$1,330)	(\$1,627)	(\$1,446)
CZ04	CPAU	\$1,963	\$0	(\$1,330)	(\$1,963)	(\$1,963)
CZ05	PGE	\$1,963	\$8	(\$1,447)	(\$1,719)	(\$1,575)
CZ05	PGE/SCG	\$1,963	\$7	(\$1,447)	(\$1,746)	(\$1,619)
CZ06	SCE/SCG	\$1,963	(\$0)	(\$1,830)	(\$1,959)	(\$1,933)
CZ07	SDGE	\$1,963	(\$2)	(\$1,896)	(\$2,003)	(\$1,964)
CZ08	SCE/SCG	\$1,963	\$3	(\$1,797)	(\$1,886)	(\$1,848)
CZ09	SCE/SCG	\$1,963	\$4	(\$1,747)	(\$1,859)	(\$1,813)
CZ10	SCE/SCG	\$1,963	\$7	(\$1,663)	(\$1,790)	(\$1,736)
CZ10	SDGE	\$1,963	\$10	(\$1,663)	(\$1,710)	(\$1,641)
CZ11	PGE	\$1,963	\$18	(\$1,264)	(\$1,500)	(\$1,325)
CZ12	PGE	\$1,963	\$12	(\$1,380)	(\$1,631)	(\$1,469)
CZ12	SMUD/PGE	\$1,963	\$8	(\$1,380)	(\$1,716)	(\$1,558)
CZ13	PGE	\$1,963	\$16	(\$1,364)	(\$1,545)	(\$1,411)
CZ14	SCE/SCG	\$1,963	\$16	(\$1,230)	(\$1,545)	(\$1,378)
CZ14	SDGE	\$1,963	\$20	(\$1,230)	(\$1,422)	(\$1,233)
CZ15	SCE/SCG	\$1,963	\$22	(\$1,463)	(\$1,460)	(\$1,410)
CZ16	PGE	\$1,963	\$16	(\$1,014)	(\$1,491)	(\$1,211)

Table 7. [1991-2010] Air Sealing at the Ceiling (CARE)

Climate Zone	Electric/ Gas Utility	First Incremental Cost	First-year Utility Savings	Lifecycle NPV Savings		
				2025 LSC NPV	On-Bill NPV Modest Gas Escalation	On-Bill NPV High Gas Escalation
CZ01	PGE	\$1,963	\$11	(\$1,314)	(\$1,642)	(\$1,452)
CZ02	PGE	\$1,963	\$7	(\$1,530)	(\$1,749)	(\$1,625)
CZ03	PGE	\$1,963	\$6	(\$1,613)	(\$1,793)	(\$1,693)
CZ04	PGE	\$1,963	\$8	(\$1,530)	(\$1,729)	(\$1,609)
CZ04	CPAU	\$1,963	\$0	(\$1,530)	(\$1,963)	(\$1,963)
CZ05	PGE	\$1,963	\$5	(\$1,613)	(\$1,804)	(\$1,708)
CZ05	PGE/SCG	\$1,963	\$5	(\$1,613)	(\$1,827)	(\$1,747)
CZ06	SCE/SCG	\$1,963	\$1	(\$1,863)	(\$1,940)	(\$1,920)
CZ07	SDGE	\$1,963	\$0	(\$1,896)	(\$1,944)	(\$1,918)
CZ08	SCE/SCG	\$1,963	\$2	(\$1,830)	(\$1,905)	(\$1,879)
CZ09	SCE/SCG	\$1,963	\$2	(\$1,780)	(\$1,908)	(\$1,878)
CZ10	SCE/SCG	\$1,963	\$4	(\$1,763)	(\$1,855)	(\$1,819)
CZ10	SDGE	\$1,963	\$6	(\$1,763)	(\$1,805)	(\$1,758)
CZ11	PGE	\$1,963	\$10	(\$1,530)	(\$1,685)	(\$1,572)
CZ12	PGE	\$1,963	\$7	(\$1,580)	(\$1,759)	(\$1,654)
CZ12	SMUD/PGE	\$1,963	\$5	(\$1,580)	(\$1,802)	(\$1,700)
CZ13	PGE	\$1,963	\$9	(\$1,580)	(\$1,732)	(\$1,644)
CZ14	SCE/SCG	\$1,963	\$9	(\$1,530)	(\$1,722)	(\$1,615)
CZ14	SDGE	\$1,963	\$11	(\$1,530)	(\$1,652)	(\$1,529)
CZ15	SCE/SCG	\$1,963	\$12	(\$1,680)	(\$1,696)	(\$1,667)
CZ16	PGE	\$1,963	\$11	(\$1,314)	(\$1,645)	(\$1,454)

3 Lighting Measures

LED lighting and exterior lighting control measures were previously evaluated in the [2019 Cost-Effectiveness Study: Existing Single Family Residential Building Upgrades](#) study.

These measures are not included in the [2022 Cost-Effectiveness Study: Existing Single Family Building Upgrades](#) study, but have been re-evaluated and included in this memo.

The updated analysis follows the same methodology as the 2019 study, but with updated costs for equipment and updated utility rates.

The three measures evaluated are LED lighting, exterior photosensor, and LED lighting plus photosensor. Table 8 through Table 10 show the results for the different lighting measures evaluated. Each measure is explained in more detail below.

LED Lighting: Replace screw-in (A-based for lamps) incandescent lamps and compact fluorescent lamps (CFLs) with light-emitting diode (LED) A-lamps. This analysis was conducted external to the energy model and evaluated replacement of a 13 W CFL lamp with an 9.6 W LED lamp operating 620 hours annually. Annual hour estimates were based on whole building average hours of operation from a 2010 lighting study by KEMA (KEMA, 2010). Lifetime assumptions were 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/Photosensor: 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 (CEE, 2014). Energy savings will be higher for incandescent or CFL luminaires.

Exterior Lighting Controls/Photosensor+LED: An additional evaluation was completed for exterior lighting controls on a per-luminaire basis external to the energy model and assumes a screw-in photosensor control is installed in outdoor lighting luminaires and incandescent lamps CFLs are replaced with light-emitting diode (LED) A-lamps. Energy savings of 14.3 kWh per year was applied based on the sum of the LED lighting and Exterior Lighting Controls with Photosensor kWh energy savings.

For the measures including a LED, a cost of \$3.49 for LED dimmable A19 lamp 60 W equivalent is used. A cost of \$1.74 is used for an equivalent CFL product which was used to estimate total replacement costs at years 10 and 25. Costs are based on a single LED lamp replacement. For the photosensor, an incremental cost of \$12.62, 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.

Table 8. [All Vintages] LED Lamp vs. CFL

Climate Zone	Electric/ Gas Utility	Measure Cost	Electricity Savings	First Year Utility Cost Savings	Customer On-Bill Modest Gas Escalation		Customer On-Bill High Gas Escalation	
					B/C Ratio	NPV	B/C Ratio	NPV
CZ01	PGE	\$1.75	2.2	\$0.77	10.05	\$15.82	10.58	\$16.74
CZ02	PGE	\$1.75	2.2	\$0.86	11.26	\$17.94	11.85	\$18.98
CZ03	PGE	\$1.75	2.2	\$0.78	10.14	\$15.99	10.68	\$16.92
CZ04	PGE	\$1.75	2.2	\$0.80	10.39	\$16.42	10.94	\$17.38
CZ04	CPAU	\$1.75	2.2	\$0.41	5.32	\$7.56	5.60	\$8.05
CZ05	PGE	\$1.75	2.2	\$0.78	10.14	\$15.99	10.67	\$16.92
CZ05	PGE/SCG	\$1.75	2.2	\$0.78	10.14	\$15.99	10.67	\$16.92
CZ06	SCE/SCG	\$1.75	2.2	\$0.66	8.44	\$13.01	8.99	\$13.97
CZ07	SDGE	\$1.75	2.2	\$0.95	13.15	\$21.24	13.03	\$21.04
CZ08	SCE/SCG	\$1.75	2.2	\$0.74	9.51	\$14.89	10.14	\$15.98
CZ09	SCE/SCG	\$1.75	2.2	\$0.71	9.17	\$14.29	9.77	\$15.33
CZ10	SCE/SCG	\$1.75	2.2	\$0.73	9.38	\$14.65	9.99	\$15.72
CZ10	SDGE	\$1.75	2.2	\$1.07	14.86	\$24.24	14.74	\$24.02
CZ11	PGE	\$1.75	2.2	\$0.85	11.05	\$17.57	11.63	\$18.59
CZ12	PGE	\$1.75	2.2	\$0.79	10.32	\$16.29	10.86	\$17.24
CZ12	SMUD/PGE	\$1.75	2.2	\$0.47	6.08	\$8.88	6.40	\$9.44
CZ13	PGE	\$1.75	2.2	\$0.86	11.27	\$17.96	11.86	\$19.00
CZ14	SCE/SCG	\$1.75	2.2	\$0.74	9.58	\$15.00	10.21	\$16.10
CZ14	SDGE	\$1.75	2.2	\$1.06	14.68	\$23.93	14.56	\$23.71
CZ15	SCE/SCG	\$1.75	2.2	\$0.78	10.01	\$15.75	10.66	\$16.90
CZ16	PGE	\$1.75	2.2	\$0.77	9.98	\$15.71	10.51	\$16.62

Table 9. [All Vintages] Exterior Photosensor

Climate Zone	Electric/ Gas Utility	Measure Cost	Electricity Savings	First Year Utility Cost Savings	Customer On-Bill Modest Gas Escalation		Customer On-Bill High Gas Escalation	
					B/C Ratio	NPV	B/C Ratio	NPV
CZ01	PGE	\$54.03	12.1	\$4.16	1.75	\$40.75	1.85	\$45.74
CZ02	PGE	\$54.03	12.1	\$4.16	1.75	\$40.75	1.85	\$45.74
CZ03	PGE	\$54.03	12.1	\$4.16	1.75	\$40.75	1.85	\$45.74
CZ04	PGE	\$54.03	12.1	\$4.16	1.75	\$40.75	1.85	\$45.74
CZ04	CPAU	\$54.03	12.1	\$2.12	0.89	(\$5.69)	0.94	(\$3.15)
CZ05	PGE	\$54.03	12.1	\$4.16	1.75	\$40.75	1.85	\$45.74
CZ05	PGE/SCG	\$54.03	12.1	\$4.16	1.75	\$40.75	1.85	\$45.74
CZ06	SCE/SCG	\$54.03	12.1	\$3.48	1.45	\$24.36	1.55	\$29.48
CZ07	SDGE	\$54.03	12.1	\$5.07	2.27	\$68.58	2.25	\$67.53
CZ08	SCE/SCG	\$54.03	12.1	\$3.48	1.45	\$24.36	1.55	\$29.48
CZ09	SCE/SCG	\$54.03	12.1	\$3.48	1.45	\$24.36	1.55	\$29.48
CZ10	SCE/SCG	\$54.03	12.1	\$3.48	1.45	\$24.36	1.55	\$29.48
CZ10	SDGE	\$54.03	12.1	\$5.07	2.27	\$68.58	2.25	\$67.53
CZ11	PGE	\$54.03	12.1	\$4.16	1.75	\$40.75	1.85	\$45.74
CZ12	PGE	\$54.03	12.1	\$4.16	1.75	\$40.75	1.85	\$45.74
CZ12	SMUD/PGE	\$54.03	12.1	\$1.46	0.62	(\$20.73)	0.65	(\$18.98)
CZ13	PGE	\$54.03	12.1	\$4.16	1.75	\$40.75	1.85	\$45.74
CZ14	SCE/SCG	\$54.03	12.1	\$3.48	1.45	\$24.36	1.55	\$29.48
CZ14	SDGE	\$54.03	12.1	\$5.07	2.27	\$68.58	2.25	\$67.53
CZ15	SCE/SCG	\$54.03	12.1	\$3.48	1.45	\$24.36	1.55	\$29.48
CZ16	PGE	\$54.03	12.1	\$4.16	1.75	\$40.75	1.85	\$45.74

Table 10. [All Vintages] LED and Photosensor

Climate Zone	Electric/ Gas Utility	Measure Cost	Electricity Savings	First Year Utility Cost Savings	Customer On-Bill Modest Gas Escalation		Customer On-Bill High Gas Escalation	
					B/C Ratio	NPV	B/C Ratio	NPV
CZ01	PGE	\$55.77	14.3	\$4.93	2.01	\$56.57	2.12	\$62.48
CZ02	PGE	\$55.77	14.3	\$5.02	2.05	\$58.70	2.16	\$64.72
CZ03	PGE	\$55.77	14.3	\$4.94	2.02	\$56.74	2.12	\$62.66
CZ04	PGE	\$55.77	14.3	\$4.95	2.03	\$57.17	2.13	\$63.12
CZ04	CPAU	\$55.77	14.3	\$2.53	1.03	\$1.87	1.09	\$4.90
CZ05	PGE	\$55.77	14.3	\$4.94	2.02	\$56.74	2.12	\$62.66
CZ05	PGE/SCG	\$55.77	14.3	\$4.94	2.02	\$56.74	2.12	\$62.66
CZ06	SCE/SCG	\$55.77	14.3	\$4.13	1.67	\$37.37	1.78	\$43.45
CZ07	SDGE	\$55.77	14.3	\$6.02	2.61	\$89.82	2.59	\$88.57
CZ08	SCE/SCG	\$55.77	14.3	\$4.22	1.70	\$39.25	1.82	\$45.46
CZ09	SCE/SCG	\$55.77	14.3	\$4.19	1.69	\$38.65	1.80	\$44.82
CZ10	SCE/SCG	\$55.77	14.3	\$4.21	1.70	\$39.01	1.81	\$45.20
CZ10	SDGE	\$55.77	14.3	\$6.14	2.66	\$92.82	2.64	\$91.55
CZ11	PGE	\$55.77	14.3	\$5.00	2.05	\$58.33	2.15	\$64.33
CZ12	PGE	\$55.77	14.3	\$4.95	2.02	\$57.05	2.13	\$62.98
CZ12	SMUD/PGE	\$55.77	14.3	\$1.93	0.79	(\$11.85)	0.83	(\$9.54)
CZ13	PGE	\$55.77	14.3	\$5.02	2.05	\$58.71	2.16	\$64.73
CZ14	SCE/SCG	\$55.77	14.3	\$4.22	1.71	\$39.37	1.82	\$45.58
CZ14	SDGE	\$55.77	14.3	\$6.13	2.66	\$92.51	2.64	\$91.24
CZ15	SCE/SCG	\$55.77	14.3	\$4.26	1.72	\$40.12	1.83	\$46.38
CZ16	PGE	\$55.77	14.3	\$4.92	2.01	\$56.46	2.12	\$62.36

4 Water Heating Package

This package includes the following:

- R-6 water heater blanket
- R-3 hot water pipe insulation
- Low flow fixtures: two low flow showerheads and three sink aerators.

This analysis assumes the homeowner installs these measures themselves and therefore no labor costs. Costs are based on Home Depot prices from August of 2025. The water heater package is evaluated over a 15-year analysis period and assumes the modest gas escalation rate.

Table 11. [All Vintages] Water Heating Package

Climate Zone	Electric/ Gas Utility	Measure Cost	Gas Savings (therms)	First Year Utility Cost Savings	Customer On-Bill	
					B/C Ratio	NPV
CZ01	PGE	\$125.68	14.69	\$31.11	3.96	\$371.76
CZ02	PGE	\$125.68	15.60	\$35.20	4.48	\$437.15
CZ03	PGE	\$125.68	15.70	\$31.43	4.00	\$376.88
CZ04	PGE	\$125.68	16.05	\$32.62	4.15	\$395.78
CZ04	CPAU	\$125.68	16.05	\$31.99	4.07	\$385.77
CZ05	PGE	\$125.68	15.83	\$31.37	3.99	\$375.88
CZ05	PGE/SCG	\$125.68	15.83	\$28.29	3.60	\$326.59
CZ06	SCE/SCG	\$125.68	16.67	\$29.18	3.71	\$340.84
CZ07	SDGE	\$125.68	16.75	\$37.25	4.74	\$469.81
CZ08	SCE/SCG	\$125.68	16.78	\$29.36	3.74	\$343.80
CZ09	SCE/SCG	\$125.68	16.66	\$29.27	3.72	\$342.34
CZ10	SCE/SCG	\$125.68	16.58	\$28.99	3.69	\$337.73
CZ10	SDGE	\$125.68	16.58	\$37.77	4.80	\$478.19
CZ11	PGE	\$125.68	15.87	\$32.96	4.19	\$401.32
CZ12	PGE	\$125.68	15.90	\$32.85	4.18	\$399.47
CZ12	SMUD/PGE	\$125.68	15.90	\$32.85	4.18	\$399.47
CZ13	PGE	\$125.68	16.32	\$33.00	4.20	\$401.93
CZ14	SCE/SCG	\$125.68	16.11	\$29.79	3.79	\$350.57
CZ14	SDGE	\$125.68	16.11	\$39.23	4.99	\$501.49
CZ15	SCE/SCG	\$125.68	17.40	\$30.16	3.84	\$356.50
CZ16	PGE	\$125.68	15.14	\$31.75	4.04	\$381.87

5 PV

The results for 3 kW PV have been updated from the 2022 study to remove the federal solar tax credit from the cost-effectiveness calculations. The removal of the solar tax credit has a substantial impact on many climate zones across all vintages and will impact the FlexPath.

The following describes the impacts and changes to cost-effectiveness from the 2022 study. These observations are utilizing standard rates. Previously, with the solar tax credit, the 3 kW PV measure in the pre-1978 vintage was on-bill cost effective in all climate zones using both the modest and high gas escalation rates. However, with the credit removed, Climate Zones 1-3, 5, 6, and 12 are no longer cost effective on-bill for both the modest and high gas escalations.

Previously for the 1978-1991 vintage the only cases that were not on-bill cost effective were climate zones 2 and 6 utilizing the modest gas escalation. Now, with the credit removed, many more climate zones are no longer cost effective. Using the modest gas escalation, climate zones 1-3, 5, 6, 12, and 16 are not cost effective on-bill. Using the high gas escalation, climate zones 1-3, 5, 6, and 12 (SMUD) are not cost effective on-bill.

Previously for the 1992-2010 vintage the following cases were not cost effective on-bill: climate zones 1-3, 5, and 6 utilizing the modest gas escalation and climate zone 6 using the high gas escalation. With the credit removed an increased number of climate zones are no longer cost effective. Using the modest gas escalation, climate zones 1-3, 4 (PGE) 5-9, 10 (SCE/SCG), 12, and 16 are not cost effective on-bill. Using the high gas escalation, climate zones 1-3, 4 (PGE), 5-7, 9, 12, and 16 are not cost effective on-bill.

The cost-effectiveness results are presented in Table 12 through Table 1717.

Table 12. [Pre-1978] 3 kW PV without Solar Tax Credit (Std)

Climate Zone	Electric/ Gas Utility	First Incremental Cost	On-Bill Savings			
			On-Bill B/C Modest Gas Escalation	On-Bill NPV Modest Gas Escalation	On-Bill B/C High Gas Escalation	On-Bill NPV High Gas Escalation
CZ01	PGE	\$13,726	0.80	(\$3,074)	0.85	(\$2,410)
CZ02	PGE	\$13,726	0.80	(\$3,072)	0.85	(\$2,409)
CZ03	PGE	\$13,726	0.77	(\$3,567)	0.81	(\$2,930)
CZ04	PGE	\$13,726	1.11	\$1,652	1.16	\$2,564
CZ04	CPAU	\$13,726	1.38	\$5,983	1.45	\$7,123
CZ05	PGE	\$13,726	0.78	(\$3,431)	0.82	(\$2,786)
CZ05	PGE/SCG	\$13,726	0.78	(\$3,431)	0.82	(\$2,786)
CZ06	SCE/SCG	\$13,726	0.87	(\$2,118)	0.92	(\$1,231)
CZ07	SDGE	\$13,726	1.31	\$4,886	1.30	\$4,711
CZ08	SCE/SCG	\$13,726	1.30	\$4,655	1.38	\$5,984
CZ09	SCE/SCG	\$13,726	1.18	\$2,821	1.26	\$4,030
CZ10	SCE/SCG	\$13,726	1.29	\$4,622	1.38	\$5,948
CZ10	SDGE	\$13,726	1.99	\$15,550	1.97	\$15,284
CZ11	PGE	\$13,726	1.55	\$8,684	1.64	\$9,967
CZ12	PGE	\$13,726	1.07	\$1,117	1.13	\$2,002
CZ12	SMUD/PGE	\$13,726	0.93	(\$1,109)	0.98	(\$342)
CZ13	PGE	\$13,726	1.80	\$12,597	1.90	\$14,085
CZ14	SCE/SCG	\$13,726	1.58	\$9,098	1.68	\$10,717
CZ14	SDGE	\$13,726	2.15	\$17,983	2.13	\$17,695
CZ15	SCE/SCG	\$13,726	2.24	\$19,477	2.39	\$21,774
CZ16	PGE	\$13,726	1.04	\$579	1.09	\$1,435

Table 13. [1978-1991] 3 kW PV without Solar Tax Credit (Std)

Climate Zone	Electric/ Gas Utility	First Incremental Cost	On-Bill Savings			
			On-Bill B/C Modest Gas Escalation	On-Bill NPV Modest Gas Escalation	On-Bill B/C High Gas Escalation	On-Bill NPV High Gas Escalation
CZ01	PGE	\$13,726	0.77	(\$3,570)	0.81	(\$2,932)
CZ02	PGE	\$13,726	0.71	(\$4,549)	0.75	(\$3,963)
CZ03	PGE	\$13,726	0.74	(\$4,106)	0.78	(\$3,497)
CZ04	PGE	\$13,726	1.00	\$7	1.05	\$833
CZ04	CPAU	\$13,726	1.35	\$5,517	1.42	\$6,633
CZ05	PGE	\$13,726	0.75	(\$3,985)	0.79	(\$3,369)
CZ05	PGE/SCG	\$13,726	0.75	(\$3,985)	0.79	(\$3,369)
CZ06	SCE/SCG	\$13,726	0.73	(\$4,249)	0.78	(\$3,501)
CZ07	SDGE	\$13,726	1.17	\$2,623	1.16	\$2,466
CZ08	SCE/SCG	\$13,726	1.20	\$3,086	1.27	\$4,313
CZ09	SCE/SCG	\$13,726	1.09	\$1,487	1.17	\$2,609
CZ10	SCE/SCG	\$13,726	1.18	\$2,884	1.26	\$4,097
CZ10	SDGE	\$13,726	1.85	\$13,356	1.84	\$13,108
CZ11	PGE	\$13,726	1.41	\$6,420	1.48	\$7,583
CZ12	PGE	\$13,726	0.97	(\$512)	1.02	\$287
CZ12	SMUD/PGE	\$13,726	0.93	(\$1,109)	0.98	(\$342)
CZ13	PGE	\$13,726	1.63	\$9,953	1.72	\$11,302
CZ14	SCE/SCG	\$13,726	1.42	\$6,655	1.52	\$8,115
CZ14	SDGE	\$13,726	2.00	\$15,653	1.98	\$15,386
CZ15	SCE/SCG	\$13,726	1.94	\$14,686	2.06	\$16,670
CZ16	PGE	\$13,726	0.95	(\$737)	1.00	\$49

Table 14. [1992-2010] 3 kW PV without Solar Tax Credit (Std)

Climate Zone	Electric/ Gas Utility	First Incremental Cost	On-Bill Savings			
			On-Bill B/C Modest Gas Escalation	On-Bill NPV Modest Gas Escalation	On-Bill B/C High Gas Escalation	On-Bill NPV High Gas Escalation
CZ01	PGE	\$13,726	0.71	(\$4,475)	0.75	(\$3,885)
CZ02	PGE	\$13,726	0.73	(\$4,198)	0.77	(\$3,593)
CZ03	PGE	\$13,726	0.72	(\$4,411)	0.76	(\$3,817)
CZ04	PGE	\$13,726	0.80	(\$3,121)	0.84	(\$2,459)
CZ04	CPAU	\$13,726	1.16	\$2,477	1.22	\$3,433
CZ05	PGE	\$13,726	0.73	(\$4,299)	0.76	(\$3,700)
CZ05	PGE/SCG	\$13,726	0.73	(\$4,299)	0.76	(\$3,700)
CZ06	SCE/SCG	\$13,726	0.61	(\$6,143)	0.65	(\$5,520)
CZ07	SDGE	\$13,726	0.94	(\$931)	0.93	(\$1,057)
CZ08	SCE/SCG	\$13,726	0.98	(\$242)	1.05	\$767
CZ09	SCE/SCG	\$13,726	0.88	(\$1,890)	0.94	(\$988)
CZ10	SCE/SCG	\$13,726	0.96	(\$676)	1.02	\$305
CZ10	SDGE	\$13,726	1.51	\$8,054	1.50	\$7,852
CZ11	PGE	\$13,726	1.10	\$1,569	1.16	\$2,477
CZ12	PGE	\$13,726	0.80	(\$3,169)	0.84	(\$2,510)
CZ12	SMUD/PGE	\$13,726	0.93	(\$1,109)	0.98	(\$342)
CZ13	PGE	\$13,726	1.27	\$4,170	1.33	\$5,215
CZ14	SCE/SCG	\$13,726	1.15	\$2,295	1.22	\$3,470
CZ14	SDGE	\$13,726	1.66	\$10,386	1.65	\$10,164
CZ15	SCE/SCG	\$13,726	1.37	\$5,788	1.46	\$7,191
CZ16	PGE	\$13,726	0.81	(\$3,006)	0.85	(\$2,338)

Table 15. [Pre-1978] 3 kW PV without Solar Tax Credit (CARE)

Climate Zone	Electric/ Gas Utility	First Incremental Cost	On-Bill Savings			
			On-Bill B/C Modest Gas Escalation	On-Bill NPV Modest Gas Escalation	On-Bill B/C High Gas Escalation	On-Bill NPV High Gas Escalation
CZ01	PGE	\$13,726	0.62	(\$6,030)	0.65	(\$5,522)
CZ02	PGE	\$13,726	0.64	(\$5,707)	0.67	(\$5,182)
CZ03	PGE	\$13,726	0.60	(\$6,344)	0.63	(\$5,853)
CZ04	PGE	\$13,726	0.83	(\$2,725)	0.87	(\$2,042)
CZ05	PGE	\$13,726	0.60	(\$6,266)	0.63	(\$5,771)
CZ05	PGE/SCG	\$13,726	0.60	(\$6,266)	0.63	(\$5,771)
CZ06	SCE/SCG	\$13,726	0.71	(\$4,578)	0.75	(\$3,852)
CZ07	SDGE	\$13,726	0.71	(\$4,508)	0.71	(\$4,604)
CZ08	SCE/SCG	\$13,726	0.97	(\$483)	1.03	\$510
CZ09	SCE/SCG	\$13,726	0.90	(\$1,530)	0.96	(\$605)
CZ10	SCE/SCG	\$13,726	0.97	(\$465)	1.03	\$530
CZ10	SDGE	\$13,726	1.19	\$3,032	1.18	\$2,872
CZ11	PGE	\$13,726	1.07	\$1,150	1.13	\$2,036
CZ12	PGE	\$13,726	0.79	(\$3,324)	0.83	(\$2,673)
CZ13	PGE	\$13,726	1.23	\$3,587	1.29	\$4,601
CZ14	SCE/SCG	\$13,726	1.17	\$2,662	1.25	\$3,861
CZ14	SDGE	\$13,726	1.28	\$4,436	1.27	\$4,264
CZ15	SCE/SCG	\$13,726	1.57	\$8,962	1.67	\$10,572
CZ16	PGE	\$13,726	0.79	(\$3,342)	0.83	(\$2,692)

Table 16. [1978-1991] 3 kW PV without Solar Tax Credit (CARE)

Climate Zone	Electric/ Gas Utility	First Incremental Cost	On-Bill Savings			
			On-Bill B/C Modest Gas Escalation	On-Bill NPV Modest Gas Escalation	On-Bill B/C High Gas Escalation	On-Bill NPV High Gas Escalation
CZ01	PGE	\$13,726	0.60	(\$6,343)	0.63	(\$5,851)
CZ02	PGE	\$13,726	0.56	(\$6,845)	0.59	(\$6,380)
CZ03	PGE	\$13,726	0.57	(\$6,757)	0.60	(\$6,287)
CZ04	PGE	\$13,726	0.76	(\$3,715)	0.80	(\$3,085)
CZ05	PGE	\$13,726	0.57	(\$6,686)	0.60	(\$6,213)
CZ05	PGE/SCG	\$13,726	0.57	(\$6,686)	0.60	(\$6,213)
CZ06	SCE/SCG	\$13,726	0.61	(\$6,195)	0.64	(\$5,575)
CZ07	SDGE	\$13,726	0.62	(\$6,004)	0.61	(\$6,087)
CZ08	SCE/SCG	\$13,726	0.91	(\$1,483)	0.96	(\$555)
CZ09	SCE/SCG	\$13,726	0.85	(\$2,368)	0.90	(\$1,497)
CZ10	SCE/SCG	\$13,726	0.90	(\$1,597)	0.96	(\$676)
CZ10	SDGE	\$13,726	1.10	\$1,560	1.09	\$1,413
CZ11	PGE	\$13,726	0.98	(\$295)	1.03	\$515
CZ12	PGE	\$13,726	0.72	(\$4,320)	0.76	(\$3,722)
CZ13	PGE	\$13,726	1.12	\$1,893	1.18	\$2,818
CZ14	SCE/SCG	\$13,726	1.07	\$1,051	1.14	\$2,144
CZ14	SDGE	\$13,726	1.18	\$2,878	1.17	\$2,719
CZ15	SCE/SCG	\$13,726	1.37	\$5,735	1.45	\$7,135
CZ16	PGE	\$13,726	0.74	(\$4,126)	0.78	(\$3,517)

Table 17. [1992-2010] 3 kW PV without Solar Tax Credit (CARE)

Climate Zone	Electric/ Gas Utility	First Incremental Cost	On-Bill Savings			
			On-Bill B/C Modest Gas Escalation	On-Bill NPV Modest Gas Escalation	On-Bill B/C High Gas Escalation	On-Bill NPV High Gas Escalation
CZ01	PGE	\$13,726	0.56	(\$6,963)	0.59	(\$6,504)
CZ02	PGE	\$13,726	0.26	(\$11,640)	0.20	(\$12,611)
CZ03	PGE	\$13,726	0.55	(\$6,997)	0.58	(\$6,540)
CZ04	PGE	\$13,726	0.62	(\$5,900)	0.66	(\$5,385)
CZ05	PGE	\$13,726	0.56	(\$6,932)	0.59	(\$6,471)
CZ05	PGE/SCG	\$13,726	0.56	(\$6,932)	0.59	(\$6,471)
CZ06	SCE/SCG	\$13,726	0.51	(\$7,652)	0.55	(\$7,127)
CZ07	SDGE	\$13,726	0.48	(\$8,115)	0.48	(\$8,180)
CZ08	SCE/SCG	\$13,726	0.78	(\$3,430)	0.83	(\$2,629)
CZ09	SCE/SCG	\$13,726	0.72	(\$4,462)	0.76	(\$3,728)
CZ10	SCE/SCG	\$13,726	0.76	(\$3,748)	0.81	(\$2,968)
CZ10	SDGE	\$13,726	0.86	(\$2,225)	0.85	(\$2,340)
CZ11	PGE	\$13,726	0.79	(\$3,259)	0.83	(\$2,605)
CZ12	PGE	\$13,726	0.63	(\$5,876)	0.66	(\$5,359)
CZ13	PGE	\$13,726	0.89	(\$1,678)	0.94	(\$941)
CZ14	SCE/SCG	\$13,726	0.89	(\$1,676)	0.95	(\$761)
CZ14	SDGE	\$13,726	0.95	(\$838)	0.94	(\$964)
CZ15	SCE/SCG	\$13,726	0.99	(\$142)	1.06	\$873
CZ16	PGE	\$13,726	0.63	(\$5,850)	0.66	(\$5,333)

6 References

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Get In Touch

The adoption of reach codes can differentiate jurisdictions as efficiency leaders and help accelerate the adoption of new equipment, technologies, code compliance, and energy savings strategies.

As part of the Statewide Codes & Standards Program, the Reach Codes Subprogram is a resource available to any local jurisdiction located throughout the state of California.

Our experts develop robust toolkits as well as provide specific technical assistance to local jurisdictions (cities and counties) considering adopting energy reach codes. These include cost-effectiveness research and analysis, model ordinance language and other code development and implementation tools, and specific technical assistance throughout the code adoption process.

If you are interested in finding out more about local energy reach codes, the Reach Codes Team stands ready to assist jurisdictions at any stage of a reach code project.



Visit

LocalEnergyCodes.com to access our resources and sign up for newsletters



Contact

info@localenergycodes.com for no-charge assistance from expert Reach Code advisors



Explore

The [Cost-Effectiveness Explorer](#) is a free resource to help California local governments and stakeholders develop energy policies for buildings.



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Revision: 1.0

Last modified: 2025/09/18



State of California - Department of Fish and Wildlife
2025 ENVIRONMENTAL DOCUMENT FILING FEE
CASH RECEIPT
DFW 753.5a (REV. 01/01/25) Previously DFG 753.5a

RECEIPT NUMBER:

56-12172025-230

STATE CLEARINGHOUSE NUMBER (If applicable)

SEE INSTRUCTIONS ON REVERSE. TYPE OR PRINT CLEARLY.

LEAD AGENCY CITY OF OJAI	LEAD AGENCY EMAIL lucas.seibert@ojai.ca.gov	DATE 12/17/2025
COUNTY/STATE AGENCY OF FILING VENTURA	DOCUMENT NUMBER 2025100014297	

PROJECT TITLE

ORDINANCE ADOPTING AMENDMENTS TO CITY OF OJAI'S MUNI CODE, TITLE NINE, CH. ONE

PROJECT APPLICANT NAME CITY OF OJAI	PROJECT APPLICANT EMAIL lucas.seibert@ojai.ca.gov	PHONE NUMBER (805)65581 EXT. 113
PROJECT APPLICANT ADDRESS 401 S. VENTURA ST	CITY OJAI	STATE CA
		ZIP CODE 93023

PROJECT APPLICANT (Check appropriate box)

☒ Local Public Agency ☐ School District ☐ Other Special District ☐ State Agency ☐ Private Entity

CHECK APPLICABLE FEES:

☐ Environmental Impact Report (EIR)	\$4,123.50	\$	
☐ Mitigated/Negative Declaration (MND)(ND)	\$2,988.75	\$	
☐ Certified Regulatory Program (CRP) document - payment due directly to CDFW	\$1,401.75	\$	

☒ Exempt from fee

☒ Notice of Exemption (attach)

☐ CDFW No Effect Determination (attach)

☐ Fee previously paid (attach previously issued cash receipt copy)

☐ Water Right Application or Petition Fee (State Water Resources Control Board only)	\$850.00	\$	
☒ County documentary handling fee		\$	\$50.00
☐ Other		\$	

PAYMENT METHOD:

☐ Cash ☒ Credit ☐ Check ☐ Other

TOTAL RECEIVED \$ 50.00

SIGNATURE

X *Esmeralda Arroyo*

AGENCY OF FILING PRINTED NAME AND TITLE

ESMERALDA ARROYO, DEPUTY COUNTY CLERK

POSTED
DEC 17 2025

MICHELLE ASCENCION
Ventura County Clerk and Recorder

By: _____ Deputy

Filed in County Clerk's Office
Michelle Ascencion
Ventura County Clerk-Recorder

2025100014297

12/17/2025 02:56 PM

FISH ,Pages: 2 Fee: \$50.00 ARROYOES

Notice of Exemption

Appendix E

To: Office of Planning and Research
P.O. Box 3044, Room 113
Sacramento, CA 95812-3044
County Clerk
County of: Ventura

From: (Public Agency): _____
401 S. Ventura Street
Ojai, CA 93023
(Address)

Project Title: Ordinance Adopting amendments to City of Ojai's Muni Code, Title nine, Ch. one

Project Applicant: City of Ojai

Project Location - Specific:

City of Ojai

Project Location - City: Ojai Project Location - County: Ventura

Description of Nature, Purpose and Beneficiaries of Project:

Ordinance amending Title Nine, Chapter One to include energy efficiency standards for single-family homeowners for certain renovations and additions to reduce greenhouse gas emissions in the City of Ojai

Name of Public Agency Approving Project: City of Ojai - City Council

Name of Person or Agency Carrying Out Project: Lucas Seibert, Community Development Director

Exempt Status: (check one):

- ☐ Ministerial (Sec. 21080(b)(1); 15268);
- ☐ Declared Emergency (Sec. 21080(b)(3); 15269(a));
- ☐ Emergency Project (Sec. 21080(b)(4); 15269(b)(c));
- ☒ Categorical Exemption. State type and section number: 15301, 15307, 15308, & 15061(b)(3)
- ☐ Statutory Exemptions. State code number: _____

Reasons why project is exempt:

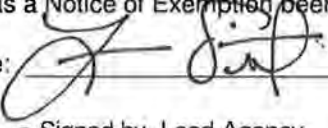
Action taken by a regulatory agency for the purpose of protecting the environment, and on the grounds that these standards are more stringent than the State energy standards, no reasonably foreseeable adverse impacts, and no possibility the activity in question may have a significant effect on the environment.

Lead Agency

Contact Person: Lucas Seibert Area Code/Telephone/Extension: 805-646-5581/113

If filed by applicant:

1. Attach certified document of exemption finding.
2. Has a Notice of Exemption been filed by the public agency approving the project? Yes No

Signature:  Date: 12/17/2025 Title: Community Development Director

▪ Signed by Lead Agency Signed by Applicant

Authority cited: Sections 21083 and 21110, Public Resources Code.
Reference: Sections 21108, 21152, and 21152.1, Public Resources Code.

Date Received for filing at OPR: _____