



CITY COUNCIL MEETING

TUESDAY, NOVEMBER 10, 2020 – 7:00 P.M. – 11:00 PM

Please Note: Per California Executive Order N-29-20, the City Council will meet Telephone/Video Conference only.

Members of the Public may join and participate in the Council meeting at <https://webinar.ringcentral.com/j/1488141784>

TO LISTEN to the City Council Meeting, members of the public may call 1-650-242-4929 (Meeting ID: **148 814 1784**). Please note that members of the public who call in using the telephone number will **NOT** be able to provide public comments.

TO COMMENT DURING THE MEETING members of the public will need to join the meeting using the above link and have a working microphone on their device. To request to speak please use the “Raise hand” feature located at the bottom of the screen. Public testimony will be taken at the direction of the Mayor and members of the public may only comment during times allotted for public comments.

TO SUBMIT WRITTEN COMMENTS, prior to the meeting, on matters listed on the agenda email PublicComment@losaltosca.gov with the subject line in the following format:

PUBLIC COMMENT AGENDA ITEM ## - MEETING DATE.

Correspondence must be received by 2:00 p.m. on the day of the meeting to ensure it can be distributed prior to the meeting. Emails received prior to the meeting will be included in the public record. [Please follow this link for more information on submitting written comments.](#)

CALL MEETING TO ORDER

REPORT ON CLOSED SESSION

ESTABLISH QUORUM

CHANGES TO THE ORDER OF THE AGENDA

SPECIAL ITEMS

- Presentation – Block Action Team Update and Presentation Of Proclamation To Sherie Dodsworth

PUBLIC COMMENTS ON ITEMS NOT ON THE AGENDA

Members of the audience may bring to the Council's attention any item that is not on the agenda. Speakers are generally given two or three minutes, at the discretion of the Mayor. Please be advised that, by law, the City Council is unable to discuss or take action on issues presented during the Public Comment Period. According to State Law (also known as “the Brown Act”) items must first be noticed on the agenda before any discussion or action.

CONSENT CALENDAR

These items will be considered by one motion unless any member of the Council or audience wishes to remove an item for discussion. Any item removed from the Consent Calendar for discussion will be handled at the discretion of the Mayor.

1. Council Minutes: Approve the minutes of the October 27, 2020 Regular Meeting (A. Chelemengos)
2. Design Contract Award: Adobe Creek Sewer Main Replacement Project WW0101221 - Appropriate \$134,981.06 from the Sewer Fund to Project WW0101221; and authorize the City Manager to execute an agreement with Schaaf & Wheeler Consulting Civil Engineers (Schaaf & Wheeler) in the not-to-exceed amount of \$573,164.60 and up to a 10% contingency amount of \$57,316.46 on behalf of the City to provide professional design services for the Adobe Creek Sewer Main Replacement Project WW0101221(A. Fairman)
3. Construction Contract Award: El Monte Avenue Sidewalk Gap Closure Project, TS-01038 Award the Base Bid for the El Monte Sidewalk Gap Closure Project to FBD Vanguard Construction, Inc., and authorize the City Manager to execute a contract in the amount of \$512,315.44 and up to 15% contingency on behalf of the City. K. Kim/J. Sandoval)
4. Resolution No. 2020-38: Accept vacation of a portion of right-of-way at 2020 El Sereno Avenue: Adopt Resolution Of The City Council Of The City Of Los Altos Approving The Vacation Of An Easement On The Property At 2020 El Sereno Avenue. (H. Musaefendic)
5. Civic Center Lands Protection: Informational update on the addition of a Public Land Protection (PLP) overlay district to Title 14, Zoning, of the Los Altos Municipal Code that will provide protection of City owned property by requiring voter approval of the sale or transfer of title of any City-owned land to which this overlay designation is applied and voter approval to remove the PLP designation once it has been applied and agreement to proceed with the review of the code amendment through the Planning Commission. (J. Biggs)
6. Ordinance No. 2020-470A Second Reading and Adoption of An Ordinance Of The City Council Of The City Of Los Altos Amending Chapter 12.22 Energy Code Of Title 12 Of The Los Altos Municipal Code Relating To Amendments To The 2019 California Energy Code For All-Electric Single-Family Buildings, Multi-Family Buildings Having From Two To Nine Residential Units, And Detached Accessory Dwelling Unit Buildings (J. Biggs)
7. Ordinance No. 2020-470B Second Reading and Adoption of An Ordinance Of The City Council Of The City Of Los Altos Amending Chapter 12.22 Energy Code Of Title 12 Of The Los Altos Municipal Code Relating To Amendments To The 2019 California Energy Code For All-Electric Multi-Family Residential Developments Having Ten (10) Or More Units. (J. Biggs)
8. Ordinance No.2020-470C Second Reading and Adoption of An Ordinance Of The City Council Of The City Of Los Altos Amending Chapter 12.22 Energy Code Of Title 12 Of The Los Altos Municipal Code Relating To Amendments To The 2019 California Energy Code For All-Electric Non-Residential Buildings, Scientific Laboratory Buildings, And Public Buildings. (J. Biggs)

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9. Ordinance 2020-471 - Second Reading and Adoption of An Ordinance Of The City Council Of The City Of Los Altos Amending Chapter 12.26 Green Building Standards Code Of Title 12 Of The Los Altos Municipal Code Relating To Amendments To The 2019 California Green Building Standards Code For Electric Vehicle (EV) Infrastructure (J. Biggs)

PUBLIC HEARINGS

10. Ordinance No. 2020-474 Limitations on Non-Reusable Food Service Ware Accessories: Introduce and Hold first Reading of an Ordinance No. 2020-474 - Amending the Los Altos Municipal Code, by Adding Chapter 6.48 Entitled "Limitations on Non-Reusable Food Service Ware Accessories for Litter and Waste Reduction". (E. Ancheta)

DISCUSSION ITEMS

11. Policing Task Force Initial Report: Receive an update from the Council ad hoc subcommittee assigned to assist the Citizens' Police Task Force. (J. Maginot)
12. Off leash hours Pilot Program at Hillview Baseball Field and Heritage Oaks Park: Consider and approve recommendations from the Parks and Recreation Commission to host a 9-month pilot off-leash hours program at the Hillview Baseball Field and Heritage Oaks Park beginning February 2021, to be implemented and evaluated at the discretion of City staff with direction to return to City Council with a status report and long-term recommendation in November 2021. (D. Legge)
13. Bocce Ball/Grant Park Master Plan: Acknowledge offer of \$20,000 from the Los Altos Legacies and \$20,000 from the Rotary Endowment Fund to build two bocce ball courts in Grant Park and direct staff to send a letter to the donors deferring a decision to accept or not accept the donation after Grant Park priorities have been identified through a comprehensive public outreach process and authorize staff to proceed with engaging a landscape architect to work with staff and the PARC Grant Park Master Plan Subcommittee to coordinate the public process and a site specific master plan for Grant Park per the recommendations of the Parks and Recreation and Senior Commissions. (D. Legge)
14. Community Center Art: Approve the commission of murals for the North Lobby and the south entrance seating area and appropriate \$9,500 from the Capital Improvement Reserve to the Annual Public Arts Project, Project CF-01003. (J. Maginot)

INFORMATIONAL ITEMS ONLY

- Tentative Council Calendar

COUNCIL/STAFF REPORTS AND DIRECTIONS ON FUTURE AGENDA ITEMS

ADJOURNMENT – 11:00 PM

(Council Norms: It will be the custom to have a recess at approximately 9:00 p.m. Prior to the recess, the Mayor shall announce whether any items will be carried over to the next meeting. The established hour after which no new items will be started is 11:00 p.m. Remaining items, however, may be considered by consensus of the Council.)

SPECIAL NOTICES TO THE PUBLIC

In compliance with the Americans with Disabilities Act, the City of Los Altos will make reasonable arrangements to ensure accessibility to this meeting. If you need special assistance to participate in this meeting, please contact the City Clerk 72 hours prior to the meeting at (650) 947-2610.

Agendas, Staff Reports and some associated documents for City Council items may be viewed on the Internet at <http://www.losaltosca.gov/citycouncil/online/index.html>.

All public records relating to an open session item on this agenda, which are not exempt from disclosure pursuant to the California Public Records Act, and that are distributed to a majority of the legislative body, will be available for public inspection at the Office of the City Clerk's Office, City of Los Altos, located at One North San Antonio Road, Los Altos, California at the same time that the public records are distributed or made available to the legislative body. If you wish to provide written materials, please provide the City Clerk with **10 copies** of any document that you would like to submit to the City Council for the public record.



Proclamation
of the
Mayor of the City of Los Altos, California
Recognizing Sherie Dodsworth

WHEREAS, the Los Altos City Council supports building resilience in our community and strengthening individuals' emergency preparedness. Taking proactive steps to prepare for disasters and emergencies can help individuals and communities respond better and stay safer during crisis; and

WHEREAS, the Los Altos City Council encourages residents to get to know their neighbors, join together in crime prevention and emergency preparedness, and build a sense of community; and

WHEREAS, resident Sherie Dodsworth founded the Block Action Team (BAT) Program in 2013, An initiative of Los Altos Community Foundation, Sherie worked to improve household preparedness levels and strengthen the community's ability to respond to disasters. Envisioning a network of neighborhood groups across Los Altos, Sherie researched best practices in surrounding cities, met with local residents, and coordinated with emergency management services to create the program; and

WHEREAS, Sherie Dodsworth led the BAT program for five years, recruiting and training BAT leaders across the City of Los Altos and holding quarterly "Inspiration Sessions" to keep volunteers engaged; and

WHEREAS, Sherie and the BAT Program have trained 300 volunteer BAT leaders since 2014, establishing over 100 Block Action Teams. Over 2500 households (approximately 25% of the City of Los Altos) are now covered by a Block Action Team; and

NOW, THEREFORE, I, Jan Pepper, Mayor of the City of Los Altos, on behalf of the Los Altos City Council do hereby honor Sherie Dodsworth for her contributions to our community and for establishing the Block Action Teams in Los Altos. I encourage all community members to take Sherie's example to improve emergency preparedness in their own homes and in our community.

Presented: November 10, 2020

Janis C. Pepper, Mayor



**MINUTES OF THE REGULAR MEETING OF
THE CITY COUNCIL OF THE CITY OF LOS ALTOS
TUESDAY, OCTOBER 27, 2020
HELD VIA VIDEO/TELECONFERENCE**

MEETING CALLED TO ORDER

At 7:20 p.m., Mayor Pepper called the meeting to order.

ESTABLISH QUORUM

Present: Mayor Pepper, Vice Mayor Fligor, Council Members Bruins, Enander and Lee Eng
Absent: None

REPORT ON CLOSED SESSION

1. Conference with Legal Counsel – Existing Litigation
Pursuant to Government Code Section 54956.9(d)(1)
Name of Case: *California Renters Legal Advocacy and Education Fund, San Francisco Bay Area Renters Federation, Victoria Fierce, and Sonja Trauss v. City of Los Altos, et al. Sixth District Court of Appeal Case No HO48270, County of Santa Clara Case No. 19CV350422*
2. Conference with Legal Counsel – Existing Litigation
Pursuant to Government Code Section 54956.9(d)(1)
Name of Case: *40 Main LLC v City of Los Altos et al. Sixth District Court of Appeal, Case Number H048270 County of Santa Clara Case No. 19CV349845*
3. Conference with Labor Negotiators
Pursuant to Government Code Section 54957.6(a)
Employee organization: Los Altos Municipal Employee Association (LAMEA)
4. Conference with Labor Negotiators
Pursuant to Government Code Section 54957.6(a)
Employee organization: The Los Altos Police Officers Association (LAPOA)

Mayor Pepper reported that the City Council met in closed session prior to this meeting. She stated that there was no action taken and nothing to report.

CHANGES TO THE ORDER OF THE AGENDA

Council Member Bruins moved to removed Item # 3 *Contract Amendment No. 2 to the Agreement between the City of Los Altos and NOVA* from the Consent a Calendar and consider the matter in conjunction with Item #10 *Contract Amendment No. 4 to the Agreement with between the City and Noll & Tam Architects* immediately following agenda Item #8. The motion was seconded by Council Member Enander and the motion passed 5-0 with the following roll call vote:

AYES: Council Members Bruins, Enander, Lee Eng, Vice Mayor Fligor, and Mayor Pepper.
NOES: None
ABSENT: None
ABSTAIN: None

SPECIAL ITEMS

- A. Commission Appointments: Appoint individuals to fill vacancies on the Complete Streets Commission, Historical Commission, and Planning Commission. (A. Chelemengos)

Complete Streets Commission

Council Member Bruins moved to appoint Tom Gschneider to the Complete Streets Commission for a term ending March 31, 2022. The motion was seconded by Council Member Lee Eng and the motion passed 5-0 with the following roll call vote:

AYES: Council Members Bruins, Enander, Lee Eng, Vice Mayor Fligor, and Mayor Pepper.
NOES: None
ABSENT: None
ABSTAIN: None

Planning Commission.

Vice Mayor Fligor moved to appoint Susan Mensinger to the Planning Commission for a term ending September 30, 2024. The motion was seconded by Council Member Enander and the motion passed 5-0 with the following roll call vote:

AYES: Council Members Bruins, Enander, Lee Eng, Vice Mayor Fligor, and Mayor Pepper.
NOES: None
ABSENT: None
ABSTAIN: None

Vice Mayor Fligor moved to appoint Richard Roche to the Planning Commission for a term ending September 30, 2024. The motion was seconded by Council Member Bruins and the motion passed 3-2 with the following roll call vote:

AYES: Council Member Bruins, Vice Mayor Fligor and Mayor Pepper.
NOES: Council Members Enander and Lee Eng
ABSENT: None
ABSTAIN: None

Historical Commission

Council Member Bruins moved to appoint Kirk Paige to the Historical Commission for a term ending September 30, 2024. The motion was seconded by Council Member Enander and the motion passed 5-0 with the following roll call vote:

AYES: Council Members Bruins, Enander, Lee Eng, Vice Mayor Fligor, and Mayor Pepper.
NOES: None
ABSENT: None
ABSTAIN: None

PUBLIC COMMENTS ON ITEMS NOT ON THE AGENDA

The following members of the public provided comments: Caltrains Rider, Renee Rashid, and Marko Radajicic.

CONSENT CALENDAR

1. Council Minutes: Approve the minutes of the October 13, 2020 Regular Meeting
2. Ordinance No. 2020-473: Hold Second Reading and Adoption of an Ordinance repealing and replacing Chapter 14.14 of the Los Altos Municipal Code (Accessory and Junior Dwelling Units) by adopting Zoning Text Amendment 20-000.
4. Contract Amendment No. 3 to Professional Services Agreement with Traffic Patterns, LLC for Engineering Support.: Authorize the City Manager to execute an amendment on behalf of the City with Traffic Patterns, LLC in an amount not to exceed \$283,372 to provide additional consulting services for the Engineering Services Department.

Council Member Bruins noted a numbering error on page 5 of the minutes. The City Clerk stated that the correction would be made.

Vice Mayor Fligor noted that Consent Calendar Item 5 was to be deferred to the next meeting and moved the City Council to approve Consent Calendar Items 1, 2 and 4. The motion was seconded by Council Member Bruins and the motion passed 5-0 with the following roll call vote:

AYES: Council Members Bruins, Enander, Lee Eng, Vice Mayor Fligor, and Mayor Pepper.
NOES: None
ABSENT: None
ABSTAIN: None

PUBLIC HEARINGS

6. APPL 20-0002 – 126 Mt Hamilton-Review of Revised Project :Hold Public Hearing and adopt Resolution No. 2020-34 approving the revised application To Demolish An Existing Residence And Construct A New Two-Story House Consisting Of 2,740 Square Feet On The First Story, 1,206 Square Feet On The Second Story And A 2,704 Square-Foot Basement.

Guido Persicone, Planning Services Director, provided a staff report and answered questions from the Council.

Eugene Sakai, project architect, was called upon to answer questions from the Council.

Mayor Pepper opened the Public Hearing.

The following individuals provide comments: Tom Shoup, Jon Baer, Eugene Hyman, Eugene Sakai (project architect) and Ann Hambly.

Since there was no one else wishing to speak, Mayor Pepper closed the Public Hearing.

Council Member Bruins moved adopt Resolution No. 2020-34 approving the revised application To Demolish the Existing Residence at 126 Mount Hamilton And Construct A New Two-Story House Consisting Of 2,740 Square Feet On The First Story, 1,206 Square Feet On The Second Story And A 2,704 Square-Foot Basement with the added language directing the applicant to minimize the mass and bulk of the chimneys located on either end of the proposed residence. The motion was seconded by Vice Mayor Fligor and the motion passed 4-1 with the following roll call vote:

AYES: Council Members Bruins, Lee Eng, Vice Mayor Fligor, and Mayor Pepper.
NOES: Council Member Enander
ABSENT: None
ABSTAIN: None

7. Ordinance Nos. 2020-470A, 2020-470B, 2020-470C and 2020-471 Building Electrification and Electric Vehicle Infrastructure Reach Codes: Hold Public Hearings, introduce and waive further readings of:
 - Ordinance No. 2020-470A An Ordinance Of The City Council Of The City Of Los Altos Amending Chapter 12.22 Energy Code Of Title 12 Of The Los Altos Municipal Code Relating To Amendments To The 2019 California Energy Code For All-Electric Single-Family Buildings, Multi-Family Buildings Having From Two To Nine Residential Units, And Detached Accessory Dwelling Unit Buildings;
 - Ordinance No. 2020-470B An Ordinance Of The City Council Of The City Of Los Altos Amending Chapter 12.22 Energy Code Of Title 12 Of The Los Altos Municipal Code Relating To Amendments To The 2019 California Energy Code For All-Electric Multi-Family Residential Developments Having Ten (10) Or More Units;
 - Ordinance No.2020-470C An Ordinance Of The City Council Of The City Of Los Altos Amending Chapter 12.22 Energy Code Of Title 12 Of The Los Altos Municipal Code Relating To Amendments To The 2019 California Energy Code For All-Electric Non-Residential Buildings, Scientific Laboratory Buildings, And Public Buildings; and
 - Ordinance 2020-471 - An Ordinance Of The City Council Of The City Of Los Altos Amending Chapter 12.26 Green Building Standards Code Of Title 12 Of The Los Altos Municipal Code Relating To Amendments To The 2019 California Green Building Standards Code For Electric Vehicle (EV) Infrastructure

Community Development Director Biggs provided a staff report and answered questions from the Council.

Mayor Pepper opened the Public Hearing. The following members for the public commented:

Angelo De Giuli, Connie Miller, Paula Zeni, Roberta Phillips, Dashiell Leeds, and Diya Gupta.

Council Member Bruins moved that the City Council introduce, as read by title only, and waive further readings of Ordinance No. 2020-470A An Ordinance Of The City Council Of The City Of Los Altos Amending Chapter 12.22 Energy Code Of Title 12 Of The Los Altos Municipal Code Relating To Amendments To The 2019 California Energy Code For All-Electric Single-Family Buildings, Multi-Family Buildings Having From Two To Nine Residential Units, And Detached Accessory Dwelling Unit Buildings. The motion was seconded by Vice Mayor Fligor and the motion passed 5-0 with the following roll call vote:

AYES: Council Members Bruins, Enander, Lee Eng, Vice Mayor Fligor, and Mayor Pepper.
NOES: None
ABSENT: None
ABSTAIN: None

Vice Mayor Fligor moved that the Council introduce Ordinance No. 2020-470B, as read by title only and waive further reading of An Ordinance Of The City Council Of The City Of Los Altos Amending Chapter 12.22 Energy Code Of Title 12 Of The Los Altos Municipal Code Relating To Amendments To The 2019 California Energy Code For All-Electric Multi-Family Residential Developments Having Ten (10) Or More Units. The motion was seconded by Council Member Bruins and the motion passed 5-0 with the following roll call vote:

AYES: Council Members Bruins, Enander, Lee Eng, Vice Mayor Fligor, and Mayor Pepper.
NOES: None
ABSENT: None
ABSTAIN: None

Council Member Bruins moved that the Council introduce, as read by title only and waive further readings of Ordinance No.2020-470C An Ordinance Of The City Council Of The City Of Los Altos Amending Chapter 12.22 Energy Code Of Title 12 Of The Los Altos Municipal Code Relating To Amendments To The 2019 California Energy Code For All-Electric Non-Residential Buildings, Scientific Laboratory Buildings, And Public Buildings. The motion was seconded by Vice Mayor Fligor and the motion passed 5-0 with the following roll call vote:

AYES: Council Members Bruins, Enander, Lee Eng, Vice Mayor Fligor, and Mayor Pepper.
NOES: None
ABSENT: None
ABSTAIN: None

At 9:00 p.m., Mayor Pepper called for a brief recess. The meeting was reconvened at 9:05 p.m.

Following discussion, Vice Mayor Fligor moved to introduce Ordinance 2020-471 - An Ordinance Of The City Council Of The City Of Los Altos Amending Chapter 12.26 Green Building Standards Code Of Title 12 Of The Los Altos Municipal Code Relating To Amendments To The 2019 California Green Building Standards Code For Electric Vehicle (EV) Infrastructure with the following amendments:

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- Revise Section 4.106.4 Exception 2. To read “If no additional parking facilities are provided for Accessory Dwelling Units (ADU) and Junior Accessory Dwelling Units (JADU).”
 - Throughout the ordinance, replace “a”, “one”, and “two” with “at least one” and “at least two”.
 - Section 4.106.4.2 Exception should include definition of “affordable housing”
 - Direct staff to investigate inclusion of language related to EV charging infrastructure in commercial building parking areas
 - Section 5.106.5.3.2 Add definition of Direct Current Fast Charger to the definition section of the ordinance
 - Delete from Section 4.106.4 and Section 5.106.5.3 the following exception language: Spaces accessible only by automated mechanical car parking systems are excepted from providing EV charging infrastructure.
 - Section 5.106.5.3.1 change 1 to read “When 10 or more parking spaces are constructed, 50% of the available parking spaces on site shall be equipped with Level 2 EVCS “
 - Section 5.106.5.3.1 change 2 to read “An additional 20% shall be provided with at least Level 1 EV Ready Spaces.”
 - Section 5.106.5.3.1 change title to Office and Institutional Buildings.
 - Section 5.105.53.1 change the first line to read: “In nonresidential new construction buildings designated primarily for office and nonresidential buildings, such as institutional uses with parking.”

The motion was seconded by Council Member Bruins and the motion passed 4-1 with the following roll call vote:

AYES: Council Members Bruins, Enander, Lee Eng, Vice Mayor Fligor, and Mayor Pepper.
NOES: Council Member Enander
ABSENT: None
ABSTAIN: None

3. Contract Amendment No. 2 to the Agreement between the City of Los Altos and NOVA: Authorize City Manager to execute an amendment to the Agreement for additional Construction Management Services for Hillview Community Center Redevelopment Project (P. Maslo/J. Sandoval)
10. Contract Amendment No. 4: Authorize the City Manager to execute Contract Amendment No. 4 on behalf of the City with Noll & Tam Architects for additional construction services necessary for the Los Altos Community Center construction project in the amount of \$425,863 and up to a 20% contingency amount of \$85,173 on behalf of the City, should additional amendments become necessary to address future unforeseen circumstances that could arise during construction. (CF-01002.) (P. Maslo)

Jim Sandoval Jim Sandoval, Engineering Services Director and Peter Maslo, Project Manager, provided a staff report and answered questions from the Council relative to the Community Center Construction project.

David Mark, Janet Tam and James Gwise of Noll and Tam and NOVA also answered questions from the Council.

Following discussion, Vice Mayor Fligor moved to authorize the City Manager to execute an amendment to the Professional Services agreement with NOVA Partners for additional management services on the Los Altos Community Center construction project in the amount of \$241,768 extending the contract term thru April 30, 2021 and increasing the not to exceed amount of the contract to 1,250, 511. The motion was seconded by Council Member Enander and the motion passed 5-0 by the following roll call vote:

AYES: Council Members Bruins, Enander, Lee Eng, Vice Mayor Fligor, and Mayor Pepper.
NOES: None
ABSENT: None
ABSTAIN: None

Vice Mayor Fligor moved to authorize the City Manager to execute Contract Amendment No. 4 on behalf of the City with Noll & Tam Architects for additional construction services necessary for the Los Altos Community Center construction project increasing the amount of the contract by \$425,863 and extending the contract term thru April 30, 2021 making the total not to exceed amount of the contract \$3,865,041. The motion was seconded by Council Member Bruins and the motion passed 5-0 with the following roll call vote.

AYES: Council Members Bruins, Enander, Lee Eng, Vice Mayor Fligor, and Mayor Pepper.
NOES: None
ABSENT: None
ABSTAIN: None

8. Park-in-Lieu Fees Resolution No. 2020-35 Park In-Lieu Fees: Hold Public Hearing and adopt Resolution No. 2020-35, modifying Park In-Lieu Fee on the FY 2020/21 Fee Schedule for the City of Los Altos. Proposed Los Altos Park In-Lieu Fees were calculated pursuant to Section 13.24.010 of the Los Altos Municipal Code. The updated calculations and the supporting land appraisal report were filed with the City Clerk of the City of Los Altos on September 29, 2020. (J. Sandoval)

Due to the late hour Council Member Enander moved that the Park In lieu Fees be deferred to a future meeting (date to be determined) and public notice reissued. The motion was seconded by Council Member Lee Eng and the motion passed 5-0 with the following roll call vote:

AYES: Council Members Bruins, Enander, Lee Eng, Vice Mayor Fligor, and Mayor Pepper.
NOES: None
ABSENT: None
ABSTAIN: None

3. 330 Distel Circle-Memorandum of Understanding with the County of Santa Clara: Discuss and Authorize City Manager to Execute a Memorandum of Understanding between the City of Los Altos and the County of Santa Clara for an Affordable Housing Project at 330 Distel Circle

Jon Biggs, Community Development Director, provided a staff report and answered questions from the Council.

Mayor Pepper moved to amend paragraph #2 under Now Therefore to include language reflecting that the Project is anticipated to contain a minimum of 90 units, with 100% of the units restricted to occupants earning 120% or less of the area medium income (AMI), with a minimum of 5% earning 30% or less of the area medium income (AMI), 50% earning 50% or less of the area medium income (AMI), and 45% earning 80% or less of the area medium income (AMI) and authorize the City Manager to Execute a Memorandum of Understanding between the City of Los Altos and the County of Santa Clara for an Affordable Housing Project at 330 Distel Circle, Los Altos. The motion was seconded by Vice Mayor Fligor and the motion passed 5-0 with the following roll call vote:

AYES: Council Members Bruins, Enander, Lee Eng, Vice Mayor Fligor, and Mayor Pepper.
NOES: None
ABSENT: None
ABSTAIN: None

11. Finance Subcommittee: Discuss City Council Finance Subcommittee

Council discussion commenced. Council Member Enander moved that the City Council establish an ad hoc committee consisting of Council Member Bruins and Council Member Enander, who will meet with members of staff and the financial commission as needed for information and advice. The purpose is to identify more effective processes to compile, present, and evaluate financial information on both routine and exception bases that will improve the quality and timeliness of financial decision-making for the city. A status report will be presented at the November 24 Council meeting, at which time Council may give further direction or disband the committee. The motion was seconded by Council Member Lee Eng and the motion passed 5-0 with the following roll call vote:

AYES: Council Members Bruins, Enander, Lee Eng, Vice Mayor Fligor, and Mayor Pepper.
NOES: None
ABSENT: None
ABSTAIN: None

INFORMATIONAL ITEM

- Tentative City Council Calendar

There was no discussion on the informational item.

COUNCIL/STAFF REPORTS AND DIRECTIONS ON FUTURE AGENDA ITEMS

Council Member Lee Eng expressed an interest in inclusion of a question and answer forum when staff presents month updates on the Community Center Construction project.

Council Member Bruins noted the transition of the Santa Clara County Cities Association to a Joint Powers Authority.

ADJOURNMENT

At 1:17 a.m., October 28, 2020, Mayor Pepper adjourned the meeting.

Janis C. Pepper, MAYOR

Andrea M. Chelemengos MMC, CITY CLERK

DRAFT



CONSENT CALENDAR

Agenda Item # 2

AGENDA REPORT SUMMARY

Meeting Date: November 10, 2020

Subject: Design Contract Award: Adobe Creek Sewer Main Replacement
Project WW0101221

Prepared by: Aida Fairman, Engineering Services Manager

Reviewed by: James Sandoval, Engineering Services Director

Approved by: Chris Jordan, City Manager

Attachment:

1. Consultant's Proposal

Initiated by:

City Council, CIP Project WW0101221

Previous Council Consideration:

None

Fiscal Impact:

\$692,297.52 (There are insufficient funds in the adopted budget for Project WW0101221)

\$500,000.00 (Approved project budget)

\$192,297.52 (Additional Appropriation needed from the Sewer Fund)

Based on the most qualified consultant fee proposal submitted, the estimated Project costs are:

| Project Item | Project Budget |
|--|-----------------------|
| Total Design & Permitting Costs (Consultant's Fee Proposal) | \$573,164.60 |
| Contingency (20%) | \$ 114,632.92 |
| Printing/Advertising/Misc. | \$ 4,500.00 |
| Total Project Expenses | \$ 692,297.52 |
| Total Funds Available in Project Budget | \$ 500,000.00 |
| Additional Appropriation | \$192,297.52 |

Environmental Review:

Categorically Exempt pursuant to CEQA Section 15301(b).

City Manager

CJ

Reviewed By:

City Attorney

JH

Finance Director

SE



Subject: Design Contract Award: Adobe Creek Sewer Main Replacement Project WW0101221

Policy Question(s) for Council Consideration:

Not Applicable

Summary:

The Adobe Creek Sewer Main Replacement Project includes replacing and/or realigning fifty-three sewer main segments located along or near Adobe Creek. This project consists of a total of 6,580 linear feet of sewer pipes. An agreement with a consultant is required to provide design and permitting services for the project.

Staff Recommendation:

Appropriate \$192,297.52 from the Sewer Fund to Project WW0101221; and authorize the City Manager to execute an agreement with Schaaf & Wheeler Consulting Civil Engineers (Schaaf & Wheeler) in the not-to-exceed amount of \$573,164.60 and up to a 20% contingency amount of \$114,632.92 on behalf of the City to provide professional design services for the Adobe Creek Sewer Main Replacement Project WW0101221



Subject: Design Contract Award: Adobe Creek Sewer Main Replacement Project WW0101221

Purpose

Appropriate \$192,297.52 from the Sewer Fund to Project WW0101221; and authorize the City Manager to execute an agreement with Schaaf & Wheeler Consulting Civil Engineers (Schaaf & Wheeler) in the not-to-exceed amount of \$573,164.60 and up to a 20% contingency amount of \$114,632.92 on behalf of the City to provide professional design services for the Adobe Creek Sewer Main Replacement Project WW0101221.

Background

This project scope includes replacing, and for some segments realigning, fifty-three sewer main segments, located along or near Adobe Creek. This comprises a total of 6,580 linear feet of pipe replacement. The existing 6-inch and 8-inch pipes will be replaced with new 8-inch pipe to increase capacity. The sewer line segments identified for this project are located near the City's border with the Town of Los Altos Hills, north of Manresa Avenue and south of Edith Avenue.

On April 28, 2020, City Council approved the staff request for appropriation of sewer funds for the creation of the Adobe Creek Sewer Main Replacement Project. The City's Maintenance Department identified this portion of the sewer system as an issue. Maintenance staff encountered difficulties when trying to perform flushing and video inspections of the sewer mains near Adobe creek due to structural deficiencies in the sewer mains. In addition, the project was prioritized due to the location of the sewer mains in proximity to the creek. There are approximately thirteen or more locations in the project areas where sewer mains cross under the creek. The proximity of these sewer mains to the creek causes an elevated potential for contamination in the event of sewer line failures or overflow. Replacement of these pipes is important to maintain the structural integrity of the sewer segments in these high-risk locations. Likewise, realignment, where possible, is an important improvement for feasibility of long-term maintenance and to reduce the risk of creek contamination in the event of an overflow. Completion of the entire project will require a phased approach and may take several years to complete.

Discussion/Analysis

On June 18, 2020, staff advertised a request for proposals for design of this project. Design includes, but is not limited to, predesign services, preparation of required environmental approvals and documentations from relevant permitting agencies, topographic survey, arborist and environmental services, geotechnical services, preparation of plans, specifications, cost estimates, contract bid documents, and construction phase support services. On July 21, 2020, the City received five proposals, which were reviewed and discussed by City staff. The City invited three of the five consulting firms to virtual interviews on September 10, 2020.

It is recommended that the award of the design contract be made to Schaaf & Wheeler in the not-to-exceed amount of \$573,164.60. Schaaf and Wheeler is the most qualified consulting firm based on their proposal and interview. Schaaf & Wheeler has been in business for more than thirty-five years



Subject: Design Contract Award: Adobe Creek Sewer Main Replacement Project WW0101221

and has satisfactorily completed similar projects for other municipalities in the Bay Area, including Port of Oakland, the City of San Mateo, and the City of Morgan Hill. Schaaf & Wheeler completed the Kingridge Sanitary Sewer Line Improvement Project in the City of San Mateo, which is comparable in size and complexity to the Adobe Creek Sewer Main Replacement Project.

Options

1) Appropriate \$192,297.52 from the Sewer Fund to Project WW0101221; and authorize the City Manager to execute an agreement with Schaaf & Wheeler Consulting Civil Engineers (Schaaf & Wheeler) in the not-to-exceed amount of \$573,164.60 and up to a 20% contingency amount of \$114,632.92 on behalf of the City to provide professional design services for the Adobe Creek Sewer Main Replacement Project WW0101221.

2)

Advantages: Completion of the Adobe Creek Sewer Main Replacement project provides necessary repairs to ensure proper maintenance and functioning of the City's sanitary sewer system to reduce risk of environmental harm in the event of a sewer overflow.

Disadvantages: None

3) Do not authorize the City Manager to execute an agreement on behalf of the City with Schaaf & Wheeler.

Advantages: None

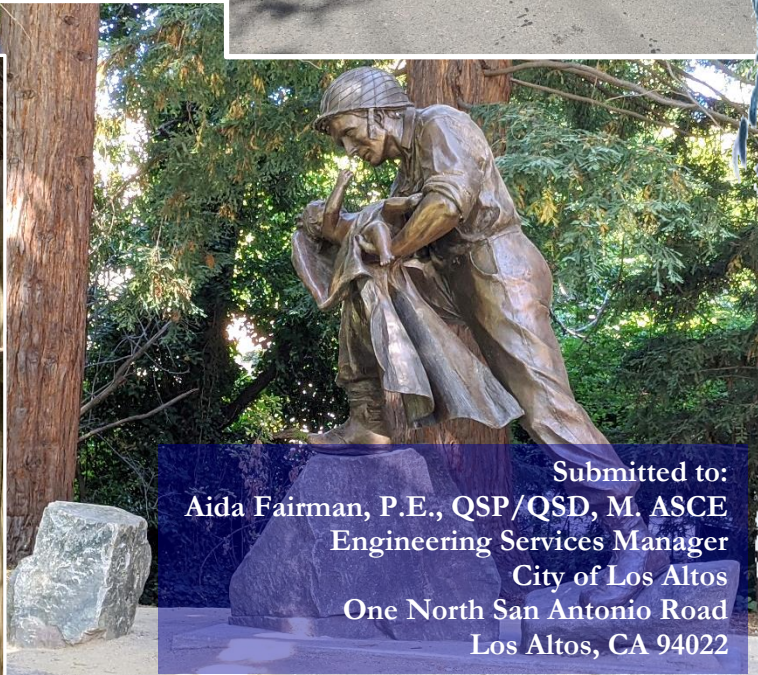
Disadvantages: Repair of the sanitary sewer segments would be delayed.

Recommendation

The staff recommends Option 1.



Proposal for City of Los Altos Adobe Creek Sewer Main Replacement Project WW0101220



Submitted to:
Aida Fairman, P.E., QSP/QSD, M. ASCE
Engineering Services Manager
City of Los Altos
One North San Antonio Road
Los Altos, CA 94022

July 21, 2020

Schaaf & Wheeler
CONSULTING CIVIL ENGINEERS



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Cost Proposal - Separately Sealed

Schaaf & Wheeler
CONSULTING CIVIL ENGINEERS

1171 Homestead Rd., Ste. 255
Santa Clara, CA 945050
408-246-4848
Fax 408-246-5624

July 21, 2020

Aida Fairman, P.E., QSP/QSD, M. ASCE
Engineering Services Manager
City of Los Altos
One North San Antonio Road
Los Altos, CA 94022

Subject: Qualifications for Professional Engineering Services Adobe Creek Sewer Main Replacement

Dear Ms. Fairman:

Schaaf & Wheeler is pleased to propose professional engineering services for design of the City's Adobe Creek Sewer Main Replacement Project. We have studied the available information, walked the pipeline alignment where accessible, and developed an approach and scope that will provide the City with a rehabilitated and replaced pipeline while minimizing the impacts to the surrounding areas.

To address the needs of this challenging project, we have included several specialty subconsultants, each of which Schaaf & Wheeler has a long history with:

Kier & Wright will provide land surveying, utility research, and easement documentation;
Engeo will provide geotechnical engineering services;
WRA will provide CEQA compliance and permitting, and;
Presidio Systems will provide CCTV inspection.

I will serve as the principal-in-charge for the project and bring more than 30 years of experience in municipal wastewater engineering services. I am authorized to bind the firm for any contracting negotiations. Glen M. Anderson, PE has been working on wastewater infrastructure projects since 2006, he will be the project manager. Benjamin L. Shick, PE will provide constructability review for the project. He brings extensive experience leading sewer projects throughout the Bay Area.

Our past experience will help us deliver work in a results-oriented manner, meeting the unique challenges of this project. The Schaaf & Wheeler team is available and would be pleased to continue working with the City of Los Altos. Should you need any further information, please contact Glen Anderson at 1171 Homestead, Ste. 255, Santa Clara, CA 95050; Ph: (408) 246-4848 or ganderson@swwsv.com

Sincerely,

Schaaf & Wheeler



Charles D. Anderson
President

Ph: 408-246-4848; Email: canderson@swwsv.com



Project Understanding and Approach

Project Understanding

The City’s sewer system in this area runs mostly adjacent to Adobe Creek, interlaced between public and private parcels, and crossing the creek at several locations. The pipeline alignment in the scope of this project totals almost 6,600 linear feet of 6-inch and 8-inch pipe, with almost 90% of the pipes being 6-inch. Portions of the alignment have previously been CIPP lined, and portions of the liner are failing.

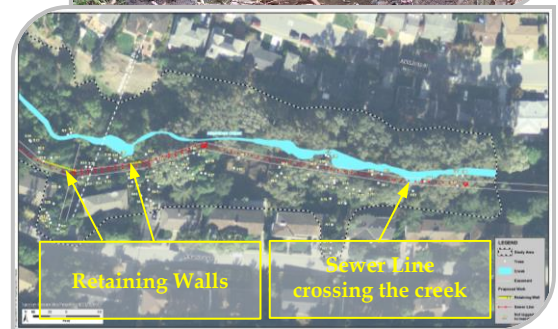
The City desires to replace the pipeline and upsize all of the 6-inch lines to 8-inch. Additionally, the City desires to evaluate the potential for realigning the pipeline to avoid private parcels and reduce the amount of pipe adjacent to Adobe Creek while also reducing the number of creek crossings.

Challenges and Mitigation

Outlined below are several of the key anticipated project challenges as well as Schaaf & Wheeler’s cursory mitigation measures. It is important to note that each project segment presents unique challenges that cannot be fully realized until detailed design is being performed.

Impact to Residents: As noted, the pipeline as well as any potential realignments will require access, use and easements to a number of private parcels. Generally speaking, residents don’t want utilities on their properties. This lack of enthusiasm is amplified when sanitary sewer systems are involved. As such, public outreach will be critical to project success. Schaaf & Wheeler would propose to work with the City to hold a series of public outreach meetings at the project outset to discuss required field work and access, and again during the design phase once conceptual alignments are developed. It is recommended that door hangers be provided to properties directly adjacent to or impacted by the project.

Environmental and Permitting: Because the project is adjacent to a creek, environmental and permitting will be required. Schaaf & Wheeler proposes to develop a CEQA and Permitting Strategy memo based on preliminary project designs. Preparation of this strategy memo will allow us to identify CEQA and Permitting requirements early on and also allow us an opportunity to shift the design in order to mitigate any potential problematic CEQA or Permitting requirements.



Similar Project: Kingridge Sanitary Sewer Line Improvements for City of San Mateo

- ✓ Sewer replacement adjacent to Kingridge Ravine, tributary of Laurel Creek
- ✓ Sewer line also crossed the ravine and required retaining walls affecting seasonal wetlands
- ✓ Environmentally sensitive area/habitat that required CEQA documentation and environmental permitting
- ✓ Areas temporarily disturbed due to grading, tree removal, retaining wall installation and sewer replacement were restored to original topography and seeded natively for erosion control.
- ✓ Permits Required:
 - US Army Corps of Engineers
 - Regional Water Quality Control Board (RWQCB)
 - California Department of Fish and Game (CDFG)

Tasks Included:

- ✓ topographic surveying,
- ✓ geotechnical investigation,
- ✓ hydraulic analysis
- ✓ condition assessment,
- ✓ improvement alternatives evaluation,
- ✓ open-cut, pipes supported on piers, and pipe rehabilitation with cured-in-place pipe (CIPP)
- ✓ bid documents
- ✓ Bid and construction support



Pipeline Condition: As part of the rehabilitation, and in an effort to minimize the residential and permitting impacts, Schaaf & Wheeler proposes to use trenchless pipe replacement techniques to the maximum extent possible. A critical requirement for trenchless replacement is to be certain that the existing pipe is suitable for trenchless replacement. The RFP did not list whether or not the City has existing CCTV data for the pipelines. As such, we have included CCTV efforts to help verify that pipe alignments are acceptable for trenchless methods.

Coordination: Schaaf & Wheeler will maintain close coordination with City staff throughout the course of the project. Monthly progress updates will be provided in addition to general correspondence throughout the course of work.

Key Elements for Completing the 2020 Repairs and Replacements Successfully:

- Detailed review and assessment of CCTV data
- Appropriate repair method selection
- Prioritization of improvements
- Stakeholder engagement
- Supplementary field investigations
- Topographic surveys
- Minimizing environmental impacts
- Efficient and timely public outreach
- Close coordination with the specialty subconsultants

Approach

Project Management Approach:

Efficient and effective project management will be a key factor in completing the project on time and on budget. Schaaf & Wheeler's project management approach is described below.

1. Develop a team of qualified engineers with extensive experience with similar projects:
 - a. **Project Manager, Glen M. Anderson, P.E.**, has successfully managed multiple sanitary sewer system projects in and around sensitive water bodies and in sensitive areas..
 - b. **Charles D. Anderson, PE – Principal in-Charge** will ensure the completion of contractual and procedural obligations.
 - c. **Benjamin L. Shick, PE** will be the QA/QC engineer for Schaaf & Wheeler.
2. Outline critical tasks and phases of work that will impact the schedule.
3. Pull in expertise and workforce as needed
4. Develop detailed and robust construction documents that accurately reflect existing site conditions.
5. Maintain close coordination with City during design, bid, and construction support.

Technical Approach:

Schaaf and Wheeler will provide the scope of services outlined in the detailed scope included herein. Our approach to specific tasks are listed below.

Schaaf & Wheeler will facilitate a project kickoff meeting with the City and necessary stakeholders. The project goals, scope, budget, and schedule will be discussed to make sure everyone is on the same page. A data request list will be submitted to the City which will include all information that would be useful during the assessment and design of the pipeline replacement.

Schaaf & Wheeler firmly believes that engaging all stakeholders including management, public relations, engineering, and operations & maintenance, early in the process is a great way to ensure all parties are on the same page and everyone is working towards the same goal.

Schaaf & Wheeler's proposed approach for the design process is identified below:

1. **Kickoff Meeting** – Used to get all stakeholders in the same room and work through key project elements including:
 - a. Project Goals – Capacity, Engineering Requirements, O&M Requirements, City standards



- b. Project Constraints – Budget, schedule, physical site constraints, utility constraints and conflicts, traffic coordination
- c. Project Expectations – Construction contract type, deliverables, project management/staffing, schedule
- d. Site Visit – Document existing conditions, verify surveying basemap, identify existing utilities

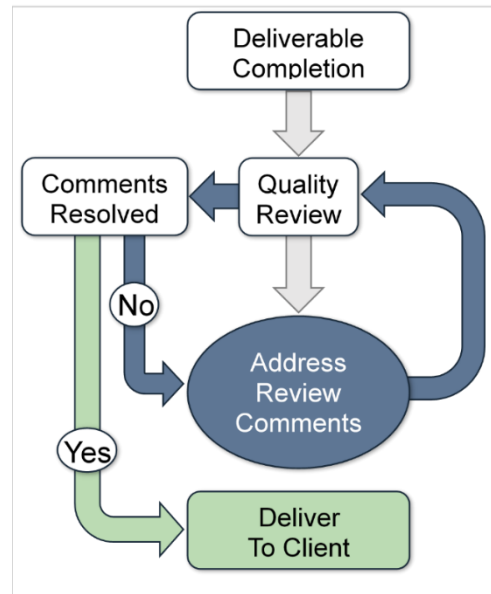
2. Predesign and Basis of Design Memorandum – Used to document design decisions and project information. The Basis of Design would serve as the starting point for detailed design and include discussions regarding construction constraints and limitations, environmental and permitting requirements, required right of way, costs, schedule, modifications to City’s pre-design information, and other key components for the design.

3. Detailed Design (65%, 100%, Bid Documents) – Each design submittal will be prepared and submitted as specified in the attached Design Services Terms. Stakeholder input is critical at each submittal level to ensure that the project meets the City’s expectations and goals. Schaaf & Wheeler will schedule and attend design review meetings with the City after each progress submittal.

4. QA/QC Process – Schaaf & Wheeler will perform an internal QA/AC review of each progress submittal prior to being submitted to the City. QA/QC staff will review all design documents, visit the site, and work with the project design team to identify and correct potential issues and conflicts.

Our typical process has multi-level review:

- Level I:** Identifying Serious Issues
- Level II:** Technical Comment – Addressed through Design
- Level III:** Editorial or Preferential
 - a. Constructability Review
 - b. Independent Peer review
 - c. City Review
 - d. Project Management Review
 - e. Calculation, Plans, Specifications and Estimates Review



Schaaf & Wheeler ‘s Typical QAQC Process to Ensure Quality Deliverables

5. Design Potholing – During the detailed design process the proposed alignments and depths of the new sewer mains will be established. Potential utility conflicts and unknowns will be identified and documented. Utility locations that cannot be accurately defined utilizing record documents and field measurements will be identified and coordinated with the City. Due to the limited available information as well as the proximity to the creek and to private residences, it is not clear how much potholing will be needed or possible. As such, Schaaf & Wheeler has included a potholing allowance within our proposed project fee. This allowance will be used only if agreed to by the City after the utility research and project alignment are developed.

6. Bid and Construction Support – Schaaf & Wheeler will stay actively involved with the project throughout construction, providing construction engineering services to review submittals, RFI’s change requests, and other items that may require the engineer’s input. At the close of construction, Schaaf & Wheeler will prepare record drawings from the Contractor supplied As-Builts.



Scope of Work and Schedule

Outlined below is a detailed scope of work that should be considered the Scope of Services Contractually proposed by Schaaf & Wheeler:

Task 1: Environmental Approvals

Task 1A: Biological Survey and Memorandum

Design team will conduct a site visit throughout the Project Area to assess existing biological conditions and to determine if sensitive biological resources would be impacted by the Project. In particular, design team will focus on identifying any potentially federal and/or state jurisdictional aquatic features that may be regulated by the Corps, the RWQCB, and the CDFW. In addition, habitats that may support special-status fish, wildlife, and plant species will be identified. This task includes time to conduct background research to determine if the site has previously been mapped as sensitive habitat by state or federal agencies, and if the site has the potential to contain special-status species. The results of the assessment will be documented in a biological resources survey memorandum for use in subsequent environmental and permitting (if required) approvals. One (1) draft memorandum describing existing conditions will be prepared, followed by a subsequent revision evaluating potential biological resources impacts from the project design will be prepared.

Task 1B: Cultural Resources Evaluation and Memorandum

If required by the permitting agencies, surveys of historic resources (Section 106) will be completed in the Project Area. This task will follow the recommendations and requirements for field work and reporting provided by the Corps and other appropriate agencies (e.g., California Office of Historic Preservation). A California licensed archaeologist with knowledge of the region will be subcontracted to complete all cultural resources work. This task assumes that reconnaissance level investigations will be required and that no detailed studies will be needed. One (1) draft memorandum summarizing findings will be prepared.

Task 1C: Arborist Survey and Report

This task includes a tree survey and arborist report. WRA's ISA-Certified arborist will conduct a tree survey to identify all trees in the Project Area, including trees that are both protected and not protected by the City of Los Altos. Data describing species, size (diameter at breast height or DBH), canopy spread, height, structural stability, health, and overall condition will be collected for each tree. The location of each tree will be captured using a handheld GPS unit with sub-meter accuracy. A photo of each tree will be taken to document condition at the time of the survey. This survey will be conducted concurrently with the biological survey discussed in Task 1B. Following the survey, the arborist will prepare a tree survey report describing the methods of the survey and including a table showing the pertinent information for all surveyed trees at the site, as well as a map depicting the location of all ordinance-size and non-ordinance-size trees, and a digital shapefile with tree location and attribute data attached. This task also includes time for one (1) round of revision to the report.

Task 1D: CEQA and Permitting Strategy

Based on the environmental technical studies described above, WRA will prepare a summary table(s) of key environmental constraints with thresholds for triggering permit requirements and additional CEQA review. The purpose of the table(s) will be to guide discussions with the engineering team and City to



evaluate the potential environmental impacts of the project design, as well as appropriate path forward for CEQA and permitting given the findings of the technical studies. This task includes time to develop the summary table, as well as up to 16 hours for email and verbal discussions about the potential path forward.

Task 1E: CEQA Support and Coordination

Based on existing available information, WRA assumes that the Project will qualify for a Categorical Exemption. This task will involve assisting the City during the CEQA determination process, including lead agency coordination, Project category recommendations, and drafting required documentation and forms. If additional CEQA analysis is deemed necessary, WRA will work with the City to determine the appropriate scope of that documentation and associated supplemental budget.

Task 1F. Geotechnical Hazard Report

We will review published geologic literature covering the project area, including reports and maps on file with the United States Geologic Survey (USGS) and the California Geologic Survey (CGS), as well as available geotechnical data from nearby sites. We will prepare a Geotechnical Hazard Report summarizing the general subsurface conditions, potential geologic hazards, seismicity and groundwater level.

Task 2: Permitting

Task 2A. Preparation of the Section 1602 Lake and Streambed Alteration Agreement Application for the CDFW

The CDFW requires any project proponent who may affect the bed or bank of a perennial, intermittent, or ephemeral river, stream, or lake to request a Section 1602 Lake and Streambed Alteration Agreement. The Lake and Streambed Alteration Agreement notification requires completion of an application form and project environmental questionnaire, and inclusion of supplemental data regarding issues covered in the project environmental questionnaire. While a CDFW permit is not required for subterranean stream crossings, it is strongly encouraged by CDFW, and would be required if staging areas for stream crossings impact riparian vegetation.

WRA will complete the application with supporting information and submit the permit application to CDFW. Additional information regarding anticipated construction means and methods beyond that required for the Corps and RWQCB permit will be required as part of the CDFW permit application. WRA will work with the Client to compile a list of construction equipment anticipated to be used during construction. Additional analysis of special-status species, including fish and avian species, will be required as part of the CDFW application. The complete Section 1602 permit application will be submitted to the CDFW after Client review. Additionally, time has been included for coordination with the Client during the permitting process. This subtask includes one (1) round or revision from the Client and one (1) response to comments provided by the regulatory agency.

Task 2B (if Required). Preparation of the Section 404 Nationwide Permit Application for the Corps

If project construction requires placement of fill or digging of channels for stream crossings, a Corps of Engineers Section 404 Permit would be required. Based on existing information, the Project should qualify for coverage under a nationwide permit. The nationwide pre-construction notification form will address potential impacts to Corps jurisdiction and the necessary permit requirements, including:



- Basic notification requirements as to site location; Project description; and type and amount of fill in potentially jurisdictional areas;
- Appropriate plan view figures that show proposed impacts to jurisdictional areas;
- Proposed mitigation;
- Information to support compliance with Section 106 of the National Historic Preservation Act through the State Historic Preservation Office; and
- Information to support an informal consultation with the U.S. Fish and Wildlife Service, or if supported by substantial evidence, determination that the project will have no effect on endangered species

WRA will act as the agent during the Corps permitting process. Typically, the Corps may request a site visit to discuss the proposed Project and potential impacts on areas within their jurisdiction. WRA will attend up to one (1) site visit with the Corps to assess the Project impacts if requested. WRA will also respond to any comments or questions related to the application and the processing of the application. Additionally, time has been included for coordination with the Client during the permitting process. This subtask includes one (1) round or revision from the Client and one (1) response to comments provided by the regulatory agency.

Task 2C (If Required). Preparation of the Section 401 Water Quality Certification Application for the RWQCB

The RWQCB must certify the use of the Corps permit and will process a 401 Water Quality Certification for the Project. WRA will act as the agent during the RWQCB permitting process. WRA will prepare a permit application for the RWQCB, which will first be reviewed by the internal team. The application contains information similar to that included in the Corps nationwide permit application; however, additional information that will be required for the RWQCB application includes:

- A storm water management plan for the Project (not scoped for herein)
- CEQA documentation (typically a Mitigated Negative Declaration, EIR, or Categorical Exemption) is required prior to issuance of the RWQCB permit
- An alternatives analysis (per the recently adopted State Wetland Definition and Procedures for Dredged or Fill Material into Waters of the State)
- A watershed profile analysis (per the recently adopted State Wetland Definition and Procedures for Dredged or Fill Material into Waters of the State)

WRA will also respond to any comments or questions related to the application. Typically, the RWQCB may request a site visit to discuss the proposed Project and potential impacts on areas within their jurisdiction. WRA will attend one (1) site visit with the RWQCB to assess the Project impacts, if requested. Additionally, time has been included for coordination with the Client during the permitting process. This subtask includes one (1) round or revision from the Client and one (1) response to comments provided by the regulatory agency.

Task 3: Right-of-Way Services

As discussed in the RFP, the sewer line is routed across 24 private parcels as well as entering the Town of Los Altos Hills. It will be necessary to obtain permanent easements for the locations where the pipeline must remain on these parcels. Where active construction must occur outside of the identified easements, it will be necessary to obtain temporary construction easements. As such, we have included the services outlined herein for 25 different easements, as necessary.



Title Report

We will order preliminary title report from First American Title Insurance Company for the property within the scope of work. We frequently utilize them for Kier & Wright projects completed in Silicon Valley and the South Bay. This translates to quick responses and turnaround times on our request.

Title Review

Title review consist of review of all the documents associated with the title report and ensuring that the boundary and easement are plotted based on these documents.

Plat & Legal for Sewer Easements

We will prepare a legal description and plat with metes and bounds legal description for new Sewer Easements.

Task 4: Predesign

Task 4A. Topographic Surveying

Design team will perform topographic surveys to locate all sewer manholes. Because the goal of the project is to utilize trenchless replacement to the maximum extent possible. As such, this task includes performing topographic surveying of approximately 50% (~3,300 LF) of the project alignment.

Task 4B. CCTV Work

Schaaf & Wheeler has included CCTV efforts for 3,300 linear feet of pipeline.

Task 4C. Alignment Study and Basis of Design

Design team will review potential alignments given site constraints and make recommendations for a preferred alignment as well as the option to replace the pipeline along the existing alignment. Basis of Design will compare the two alignments, and make a recommendation for which to implement. Report will identify site constraints, sensitive receptors, and potential environmental and permitting impacts for each alignment. Based on the City's review and preferred alignment, Schaaf & Wheeler will finalize the Basis of Design and highlight the selected rehabilitation.

Task 4D. Detailed Geotechnical Report

We will perform and geotechnical exploration and summarize our findings in a geotechnical exploration report as defined under Task IV Predesign. Based on our experience on similar pipeline projects, we propose the following geotechnical exploration program to provide design recommendations to support design of the project:

| Project | # of Borings | Boring Depth |
|----------------------|----------------|------------------------------------|
| 6580 LF Pipe Upgrade | Up to 10 total | 15 to 25 feet below ground surface |

Approximately 200 lineal feet of drilling is estimated. We anticipate the exploration outlined above will be completed in 3 days. We will contact Underground Services Alert after we marked the exploration locations and no less than 48 hours prior to drilling. We will also retain a private utility locator to clear the exploration locations. Prior to drilling, we will coordinate with Santa Clara Valley Water District (SCVWD) and City of



Los Altos to obtain required drilling and encroachment permits. Our engineer or geologist will observe the drilling, log subsurface conditions, and collect representative samples for visual classification, field testing, and laboratory testing described herein.

We will transport soil samples collected from the field exploration to our in-house laboratory to evaluate engineering characteristics of the soils. The samples will be reexamined in our laboratory to verify field classifications and will be tested for moisture content, dry unit weight, Plasticity Index, Liquid Limit, gradation, strength characteristics, and other physical properties as appropriate. Chemical testing of the site soils for full corrosion potential on buried metal pipes and foundation concrete will also be performed on select soil samples. We will prepare a Geotechnical Exploration Report, which will include a summary of data collected during the proposed field investigation, such as boring logs, laboratory test results, and groundwater measurements. We will also provide trench backfill, grading and dewatering recommendations as necessary in the Geotechnical Exploration Report.

Task 4E. Potholing Allowance

This optional allowance is to cover costs associated with potholing efforts that can not be well defined as part of this proposal.

Task 5: 65% Design

Task 5A. 65% Documents

Prepare and submit 65% level project plans, specifications, and cost estimates for City review.

Task 6: 100% Design

Task 6A. 100% Documents

Prepare and submit 100% level project plans, specifications, and cost estimates for City review. Documents shall include revisions based on comments received from City on 65% level documents. Plans will be complete and submittal is considered as a final opportunity for City review and comment.

Task 7: Final Design

Task 7A. Final Documents

Prepare and submit Bid level project plans, specifications, and cost estimates for City review. Documents shall include revisions based on comments received from City on 100% level documents.

Task 8: Bid Support

Task 8A. Bid Support

- Prepare up to two addenda to answer bidder questions
- Attend pre-bid Meeting

Task 9: Construction Support

Task 9A. Construction Support

- Review and Respond to up to 15 RFIs
- Review up to 25 material submittals and 13 resubmittals

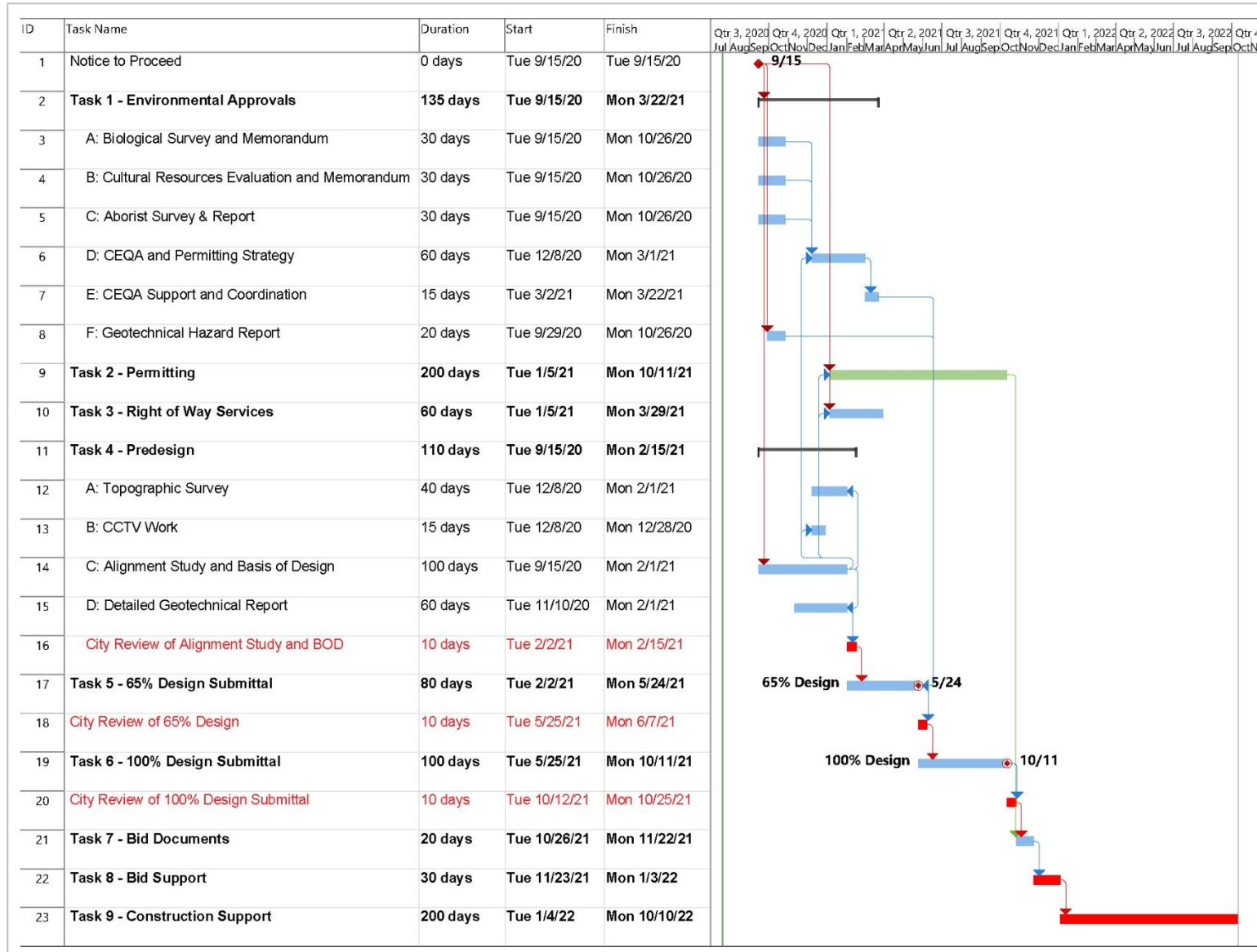


- Attend up to 18 site visits and provide summary notes for site visits
- Prepare record drawings based on Contractor-provided markups

Please note that because the scope, magnitude and alignment of the project will not be truly defined until detailed design begins, it is not possible to provide a relevant scope and fee for Biological surveys and Arborist support. Once the project scope(s) are defined, we recommend an amendment to add these services.



Project Schedule





Company Profile

About Schaaf & Wheeler

| | |
|---|--|
| Firm Name | Schaaf & Wheeler CONSULTING CIVIL ENGINEERS |
| Principal Place of Business and Project Team Location | 1171 Homestead Rd., Ste. 255, Santa Clara, CA 95050 Phone: (408) 246-4848 ; Fax: (408) 246-5624 |
| Main Contact | Glen M. Anderson, PE - Project Manager 1171 Homestead Rd., Ste. 255, Santa Clara, CA 95050 Phone: (408) 246-4848; Cell: (408) 966-5341 Email: ganderson@swsv.com Charles D. Anderson, PE – Principal-in-Charge Phone: (408) 246-4848; Email: canderson@swsv.com |
| Tax Identification Number | 77-0061375 |
| Year of Establishment and Years in Business | 1985 – 35 Years in Civil Engineering Design |
| Type of Organization | Corporation, Incorporated in California |
| Company Certifications | State of California Certified Small Business Enterprise (SBE) Certification No. 40527 |

Schaaf & Wheeler is a civil engineering firm focused in water resources. With over thirty years of commitment to solving flood control, stormwater, wastewater, potable water, and recycled water problems; Schaaf & Wheeler is recognized by public and private sector clients for its value-adding engineering. Certified as a small business enterprise by the State of California, Schaaf & Wheeler engineers operate from four locations: Santa Clara, San Francisco, Santa Rosa and Salinas.



Our Areas of Focus: Schaaf & Wheeler has ten areas of focus:

- **Waste water** system master planning, engineering, and design of conveyance systems, including lift stations and pump stations;
- **Stormwater** management and drainage services, including master planning, engineering, and design of urban storm drain systems and pump stations;
- **Potable water** system master planning, modeling, engineering; and design of supply, storage, distribution systems, including tanks and booster stations;
- **Recycled water** systems planning, engineering, and design; including reclamation feasibility studies and customer retrofits;
- **Hydrology and hydraulics** analyses, including site evaluations and modeling;
- **Flood control analyses**, including floodplain studies and channel design, filing of letters of map revision, and FEMA coordination;
- **Watershed assessments**, erosion and sediment control, and bioengineered channel stabilization;
- **Water quality**, including design or review of best management practices (BMPs) for storm water treatment and hydromodification flow control facilities;

We will serve the City from our Santa Clara Office and the Santa Rosa Office

✓ *Currently Completing City-wide Sewer Design Projects for:*

- City of Belmont
- City of San Mateo
- Town of Corte Madera
- City of Milly Valley
- City of Morgan Hill

✓ *Assessed and Designed more than 200 pump stations*

✓ *Proficient in CIP Design, Bid and Construction Support*



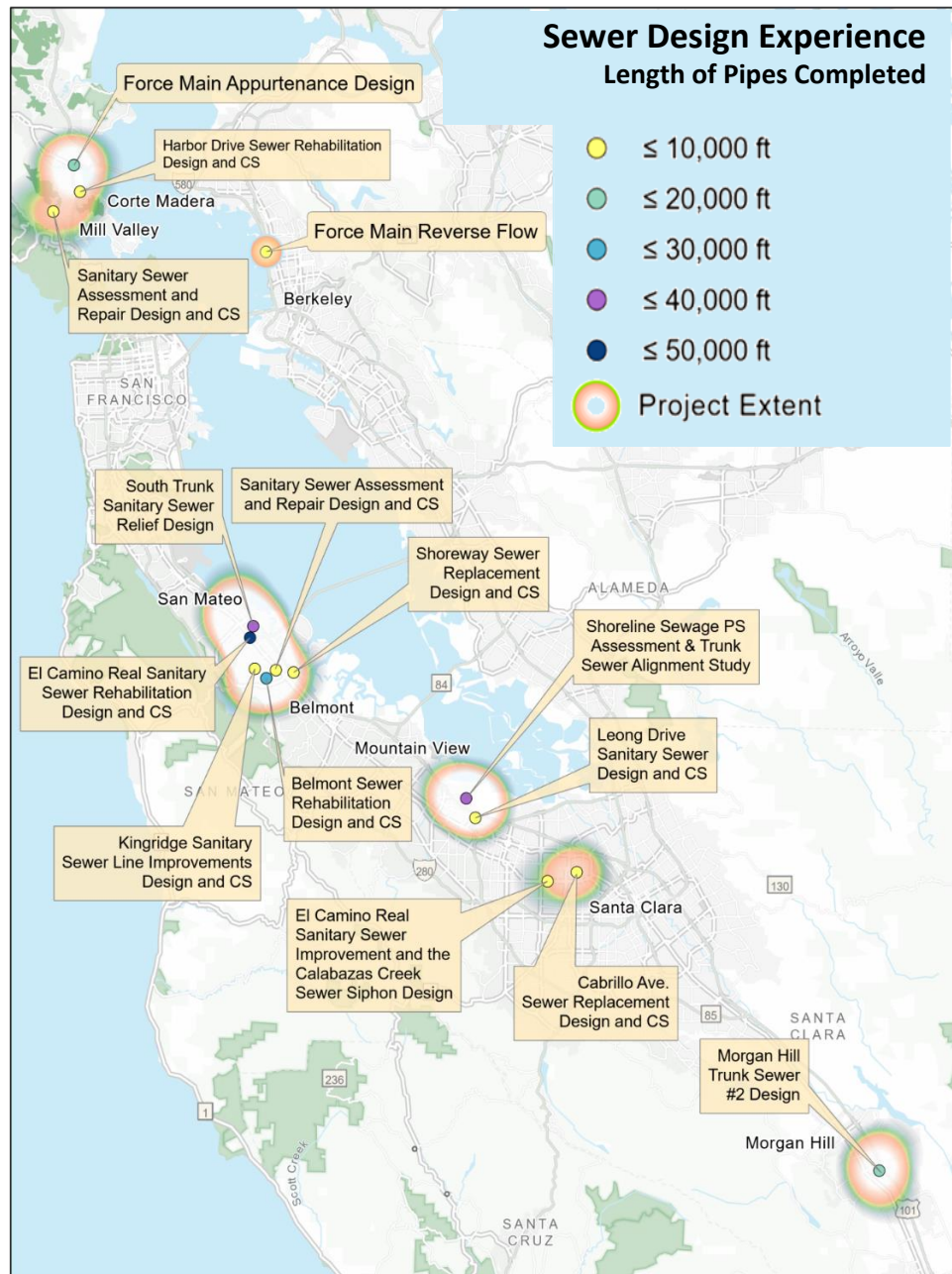
- Construction management, construction site observation, construction inspection services, value engineering, construction cost analysis, and constructability reviews;
- H6 d Program management, including management of subconsultants, containment of schedule and cost, and communications with client and stakeholders.

Schaaf & Wheeler’s Experience in Wastewater Infrastructure Planning, Design and Construction Support

Sewer Design - The following table and map present Schaaf & Wheeler’s experience in sanitary sewer replacement/rehabilitation, trunk alignment study and design.

The represented projects include:

- inspection,
- trenchless technology,
- CIPP,
- pipe reaming,
- pipe bursting,
- horizontal directional drilling (HDD)
- siphon design
- condition assessment,
- surveying and mapping,
- constructability review, and
- construction support



Award-Winning Projects

- Water/ Sewer Main Replacement Project ,Mid-Peninsula Water District/ City of Belmont, APWA Honor Award for 2019
- Shoreway Sewer Replacement Project, City of Belmont, Project of the Year Award for 2019



Schaaf & Wheeler Experience in Design of Wastewater Infrastructure

| Project | Client | Services Provided | | | | | | | | |
|--|--|---------------------|-----------------|------------------------|-------------------|------|--------------------|-----------------------|-------------|----------------------|
| | | Detailed Assessment | Detailed Design | Project Prioritization | Trenchless Design | CIPP | Construction Plans | Engineering Estimates | Bid Support | Construction Support |
| Sanitary Sewer Improvement Project | City of Morgan Hill | • | • | • | • | • | • | • | • | • |
| Sanitary Sewer Assessment and Repair Design and CS | City of Mill Valley | • | • | • | • | • | • | • | • | • |
| Woodland Sewer Improvement Project | San Rafael Sanitation District | • | • | • | | | • | • | • | • |
| Harbor Drive Sewer Rehabilitation Design and CS, CIP Project #18-201 | Sanitary District No. 2 of Marin County | • | • | • | | | • | • | • | • |
| El Camino Real Sanitary Sewer Rehabilitation Design and CS | City of San Mateo | • | • | • | • | • | • | • | • | • |
| Leong Drive Sanitary Sewer Design and CS | City of Mountain View | • | • | • | | • | • | • | • | • |
| Pump Station Q Force Main Reverse Flow Project | East Bay Municipal Utility District | | • | • | | | • | • | • | • |
| Force Main Appurtenance Projects | Ross Valley Sanitary District | • | • | • | | | • | • | • | • |
| Sewer and Water Replacement Design and CS | City of Belmont and Mid-Peninsula Water District | • | • | • | | • | • | • | • | • |
| Shoreway Sewer Replacement Design and CS | City of Belmont | • | • | • | | | • | • | • | • |
| 2018 Sanitary Sewer Rehabilitation Project – Various Locations | City of San Mateo | • | • | • | • | • | • | • | • | • |
| Force Main Appurtenance Design | Ross Valley Sanitary District | • | • | | | | • | • | • | • |
| Shoreline Sewage PS Assessment & Trunk Sewer Alignment Study | City of Mountain View | • | | • | • | | | • | | |
| El Camino Real Sanitary Sewer Improvement, and the Calabazas Creek Sewer Siphon Design | BRE Properties & City of Santa Clara | • | • | | • | • | • | • | • | • |
| Cabrillo Ave. Sewer Replacement Design and CS | City of Santa Clara | • | • | | | | • | • | • | • |
| Belmont Sewer Rehabilitation Design and CS | City of Belmont | • | • | • | • | • | • | • | • | • |
| Kingridge Sanitary Sewer Line Improvements Design and CS | City of San Mateo | • | • | • | • | • | • | • | • | • |
| South Trunk Sanitary Sewer Relief Design | City of San Mateo | • | • | • | • | • | • | • | • | |
| Sewer Infrastructure Evaluation and Design | City of Morgan Hill | • | • | • | • | • | • | • | • | • |
| Morgan Hill Trunk Sewer #2 Design | City of Morgan Hill | • | • | • | • | | • | • | • | • |



Our Subconsultants



WRA – CEQA/NEPA and Permitting. WRA provides full service environmental consulting services including plant, wildlife, and wetland ecology, regulatory compliance and agency permitting, mitigation banking, CEQA/ NEPA, GIS, and landscape architecture. Formed in 1981, WRA is a certified small business (OSBCR ref. #13333) with 70 professionals that have completed more than 3,000 projects for public agencies, non-profit, and private organizations. WRA has a wide range of project experience throughout California in a variety of region-specific habitats.

WRA has a local office in Emeryville with more than 20% of total company staff working and residing in the East Bay. Their team provides expertise in the local habitats and species and has a large portfolio of regional projects. This has helped develop positive relationships with regulatory agency personnel at federal, state, and local levels.

WRA has a long history in the San Francisco Bay Area with more than 300 unique and diverse projects that include infrastructure and public works projects. Their portfolio includes biological assessment, environmental planning, and regulatory permitting for public agencies, focused on sensitive plants, wildlife, wetlands and streams, natural communities, and sensitive species.

| |
|---|
| <i>Years in Business: 38</i> |
| <i>DIR Registration Number: 1000014971</i> |
| <i>SLEB Status: Certified small business in Alameda County SLEB #17-00033; Exp: 2/28/2021</i> |

WRA has a long history working with Schaaf & Wheeler staff on public infrastructure projects. Schaaf & Wheeler and WRA are currently working together on several sewer replacement and pump station rehabilitation.
Some other relevant projects include:
✓ *Ross Valley Sanitary District, Force Main Appurtenance Project, Larkspur*
✓ *City of Alameda, Phase 4 Sanitary Sewer Pump Stations Upgrades*



Kier & Wright – Survey and Mapping. Kier & Wright Civil Engineers & Surveyors, Inc. (K&W) has been committed to providing both public and private sector clients with high-quality, cost-effective, efficient land surveying and civil engineering services since 1972. Kier & Wright maintains a large-scale field survey, survey scheduling, and survey drafting operation and is resourced to efficiently produce a high volume of topographic surveys concurrently. Related services include:

- Topographic & Utility Surveys
- Right-of-Way Surveying
- Field Cross-Section Surveys
- Horizontal & Vertical Control Surveys
- ADA Surveys
- Topographic Boundary Surveys
- GPS Surveys
- As-Built Surveys
- Surveying for Due Diligence
- 3-D Laser Scanning

Kier & Wright’s field survey operation is one of the largest in the Northern California. Kier & Wright surveyors successfully prepare and process parcel maps, records of survey, lot line adjustments, and other survey documents involved in establishing and recording the precise locations of property lines. Kier & Wright’s ALTA surveys conform to the Minimum Standard Detail Requirements for ALTA/NSPS Land Title Surveys and include additional

| |
|--|
| <i>Years in Business: 47</i> |
| <i>DIR Registration Number: 1000005105</i> |
| <i>Contact Information: Ryan Amaya, PLS Ph: 408-727-6665 ramaya@kierwright.com</i> |

Kier & Wright has been working with Schaaf & Wheeler engineers for more than 15 years to provide wastewater, storm water and potable water services for Bay Area municipalities. K&W provided survey and mapping services for the:
✓ *San Rafael Sanitation District, Woodland Ave Sewer*
✓ *City of Belmont, North Road Pump Station and Force Main Project*



details, such as land use zoning classifications and FEMA flood zone designations. Kier & Wright has prepared ALTA surveys for large real estate portfolios comprised of as many as 104 separate properties.

ENGEO **ENGEO – Geotechnical Engineers.** ENGEO is an employee-owned, award-winning firm of geotechnical and civil engineers, geologists, hydrologists, environmental scientists, construction quality assurance representatives, and laboratory testing specialists. Founded in 1971, we have offices throughout California, Nevada, New Zealand, and Australia. ENGEO serves projects in transportation; infrastructure; water storage, conveyance and treatment; industrial facilities; geologic hazard mitigation; flood control facilities; civic structures; healthcare; education; energy; manufacturing; ports, harbors and waterfront development; residential and mixed-use communities; and urban development.

ENGEO's engineers and geologists have helped companies and public agencies manage their project development risk, drive down construction costs, and improve schedules.

ENGEO's geotechnical services are uniquely designed to address client objectives. Geotechnical services include:

- Foundation Engineering
- Seismic Analysis
- Construction-Phase Testing and Observation
- Grading Design
- Earthquake Engineering
- Laboratory Testing
- Seismic Retrofit
- Slope Analysis and Stabilization
- Levee and Dam Design
- Subgrade Stabilization
- Subsurface Characterization
- Slope Instrumentation and Monitoring
- Pavement Analysis and Design
- Fault Characterization

Presidio Systems Inc. – CCTV Inspection. Presidio Systems, Inc. (PSI) is a certified small, woman-owned business enterprise that provides professional storm water and sewer pipe inspection. PSI has dedicated Vac-Con trucks for initial cleaning of pipes and a fleet of state-of-the-art camera inspection trucks, fully equipped computerized camera vans, mobile hand held camera crews for smaller non-accessible projects, fully equipped Vector trucks, mobile Vector crews for smaller cleaning projects and a full crew for routine and emergency repairs. PSI also provides mechanical, electrical plumbing, industrial process controls, construction, environmental, and specialized engineering services to private and public sector clients throughout the United States. PSI delivers services for diverse projects to government agencies including the US Department of Defense Air Force and US Army COE, the Department of Energy - Sandia and Pacific Northwestern Laboratories, and the Department of Homeland Security - Customs and Border Patrol US Coast Guard and National Nuclear Safety Agency, among many others.



PSI has dedicated Vac-Con trucks for initial cleaning of pipes and a fleet of state-of-the-art camera inspection trucks, fully equipped computerized camera vans, mobile hand held camera crews for smaller non-accessible projects, fully equipped Vector trucks, mobile Vector crews for smaller cleaning projects and a full crew for routine and emergency repairs. PSI also provides mechanical, electrical plumbing, industrial process controls, construction, environmental, and specialized engineering services to private and public sector clients throughout the United States. PSI delivers services for diverse projects to government agencies including the US Department of Defense Air Force and US Army COE, the Department of Energy - Sandia and Pacific Northwestern Laboratories, and the Department of Homeland Security - Customs and Border Patrol US Coast Guard and National Nuclear Safety Agency, among many others.

| |
|---|
| <i>Years in Business: 48</i> |
| <i>DIR Registration Number: 1000009116</i> |
| <i>Contact Information: Janet Kan, GE, CEG, LEED AP Ph: 925-570-7982 jkan@engeo.com</i> |

✓ *Corporation Way System Upgrades and Pump Station, West Bayshore Road Pump Station and West Bayshore Road Trunkline Improvements Project, City of Palo Alto*

| |
|---|
| <i>Years in Business: 29</i> |
| <i>DIR Registration Number: 1000015049</i> |
| <i>CSLB Number: 832413</i> |
| <i>Contact Information: Mike Schratz Ph: 925-575-0175 mike.schratz@presidio-inc.com</i> |

Presidio is currently working with Schaaf & Wheeler to provide CCTV inspection services in the

- ✓ *Cities of Mill Valley and the Town of Corte Madera.*
- ✓ *Previously they have provided CCTV services for the Storm Drain Master Plan for the Town of Moraga and Sinkhole Rehabilitation project; and the*
- ✓ *Port of Oakland, 7th Street Outfall Investigation project.*



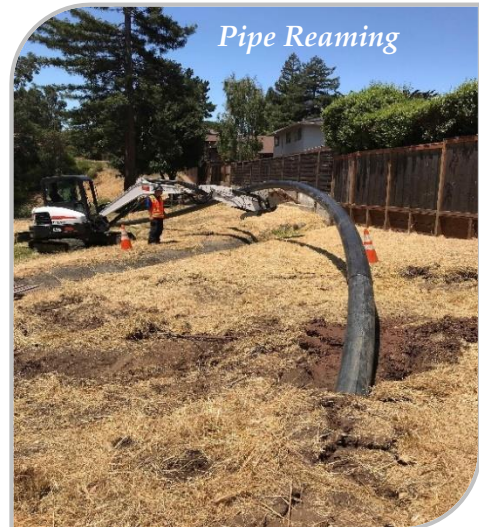
What does the Schaaf & Wheeler Team Bring?

The Schaaf & Wheeler team brings a number of assets that the City of Los Altos can benefit from, including the following:

- Schaaf & Wheeler is a small, local firm, responsive towards clients, specializing in wastewater systems design and engineering. *The work will be conducted from our local Santa Clara Office.*
- Our engineers provide cost-effective, implementable solutions and designs that expedite the project completion with *minimal change orders during the construction phase.*
- Our proposed team is proficient at *assessing existing condition and recommending pipe repairs* for optimal performance.
- Our engineers specialize in various technologies including *open-cut, trenchless technologies, CIPPs, pipe reaming, pipe bursting, etc.*
- Our engineers regularly *work with the agencies* identified for this project and will be *instrumental in obtaining permits* to keep the project on schedule
- We are *familiar with the issues and conditions specific to the City* and have identified a number of specific issues and solutions for this project in our proposal.
- Schaaf & Wheeler has been *providing engineering services to the City of Los Altos since 2010* and have completed several wet utility projects. Our engineers are familiar with the City's standards, procedures and regulations.
- We bring a strong team under the leadership of a detailed-oriented, experienced, and skillful *Project Manager – Glen M. Anderson, PE*. He is currently providing City-wide sewer repair service to the City of Morgan Hill and has recently completed a \$7.5 million gravity main and force main project for EBMUD. He regularly obtains permits for projects and lead multidisciplinary teams.
- *Benjamin L. Shick, PE is the QAQC Manager* and will provide *constructability review* for this project. Ben has completed several ward-winning sewer projects and intimately experienced in *alternatives analysis* and provides *cost-effective construction methods*.
- Our subconsultants and our engineers together bring a collaborative multidisciplinary team to provide a complete set of services required to prepare bid-ready sewer replacement and rehabilitation projects.
- We have more than *30 years of experience* providing engineering services for large infrastructure projects in busy urban corridors and rural settings and understand the challenges involved with these settings and the methods to resolve them.



Open Trench



Pipe Reaming



CIPP Lining

Our multidisciplinary team consists of all the services required to successfully complete the projects in time and schedule.



Project Team Qualifications and Experience

Team and its Management - Our Project Manager

Has Necessary Experience - Our results-oriented team for the City of Los Altos Adobe Creek Sewer Replacement project is under the strong leadership of **Glen M. Anderson, PE**. **Glen has more than 14 years of experience** in infrastructure planning, assessment; and design of waste water conveyance systems, water supply and distribution systems and stormwater systems. Most of these projects have required multidisciplinary subconsultant coordination including geotechnical engineering, structural engineering, RWQCB compliance, electrical engineering, survey and mapping, utility relocation, environmental permitting and stakeholder involvement.

Is an Accomplished Project Manager – Glen M. Anderson, PE is an owner and Senior Project Manager at Schaaf & Wheeler. He will provide his expertise in assessment, design and construction support of sewer pipe replacement. **Glen has completed design of more than 15,000 LF of Sewer pipes. He brings experience in open-cut and trenchless technologies.** Additionally, he has worked on numerous pump station rehabilitation/replacement design projects throughout the Bay Area. Glen Anderson has performed condition assessments for more than 150 pump stations and designed about 100 of them.

Glen has served as project manager and project engineer of gravity sewers, force mains, sewage lift stations, water pipes, water booster stations, storm drains and stormwater pumping stations for public agencies throughout Northern California. His management skills in every phase of the project - from assessment and feasibility studies to construction document preparation and construction support – help complete the projects within schedule and budget.

Some of his relevant projects are:

- City-wide Sewer Repairs, City of Morgan Hill
- Assessment and Engineering for Sanitary Sewer Main Rehabilitation, City of San Mateo
- Crestmoor & Lomita Pump Stations and Forcemain, City of San Bruno
- Force Main Appurtenance Projects ESDC, Ross Valley Sanitary District
- Cabrillo Avenue Sewer Main Abandonment and Replacement, City of Santa Clara
- South Trunk Sewer Relief Line, City of San Mateo
- Morgan Hill Trunk Sewer No. 2 - City of Morgan Hill
- PSQ Reserve Flow and URD Project, East Bay Municipal Utility District

Project Role: *Glen will be responsible for day-to-day project management for the entire length of the project. He will focus and maintain the project schedule and budget as well as undertake ultimate responsibility for the quality of all work products. Glen will hold regular team meetings to make sure issues are resolved effectively and to allocate resources to critical tasks. He will work closely with the City*



Education

BSCE, Civil and Environmental Engineering, University of California, Davis

Licenses

Registered Civil Engineer
California C 76720

Certifications

NASSCO PACP, MACP and LACP Certified, Cert. No. U-714-06021855

Hydraulic Institute, Pump System Assessment Certified

Years with S&W: 12

District's Day-to-Day Contact:

1171 Homestead Rd., Ste. 255,
Santa Clara, CA 95050

Ph: 408.246.4848

Email: ganderson@swsv.com

Qualification Highlights:

- ✓ Knowledge and Experience in Open Cut and Trenchless Technologies: CIPP, Pipe Bursting, Pipe Reaming
- ✓ Project Design Manager for Sewer Rehabilitation Projects for:
 - City of San Mateo
 - City of Santa Clara
 - City of Morgan Hill
- ✓ Completed design and CS of a \$7.5 million gravity main and force main project for EBMUD

Total Years of Experience: 14

Years with Schaaf & Wheeler: 14



staff to make sure contractual and procedural issues are exposed and resolved. Glen will attend all the field assessments and meetings with the City Department personnel.

Other Key Personnel

Charles D. Anderson, P.E. – Principal-in-Charge - Chuck is the president and an owner of Schaaf & Wheeler. He will provide expert peer review for the project. He brings **30 years of experience** encompassing the areas of wastewater conveyance and pumping, stormwater collection and pumping, water supply and distribution, flood mapping and protection design, tide gate structures, FEMA requirements, sea level rise assessment, and groundwater and surface water hydrology. Chuck has led numerous multidisciplinary project teams to deliver responsively and responsibly from concept verification to design and construction. He has managed two large award winning levee projects for the City of Foster City and San Mateo. He has interacted often with FEMA, having completed numerous flood insurance studies (FIS) and letters of map revision (LOMRs) on behalf of public and private clients. His management skills in every phase of the project - from feasibility studies to construction document preparation and construction support - help complete projects within schedule and budget.

Qualification Highlights:

- ✓ Completed Design and CS for CIP Projects since 1998
- ✓ Proficient at Providing QA/QC for Infrastructure Projects, especially Storm and Sewer Design
- ✓ Completed Award Winning Projects
- ✓ Completed Design of more than 40 Stormwater and Wastewater Pump Stations.

Total Years of Experience: 30+

Years with Schaaf & Wheeler: 25

Benjamin L. Shick, P.E. - Quality Control and Quality Assurance and Constructability Review – Ben Shick is a vice president and owner at Schaaf & Wheeler. Ben has more than **17 years of experience** in infrastructure planning and design of wastewater, stormwater and potable water systems. He provides expertise in alternative analyses, trenchless technologies, design and construction support sewer main rehabilitation. He has served as project manager and project engineer for design of large diameter pipes, sewage lift stations, stormwater pumping stations and gravity sewers.

Qualification Highlights:

- ✓ Design & CS of ~150,00 LF of sanitary sewer pipes
- ✓ Knowledge and Experience in Open Cut and Trenchless Technologies: CIPP, Pipe Bursting, Pipe Reaming
- ✓ 10 Years of QA/QC experience
- ✓ Resource optimization and cost control
- ✓ Stakeholder coordination
- ✓ Award-Winning Projects
- Water/ Sewer Main Replacement Project Completed for Mid-Peninsula Water District/ City of Belmont, APWA Honor Award for 2019
- Shoreway Sewer Replacement Project Completed for City of Belmont, Project of the Year Award for 2019

Total Years of Experience: 17+

Years with Schaaf & Wheeler: 17

Ben's sewer rehabilitation/replacement projects generally include flow monitoring, CCTV inspections, pipe rehabilitation and replacement, manhole rehabilitation and replacement, pipe placed on structural supports, etc. Ben is proficient in water resources modeling tools: AutoCAD, WaterCAD, HEC-RAS, HEC-HMS, GeoRAS, MOUSE, and ArcGIS 9.0.

Ben is currently providing On-Call engineering services to the City of San Mateo, City of Belmont, and the City of Alameda. Some of his relevant sewer projects are:

- Woodland Avenue Sewer Improvement Project, San Rafael Sanitation District
- Harbor Drive Sewer Rehabilitation Project, Town of Corte Madera
- Sanitary Sewer Rehabilitation and Replacement Projects, City of Belmont
- Sanitary Sewer Repair Project, City of Mill Valley
- El Camino Real Sanitary Sewer Rehabilitation, City of San Mateo
- North Road Pump Station Rehabilitation Project, City of Belmont
- Belmont Sewer and Water Main Replacement, City of Belmont and Mid-Peninsula Water District
- Sanitary Sewer Rehabilitation Projects, City of San Mateo
- Force Main Appurtenance Projects, Ross Valley Sanitary District



- El Camino Real Sanitary Sewer/Water Improvement Project, BRE Properties/City of Santa Clara
- Cabrillo Avenue Sewer Main Abandonment and Replacement, City of Santa Clara
- Kingridge Sanitary Sewer and Storm Drain Improvement Project – City of San Mateo
- Sanitary Sewer Pump Station Evaluation and Design, Town of Hillsborough
- Rehabilitation and Replacement Design of 32 Sanitary Sewer Pump Station, City of Alameda
- Rehabilitation and Replacement Design of Sanitary Sewer Pump Stations, City of Oakland

Project Role: Ben will ensure quality control and quality assurance for all deliverables of the project. He will perform quality control several times throughout the project to minimize the need to fix problems further along in the project. Ben will work with Glen Anderson at Schaaf & Wheeler to provide critical reviews of alternatives and design methods. He will also scrutinize improvements for constructability and cost.

Subconsultant Key Personnel



Ryan Amaya, PLS - Principal Surveyor. Ryan Amaya is a Principal Engineer at K&W. He has over 21 years of land surveying experience, including construction surveying, boundary surveying, mapping, and subdivision work related to land development. Specific survey experience includes construction staking, topographic surveys, benchmark-level circuits, elevation monitoring surveys, tentative maps, parcel maps, final maps, condominium plans, plats and legal descriptions, lot line adjustments, lot combinations, reversion to acreage maps and ALTA/ACSM Land Title Surveys. Mr. Amaya has had the privilege of managing the topographic survey scope for a variety of public improvement projects throughout the San Francisco Bay Area. He has managed land surveying/base mapping scope for a number of municipal design contracts held by Schaaf & Wheeler and is experienced in working with the proposed project team. Mr. Amaya has been at Kier & Wright since February of 1999.

Qualification Highlights:

- ✓ Managed the survey scope for Schaaf & Wheeler projects completed for public agencies throughout the Bay Area.
- ✓ Manages all mapping and survey operations based in Kier & Wright's Santa Clara and Gilroy offices.

Total Years of Experience: 21

Years with Kier & Wright: 21

Project Role: Ryan will serve as the lead surveyor and project manager for K&W's services for this contract.



Greg Sproull – Biologist. Greg Sproull is an associate biologist and project manager in WRA's San Rafael office. He has over a decade of scientific experience in the private and academic sectors in the United States and abroad. Greg manages floristic surveys, vegetation mapping, and habitat assessments; coordinates and performs wetland delineations; and authors and manages regulatory permit applications, biological resource assessments for CEQA documents, and client reports. Greg regularly interfaces with local, state, and federal regulatory agencies, including the U.S. Army Corps of Engineers (Corps), the Regional Water Quality Control Board (RWQCB), the U.S. Fish and Wildlife Service (USFWS), the California Department of Fish and Wildlife (CDFW), California Coastal Commission (CCC), and the Bay Conservation and Development Commission (BCDC). Greg combines his scientific expertise, critical thinking, and scientific editing experience to address clients' natural resource challenges with an efficient, measured, and objective approach. Some of his relevant projects are:

Qualification Highlights:

- ✓ Experienced project manager for biological and regulatory agency permitting projects
- ✓ Established relationships with local, state, and federal regulatory agencies
- ✓ Instructor for wetland delineation training at San Francisco State's Romberg-Tiburon Center
- ✓ CDFW Plant Voucher Collecting Permit Holder (#2081a-18-008-V)
- ✓ Professional Wetland Scientist (PWS; ID 3193)
- ✓ Serves as Association of Environmental Professionals, North Bay Vice President

Total Years of Experience: 11

Years with WRA, Inc.: 2



- Alameda County Water District, Curtner Road and Canyon Heights Booster Stations Improvements
- Department of Water Resources/Ecosystem Investment Partners, Lookout Slough Restoration Project, Dixon
- Santa Clara Valley Water District, Rancho Cañada de Pala Preserve Annual Monitoring Project – Santa Clara County

Project Role: Greg Sproull will lead the environmental documentation and permitting. He will lead WRA's team for this project.



Janet Kan, GE, CEG, LEED AP – Geotechnical Engineering.

Janet Kan is a Principal Engineer at ENGEO. She brings extensive experience in geotechnical engineering. She has managed numerous large-scale projects in the South Bay including residential, commercial, mixed-use and master planned developments. Furthermore, Janet is familiar with preparation of geotechnical reports according to Caltrans, SP 117, and OSHPD guidelines.

Both as geotechnical engineer and a professional geologist, Janet's expertise includes developments on compressible deposits; mitigation of liquefiable sites; and seismic analyses including site response and spectral acceleration development. Janet is a proven and adept lead geotechnical engineer for many complex projects with technical challenges and multiple stakeholders.

Some of her relevant projects are:

- City of San Mateo Basin 2 and 3 - Pipelines and Pump Stations—San Mateo, CA
- City of San Mateo South Trunk Sanitary Sewer Relief Line—San Mateo, CA
- San Mateo Bayfront Levee Improvement—San Mateo, CA

Project Role: Janet will serve as the lead geotechnical engineer and project manager for ENGEO's services for this contract.



Mike Schratz - CCTV Inspector.

Mike Schratz is a Project Manager at Presidio Systems, Inc. He has over 10 years of experience in sewer and storm drain maintenance projects. Mike is proficient at sewer pipe and storm water CCTV inspections, hydrocleaning and condition assessment. He uses dedicated video equipment, state-of-the art systems and highly trained inspection personal to provide a complete turnkey inspection system. He leads the team with dedicated Vac-Con trucks for initial cleaning of pipes and a fleet of state-of-the-art camera inspection trucks, fully equipped computerized camera vans, mobile hand held camera crews for smaller non-accessible projects, fully equipped Vactor trucks, mobile Vactor crews for smaller cleaning projects and a full crew for routine and emergency repairs. He also prepares CCTV assessment reports that can be easily used to analyze repair methods.

Project Role: Mike will serve as the lead CCTV inspector and project manager for Presidio's services for this contract.

Qualification Highlights:

- ✓ Experienced project manager for infrastructure geotechnical projects
- ✓ Geotechnical analysis and environmental investigations and reporting
- ✓ Familiar with Caltrans, OSHPD and USACE guidelines
- ✓ Has been working with Schaaf & Wheeler engineers for more than a decade

Total Years of Experience: 11

Years with WRA, Inc.: 2

Qualification Highlights:

- ✓ NASSCO, PACP, LACP, MACP 40-Hour OSHA Hazwoper Training OSHA Confined Space Certified Manages all mapping and survey operations based in Kier & Wright's Santa Clara and Gilroy offices.
- ✓ Working with Schaaf & Wheeler since 2014 on wastewater and stormwater infrastructure projects
- ✓ CCTV on Storm Drain System at LBNL, Berkeley

Total Years of Experience: 10

Years with PSI: 10



The table below presents our entire team’s role, experience and qualifications.

Table: Key Personnel Qualifications, Experience and Role

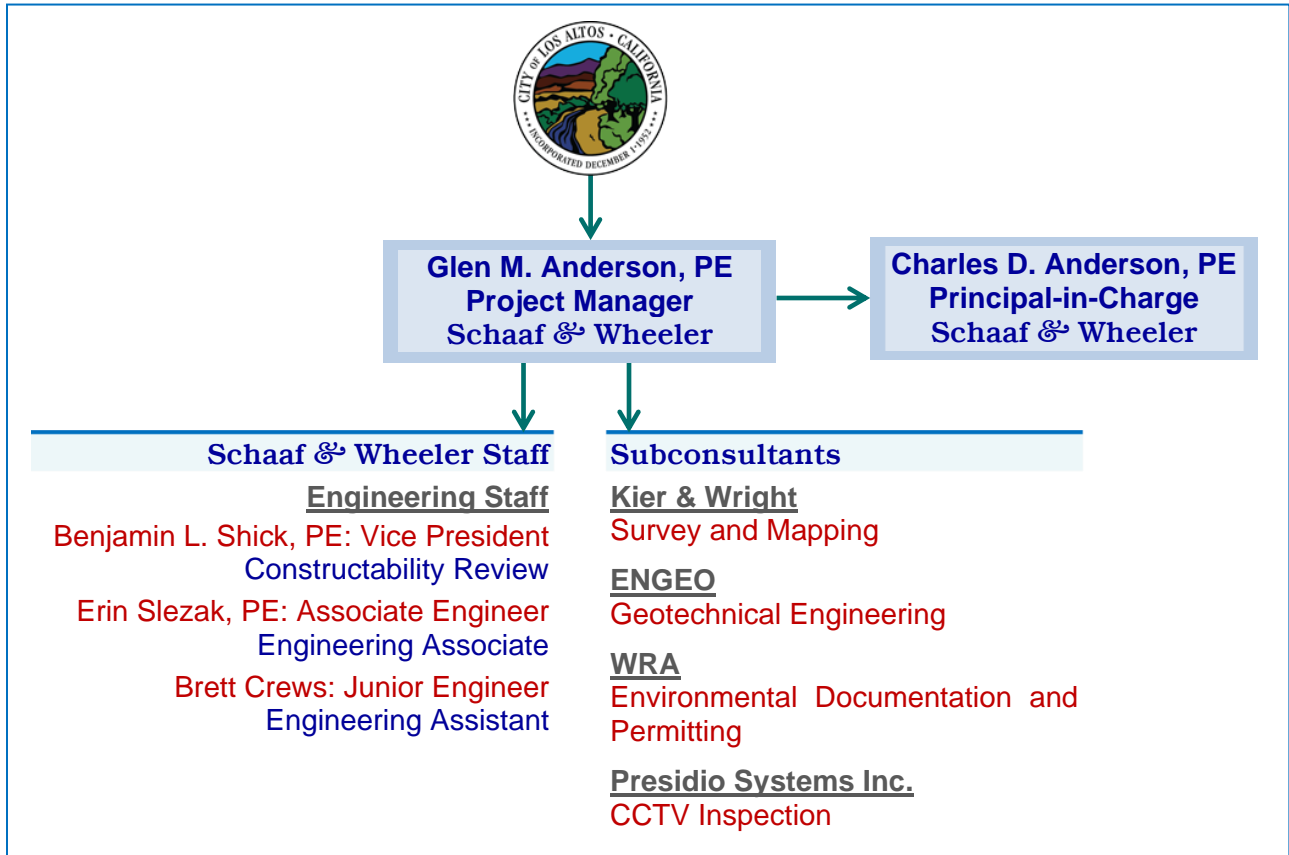
| Name & Firm | Years of Experience | Role and Responsibility | License, Certifications and Education |
|---|----------------------------|--|---|
| Glen M. Anderson, PE, PACP S&W | 13 | Project Manager | Registered Civil Engineer, California C76720 BSCE, Civil and Environmental Engineering, University of California, Davis NASSCO PACP Cert. U-714-06021855 Hydraulic Institute, Pump System Assessment Certified |
| Charles D. Anderson, PE | Principal- in-Charge | 30 | Registered Civil Engineer California C43776 Hawaii 15647; Nevada 11518; Washington 39715 MSCE (Water Resources Engineering), Stanford University, California BCE, Georgia Institute of Technology |
| Benjamin L. Shick, PE S&W | 17 | Quality Control and Quality Assurance | Registered Civil Engineer, California C68813 MSCE, Montana State University-Bozeman BSCE, Montana State University-Bozeman |
| Subconsultants | | | |
| Ryan Amaya, PLS Kier & Wright | 20 | Survey and Mapping, Utility Research | Professional Land Surveyor, California L8134 |
| Gregory Sproull WRA, Inc. | 11 | Biologist | Professional Wetland Scientist (PWS) from the Society of Wetland Scientists (SWS) (ID 3193) Plant Voucher Collection Permit from the California Department of Fish and Wildlife (ID 2081(a)-18-008-V) Master of Science, Biological Sciences, University of Denver; Bachelor of Science, Integrated Science and Technology, James Madison University; Fulbright Research Scholar in Ecology |
| Janet Kan, PE, GE, CEG Engeo | 18 | Geotechnical Engineer | Registered Civil Engineer, California C67311 Registered Geotechnical Engineer, California 2880 Certified Engineering Geologist, California 2590 MS, Civil Engineering, University of California, Berkeley BS, Geological Engineering, University of British Columbia |
| Mike Schratz Presidio Systems, Inc. | 10 | CCTV | CCTV/Controls/ Pump Stations Upgrades to Plant NASSCO LACP,PACP,MACP |



Team Organization

We have put together a dedicated team for the City of Los Altos. The team will be led by Glen Anderson, who has successfully completed sewer design projects in Bay Area. *Detailed resumes of the entire team are attached as Appendix.*

Organization Chart





Relevant Project Experience

Sanitary Sewer CCTV Inspection and Data Review, Port of Oakland, 2020

Client and Contact:

Quynh Nguyen
Port of Oakland
Engineering Division
530 Water St
Oakland, CA 94607
Ph: 510. 627.1240
qnguyen@portoakland.com

Contract Value:

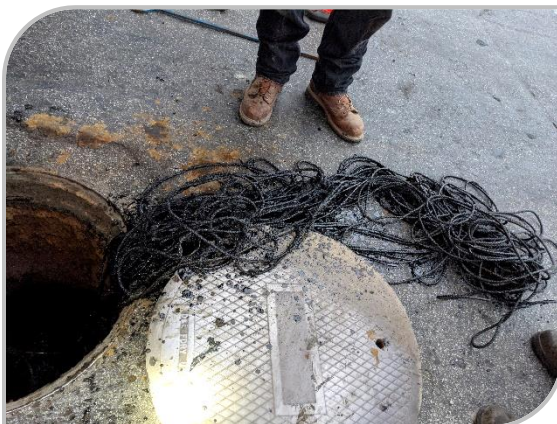
\$429,094

Construction Cost: NA**Team Members:**

Glen M. Anderson, PE
Erin Slezak, PE

Subconsultants:

Presidio Systems Inc.

**Key Elements:**

- ✓ 50,000 LF of sanitary sewer inspection, 6" to 36"
- ✓ CCTV data review and evaluation for all sewer infrastructure within and connected to the Port
- ✓ Manhole inspections and assessment
- ✓ Evaluation of condition related deficiencies
- ✓ Rehabilitation strategies

The includes the cleaning and CCTV inspection of approximately 50,000 linear feet of sanitary sewer piping within the Port of Oakland's Seaport Facility including the TraPac, 7th Street, Middle Harbor Road, Middle Harbor Shoreline Park, Joint Intermodal Terminal, Matson Terminal, and other areas as requested by the Port. CCTV inspection reports are generated in conformance to NASSCO PACP and LACP standards. The findings of these inspections are summarized in a technical memorandum that ranks the pipeline segments in order of severity and provides recommended improvements for pipelines receiving a level 4 or level 5 rating through the ranking process. Manholes with observed deficiencies are noted and assessed in conformance NASSCO MACP standards. The inspected pipeline that shows breakage, Inflow and infiltration, blockage are identified and made known to the Port in real-time.

Tasks included:

- Pre-Inspection Investigations and Field Reconnaissance
- Hydro-jetting and CCTV inspections of Port and City of Oakland Sewers
- Technical memorandum including maps, tables, and figures
- Ranking and grouping for rehabilitation prioritization
- Suggest rehabilitation strategies



El Camino Real Sanitary Sewer Rehabilitation, City of San Mateo, 2017 – 2020

Client and Contact:

Jimmy Vo
City of San Mateo
330 W. 20th Avenue
San Mateo, CA 94403
Ph: 650.522.7300
jvo@cityofsanmateo.org

Contract Value:

\$500,000

Construction Cost (2020):

\$3,100,000

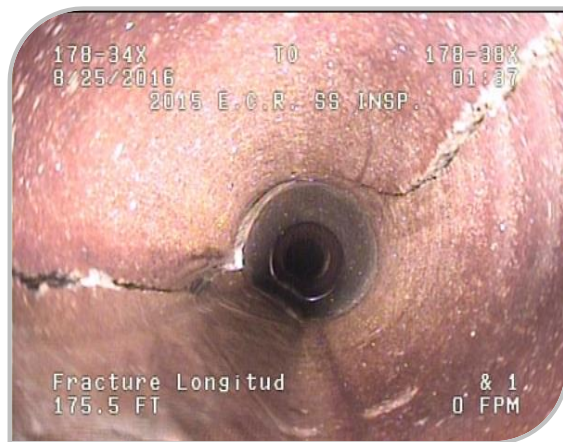
The design was completed in
time and budget.

Team Members:

Benjamin L. Shick, PE
Glen M. Anderson, PE
Curran L. Price, PE
Larry D. Johnson, PE
Jonathan F. Ondracek

Subconsultants:

Kier & Wright
Bess Testlab

**Key Elements:**

- ✓ 9,500+ LF of sanitary sewer rehabilitation, 6" to 18"
- ✓ CCTV data review and evaluation for all sewer infrastructure within and connected to El Camino Real.
- ✓ Manhole inspections and rehabilitation design
- ✓ Evaluation of condition related deficiencies
- ✓ Rehabilitation with cured-in-place pipe (CIPP), pipe bursting, open-trench, and spot repairs
- ✓ Utility investigation

The project includes addressing all of the City's condition related deficiencies along the El Camino Real corridor. Schaaf & Wheeler reviewed and evaluated the condition of all the City's sanitary sewer pipes and manholes within and adjacent to El Camino Real and developed a recommended improvement project to address all significant condition related issues. Subsequently Schaaf & Wheeler designed the rehabilitation and replacement of 9,050 LF of pipe and the rehabilitation and replacement of 110+ manholes. Rehabilitation methods were primarily cured-in-place pipe (CIPP) and spot repairs; however, pipe bursting and open trench replacement methods were also used.

Tasks included:

- Review and evaluation of CCTV data
- Manhole inspections and rehabilitation
- Develop and design recommended improvements
- Replacement of sewer lines in easements with tight access
- Sewer line rehabilitation with cured-in-place pipe (CIPP)
- Sewer main replacement

The work included geotechnical investigations, easement research, Utility investigations, and Caltrans Encroachment Permit.

The project required close coordination with the City and the City's consultants working on additional sewer improvement projects in the area to ensure there weren't conflicts and overlap between projects. The project also required a detailed Caltrans Encroachment Permit application which was successfully handled and obtained by Schaaf & Wheeler.



Sanitary Sewer Rehabilitation Projects, 2015 – Ongoing. Contract Value: ~\$191,000; Construction Cost: \$885,000; Construction Dates: June 2018 – October 2018. The project includes 6”, 8”, and 12” of 4,000+ LF of sanitary sewer rehabilitation. Schaaf & Wheeler completed site investigations, inspections, researched existing data, and developed recommended alternatives for various sewer rehabilitation projects within the City. As directed, Schaaf & Wheeler proceeded with detailed design of the recommended alternatives which consisted of:

- Sewer line rehabilitation with cured-in-place pipe (CIPP)
- Sewer main replacement and realignment
- Sewer replacement across drainage channels (both above ground on piers and below ground)
- Replacement of sewer lines through large drainage box culverts
- Manhole rehabilitation and replacement

The work included geotechnical investigations, easement research, topographical surveying, and environmental permitting. S&W also assisted with environmental permitting and Caltrans E.P.

Kingridge Sanitary Sewer Line Improvements, City of San Mateo, 2008 - 2014

Client and Contact:

Jimmy Vo
City of San Mateo
330 W. 20th Avenue
San Mateo, CA 94403
Ph: 650.522.7300
jvo@cityofsanmateo.org

Contract Value:

\$927,673

Construction Cost:

\$2.5 million

Team Members:

Benjamin L. Shick, PE
Glen M. Anderson, PE

Subconsultants:

Environmental
Geotechnical
Structural
CCTV and Potholing



Key Elements:

- ✓ 3,000 LF of sanitary sewer main replacement, 6”
- ✓ Open-cut, pipes supported on piers, and pipe rehabilitation with cured-in-place pipe (CIPP)
- ✓ Obtained construction and regulatory permits from CDFW, RWQCB, US Army Corps of Engineers
- ✓ Project outreach program for the design and construction phases

The Kingridge sewer line improvement project rehabilitates the 6-inch sanitary sewer main located within a 10-foot utility easement in a steeply-sloped and wooded canyon behind homes on Kingridge Drive. The City has experienced very high maintenance issues with the sewer pipe and due to several operational issues, the RWQCB issued a Cease and Desist Order requiring immediate action.

This main is located within a 10-foot utility easement in a steeply-sloped and wooded canyon behind homes on Kingridge Drive, between 36th and 42nd Avenues. The sewer main is constructed out of vitrified clay pipe (VCP) with cement joints. The City has experienced very high maintenance issues with the sewer pipe including root intrusion, overflows and physical displacement of the pipeline. Slope failures in this steep terrain have torn away portions of the pipe. Access to the sewer main for maintenance and repairs was also an issue, because it was located on a steep embankment and did not have a trail or roadway for access.



Due to several issues with the operation of the sewer, the Regional Water Quality Control Board (RWQCB) issued a Cease and Desist Order (CDO) requiring immediate action - the main impetus for the improvements.

Similar Scope and Complexity. Schaaf & Wheeler provided consulting services to the City of San Mateo including:

- Investigation of existing conditions
- Hydraulic analysis of the existing Kingridge Canyon sewer system
- Development of improvement alternatives for the sewer main
- Development and production of construction documents for the selected alternative

The selected improvement alternative included slope stabilization, access improvements, pipe replacement, pipe rehabilitation with cured-in-place pipe (CIPP), pipe placed on structural supports, and various drainage improvements. Limited site access required the use of specialty construction methods and materials.

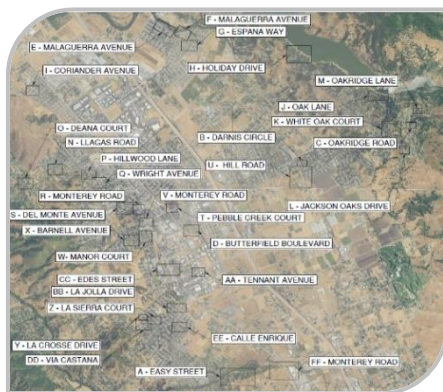
The project also included close coordination with subconsultants for environmental permitting and mitigation, geotechnical/geological investigation, surveying, and structural design. Access to the sewer line required entry through private property during design and construction. Schaaf & Wheeler worked with the City to develop and implement a project outreach program for the design and construction phases of the project. The public outreach aimed to engage residents throughout the project duration, providing transparency and a collaborative atmosphere.

Sanitary Sewer Rehabilitation Projects for City of Morgan Hill, 2019 – Present

Client and Contact:
 Yat Cho
 Senior Project Manager
 City of Morgan Hill
 17575 Peak Avenue
 Morgan Hill, 95037
 Ph: 408.310.4641
Yat.cho@morganhill.ca.gov

Contract Value: \$162,285
Construction Cost:
 \$1,000,000 (estimate)

Key Personnel:
 Benjamin L. Shick, PE
 Glen M. Anderson, PE
 Curran L. Price, PE
 Jonathan F. Ondracek



City-Wide Rehabilitations

Key Elements:

- ✓ Sanitary sewer infrastructure evaluations
- ✓ Sanitary sewer design and CS
- ✓ Open trench excavation
- ✓ Pipe Bursting
- ✓ CIPP lining

The City of Morgan Hill identified 47 pipe segments that need to be reviewed and evaluated. Schaaf & Wheeler assisted the City with evaluating and assessing the existing sewer infrastructure. The City’s existing sanitary sewer model was reviewed to evaluate the sizes of the pipe segments in question and recommend the rehabilitation/replacement method. Schaaf & Wheeler also visited each site to collect additional field data to properly assess the pipes and make recommendations.



Schaaf & Wheeler prepared a Technical Memorandum which summarized the assessment and provided capital improvement recommendations and estimated construction costs. Subsequently the City contracted with Schaaf & Wheeler to design the recommended improvements. Detailed design tasks include project basemapping, detailed utility investigations, evaluations to re-route sewer mains and laterals from backyard easements, plan and profiles of sewer lines, construction details, technical specifications, and estimate of probable construction costs.

The proposed construction methods were tailored to minimize the impacts and costs at each location while meeting the City’s goals of addressing the condition and maintenance related issues. Proposed construction methods include pipe bursting, open trench, spot repairs, and cured-in-place pipe rehabilitation.

Shoreway Sanitary Sewer Rehabilitation, City of Belmont, 2017 - 2019

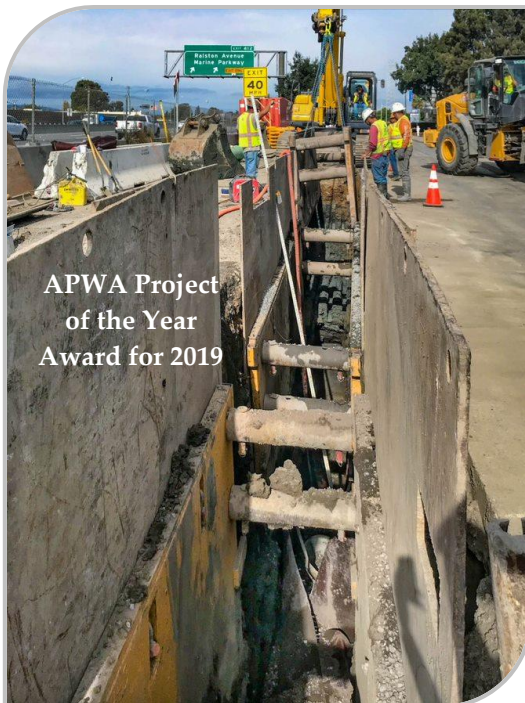
Client and Contact:
Bozhena Palatnik
Associate Civil Engineer
Department of Public Works
City of Belmont
1 Twin Pines Lane
Belmont, CA 94002
Ph: 650.595.7463
bpalatnik@belmont.gov

Contract Value:
\$129,000
Construction Cost (2018):
\$1,857,000

The design was completed in time and budget.

Team Members:
Benjamin L. Shick, PE
Curran L. Price, PE
Jonathan F. Ondracek

Subconsultants:
Kier & Wright
Bess Testlab



Key Elements:

- ✓ Sanitary sewer rehabilitation and replacement, 8” to 18”
- ✓ CCTV data review, evaluation, and prioritization to identify project
- ✓ Hydraulic Analysis and Modeling of sewer system
- ✓ Utility investigation, potholing, utility relocation, etc.
- ✓ Easement evaluation and relinquishment
- ✓ Deep linear excavations within poor soils (Bay Mud) and high ground water
- ✓ Construction support services

Schaaf & Wheeler assisted the City of Belmont with the assessment of the feasibility of eliminating the existing sanitary sewer pump station along Shoreway Drive by installing a new deeper gravity sewer main. The feasibility analysis included detailed topographic surveying, geotechnical investigations, detailed utility investigations, sewer system modeling, and alternative evaluation.

The alternative of constructing a new 13 foot deep 18” PVC sewer main, demolishing and removing the existing sewer pump station, and re-routing all sewer laterals was selected as the most feasible and economical solution. Subsequently Schaaf & Wheeler developed detailed construction documents for the design and provided bid and construction support services.

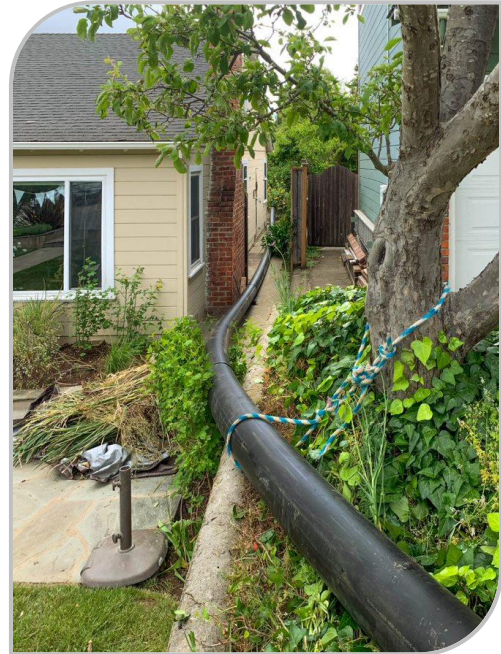


Shoreway Drive is located in an area of shallow Bay Mud, high ground water, congested utilities, heavy traffic, and it parallels U.S. 101. Schaaf & Wheeler developed detailed construction documents identifying the existing conditions and requirements for excavation, trenching, shoring, dewatering, and backfilling.

The Shoreway sewer project was successfully designed and constructed within budget and schedule. The project resulted in significant long-term savings by eliminating an existing sewer pump station and reducing the operation and maintenance of the previously undersized flat sloped sewer mains (two sewer mains were replaced with one larger and deeper sewer main).

City of Belmont Sanitary Sewer Rehabilitation Projects, 2014, 2015, 2016 and 2017. Contract Value: 2014 - \$98,840; 2015 - \$567,000; 2016 - \$456,961; 2017 - \$194,000; Construction Cost: \$1,530,000 (2015 Project). Construction Dates: 2015 - Current.

The City of Belmont selected Schaaf & Wheeler to evaluate, prioritize, and design the rehabilitation and replacement of their high priority gravity sewer lines throughout the City. Construction methods include pipe bursting, pipe reaming, horizontal directional drilling (HDD), open trench excavation, and CIPP lining. Schaaf & Wheeler has completed the rehabilitation and replacement design and construction support for:



| Liner Feet (lf) of Sewer | Year |
|--|------|
| 2.5 miles of City sewer gravity lines and associated manholes | 2014 |
| 2 miles of gravity sewer lines and associated manholes | 2015 |
| 5 miles of gravity sewer lines | 2016 |
| 2.5 miles of sewer rehabilitation | 2017 |
| 1,500 lf of sewer rehabilitation, Shoreway Sewer Replacement Project | 2018 |
| 3,200 lf of force main and gravity sewer mains within El Camino Real | 2019 |
| 1,600 linear feet of gravity sewer mains within El Camino Real | 2020 |

These sewer lines (some of them, gravity sewer lines) are located throughout the City in back yard easements and in City streets. Schaaf & Wheeler also applied for and obtained two separate Caltrans Encroachment Permits for se



Appendix: Resumes

Glen M. Anderson, P.E. – Senior Project Manager - Schaaf & Wheeler

Education

BSCE, Civil and
Environmental Engineering,
University of California,
Davis

Licenses

Registered Civil Engineer
California C76720

Certifications

NASSCO PACP, MACP
and LACP Certified, Cert.
No. U-714-06021855
Hydraulic Institute, Pump
System Assessment
Certified

Affiliations

Pipe Users Group - NorCal



Years of Experience: 13

Project Management Experience: 10 years

Completed Design of 15,000 LF of Sewer

*Knowledge and Experience in Sewer Rehabilitation Trenchless
Technologies: CIPP, Pipe Bursting, Pipe Reaming, etc.*

Glen M. Anderson, P.E., has 13 years of experience in sanitary sewer system, stormwater and potable water assessment and design, as well as the construction support and management associated with these projects. Glen has successfully completed work on several sanitary sewer main and trunk rehabilitation projects. He has worked on sanitary sewer pump station rehabilitation projects throughout the Bay Area. Additionally, Glen has performed condition assessments for more than 150 sanitary sewer and stormwater pump stations. Glen's potable water experience projects include the assessment and rehabilitation of booster pump stations, design of a water, wells and pipelines. Most of his projects require multidisciplinary subconsultant coordination including structural and electrical engineering, survey and mapping, utility relocation, environmental permitting, RWQCB compliance and stakeholder involvement. In addition to design, Glen provides construction support and management services for a variety of projects, including pump stations, pipelines, wells, storage tanks, and generator installations.

Relevant Projects

Sanitary Sewer CCTV Inspection and Data Review, Port of Oakland (2020 – 2022), Contract Value: \$429,094. As Project Manager, Glen Anderson is leading the cleaning and CCTV inspection of approximately 50,000 linear feet of sanitary sewer piping within the Port of Oakland's Seaport Facility including the TraPac, 7th Street, Middle Harbor Road, Middle Harbor Shoreline Park, Joint Intermodal Terminal, Matson Terminal, and other areas as requested by the Port. CCTV inspection reports are generated in conformance to NASSCO PACP and LACP standards. The findings of these inspections are summarized in a technical memorandum that ranks the pipeline segments in order of severity and provides recommended improvements for pipelines receiving a level 4 or level 5 rating through the ranking process. Manholes with observed deficiencies are noted and assessed in conformance NASSCO MACP standards. The inspected pipeline that shows breakage, Inflow and infiltration, blockage are identified and made known to the Port in real-time.

Pump Station Q Force Main Reverse Flow Project, East Bay Municipal Utility District (2015 – 2019), Contract Value: \$1,100,000. As Project Manager, Glen Anderson led the design and construction support for the pump station and the force main. This project involved the design of a 36" gravity sewer interceptor and relief structure that utilized an existing 36-inch force main via gravity to provide additional conveyance to the District's North Interceptor that serves the Cities of El Cerrito, Albany, Berkeley and Oakland. The 36-inch gravity portion was extended past an existing bottleneck in the District's north interceptor to effectively double it's capacity. The 36-inch line utilizes valves which allow it to operate as a gravity system when draining to the south and can still be switched back to a pressurized system to be utilized as a force main during extreme precipitation conditions. Extensive modeling was developed for this project using historical flows and rain events to determine the benefits of proposed improvements.

Sanitary Sewer Rehabilitation Projects, City of San Mateo, (2014 – 2017), Contract Value: \$190,913; 2017 – 2018 - \$500,000. As Project Engineer, Glen Anderson led and completed site investigations, inspections, researched existing data, and developed recommended alternatives for various sewer rehabilitation projects within the City. Provided detailed design of the recommended alternatives which consisted of: replacement of sewer lines across drainage channels (both above ground on piers, and below ground); in back yard easements with tight access; through large drainage box culverts; sewer line rehabilitation with cured-in-place pipe (CIPP); sewer main replacement and realignment; manhole rehabilitation and replacement; the work included geotechnical investigations, easement research, topographical surveying, environmental permitting, and Caltrans Encroachment Permit.

Cabrillo Avenue Sewer Main Abandonment and Replacement, City of Santa Clara (2013 – 2014), Contract Value: \$101,650. As Project Manager, Glen Anderson provided design and construction support services for the replacement of sewer pipe located within Cabrillo Avenue, running parallel to the existing sewer line. Design included plan and



Glen M. Anderson, P.E. – Senior Project Manager - Schaaf & Wheeler

profile of a new 12-inch PVC sewer main, associated manholes, and lateral connections. An inverted siphon was required to cross under an existing 24-inch storm drain line. The siphon consists of two 8-inch barrels, inlet structures, outlet structures, and an air jumper. In addition to the 12-inch mainline design, replacement of several smaller sewer and storm drain lines necessary to facilitate the installation of the new sewer mainline were also designed.

El Camino Real Sanitary Sewer Rehabilitation, City of San Mateo (2017 - 2018), Contract Value:\$500,000 . As Project Engineer, Glen Anderson reviewed and evaluated the condition of all of the City's sanitary sewer pipes within and adjacent to El Camino Real and developed a recommended improvement project to address all significant condition related issues. Subsequently the rehabilitation and replacement design of 10,050 LF of pipe and the rehabilitation and replacement design of 110 manholes were also prepared. Rehabilitation methods were primarily cured-in-place pipe (CIPP), pipe bursting and open trench replacement methods were also used.

Sanitary Sewer Rehabilitation Projects, City of Belmont (2015, 2016 and 2017), Contract Value: 2015 - \$567,000; 2016 - \$456,961; 2017 - \$194,000. As Project Engineer, Glen assisted with the evaluation, prioritization, and design of the rehabilitation and replacement of their high priority gravity sewer lines throughout the City. The 2015 Sewer Rehabilitation project consisted of the replacement and rehabilitation of approximately 2 miles of gravity sewer lines and associated manholes. Schaaf & Wheeler team provided detailed utility investigations, potholing, and sewer modeling services. The 2016 sewer rehabilitation project consisted of evaluating and preparing design documents for approximately 5 miles of gravity sewer lines located throughout the City in back yard easements and in City streets. Construction methods include pipe bursting, open trench excavation, and CIPP lining. A large portion of the sewer mains included within the City of Belmont sewer rehabilitation projects are located within backyard and side yard easements with difficult access and easement issues.

Basin 2 and 3 Collection System Improvements Project: Sanitary Sewer Pump Stations Rehabilitation, City of San Mateo (2016 – 2019), Contract Value: \$410,140. As Project Manager, Glen Anderson completed the preliminary evaluation, alternatives analysis, and design for the rehabilitation of the 38th Avenue pump station, 41st Avenue pump station, and Dale Avenue pump stations. The 38th Ave and 41st Ave pump stations are significantly under capacity. Tasks included alternatives analyses for capacity augmentation, upgrade of the standard equipment including flygt rail-mounted submersible pumps; modern electrical panels, pump starters, and automatic transfer switch; Hydroranger 200 pump controller; Motorola ACE6300 RTU; and Cummins standby diesel engine generator. Dale Avenue pump station upgrades include: replacement of existing pumps and motors; replacement of control panels; installation of new VFDs; replacement of engine generator; improved SCADA and controls system; and wetwell improvements.

Force Main Appurtenance Projects - Ross Valley Sanitary District, San Rafael, Contract Value: Preliminary Design: \$220,885; Design: \$155,570. As Project Engineer, Glen Anderson assisted the preliminary design of the replacement of five air release valves. The project includes replacement of four failing air-release valves (ARVs) on District-owned force mains and install a new ARV at a critical location, install four cathodic protection (CP) test stations at various locations along Pump Station 13 (PS13) force main, and to install an impressed current cathodic protection (ICCP) system at PS13. This project required Caltrans and environmental permitting coordination. It also involved pipeline excavation, removal and disposal of existing ARV and piping and site restoration to pre-construction condition.

El Camino Real Sanitary Sewer Improvement Project and the Calabazas Creek Sewer Siphon Design Projects, City of Santa Clara, 2006 – 2009; Contract Value: \$480,520. As Project Manager, Ben Shick led the design of 2,600 feet of parallel sewer line in El Camino Real from Flora Vista Avenue to Calabazas Boulevard. The project also included a separate design plan set for a replacement sewer siphon with dual pipes under Calabazas Creek as part of a Santa Clara Valley Water District channel improvement project. The project also included cured-in-place pipe (CIPP) lining of 2,600 feet of parallel collector sewer and reconstruction of existing lateral connections. Tasks included the design of relocation of existing water mains, storm drains, sewer laterals, and traffic signals to accommodate the design of new sewer mains.

**Benjamin L. Shick, P.E. – Principal-In-Charge – Schaaf & Wheeler****Education**

BSCE, Montana
State University-
Bozeman

MSCE, Montana
State University-
Bozeman

Licenses: Registered
Civil Engineer
California C68813

Affiliations:

American Society of
Civil Engineers;
Floodplain
Management
Association



Years of Experience: 17+

Completed Design & Construction of ~150,000 LF of Sewer

Project Management Experience: 13+ years

Knowledge and Experience in Sewer Rehabilitation Trenchless

Technologies: CIPP, Pipe Bursting, Pipe Reaming, etc.

Benjamin L. Shick, P.E., has more than 17 years of experience in water resources infrastructure planning and design of wastewater conveyance systems, water supply and distribution systems, stormwater systems, and pump stations. Ben has completed the design of 50,000+ LF of sewer main rehabilitation and replacement projects in the recent past. Ben has conducted floodplain investigation, shoreline protection studies, drainage studies, channel design and modeling, water rights permitting, wetland analysis and design, small bridge design, infrastructure design, surveying, construction management, and construction quality control testing. He has been involved with all project phases from project initiation to construction document preparation and construction support. Ben is proficient in water resources modeling tools: AutoCAD, WaterCAD, HEC-RAS, HEC-HMS, GeoRAS, MOUSE, and ArcGIS.

Relevant Projects

Shoreway Sanitary Sewer Rehabilitation Design, City of Belmont, 2017 - 2019, Contract Value: \$129,000. As Project Manager, Ben Shick led the assessment of the feasibility of eliminating the existing pump station along Shoreway Drive by installing a new deeper gravity sewer main. The feasibility analysis included detailed topographic surveying, geotechnical investigations, detailed utility investigations, sewer system modeling, and alternative evaluation. Subsequently Schaaf & Wheeler developed detailed construction documents and provided bid and construction support services. The Shoreway sewer project was successfully designed and constructed within budget and schedule.

Sanitary Sewer Rehabilitation Projects, City of Belmont 2015 - 2020, Contract Value: 2015 - \$567,000; 2016 - \$456,961; 2017 - \$194,000. As Project Manager, Ben Shick led the evaluation, prioritization, and design of the rehabilitation and replacement of their high priority gravity sewer lines throughout the City. The 2015 Sewer Rehabilitation project consisted of the replacement and rehabilitation of approximately 2 miles of gravity sewer lines and associated manholes. Under Ben's supervision, Schaaf & Wheeler team provided detailed utility investigations, potholing, and sewer modeling services. The 2016 sewer rehabilitation project consisted of evaluating and preparing design documents for approximately 5 miles of gravity sewer lines located throughout the City in back yard easements and in City streets. Construction methods include pipe bursting, open trench excavation, and CIPP lining. A large portion of the sewer mains included within the City of Belmont sewer rehabilitation projects are located within backyard and side yard easements with difficult access and easement issues.

San Mateo Sanitary Sewer Rehabilitation Projects, City of San Mateo, 2014 – 2017, Contract Value: 2015 - \$191,000; 2017 – 2018 - \$500,000. As Project Manager, Ben Shick led site investigations, inspections, researched existing data, and developed recommended alternatives for sewer rehabilitation projects within the City. Provided detailed design of the recommended alternatives which consisted of: replacement of sewer lines across drainage channels (both above ground on piers, and below ground); replacement of sewer lines in back yard easements with tight access; replacement of sewer lines through large drainage box culverts; sewer line rehabilitation with cured-in-place pipe (CIPP); sewer main replacement and realignment; manhole rehabilitation and replacement; the work included geotechnical investigations, easement research, surveying, environmental permitting, and Caltrans Encroachment Permit.

Sanitary Sewer Rehabilitation Projects for City of Morgan Hill, 2019 – Present, Contract Value: \$162,285. Project Manager for 47 pipe segments. Evaluated and assessed the existing sewer infrastructure. Reviewed the existing sewer model to evaluate the pipe sizes and recommend the rehabilitation/replacement method. Visited each site to collect additional field data to properly assess the pipes and make recommendations. Prepared a TM summarizing the assessments, capital improvement recommendations and construction cost estimates. Subsequently designed the recommended improvements that include project basemapping, detailed utility investigations, evaluations to re-route sewer mains and laterals from backyard easements, plan and profiles of sewer lines, construction details, technical specifications, and cost estimates. The proposed construction methods were tailored to minimize impacts and costs at each location. Construction methods include pipe bursting, open trench, spot repairs, and CIPP rehabilitation.

**Benjamin L. Shick, P.E. – Principal-In-Charge – Schaaf & Wheeler**

Woodland Sewer Improvement Project, San Rafael Sanitation District, 2019 – 2020, Contract Value: \$237,213. This project includes pipe replacement, rehabilitation, adjusting pipe slope, and re-routing laterals along B Street, Woodland Avenue, Warner Court, Woodland Place, and Octavia Street. As Project Manager, Ben Shick coordinated topographic surveying, utility investigations and geotechnical investigation. Tasks included condition assessment and development of alternatives. Subsequently detailed design and bid documents are being prepared.

Harbor Drive Sewer Rehabilitation, Town of Corte Madera Sanitary District No. 2, 2019 – 2020, Contract Value: \$234,060. This project includes rehabilitation/replacement of 7,100+ LF of existing 6” and 8” VCP pipes - existing sewer mains within the Harbor Drive area. As Project Manager, Ben Shick coordinated CCTV inspection, conducted assessments and identified rehabilitation and replacement alternatives and methods. Subsequently the improvements were designed; currently our team is providing support services during construction.

Mill Valley Sewer Repair Project, City of Mill Valley, 2019 – 2020, Contract Value: \$131,000. As Project Manager, Ben Shick provided evaluation, assessment, and design services for the City of Mill Valley’s sanitary sewer system. This project prioritizes and develops a strategic plan to address the most critical infrastructure needs for future repairs to be constructed under the 2020 budget. Project tasks include surveys, investigations, and inspections for each project location to identify proposed improvements. 75% and 100% design documents along with construction support were provided for this project.

Belmont Water/Sewer Main Replacement, Mid-Peninsula Water District, 2017, Contract Value: \$87,610. As Project Manager, Ben Shick prepared engineering design for this joint CIP for the water and sewer mains. The project consists of replacing and rehabilitating the water mains, service lines and meters to address condition issues with the sewer mains. The project also includes additional street improvements. This project required close coordination and approval with multiple agencies including the City of Belmont, Mid-Peninsula Water District, Fire Marshal, Caltrans, and private developers. A Caltrans Encroachment Permit for work along El Camino Real was prepared, submitted, and obtained.

Kingridge Sanitary Sewer Improvements (6” and 8”; 3,100 LF), City of San Mateo, 2010 – 2015; Contract Value: \$927,673. As Project Manager, Ben Shick led the team for system evaluation, hydraulic analysis of the existing Kingridge canyon sewer and storm drain system, development of improvement alternatives for the sewer main, and development and production of construction documents for the selected alternative of the project to replace and rehabilitate the 6-inch sanitary sewer main. Some of the key features were: Alternative evaluation for alignment and construction methods; Emergency repairs to mitigate active land movement; Capacity evaluation; Open cut pipe replacement, CIPP rehabilitation, pipe on piers, retaining walls, etc.; Securing right-of-access to project location including permanent sewer easements; Environmental permitting, mitigation, and monitoring; Construction support, special inspection, and material testing services.

El Camino Real Sanitary Sewer Improvement Project and the Calabazas Creek Sewer Siphon Design Projects, City of Santa Clara, 2006 – 2009; Contract Value: \$480,520. As Project Manager, Ben Shick led the design of 2,600 feet of parallel sewer line in El Camino Real from Flora Vista Avenue to Calabazas Boulevard. The project also included a separate design plan set for a replacement sewer siphon with dual pipes under Calabazas Creek as part of a Santa Clara Valley Water District channel improvement project. Existing lateral connections were improved through cured-in-place pipe (CIPP) lining of 2,600 feet of parallel collector sewer and reconstruction. Tasks included the design of relocation of existing water mains, storm drains, sewer laterals, and traffic signals.

Cabrillo Avenue Sewer Replacement Project, City of Santa Clara, 2013 – 2014; Contract Value: \$104,793. As Project Manager, Ben Shick led the installation of a new 12-inch sewer line in Cabrillo Ave to replace the existing sewer line that ran in a utility easement through residential parcels. Design included plan and profile of a new 12-inch PVC sewer main, associated manholes, and lateral connections. This project also included the design for replacement of several smaller sewer and storm drain lines necessary to facilitate the installation of the new sewer mainline.

**Charles D. Anderson, P.E., President – Schaaf & Wheeler****Education**

BCE, Georgia Institute of Technology

MSCE (Water Resources Engineering), Stanford University, California

Licenses

Registered Civil Engineer
California C43776 Hawaii
15647

Nevada 11518

Washington 39715

Affiliations

FMA, ASCE



Charles D. Anderson, P.E. has 30+ years of experience in the areas of wastewater and stormwater collection and pumping, water supply and distribution, flood control and drainage, surface water hydrology and groundwater. As a project manager he is involved in all phases of project management and implementation from project feasibility to construction document preparation and construction support for a wide range of public and private clients. He has completed numerous flood insurance studies (FIS) and letters of map revision (LOMRs) for FEMA. Chuck's projects generally have multidisciplinary teams that help policy makers to arrive at reliable decisions that protect

communities from flood risk and the threat of climate change, most particularly sea level rise. His San Mateo Bayfront Levee Improvement project has won several state and regional awards. Chuck has demonstrated expertise in watershed and stochastic hydrology, open channel hydraulics, closed conduit hydraulics, pump station design, and storm drainage as well. His background also includes pipeline design, storage tank design, pump station design, hydraulic network modeling, wastewater collection includes septic systems, sanitary sewer design, pump station design, sanitary sewer modeling, and master planning.

Relevant ProjectsWastewater System Planning and Design

Rehabilitation of So. San Francisco Industrial Sewage Pump Stations 1, 2, 3, 4, 6, 7 and 8 (2010-19)

Sierra Point Sewage Pump Station – City of Brisbane/Wilsey Ham (2019)

Sanitary Sewer Pump Station Assessments - Cities of Alameda and San Mateo (2010)

South Trunk Relief Line - City of San Mateo (2010)

Sanitary Sewer Disposal System and Leachfields for Coyote Creek Golf Club – Castle & Cooke (1998)

Purissima Sanitary Pumping Station - Los Altos Hills (2000)

O'Keefe Road Sanitary Pump Station Relocation, Los Altos Hills - Biggs Cardosa Inc. (2003)

Mariner's Island No. 2 Sanitary Sewer Pump Station Rehabilitation - City of San Mateo (2004)

Stormwater System Planning and Design

Diridon Station Area Infrastructure Analysis – HMM Engineers (2016)

Warren Avenue Storm Drain Assessment – City of San Mateo (2016)

Storm Drain Master Plans - Half Moon Bay (2017), Santa Clara (2015), Milpitas (2012), Alameda (2008), Livermore (2006), and San Mateo (2004)

Laguna Area Storm Drain Analysis - City of Burlingame (2012)

Esplanade Storm Drain Outfall Replacement - Cotton Shires/City of Pacifica (2010)

Storm Drain Infrastructure PM and E. Laurel Creek Culvert Repair and Erosion Control - City of Belmont (2006)

Greenwood Avenue and Barroihlet Avenue Storm Drain Improvements - City of San Mateo (2006)

Soscol Area Residual Drainage Master Plan - City of Napa (2005)

Interior Drainage Analysis/LOMR for Lower Guadalupe River Project - CH2M-Hill and SCVWD (2005)

Stormwater Pump Stations

Chrysler Drive Pump Station Rehabilitation (230 cfs) – City of Menlo Park (2017)

Coyote Point and Poplar Avenue Pump Station Rehabilitation (250 cfs each) - City of San Mateo (2017)

Matadero Creek Storm Water Pump Station (390 cfs) - City of Palo Alto (2017)

PLC Programming Upgrades to 11 Stormwater Handling Sites – City of Palo Alto (2015 – 2017)

Design of Gippetti Pump Stations, Stormwater and Sewer Pump Stations – RJA & Assoc. (2015-2016)

City of Sunnyvale WPCP Master Plan and Primary Treatment Design – HDR, Inc. (2015)

Northside Pump Station Upgrades (180 cfs) - City of Alameda (2010)

San Francisquito Creek Storm Water Pump Station (300 cfs) - City of Palo Alto (2009)

Baylands Storm Water Pump Station No. 1 - City of Sunnyvale (2006)

Railroad Avenue OC Pumping Plant for Route 4 in Pittsburg - Mark Thomas & Company/Caltrans (2003)

Freedom Circle Stormwater Pump Station (70 cfs) - City of Santa Clara (2003)

Nelo-Victor Stormwater Pump Station Rehabilitation (200 cfs) - City of Santa Clara (2003)

Rambo Pump Station (150 cfs) - City of Santa Clara (2000)

Water Supply, Storage, and Distribution

**Charles D. Anderson, P.E., President – Schaaf & Wheeler**

Anderson Dam Seismic Retrofit Project - Santa Clara Valley Water District (ongoing)
San Jose General Plan Update, Water Supply Summary – David J. Powers & Assoc. (2015)
Kahakuloa Acres Private Water System Evaluation and Two Storage Tanks - Maui, Hawaii (2014)
Upper Miocene Canal, Paradise - Cotton Shires and Associates (2012)
Vista Pump Station and Water Tank Improvement - Town of Hillsborough/CSG Consultants (2010)
Kern River Raw Water Pumping Plant Forensic Investigation- Noriega and Bradshaw, LLP (2008)
Konocti Harbor Water Treatment, Storage, and Distribution Evaluation - Page Mill Properties (2007)
Potable wells, storage tanks, and water mains for Coyote Valley Specific Plan - City of San Jose (2006)
Waimanalo Reservoir Assessment, Martin v. State of Hawaii - State of Hawaii (2003)
Carmel Development Company Water System Mediation, Monterey - Harry & Linker, LLP (2000)
Highlands Booster Pump Station and Water Storage Tanks - Great Oaks Water Company (1998)
Well Nos. C-20, C-21, C-22, and C-23 - City of San Jose (2002)
Potable and Irrigation Water Supply, Storage & Distribution Systems for Coyote Creek Golf Club (1998)
Water System Network Modeling, Flow Testing, & Fire Flow Calculations - City of San Jose (2006)
[Floodplain Management and Infrastructure](#)
West Channel Enhancement – Google, Inc. (2018-2019)
San Francisquito-Adobe Creek Flood Study - Wood Rogers/ SCVWD (2016 – 2017)
Deer Island Flood Detention Basin – Marin County (2016-2017)
Drainage Review of Emergency Stabilization for Bear Gulch Road – Foundation Technologies, Inc. (2017)
Foster City Levee Improvements - City of Foster City (2016 – 2020)
Climate Change Impact Analyses - Alameda, Foster City, Menlo Park, Newark, San Jose, San Mateo (ongoing)
Berryessa/Penitencia Watershed Flood Study - Wood Rogers/SCVWD (2016)
Palo Alto Flood Basin Sea Level Rise Impact Study - SCVWD (2016)
Lower Penitencia Creek Improvements - Wood Rogers/SCVWD (2016)
Annual Levee Inspection - City of San Mateo (2016)
Colma Creek Floodplain Analysis – City of South San Francisco (2016)
Guadalupe River Bridge Hydraulics at Railyard Place - Biggs Cardosa Associates (2016)
Upper Llagas Creek Flood Protection Project - RMC Water & Environment/SCVWD (2016)
Permanente Creek Flood Protection Project - Hatch Mott MacDonald/SCVWD (2016)
Storm Water Detention Basins at Truckee River Floodwall - Reno-Sparks Indian Colony (2016)
San Francisquito Creek Hydrology Study Peer Review – SCVWD (2015)
Christopher Ranch Flood Study (2015)
Bayfront Canal Redwood City Flooding Issues – Stanford Real Estate (2015)
Old Mountain View Alviso Rd. Bridge Replacment Hydraulic Study - Biggs Cardosa Associates (2015)
Highway 101 Pedestrial/Bicycle Overcrossing at Adobe Creek – Biggs Cardosa Associates (2015)
Wrigley-Ford Creek Long Term Monitoring – HT Harvey & Associates (2015)
North Gilroy Neighborhood District Urban Services Area Amendment – EMC Planning Group (2014-2015)
Silicon Valley BART Extension Floodplain Analysis - Santa Clara Valley Transportation Authority (2013)
Bayfront Levee Improvement Project - City of San Mateo (2012)
San Tomas Aquino Creek Flood Study - Santa Clara Valley Water District (2012)
Recertification of Uvas, Stevens and Lower Penitencia Creek Levees – SCVWD (2009)
Truckee River Levee and Floodwall System - CFA Engineers (Sparks, NV) (2008)
O’Neill Slough Tide Gate Structure - City of San Mateo (2007)
Julian Street and William Street Bridge Retrofits at Coyote Creek - Biggs Cardosa Associates (2007)
S. Sutter County Flood Control Alternatives - Sacramento Area Flood Control Agency (2004)
SW Lemmon Valley Flood Control Master Plan/Channel Improvements - CFA, Inc. (Reno, NV) (2003)
Wooster Avenue Bridge Replacement - Advanced Engineering Design (San Jose) (2001)



Ryan Amaya, PLS

Principal Surveyor, Kier & Wright

Ryan Amaya has over 20 years of land surveying experience. His experience includes construction surveying, boundary surveying, mapping, and subdivision work related to land development. Specific survey experience includes construction staking, topographic surveys, benchmark level circuits, elevation monitoring surveys, tentative maps, parcel maps, final maps, condominium plans, plats and legal descriptions, lot line adjustments, lot combinations, reversion-to-acreage maps and ALTA/ACSM Land Title Surveys.



He is one of two managing principals in Kier & Wright’s Silicon Valley office. He manages all land surveying operations provided out of Kier & Wright’s Santa Clara and Gilroy office locations.

CERTIFICATION

California Professional Land Surveyor 8134

REPRESENTATIVE PROJECT EXPERIENCE

- Hayne Pump Station & Sugar Hill Pump Station Gravity Sewer Line Survey, Hillsborough
- City of San Mateo South Trunk Sanitary Sewer Relief Line, San Mateo
- City of San Mateo 42nd Avenue Sanitary Sewer Pump Station Project, San Mateo
- City of San Mateo B Street Storm Drain Project, San Mateo
- City of San Mateo Pump Station Laurie Meadows Site, San Mateo
- City of Half Moon Bay Bell Moon Sanitary Sewer Pump Station, Half Moon Bay
- City of San Bruno Crestmoor & Lomita Pump Station, San Bruno
- Old County Road Corridor Survey, Belmont
- Mid-Block Crossing for Google 475 Ellis Street, Mountain View
- Mid-Block Crossing for Google 1500 Salado, Mountain View
- Coleman/Hedding Intersection Improvements (permitted), San Jose
- Lexington Avenue Street Extension, San Jose
- City of Sunnyvale Tasman-Fair Oaks Pedestrian & Bicycle Circulation Plan, Sunnyvale
- 1900, 1950 & 2000 Charleston Rd. (surveying for pedestrian bike path), Mountain View
- Bubb Road Sidewalk Improvements, Cupertino
- Google Moffett Place Pedestrian & Bike Lane Improvements, Sunnyvale
- City of San Jose Coyote Creek Trail/Ridder Park Drive, San Jose
- City of Sunnyvale City-wide Water Line Replacement, Sunnyvale
- Alta Loma Park, South San Francisco
- Brentwood Park, South San Francisco
- City of Santa Clara El Camino Sanitary Sewer Improvements, Santa Clara
- City of Hermosa Beach Storm Drain Master Plan, Hermosa Beach
- Lafayette Street & Franklin Street Crosswalk, Santa Clara
- Lafayette Street & Lexington Street Crosswalks, Santa Clara
- City of Palo Alto Colorado Avenue Storm Drain Improvements, Palo Alto
- Topographic Survey for all Redwood City School District campuses (campuses located in Atherton, Menlo Park & Redwood City)



GREG SPROULL
Associate Biologist
sproull@wra-ca.com
o: 415.454.8868 x1870
c: 717.329.4451

Years of Experience: 11

Education

Master of Science, Biological Sciences, University of Denver, 2014

Bachelor of Science, Integrated Science and Technology, James Madison University, 2006

Professional Affiliations/Certifications

Association of Environmental Professionals, North Bay Vice President

Professional Wetland Scientist (PWS)-Society of Wetland Scientists (ID 3193)

CDFW Plant Voucher Collecting Permit Holder (#2081a-18-008-V)

California Native Plant Society

Northern California Botanists

Specialized Training

Basic Wetland Delineations (40 hrs), Wetland Training Institute, 2017

Advanced Hydric Soils, Wetland Training Institute, 2019

Special Recognitions

Fulbright Research Scholarship Award Winner, Department of State, Ecological Research, Poland, 2014

Integrated Science and Technology Methodology Award Winner, James Madison University, 2006



Greg Sproull is an associate biologist and project manager in WRA's San Rafael office. He has over a decade of scientific experience in the private and academic sectors in the United States and abroad. Prior to his time at WRA, Greg was a regulatory permitting specialist, wetland scientist, and botanist for an environmental consulting firm in the South San Francisco Bay Area, where he contributed to more than 50 environmental services projects. At WRA, Greg manages floristic surveys, vegetation mapping, and habitat assessments; coordinates and performs wetland delineations; and authors and manages regulatory permit applications, biological resource assessments for CEQA documents, and client reports. Greg regularly interfaces with local, state, and federal regulatory agencies, including the U.S. Army Corps of Engineers (Corps), the Regional Water Quality Control Board (RWQCB), the U.S. Fish and Wildlife Service (USFWS), the California Department of Fish and Wildlife (CDFW), California Coastal Commission (CCC), and the Bay Conservation and Development Commission (BCDC), for land use permits associated with restoration, development, mining, and mitigation banking. He also teaches a weeklong basic delineation course and a two-day advanced wetland delineation course at San Francisco State's Romberg-Tiburon Center. Greg combines his scientific expertise, critical thinking, and scientific editing experience to address clients' natural resource challenges with an efficient, measured, and objective approach.

Representative Projects

Curtner Road and Canyon Heights Booster Stations Improvement Project, Alameda County, California

Greg manages the biological resources and regulatory permitting component of the Curtner Road and Canyon Heights Booster Stations Improvement Project for the Alameda County Water District. Partnering with a development firm, Greg drafted a competitive proposal that won the bid for this project. Greg is responsible for supervising a team of biologists that will ensure that the rehabilitation of the subject booster stations is permitted effectively with the Corps, RWQCB, and CDFW. Greg has overseen the drafting of jurisdictional delineation memos, CEQA and permitting memos, CEQA-level biological resources assessments, and tree survey reports for this project. Greg's work in this capacity has been a boon to the County's timeline and overall vision of project implementation.

County of San Mateo, Mid-Coast Multi-Modal Trail Project, Unincorporated San Mateo County, California

The County's Department of Public Works proposed to construct a new two-directional multi-use trail parallel to Highway 1 from Coronado Street to Alto Avenue, which would be open for public access year-round. Greg coordinated with regulatory agencies, including the RWQCB and CDFW, to apply for permits that would enable the project to be implemented with a small environmental impact footprint. Greg's work facilitated a streamlined approach to regulatory permitting and provided agencies with pertinent guidance and feedback.



GREG SPROULL

Department of Water Resources/EIP, Lookout Slough Restoration Project, Dixon, California

The Lookout Slough Restoration project will create, restore, and maintain ideal habitat conditions to encourage the proliferation of Delta smelt, winter-run and spring-run Chinook salmon, as well as Central Valley steelhead, and longfin smelt. Restoration of the site will provide important spawning and rearing habitat, would support the aquatic food web, and would be generally beneficial to the recovery of these imperiled species. For this project, Greg managed applicable aquatic resource permits, including a Section 404 Nationwide permit for the Corps, a Section 401 Water Quality Certification for the RWQCB, and a Section 1602 Lake and Streambed Alteration Agreement for the CDFW. Additionally, Greg was a contributing author of the biological resources assessment that was included in the permit package.

Halo Ranch and North Bay Wetland Mitigation Banks, Petaluma and Unincorporated Marin County, California

The Halo Ranch Wetland Mitigation Bank proposed to convert undeveloped/agricultural land into a mitigation bank. Restoration would include establishment, re-establishment and rehabilitation of intermittent streams, tidal wetlands, and seasonal wetlands. These restored aquatic resources would mimic the historical conditions of the area and provide valuable ecosystem services for the watershed. Similarly, the North Bay Wetland Mitigation Bank proposed to construct a wetland mitigation bank to provide seasonal wetland re-establishment and enhancement mitigation credits for impacts to wetlands and waters regulated by Sections 404 and 401 of the Clean Water Act and the Porter-Cologne Act. For both mitigation bank projects, Greg served as project lead for all aquatic resource permits including Section 404 Nationwide Corps permits, Section 401 RWQCB Water Quality Certifications, Section 1602 CDFW Lake and Streambed Alteration Agreements, and BCDC permits.

Bayview Development Project, Mountain View, California

Greg is project manager of all biological requests associated with the construction of an extensive office park in Mountain View, California. In this capacity, Greg manages a team of four staff members who conduct invasive species and burrowing owl surveys, while also coordinating and contributing to ancillary projects for the client, including photometric analyses, biological monitoring, nesting bird surveys, and biological document review requests as they pertain to mitigation strategies. Greg also manages the project's budget, provides applicable guidance and instruction to staff, and regularly interfaces with an array of stakeholders with varying needs in his role with this project.

Malakoff Diggins Historic State Park Remediation Project, Nevada City, California

Greg manages this project from a biological resources and regulatory permitting perspective. Greg oversaw the completion of a large-scale (617-acre) biological resources assessment and actively coordinates with a diverse array of stakeholders associated with the project. Greg is also responsible for managing a formal wetland delineation of the property, as well as a series of focused rare plant surveys. Greg provides high-level guidance on regulatory permitting pathways with the Corps, RWQCB, and CDFW to ensure that the project is implemented as effectively as possible.

Santa Clara Valley Water District, Rancho Cañada de Pala Preserve Annual Monitoring Project, Santa Clara County, California

In December of 2015, the Santa Clara Valley Water District purchased the Rancho Cañada de Pala Preserve from The Nature Conservancy for providing mitigation for impacts associated with their Stream Maintenance Program. On the preserve, Greg conducted quarterly assessments of biological resources as they related to grazing. Additionally, Greg authored the majority of the annual monitoring reports for the site.



JANET KAN, GE, CEG, LEED AP

Principal Engineer

Janet joined ENGEO in 2003 and has extensive experience in geotechnical engineering. She has managed numerous large-scale projects in the South Bay including residential, commercial, mixed-use and master planned developments. Furthermore, Janet is familiar with preparation of geotechnical reports according to Caltrans, SP 117, and OSHPD guidelines.

Both a geotechnical engineer and a professional geologist, Janet's expertise includes developments on compressible deposits; mitigation of liquefiable sites; and seismic analyses including site response and spectral acceleration development. Janet is a proven and adept lead geotechnical engineer for many complex projects with technical challenges and multiple stakeholders.

EDUCATION

MS Civil Engineering University of California, Berkeley 2003

BS Geological Engineering University of British Columbia 2000

EXPERIENCE

Years with ENGEO: 16

Years with Other Firms: 2

REGISTRATIONS & CERTIFICATIONS

Geotechnical Engineer, CA 2880

Professional Engineer, CA 67311

Certified Engineering Geologist, CA 2590

Professional Geologist, CA 8557

LEED AP, CA

Professional Engineer, BC 45683

SPECIALIZATIONS

- Compressible Soils
- Construction Observation
- Deep Foundations
- Earth Retaining Structures
- Excavation and Shoring
- Foundation Design
- Levee Analyses
- Liquefaction Analyses
- Seepage Evaluation
- Seismic Spectra Development
- Slope Stability
- Tunneling

AFFILIATIONS

ASCE American Society of Civil Engineers



SELECT PROJECT EXPERIENCE

City of San Mateo Basin 2 and 3 - Pipelines and Pump Stations—San Mateo, CA

Principal Engineer. Janet is the geotechnical lead for the Basin 2 and 3 Collection System improvement project in San Mateo. She oversaw and reviewed geotechnical analysis and geotechnical and environmental reports. She is in charge of quality control of the geotechnical data reports and supported the design team during 30 and 60 percent design. The proposed collection system improvements include a new 5.2MG storage tank, new pump stations, rehabilitation of over 5 miles of existing and new pipelines in the City of San Mateo. The project is part of the Clean Water Program to upgrade aging infrastructure, enhance reliability, and provide capacity for wet weather flows in the collection system.

City of San Mateo South Trunk Sanitary Sewer Relief Line—San Mateo, CA

Senior Engineer. Janet provided technical review and oversight on the geotechnical and environmental studies for the South Trunk Sanitary Sewer relief project. She performed technical of the exploration program and laboratory testing program scheme improvements. She guided the project team with implementing micro-tunneling and trenchless pipeline installation technology in a seismically active area. The planned 8,025 linear foot, South Trunk Sanitary Sewer Relief Line extends from the Dale Avenue Pump Station to the intersection of Delaware Street and 25th Avenue. The currently planned South Trunk consists of a 36- to 54-inch-diameter pipe installed roughly 18 to 27 feet below grade. The South Trunk extends under Highway 101, the 16th Avenue culvert, and the 19th Avenue culvert. The planned 8,025 linear foot, South Trunk Sanitary Sewer Relief Line extends from the Dale Avenue Pump Station to the intersection of Delaware Street and 25th Avenue, aligned along Sunnybrae Boulevard and Delaware Street. The plan consists of a 36- to 54-inch-diameter pipe installed roughly 18 to 27 feet below existing grade at a very mild gradient. The South Trunk extends under three major undercrossings including Highway 101.

**JANET KAN, GE, CEG, LEED AP**
Principal Engineer**San Mateo Bayfront Levee Improvement—San Mateo, CA**

Project Manager. Janet prepared a supplemental geotechnical report for the Seal Slough Levee and the East End Levee of the master San Mateo Bayfront Levee Improvement project. The supplemental geotechnical services included drilling boreholes followed by settlement and liquefaction analyses, seepage analyses and slope stability analyses performed in accordance with guidelines provided by the U.S. Army Corp of Engineers. Janet provided recommendations for a below-grade slurry cut-off wall, sheet piling, and flood wall foundations design. In addition, Janet reviewed the project plans and specifications, and she assisted the civil engineer in preparing the bid package. The San Mateo Bayfront Levee Improvement project includes construction of over 2,000 feet of flood walls, reconstruction of several thousand feet of select sections of the Bayfront levee system, and construction of below-grade slurry wall cut-off structures. *This project received the 2012-13 CalGeo Outstanding Project Award and the 2013 ASCE Region 9 Outstanding Geotechnical Project Award.*

Northwest Wastewater Treatment Plant—Rio Vista, CA

Project Engineer. Janet performed geotechnical exploration and provided recommendations during grading operations of the project. She performed geotechnical analysis to evaluate soil strength, compressibility and risk of liquefaction. She developed different design recommendations for the bioreactor and pipeline due to difference in desired performance. The Northwest Wastewater Treatment Plant consists of constructing the bioreactor, detention and retention basins, solar drying beds, and other administrative and mechanical buildings. In addition, it also includes an effluent pipeline that extends into the Sacramento River.

Taube Koret Campus for Jewish Life—Palo Alto, CA

Project Manager. Janet oversaw the construction monitoring services provided for the project. She made frequent site visits and provided recommendations to mitigate shallow groundwater conditions and soft soil conditions within the project site. Mitigation efforts included ground improvement using compaction grouting. A sand slurry grout mixture was injected into soft ground to create grout columns roughly three feet in diameter.

Janet coordinated a cone penetration test within the soft ground area before and after ground improvement efforts. Janet worked closely with the client, contractor, and environmental team to handle hazardous materials removal problem. The Campus for Jewish Life project is a community center campus consisting of nine concrete buildings, ranging from 3 to 6 stories high, supported on shallow footings. The ground floors of the buildings are used as the parking garage and the buildings are linked by elevated walkways. The community center includes two elevated pools (a covered children's pool and an uncovered full-size lap pool), a soccer field, a senior center, a pre-school, and numerous rooms for community activities.



Mike Schratz - Project Manager

Experience: More than 10 years of experience in sewer and storm drain maintenance projects

Certifications:

NASSCO, PACP, LACP, MACP
40-Hour OSHA Hazwoper Training
OSHA Confined Space Certified

OSHA Fall Protection/Competent Person Certification
Certificate Flagger
Certified Traffic Control



Regular Sewer and Storm Drain Project Work at Presidio Systems, Inc. (PSI)

PSI utilizes Pipeline Observation System Management (POSM), the industry's preeminent sewer, storm drain, manhole, and pipeline inspection system.

Evaluation - Currently, PSI operates 3 mobile units to inspect and plot structural and maintenance deficiencies, grade the deficiency and prioritize the work load for the repair crews. PSI's PACP certified technicians go to assigned quadrants behind the cleaning crews. The data produced by PSI is standardized and reproducible, quality control verified and easily incorporated into GIS and other commonly used maintenance information systems. Once inspections are complete all information is uploaded on PSI's internal server and is pushed to the GIS program so that repair or engineering crews can click on a pipe tangent in the GIS and have access to the reports. Once repairs are completed there is a quadrant that is cleaned, inspected, and repaired in one operation.

Tracking - PSI tracks maintenance deficiencies to get a better idea of what is required for upcoming budgets. This feature is a specialty of PSI. PSI supports key clients to establish routine preventative maintenance schedules and often times PSI is requested to maintain or support a customized database of completed work. PSI has also assisted clients with tracking their problem areas so that they can properly assign cleaning crews, if needed.

Data Management - PSI clients focuses on the storm water system inventory, sewer audits, repair and rehabilitation programs on the lines that need it the most. The ability to look at pipe defects in GIS allows more cost benefit analysis to be conducted when making decisions on what repairs to conduct.

Action - PSI helps present the condition of the sewer to the decision-makers and enables the staff to visually present the efforts made to repair and rehabilitate the system. The database of sewer video inspections is made available to the field and office staff and contains the most up to date information from the video inspections.

Relevant Project

Mill Valley Stormwater Master Plan and Flood Control, Mill Valley, CA (2018). As a subconsultant to Schaaf & Wheeler, Presidio provided CCTV Inspection for 16 separate locations in Mill Valley for the Storm Drain Master Plan. The watersheds within Mill Valley are a combination of steep, highly vegetated lands in the upper reaches that flatten out quickly and outlet to Richardson Bay. The runoff is conveyed by natural gullies and creek channels; however, urbanization has modified this natural process. Many of the natural channels have been constrained by road crossings (culverts) and encroachment of the floodplain. The urbanized portions of Mill Valley rely on pipes, ditches and pumps to drain roads and parcels. **Contract Value: \$6,600. Role: CCTV Inspector**

Moraga Storm Drain Master Plan and Sinkhole Rehabilitation, Moraga, CA (2014 – 2017). As a subconsultant to Schaaf & Wheeler, Presidio provided CCTV Inspection for up to 15,000-ft of linear pipe along with as required cleaning and additional televising on as need basis. Much of the current storm drain system of the Town of Moraga is made up of hillside systems that incorporate pipe networks, ditches and culverts. These are in various conditions ranging from good to highly corroded. **Contract Value: \$15,000. Role: CCTV Inspector**

CCTV on Storm Drain System at LBNL, Berkeley, CA (Ongoing). CCTV inspection on the Storm Drain system at LBNL. Work is on incredibly steep grades and has to be all done at night. It also involves traffic control of all the equipment. The work is 3 weeks long with 40 hours a week. Services include CCTV truck and crew and one traffic control flagger all at night. **Contract Value: \$57,000 - 3 Man certified crew. Role: CCTV Inspections Project Manager**

Port of Oakland, 7th Street Outfall Investigation, Oakland, CA (2017). As subcontractor to Schaaf & Wheeler, Presidio Systems provided Hydro-Cleaning and CCTV for a 75 linear foot section of the outfall pipe located at the Port. The work was done at low tide. The existing outfall is an 18-inch reinforced concrete pipe and is embedded in the existing rip-rap covered shoreline. There is an existing hydro-dynamic separator trash capture unit directly upstream of the outfall. **Contract Value: \$4,500. CCTV Inspections Project Manager**

Blue Line Transfer Facility CCTV, San Francisco, CA (2018). This project investigates industrial discharge to improve water quality to meet NPDES discharge limits or to compare to diversion to SSF WTP. As subcontractor to Schaaf & Wheeler, Presidio Systems CCTV/Hydro-Clean approximately 3,000 linear feet of storm drain pipe located at Blue Line Transfer Facility in San Francisco. Due to the traffic at the facility the work was done off hours. The cleaning took 4 days as there was large amount of debris in the line. **Contract Value: \$11,000. Role: CCTV Inspections/Hydro-Clean Project Manager**

| City of Los Altos Adobe Creek Sewer Replacement Schaaf & Wheeler Revised September 23, 2020 | | | | | | Principal Project Manager | Senior Project Manager | Associate Engineer | Junior Engineer | Drafter | Schaaf & Wheeler Total | Geotechnical Subconsultant - Engo | Environmental and Permitting Subconsultant - WRA | Surveying Consultant - Kier & Wright | CCTV Subconsultant - Presidio Systems Inc. | Project Total |
|--|----------|----------|----------|----------|----------|---------------------------|------------------------|--------------------|-----------------|-------------|------------------------|-----------------------------------|--|--------------------------------------|--|---------------|
| Task: | \$225.60 | \$211.50 | \$178.60 | \$155.10 | \$145.70 | | | | | | | | | | | |
| 1 Environmental Approval | 0 | 12 | 0 | 0 | 0 | \$2,538.00 | \$10,000.00 | \$35,500.00 | | | | | | | | \$48,038.00 |
| A Biological Survey and Memorandum | | | | | | \$0.00 | | \$9,600.00 | | | | | | | | \$9,600.00 |
| B Cultural Resources Evaluation and Memorandum | | | | | | \$0.00 | | \$9,500.00 | | | | | | | | \$9,500.00 |
| C Arborist Survey and Report | | | | | | \$0.00 | | \$8,500.00 | | | | | | | | \$8,500.00 |
| D CEQA and Permitting Strategy | | 4 | | | | \$846.00 | | \$3,900.00 | | | | | | | | \$4,746.00 |
| E CEQA Support and Coordination | | 4 | | | | \$846.00 | | \$4,000.00 | | | | | | | | \$4,846.00 |
| F Geotechnical Hazard Report | | 4 | | | | \$846.00 | \$10,000.00 | | | | | | | | | \$10,846.00 |
| 2 Permitting & CEQA (Optional/As-Required) | 0 | 16 | 0 | 0 | 0 | \$3,384.00 | \$0.00 | \$77,200.00 | | | | | | | | \$80,584.00 |
| A Preparation of Section 1602 Lake and Streambed Alteration Agreement Application for the CDFW | | 4 | | | | \$846.00 | | \$7,700.00 | | | | | | | | \$8,546.00 |
| B Preparation of Section 404 Nationwide Permit Application for the Corps | | 4 | | | | \$846.00 | | \$16,700.00 | | | | | | | | \$17,546.00 |
| C Preparation of the Section 401 Water Quality Certification Application for the RWQCB | | 4 | | | | \$846.00 | | \$17,800.00 | | | | | | | | \$18,646.00 |
| D Preparation of Initial Study/Mitigated Negative Declaration | | 4 | | | | \$846.00 | | \$35,000.00 | | | | | | | | \$35,846.00 |
| 3 Right-of-Way Services (15 Plat & Legal Descriptions, 25 Title Reports) | | 6 | 6 | | | \$2,340.60 | | | | | \$112,500.00 | | | | | \$114,840.60 |
| 4 Predesign | 8 | 76 | 48 | 28 | 0 | \$30,794.40 | \$60,000.00 | \$0.00 | | | \$78,900.00 | \$25,000.00 | | | | \$194,694.40 |
| A Topographic Survey (3,300 LF) | | | 8 | 8 | | \$2,669.60 | | | | | \$78,900.00 | | | | | \$81,569.60 |
| B CCTV and Potholing Allowance | | 8 | | | | \$1,692.00 | | | | | | \$25,000.00 | | | | \$26,692.00 |
| C Alignment Study and Basis of Design | 8 | 60 | 40 | 20 | | \$24,740.80 | | | | | | | | | | \$24,740.80 |
| D Detailed Geotechnical Report | | 8 | | | | \$1,692.00 | \$60,000.00 | | | | | | | | | \$61,692.00 |
| 5 65% Design | 8 | 32 | 80 | 80 | 120 | \$52,752.80 | \$6,000.00 | | | | | | | | | \$58,752.80 |
| 6 100% Design | 8 | 32 | 60 | 60 | 84 | \$40,833.60 | \$6,000.00 | | | | | | | | | \$46,833.60 |
| 7 Final Design | 8 | 16 | 20 | 24 | 40 | \$18,311.20 | \$5,000.00 | | | | | | | | | \$23,311.20 |
| 8 Bid Support | 2 | 20 | 8 | | | \$6,110.00 | | | | | | | | | | \$6,110.00 |
| Total (Including Optional Task) | 34 | 210 | 222 | 192 | 244 | \$157,064.60 | \$87,000.00 | \$112,700.00 | \$191,400.00 | \$25,000.00 | | | | | | \$573,164.60 |
| Total (Excluding Optional Task) | 34 | 194 | 222 | 192 | 244 | \$153,680.60 | \$87,000.00 | \$35,500.00 | \$191,400.00 | \$25,000.00 | | | | | | \$492,580.60 |

**CONSENT CALENDAR****Agenda Item # 3****AGENDA REPORT SUMMARY**

Meeting Date: October 27, 2020

Subject: Construction Contract Award:
El Monte Avenue Sidewalk Gap Closure Project, TS-01038

Prepared by: Kathy Kim, Assistant Civil Engineer

Reviewed by: Jim Sandoval, Engineering Services Director

Approved by: Chris Jordan, City Manager

Attachment(s):

1. Bid Summary dated October 22, 2020
2. Project Site Plan

Initiated by:

City Council CIP Project TS-01038

Previous Council Consideration:

None

Fiscal Impact:

Based on the lowest responsive and responsible bidder, the estimated project costs and funding sources are broken down, as follows:

El Monte Avenue Sidewalk Gap Closure Project, TS-01038

| Project Item | Project Budget |
|---|-----------------------|
| Estimated Project Costs | |
| Design and Engineering (TJKM) | \$45,340 |
| Design and Engineering (Traffic Patterns/ActiveWayz) | \$33,527 |
| Construction | \$512,315.44 |
| Construction Contingency (15%) | \$76,847.32 |
| Inspection | \$33,592 |
| Engineering Support during Construction (Traffic Patterns/ActiveWayz) | \$7,625 |
| Printing/Advertising/Mailing/Misc. | \$ 10,000 |
| Estimated Total Cost | \$ 721,246.76 |
| Breakdown of Budget Funding Sources | |
| CIP – Prior Appropriations | \$191,000 |
| Community Development Block Grant (CDBG) – FY19/20 | \$303,933 |
| Current Approved Budget | \$511,000 |
| Budget Requested from Traffic Impact Fee (TIF) Fund above the Current Approved Budget | \$226,313.76 |
| Total Project Budget | \$721,246.76 |



Subject: Construction Contract Award: El Monte Avenue Sidewalk Gap Closure Project, TS-01038

The CIP and CDBG funding sources are included in the approved budget. However, since these funding sources are insufficient to cover the project's costs, staff recommends the use of Traffic Impact Fee in the amount of \$226,313.76. The TIF fund currently has approximately \$530,000 in unencumbered funds. Staff is anticipating another \$1.4M in TIF revenue from housing development projects approved in FY-2018/19 and FY-2019/20.

Environmental Review:

Categorically Exempt pursuant to CEQA Section 15301(c)

Policy Question(s) for Council Consideration:

None

Summary:

- On September 29, 2020, City advertised the El Monte Sidewalk Gap Closure Project.
- On October 22, 2020, City received and opened 10 bids in public virtual session.

Staff Recommendation:

Award the Base Bid for the El Monte Sidewalk Gap Closure Project to FBD Vanguard Construction, Inc., and authorize the City Manager to execute a contract in the amount of \$512,315.44 and up to 15% contingency on behalf of the City.

Purpose

Award the Base Bid for the El Monte Avenue Sidewalk Gap Closure Project to FBD Vanguard Construction, Inc., and authorize the City Manager to execute a contract in the amount of \$512,315.44 and up to 15% contingency on behalf of the City.

Background

The El Monte Avenue Sidewalk Gap Closure project was initiated in 2017, but then delayed since 2018 due to design restrictions impacting private properties, staffing and General Fund budget constraints. The intent of the project is to provide a dedicated pedestrian pathway along the west side of El Monte Avenue between Almond Avenue and S. Clark Avenue. The City reinitiated the project with a simpler design at the end of summer to take advantage of existing Community Development Block Grant (CDBG) Funds, which will expire on June 30, 2021. The City held a community outreach meeting on August 19, 2020 to identify a preferred community design alternative between the 2018 design and the 2020 simplified design alternative.

The new design limits private property impacts by building a shared use bicycle and pedestrian facility with pavement treatments to define a designated pedestrian pathway. The new design concept is more cost effective to the City and eliminates private property impacts to vegetation along El Monte Avenue, helping to preserve the street's rural character. Specific design treatments include:



Subject: Construction Contract Award: El Monte Avenue Sidewalk Gap Closure Project, TS-01038

- **Buffered Bicycle Lanes on both sides of El Monte Avenue**
A 2-FT striped buffer will be provided on both sides of El Monte Avenue to provide consistent design treatments between S. Clark Avenue and Almond Avenue.
- **Low-Profile Rubber Curbing within Buffer Zones**
The project proposed the use of low-profile (~3.5-Inches) at intersection approaches only to discourage cars from driving into the bicycle/pedestrian zones to pass other vehicles waiting to make left turns off El Monte Avenue. Limiting the low-profile curb to intersection approaches maintains easy access to private properties along El Monte Avenue and parking spaces on the street.
- **Roadway Widening Treatment**
A shared use bicycle-pedestrian space along the north side of Almond Avenue is proposed that is approximately 11-FT wide, including the 2-FT striped buffer zone. The roadway widening will provide consistent pavement treatment along El Monte Avenue.
- **Distinctive Pedestrian Pathway Treatments**
To designate the pedestrian portion of the shared bicycle-pedestrian space, a muted but distinctive pavement treatment will be used to distinguish pedestrian vs bicycle pathways. Input on specific color tones and texture treatment is requested.
- **Painted Intersection Returns at Higgins Avenue and El Monte Court**
The original design concept delayed in 2018 removed landscape and vegetation at each of the intersection returns at Higgins Avenue and El Monte Court. The new design concept tightens the returns at each intersection using striping treatments and the low-profile rubber curbing.
- **All-Way STOP at N. El Monte Avenue & S. Clark Avenue**
A new All-Way STOP at N. El Monte Avenue & S. Clark Avenue is proposed in response to resident input regarding speeding concerns and to improve the pedestrian crosswalk experience at the intersection for students at Almond Elementary School.
- **Flashing Beacon at El Monte Avenue & Mills Avenue**
The proposed project retains the proposed rectangular rapid flashing beacon to cross El Monte Avenue at Mills Avenue.

On September 30, 2020, the Complete Streets Commission reviewed and provided input on the design alternatives and concurred with implementation of the 2020 design.

Discussion/Analysis



Subject: Construction Contract Award: El Monte Avenue Sidewalk Gap Closure Project, TS-01038

On September 29, 2020, City advertised CIP Project TS-01038. On October 22, 2020, 10 bids were received and opened in a public virtual session via RingCentral in order to avoid indoor gathering. The bid result summary is provided in Attachment 1. The three lowest bidders, Guerra Construction, ASG Builders, and Kerex Engineering, did not use revised quantities as indicated in the Addendum No.1 or had errors in the bid schedule. These bidders have been disqualified and the next lowest bidder, FBD Vanguard Construction, Inc, was found responsive and responsible in the amount of \$512,315.44. The City Attorney has reviewed disqualified bids and concurs with staff's findings.

Base Bid items include pathway improvement work for pedestrians and bicyclists, concrete driveway installation in the public right-of-way, Rectangular Rapid Flashing Beacon installations, signage and thermoplastic striping.

Public notices will be sent to residents as soon as the project is awarded by Council. Residents will be provided with information to follow project details, schedule and updates on the City website. The Contractor will also be required to distribute notification letters to affected residents and post street signages at least 48-hours prior to start of work.

Options

- 1) Award the Base Bid for the El Monte Sidewalk Gap Closure Project to FBD Vanguard Construction, Inc., and authorize the City Manager to execute a contract in the amount of \$512,315.44 and up to 15% contingency on behalf of the City.

Advantages: Contractor is the lowest responsive and responsible bidder. Project will provide preventative maintenance and improve street and alley conditions.

Disadvantages: None

- 2) Reject all bids and re-advertise the project.

Advantages: None

Disadvantages: It is not anticipated that re-advertising the bid will result in lower bids. Bicycle and pedestrian pathway improvements on El Monte Avenue will be delayed, and the City will miss the opportunity to use the CDBG funding.

Recommendation

- 1) The staff recommends Option 1. Award the Base Bid for the El Monte Sidewalk Gap Closure Project to FBD Vanguard Construction, Inc., and authorize the City Manager to execute a contract in the amount of \$512,315.44 and up to 15% contingency on behalf of the City.

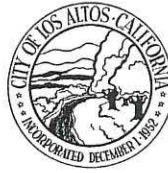


CITY OF LOS ALTOS
El Monte Sidewalk Gap Closure Project TS-01038
BID OPENING

October 22, 2020 2:00 PM
Virtual Bid Opening via Ring Central Conference Call

| CONTRACTOR | TOTAL BID |
|---------------------------|---------------|
| ASG Builders | \$446,968.00 |
| Ray's electric | \$ 549,767.00 |
| Wattis Construction | \$ 549,651.00 |
| Kerex Engineering | \$ 489,956.00 |
| Sposeto Engineering | \$ 530,498.35 |
| Guerre Construction Group | \$ 444,469.00 |

BIDS HAVE NOT BEEN VERIFIED



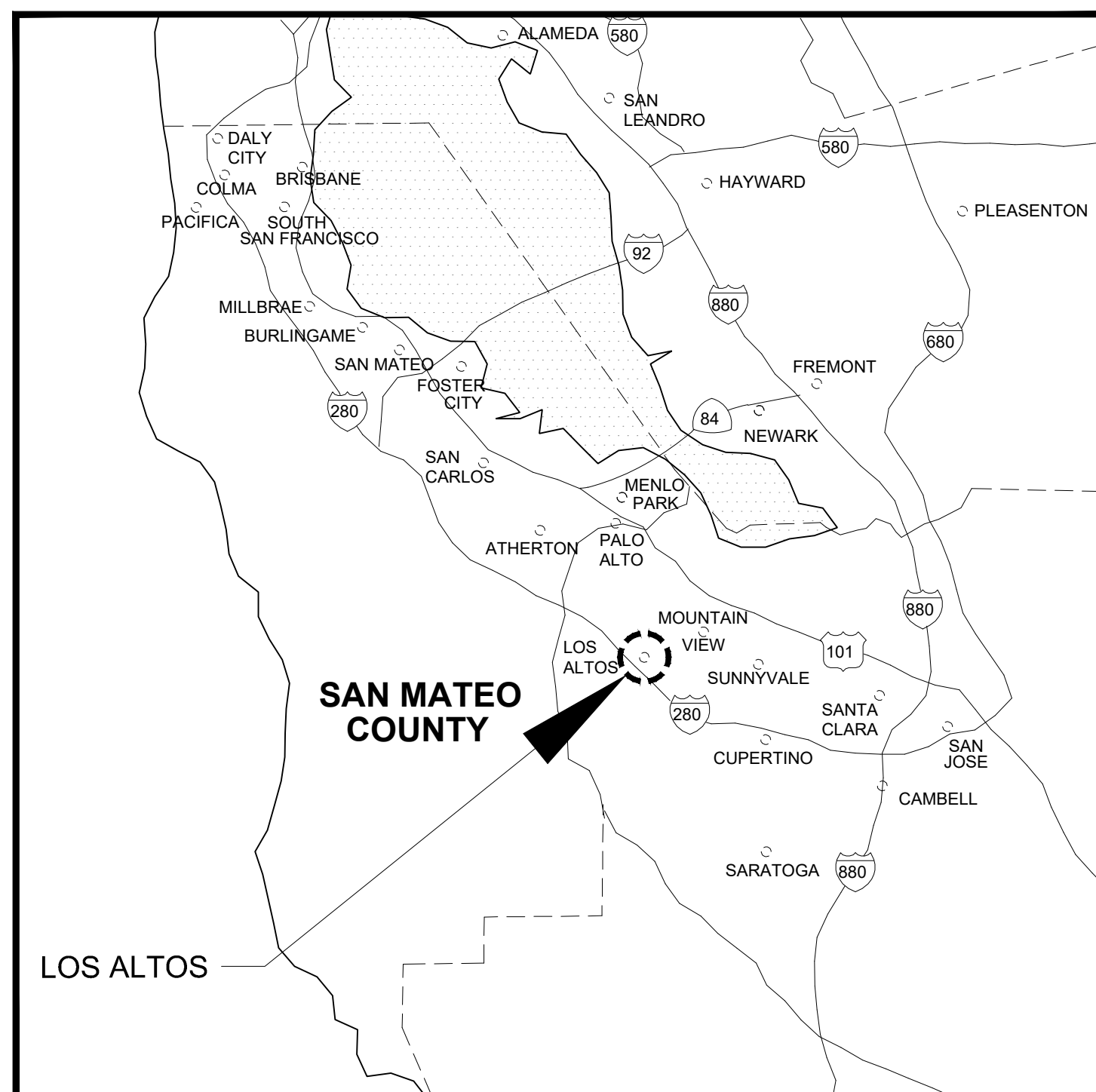
CITY OF LOS ALTOS
El Monte Sidewalk Gap Closure Project TS-01038
BID OPENING
October 22, 2020 2:00 PM
Virtual Bid Opening via Ring Central Conference Call

| CONTRACTOR | TOTAL BID |
|---------------------------|---------------|
| Galeb Paving Inc. | \$ 678,909.00 |
| FBD Vanguard construction | \$ 512,315.44 |
| Redgewick construction | \$ 533,776.00 |
| Grade Tech Inc. | \$ 724,016.00 |
| | |
| | |

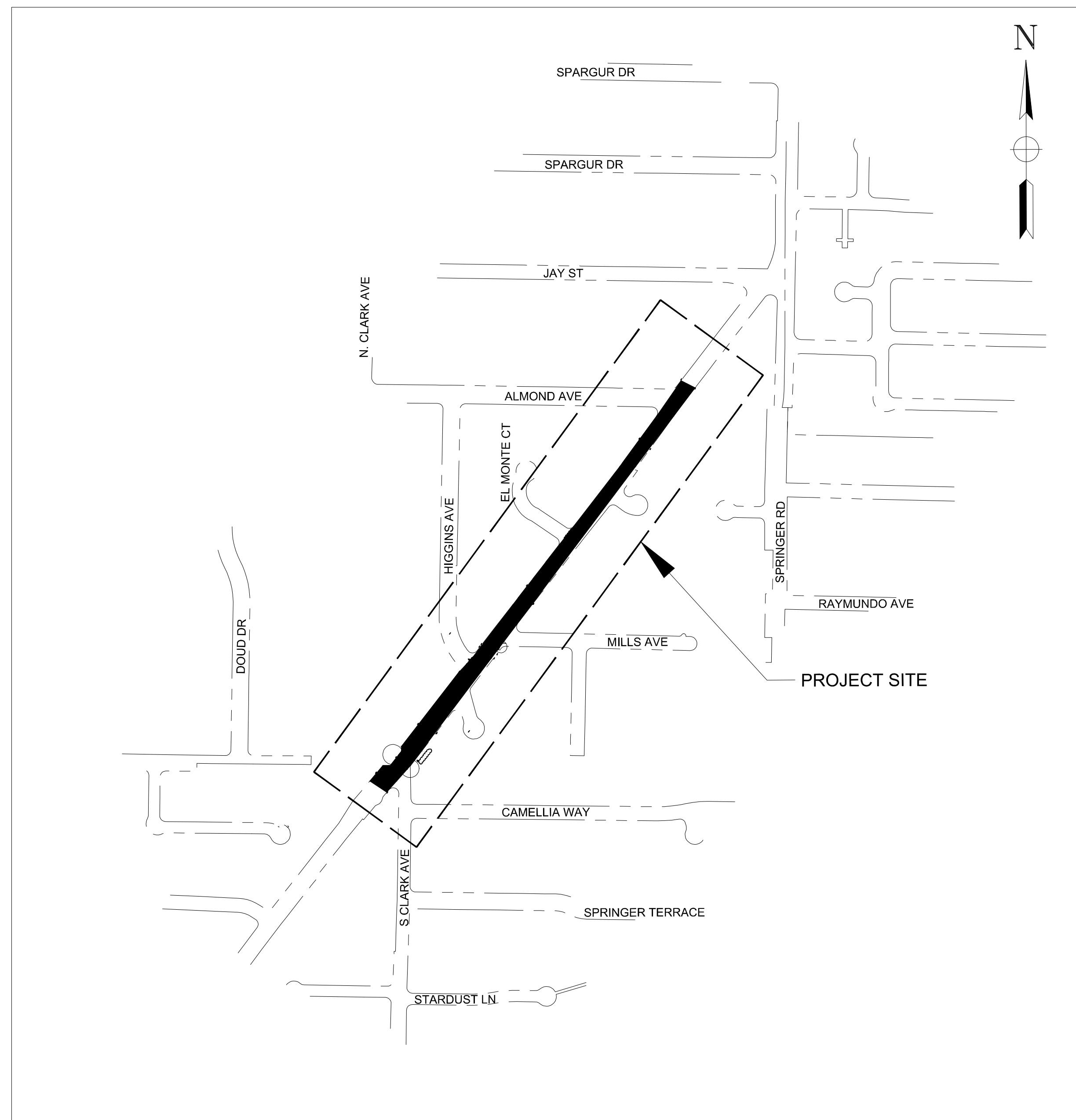
BIDS HAVE NOT BEEN VERIFIED

CITY OF LOS ALTOS

EL MONTE AVE SIDEWALK GAP CLOSURE PROJECT (TS-01038)



PROJECT VICINITY MAP
NOT TO SCALE




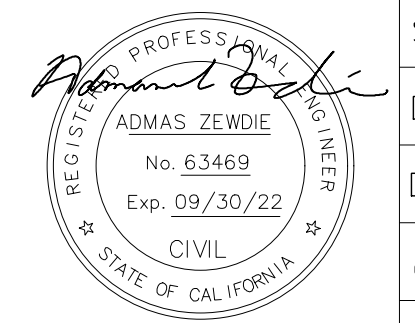
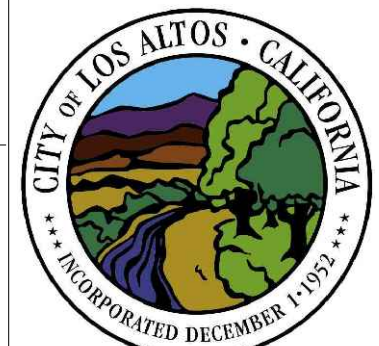
PROJECT LOCATION MAP
NOT TO SCALE

SHEET INDEX

- 1 TITLE SHEET
- 2 GENERAL NOTES, LEGEND AND ABBREVIATIONS
- 3 EL MONTE AVE SIDEWALK GAP CLOSURE IMPROVEMENT PLAN
- 4 EL MONTE AVE SIDEWALK GAP CLOSURE IMPROVEMENT PLAN
- 5 CONSTRUCTION DETAILS
- 6 CONSTRUCTION DETAILS
- 7 CITY STANDARD DETAILS
- 8 CALTRANS STANDARD DETAILS
- 9 SIGNAGE AND STRIPING PLAN
- 10 RRFB INSTALLATION AT N EL MONTE AVENUE & MILLS AVENUE
- 11 BLUEPRINT FOR A CLEAN BAY



Know what's below.
Call before you dig.

| | | | | | | | | | | |
|------|-------------|------------|--|---|--------------|-------------------------|--|---|---|--|
| 01 | Bid Set | 09/28/2020 |  <p>7901 Oakport St, Suite 4225 Oakland, CA 94621 www.activewayz.engineering (510) 989-2420</p> |  <p>REGISTERED PROFESSIONAL ENGINEER ADAMAS ZEWDIE No. 63469 Exp. 09/30/22 CIVIL STATE OF CALIFORNIA</p> | SCALE: | AS SHOWN | EL MONTE AVE SIDEWALK GAP CLOSURE PROJECT TS-01038 |  | City of Los Altos Santa Clara County California | City of Los Altos Project No. TS-01038 |
| Rev. | Description | Date | | | R.C.E. 63469 | DATE SIGNED: 09/28/2020 | | | | |
| | | | | | DRAWING BY: | AZ | | | | |
| | | | | | CHECKED BY: | DA | | | | |

LEGEND

GENERAL NOTES

- TYPICAL DETAILS REFERENCED ON THESE DRAWINGS ARE FROM THE CITY OF LOS ALTOS STANDARD PLANS FOR STREET, SEWER, STORM DRAIN AND CONCRETE IMPROVEMENTS AND FROM THE CALTRANS STANDARD PLANS (2018 EDITION).
- CONTRACTOR SHALL RESTORE ALL FACILITIES OUTSIDE LIMITS OF WORK DAMAGED BY CONSTRUCTION OPERATIONS TO THEIR ORIGINAL CONDITION AT NO ADDITIONAL COST TO THE CITY. ANY DAMAGE TO THE EXISTING FACILITIES INCLUDING, BUT NOT LIMITED TO: TREES, LANDSCAPING, IRRIGATION, STORM, SEWER, UTILITY SERVICES, FENCES, WALLS, SIDEWALK, AND PAVEMENT SURFACES SHALL BE RESTORED AT CONTRACTOR'S EXPENSE.
- THE PLANS MAY NOT SHOW ALL OF THE UTILITIES. THE CONTRACTOR SHALL VERIFY BY POTHOLES ALIGNMENT AND ELEVATION OF EXISTING UTILITIES AFFECTING THE WORK PRIOR TO CONSTRUCTION. PRIOR TO ANY DIGGING, CALL U.S.A. (800) 227-2600 OR 811 A MINIMUM OF 2 WORKING DAYS IN ADVANCE OF EXCAVATION. CONTRACTOR TO REMOVE ALL TEMPORARY MARKINGS AT THE END OF THE PROJECT.
- IF SAW CUTTING AND/OR TRENCH EXCAVATION ACTIVITIES RESULT IN A WIDTH OF LESS THAN 4 FEET OF EXISTING PAVEMENT REMAINING BETWEEN THE PROPOSED EDGE OF TRENCH AND EXISTING EDGE OF PAVEMENT, THE CONTRACTOR SHALL REMOVE THIS REMNANT "SLIVER" OF PAVEMENT ENTIRELY AND RESTORE IT TO ITS ORIGINAL FULL WIDTH DURING SURFACE RESTORATION. THIS PAVING WORK SHALL BE CONSIDERED INCIDENTAL AND NO ADDITIONAL COMPENSATION WILL BE ALLOWED.
- ALL PAVEMENT SHALL BE SAWCUT FULL DEPTH FOR PAVEMENT REMOVAL.
- EXISTING UTILITY CROSSINGS AS SHOWN ON THE PLANS ARE APPROXIMATE. VERIFICATION BY POTHOLES OF HORIZONTAL AND VERTICAL EXISTING UTILITY ALIGNMENTS SHALL BE THE RESPONSIBILITY OF CONTRACTOR.
- TRAFFIC CONTROL DURING CONSTRUCTION SHALL BE THE CONTRACTOR'S RESPONSIBILITY AND IN ACCORDANCE WITH THE CONTRACT DOCUMENTS. THE CONTRACTOR SHALL SUBMIT A WRITTEN TRAFFIC CONTROL & SIGNED PLANS TO BE APPROVED BY CITY PRIOR TO START OF WORK. THE CONTRACTOR SHALL PROVIDE ALL LIGHTS, SIGNS, BARRICADES, FLAGGERS AND OTHER DEVICES TO PROVIDE VEHICULAR, BICYCLE, AND PEDESTRIAN SAFETY.
- CONTRACTOR SHALL PROTECT ALL UTILITY STRUCTURES AND SURVEY MONUMENTS WITHIN THE WORK AREAS. THE CONTRACTOR SHALL REVIEW THE WORK SITES PRIOR TO SUBMISSION OF BIDS.
- EXISTING CITY MONUMENTS SHALL NOT BE DISTURBED. PER SECTION 8771 OF THE CALIFORNIA BUSINESS AND PROFESSIONAL CODE, ANY MONUMENTS THAT ARE ACCIDENTALLY DISTURBED BY THE CONTRACTOR SHALL BE REPLACED BY A PROFESSIONAL LAND SURVEYOR REGISTERED IN THE STATE OF CALIFORNIA, AND A RECORD OF SURVEY OR CORNER RECORD SHALL BE PREPARED AND FILED. THE REPLACEMENT OR RELOCATION OF THESE SURVEY MONUMENTS MUST BE COORDINATED WITH THE COUNTY SURVEY DEPARTMENT. THE REPLACEMENT OR RELOCATION OF THESE MONUMENTS SHALL BE AT NO ADDITIONAL COST TO THE CITY.
- ALL NEW STREET SURFACES AND CONCRETE GUTTERS SHALL BE WATER TESTED BY THE CONTRACTOR TO ENSURE POSITIVE DRAINAGE AND ELIMINATION OF BIRD BATHS PRIOR TO INITIAL ACCEPTANCE.
- THE CONTRACTOR SHALL VERIFY AND OBTAIN APPROVAL FROM THE CITY ARBORIST PRIOR TO ANY TRIMMING, REMOVAL, AND/OR DISTURBANCE OF EXISTING TREE ROOTS.
- THE CONTRACTOR'S DAY WORK OPERATIONS SHALL BE LIMITED TO THE HOURS BETWEEN 7:00 A.M. AND 5:00 P.M., UNLESS OTHERWISE SPECIFIED IN THE SPECIAL PROVISIONS, THE CONTRACT PLANS, OR APPROVED IN ADVANCE BY THE CITY ENGINEER.
- NOT ALL OVERHEAD UTILITIES ARE SHOWN ON THESE PLANS. CONTRACTOR SHALL VERIFY LOCATIONS AND USE CAUTION WHEN WORKING WITH EQUIPMENT NEAR OVERHEAD UTILITIES.
- ALL STREETS SHALL BE SWEEPED AND KEPT CLEAN AT THE END OF EACH DAY AND SHALL COMPLY WITH ALL APPLICABLE REGIONAL WATER QUALITY CONTROL BOARD REQUIREMENTS FOR THE DURATION OF THE PROJECT.
- DRIVEWAY ACCESS SHALL BE PROVIDED AT ALL TIMES. TRENCHING AND EXCAVATION SHALL BE PLATED OR TEMPORARILY BACKFILLED WITH AGGREGATE BASE MATERIAL. TEMPORARY CLOSURES SHALL BE ALLOWED WITH A MINIMUM 48 HRS NOTIFICATION TO RESIDENT(S) AND APPROVAL OF CITY.

DATUM

THE HORIZONTAL DATUM USED TO THIS PROJECT IS ON " STATE PLANE COORDINATES CALIFORNIA ZONE 3" - SPC CA3 AND VERICAL DATUM IS ON "NORTH AMERICAN VERTICAL DATUM 88"-NAVD88".

| SURVEY POINT # | NORTHING (FT) | EASTING (FT) | ELEV (FT) | DESCRIPTION |
|----------------|---------------|--------------|-----------|---------------------------|
| EL MO 1 | 1,965,222.28 | 6,096,533.91 | 152.03 | PK ON EL MONTE |
| EL MO 2 | 1,966,600.18 | 6,097,577.51 | 126.42 | PK AT EL MONTE AND ALMOND |
| EL MO 4 | 1,965,737.35 | 6,096,971.58 | 140.91 | PK AT ELMONTE AND MILLS |
| EL MO 5 | 1,966,311.06 | 6,097,416.87 | 128.99 | PK AT EL MONTE AND CASTLE |
| EL MO 6 | 1,965,289.16 | 6,096,627.16 | 151.16 | PK AT EL MONTE AND CLARK |

| EXISTING | PROPOSED | |
|------------|----------|--|
| SS | SS | SANITARY SEWER |
| SD | SD | STORM DRAIN |
| DW | DW | DOMESTIC WATER LINE |
| G | G | GAS LINE |
| CATV | CATV | CABLE TELEVISION LINE |
| EOH | EOH | OVERHEAD LINE |
| T | T | TELEPHONE LINE (UNDERGROUND) |
| FO | FO | FIBER OPTICS LINE |
| COM | COM | COMMUNICATION (CABLE AND TELEPHONE) LINE |
| JP | JP | JOINT UTILITY POLE |
| PP | PP | POWER POLE |
| SSMH | SSMH | SANITARY SEWER MANHOLE |
| SDMH | SDMH | STORM DRAIN MANHOLE |
| W | W | WATER VALVE |
| (FS XX.XX) | FG XX.XX | FINISHED GRADE |
| (TC XX.XX) | TC XX.XX | TOP OF CURB |
| (X.XX%) | X.XX% | SLOPE |
| | | FIRE HYDRANT |
| | | STREET LIGHT |
| | | CURB & GUTTER |
| | | SAW CUT LINE |
| | | CENTERLINE |
| | | RIGHT OF WAY |

| | |
|--|--|
| | EXISTING DRIVEWAY |
| | METHYL METHACRYLATE RESIN (MMA) |
| | PCC |
| | HMA (TYPE A) DEEPLIFT (6" DEPTH) |
| | GRIND AND OVERLAY (2" MIN) |
| | SHOULDER BACKING (CRUSHED GRAVEL OR NATURAL ROUGH SURFACED GRAVEL) |
| | DETECTABLE WARNING SURFACE (CAST IRON) |
| | CURB RAMP PAY LIMIT |
| | RECTANGULAR RAPID FLASHING BEACON |
| | RUBBER CURB |
| | RUBBER CURB END CAP |
| | GRADE TO DRAIN |

ABBREVIATIONS

| | | | | | |
|------|---------------------|------------|-------------------------|-------|-------------------------|
| AC | ASPHALT CONCRETE | EX / EXIST | EXISTING | PROP | PROPOSED |
| AB | AGGREGATE BASE | FC | FACE OF CURB | PT | POINT ON TANGENT |
| AP | ANGLE POINT | FG | FINISHED GRADE | PVC | POLYVINYL CHLORIDE PIPE |
| BC | BEGIN CURVE | FH | FIRE HYDRANT | RT | RIGHT |
| BCR | BEGIN CURB RETURN | FL | FLOW LINE | ROW | RIGHT OF WAY |
| BEG | BEGIN | FO | FIBER OPTICS | SD | STORM DRAIN |
| BLVD | BOULEVARD | FS | FINISHED SURFACE | SDMH | STORM DRAIN MANHOLE |
| BW | BACK OF SIDEWALK | G | GAS | SW | SIDEWALK |
| CATV | CABLE, TELEVISION | GB | GRADE BRAKE | SERV | SERVICE |
| CB | CATCH BASIN | IMP | IMPROVEMENT | SS | SANITARY SEWER |
| C&G | CURB AND GUTTER | INV | INVERT | SSCO | SANITARY SEWER CLEANOUT |
| CL | CENTERLINE | IRR | IRRIGATION | SSMH | SANITARY SEWER MANHOLE |
| COMM | COMMUNICATION | JP | JOINT POLE | STD | STANDARD |
| CONC | CONCRETE | LF | LINEAR FOOT | TC | TOP OF CURB |
| COND | CONDUIT | LS | LANDSCAPE | TEL | TELEPHONE |
| DI | DROP INLET | LT | LEFT | TOP | TOP OF PIPE |
| DG | DRAINAGE GRATE | MED | MEDIAN | TG | TOP OF GRADE |
| DW | DOMESTIC WATER LINE | MISC | MISCELLANEOUS | TS | TRAFFIC SIGNAL |
| EB | ELECTRIC BOX | MON WELL | MONITORING WELL | TYP | TYPICAL |
| EC | END CURVE | MH | MANHOLE | UNKN. | UNKNOWN |
| ECR | END CURB RETURN | N'LY | NORTHERLY | VAR. | VARIES |
| EG | EXISTING GRADE | N.T.S. | NOT TO SCALE | WM | WATER METER |
| EL | ELEVATION | OC | ON CURB | WV | WATER VALVE |
| ELEC | ELECTRICAL | OG | ORIGINAL GRADE | | |
| E'LY | EASTERLY | OHL | OVERHEAD LINE | | |
| EP | EDGE OF PAVEMENT | PB | PULL BOX | | |
| ESMT | EASEMENT | PC | POINT ON CURVE | | |
| | | PCC | POINT ON COMPOUND CURVE | | |
| | | PRC | POINT OF REVERSE CURVE | | |
| | | PROF | PROFILE | | |

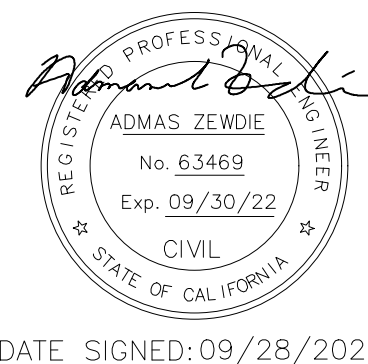
CIVIL NOTES:

- FOR CITY OF LOS ALTOS STANDARD DETAILS AND CALTRANS STANDARD PLANS REFERENCED, SEE SHEET No. 7 & 8.
- FOR SIDEWALK DETAILS, SEE CITY OF LOS ALTOS STANDARD DETAILS, SHEET SU-8.
- FOR CURB AND GUTTER DETAILS, SEE CITY OF LOS ALTOS STANDARD DETAILS, SHEET SU-6. ADJUST GUTTER SLOPE TO MATCH EXISTING PAVEMENT ELEVATION AT GUTTER LIP.
- FOR VERTICAL CURB DETAILS, SEE CITY OF LOS ALTOS STANDARD DETAILS, SHEET SU-7.
- FOR ROLLED CURB AND GUTTER DETAILS, SEE CITY OF LOS ALTOS STANDARD DETAILS, SHEET SU-6.
- FOR CURB RAMP DETAILS NOT SHOWN, SEE CALTRANS STANDARD PLANS A88A.
- FOR CURB INLET DETAILS, SEE CITY OF LOS ALTOS STANDARD DETAILS, SHEET SD-4.
- SIDEWALK AND CURB RAMP SHALL BE CONSTRUCTED WITH 4" PCC OVER 6" AB.
- THE WIDTH OF DETECTABLE WARNING SURFACE SHALL MATCH THE WIDTH OF THE WALKWAY OR RAMP. THE DIMENSION OF THE DETECTABLE WARNING SURFACE SHALL BE 3 FEET IN THE DIRECTION OF TRAVEL.
- ALL CONFORM SAWCUTS FOR CONCRETE SECTIONS SHALL BE PLACED ALONG THE NEAREST SCORE LINE BEYOND THE IMPROVEMENT LIMITS SHOWN ON THE PLANS UNLESS DIRECTED OTHERWISE BY ENGINEER.
- REMOVE EXISTING CONCRETE IMPROVEMENTS THAT INTERFERE WITH PROPOSED IMPROVEMENTS.



7901 Oakport St, Suite 4225
Oakland, CA 94621
www.activewayz.engineering
(510) 989-2420

R.C.E. 63469

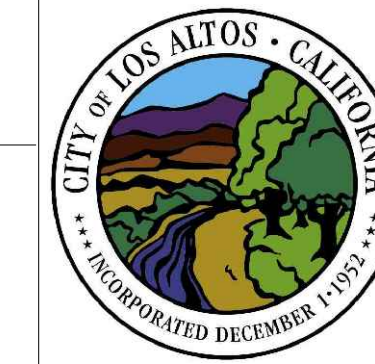


DATE SIGNED: 09/28/2020

| | |
|-------------|----------|
| SCALE: | AS SHOWN |
| DESIGN BY: | AZ |
| DRAWING BY: | AZ |
| CHECKED BY: | DA |

**EL MONTE AVE SIDEWALK GAP CLOSURE PROJECT
TS-01038**

GENERAL NOTES, LEGEND AND ABBREVIATIONS



City of Los Altos
Santa Clara County
California

Engineering Services
Department
1 N. San Antonio Rd
Los Altos, CA
94022-3000

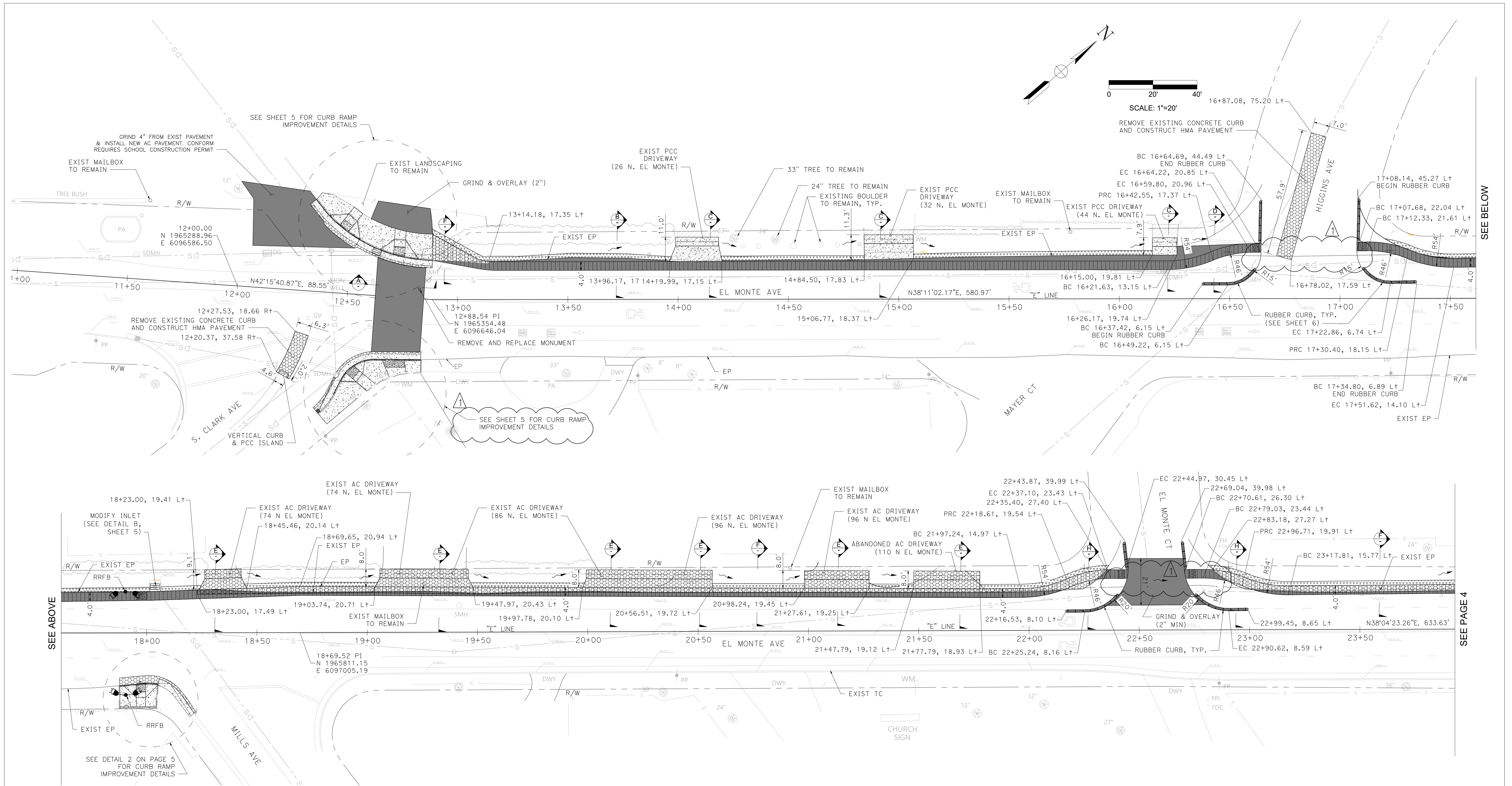
City of Los Altos
Project No.
TS-01038

Drawing No.

SHT 2 OF 11



**Know what's below.
Call before you dig.**



NOTES:
 1. FOR NOTES, LEGEND, AND ABBREVIATIONS, SEE SHEET 2.



Know what's below.
 Call before you dig.

| Rev. | Description | Date |
|------|-------------|------------|
| 01 | Bid Set | 09/28/2020 |
| | Addendum 1 | 10/07/2020 |

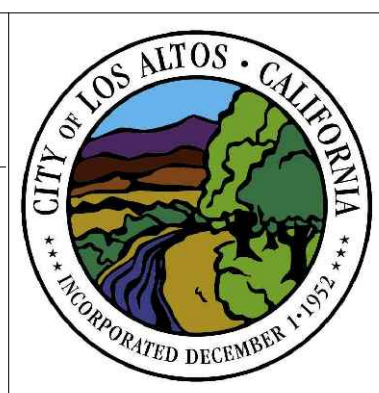
7901 Oakport St, Suite 4225
 Oakland, CA 94621
 www.activewayz.engineering
 (510) 989-2420

REGISTERED PROFESSIONAL ENGINEER
 ADMAS ZEWIDIE
 No. 63469
 Exp. 09/30/22
 CIVIL
 STATE OF CALIFORNIA

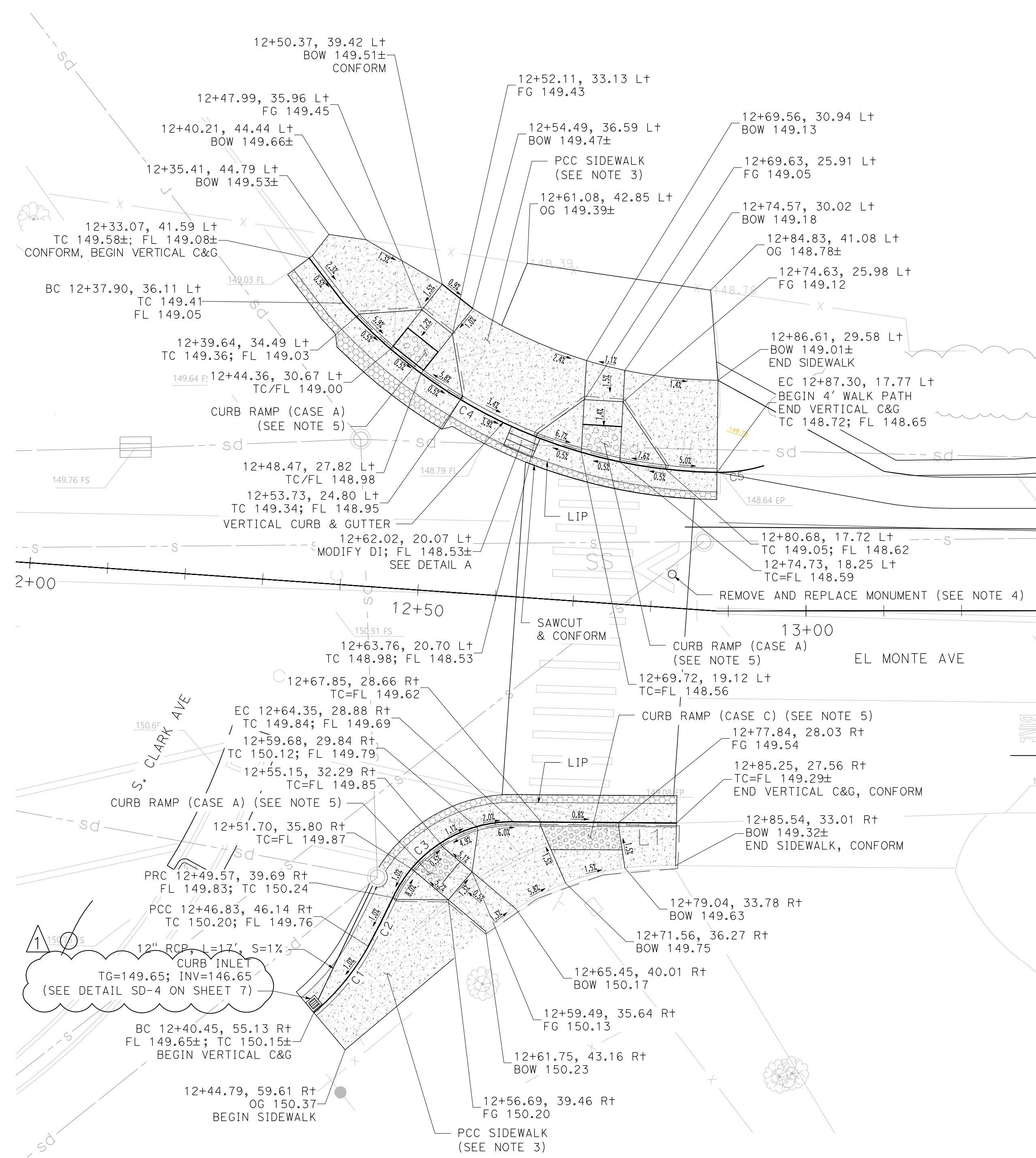
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| SCALE: | AS SHOWN |
| DESIGN BY: | AZ |
| DRAWING BY: | AZ |
| CHECKED BY: | DA |

EL MONTE AVE SIDEWALK GAP CLOSURE PROJECT
 TS-01038

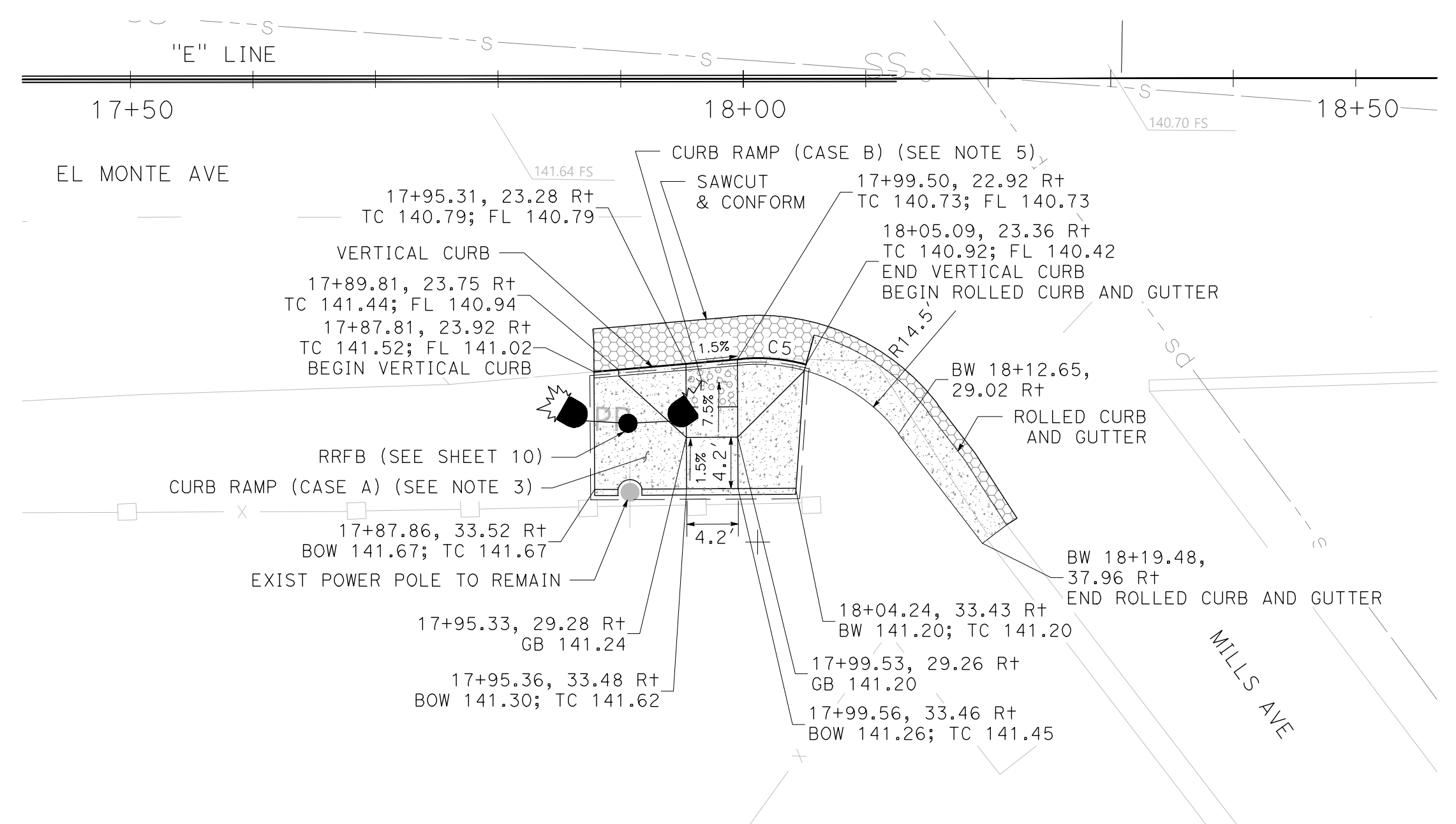
SIDEWALK GAP CLOSURE IMPROVEMENT PLAN



| | |
|--|--|
| City of Los Altos Santa Clara County California | City of Los Altos Project No. TS-01038 |
| Engineering Services Department 1 N. San Antonio Rd Los Altos, CA 94022-3000 | Drawing No. SHT 3 OF 11 |

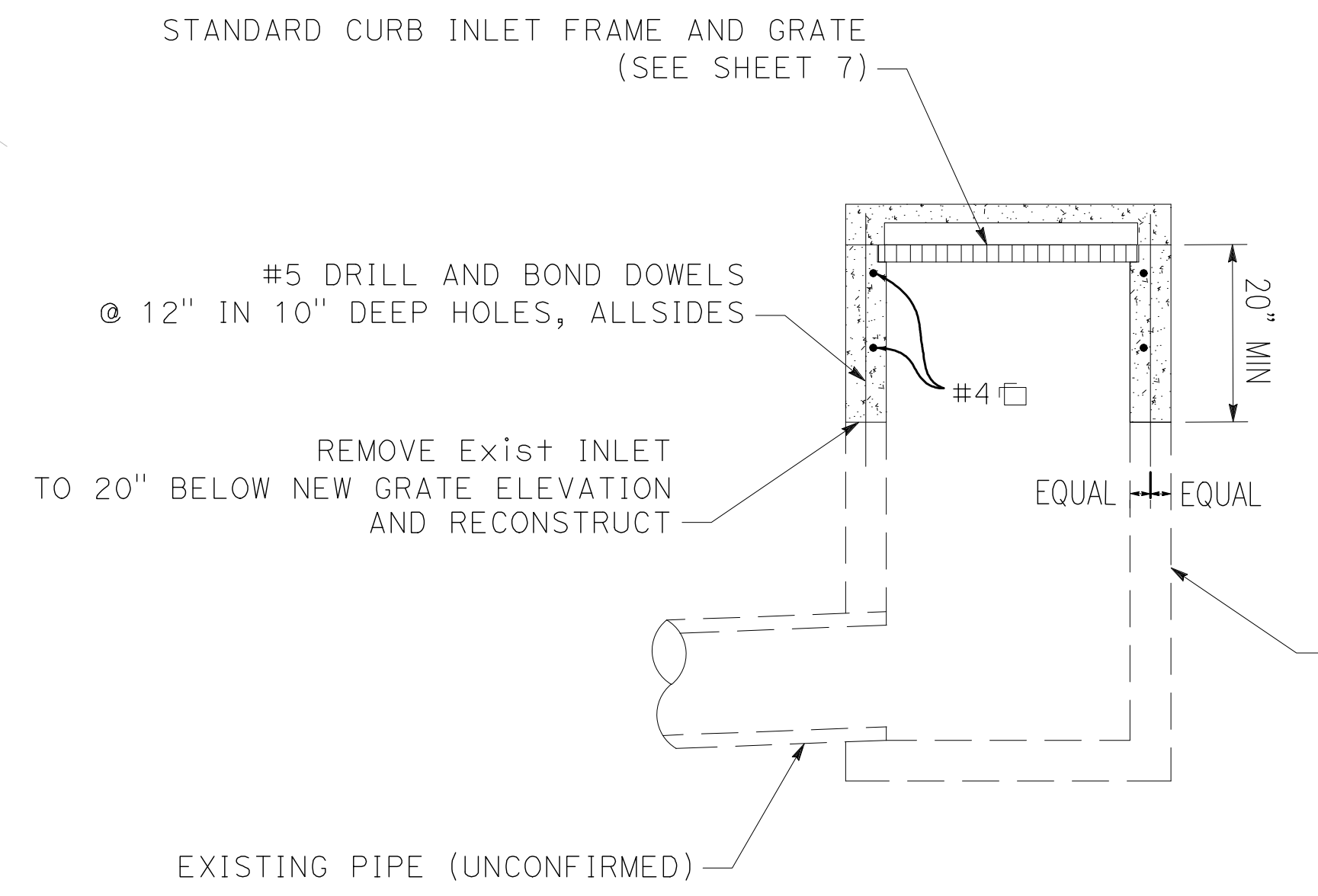


1 CLARK AVE / EL MONTE AVE CURB RAMP DETAIL
SCALE: 1"=10'

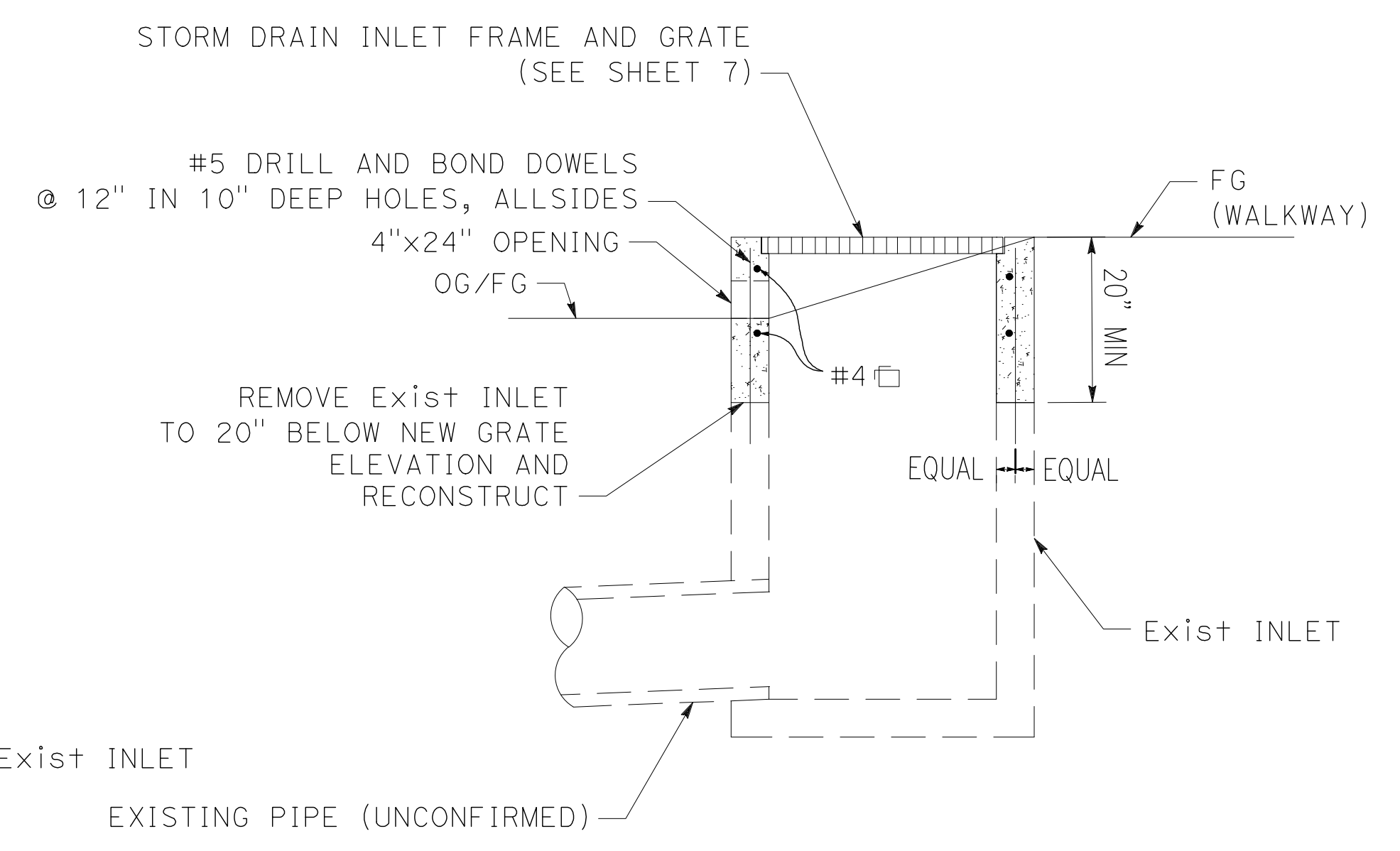


2 MILLS AVE / EL MONTE AVE CURB RAMP DETAIL
SCALE: 1"=10'

| Curve Table | | | | |
|-------------|---------|-----------|--------|--------|
| No. | R | Δ | T | L |
| C1 | 30.00' | 21°10'07" | 5.61' | 11.08' |
| C2 | 113.58' | 3°32'21" | 3.51' | 7.02' |
| C3 | 17.00' | 65°09'43" | 10.86' | 19.33' |
| C4 | 65.55' | 47°23'43" | 28.77' | 54.22' |
| C5 | 15.00' | 20°10'04" | 2.67' | 5.28' |



A MODIFY INLET
SCALE: NO SCALE



B MODIFY INLET
SCALE: NO SCALE

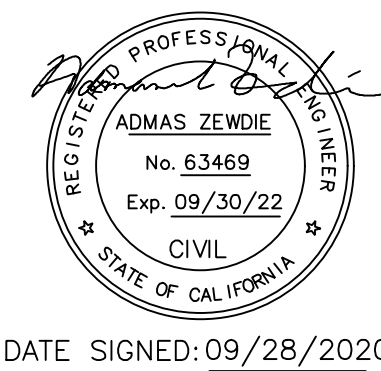
- NOTES:
- FOR NOTES, LEGEND, AND ABBREVIATIONS, SEE SHEET 2.
 - FOR "E" LINE ALIGNMENT INFORMATION, SEE SHEETS 3 AND 4.
 - ALL CONCRETE IMPROVEMENTS WITHIN THE LIMITS OF THE RESPECTIVE PROPOSED CONCRETE WORK SHALL BE REMOVED.
 - MONUMENT ADJUSTMENT SHALL BE RECORDED AT THE COUNTY PER SURVEYORS ACT.
 - COUNTER SLOPE OF ADJOINING GUTTERS AND ROAD SURFACES IMMEDIATELY ADJACENT TO AND WITHIN 24 INCHES OF THE CURB RAMP SHALL NOT BE STEEPER THAN 5%.

| Rev. | Description | Date |
|------|-------------|------------|
| 01 | Bid Set | 09/28/2020 |
| | Addendum 1 | 10/07/2020 |



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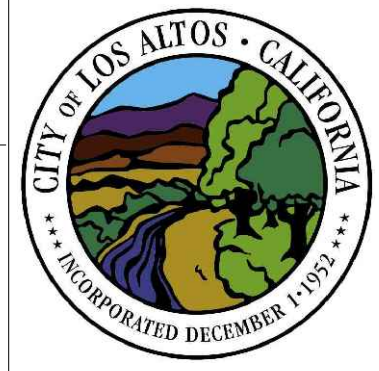


DATE SIGNED: 09/28/2020

| | |
|-------------|----------|
| SCALE: | AS SHOWN |
| DESIGN BY: | AZ |
| DRAWING BY: | AZ |
| CHECKED BY: | DA |

EL MONTE AVE SIDEWALK GAP CLOSURE PROJECT
TS-01038

CONSTRUCTION DETAILS



City of Los Altos
Santa Clara County
California

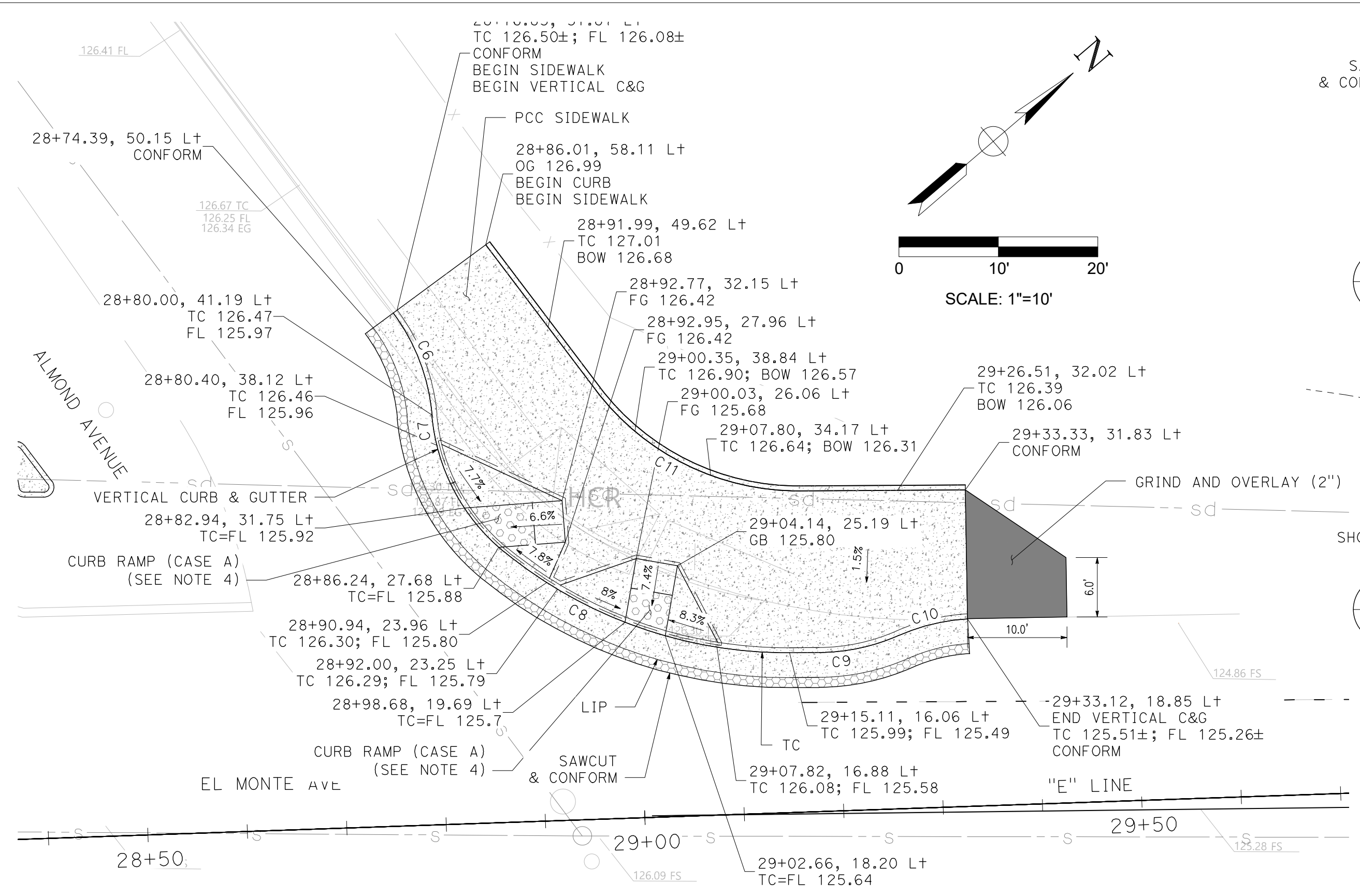
Engineering Services
Department
1 N. San Antonio Rd
Los Altos, CA
94022-3000

City of Los Altos
Project No.
TS-01038

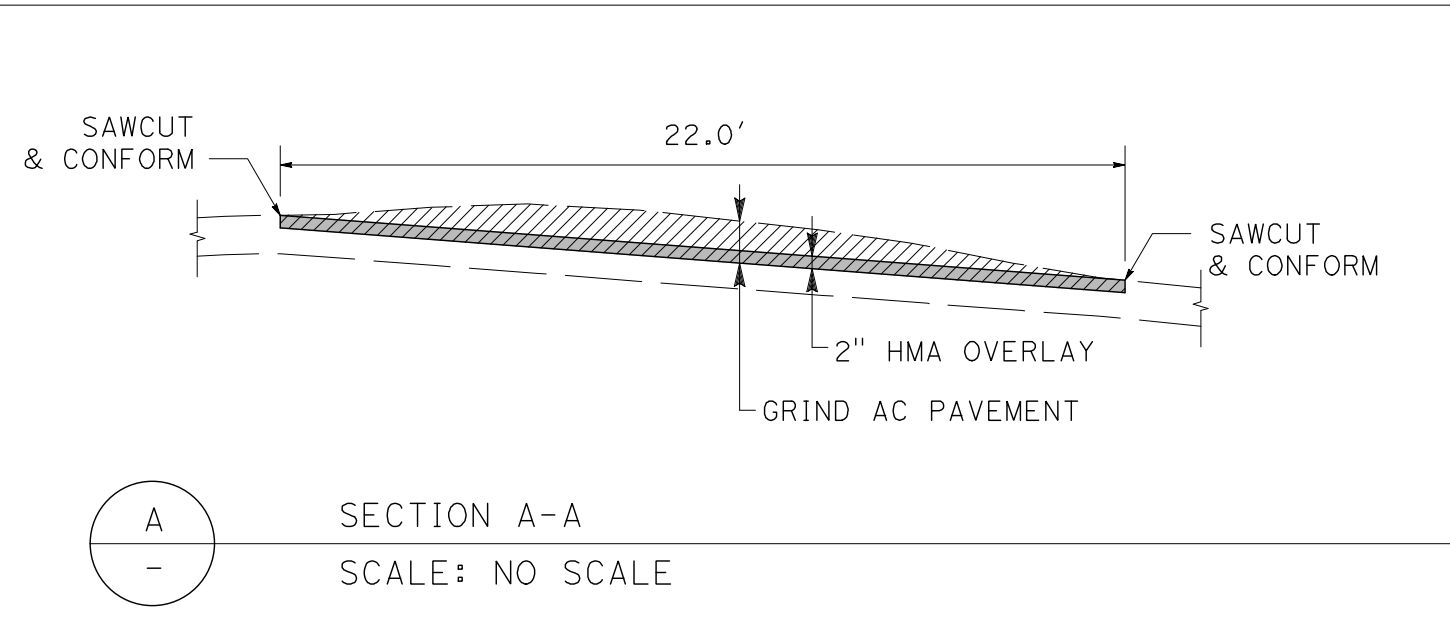
Drawing No.
SHT 5 OF 11



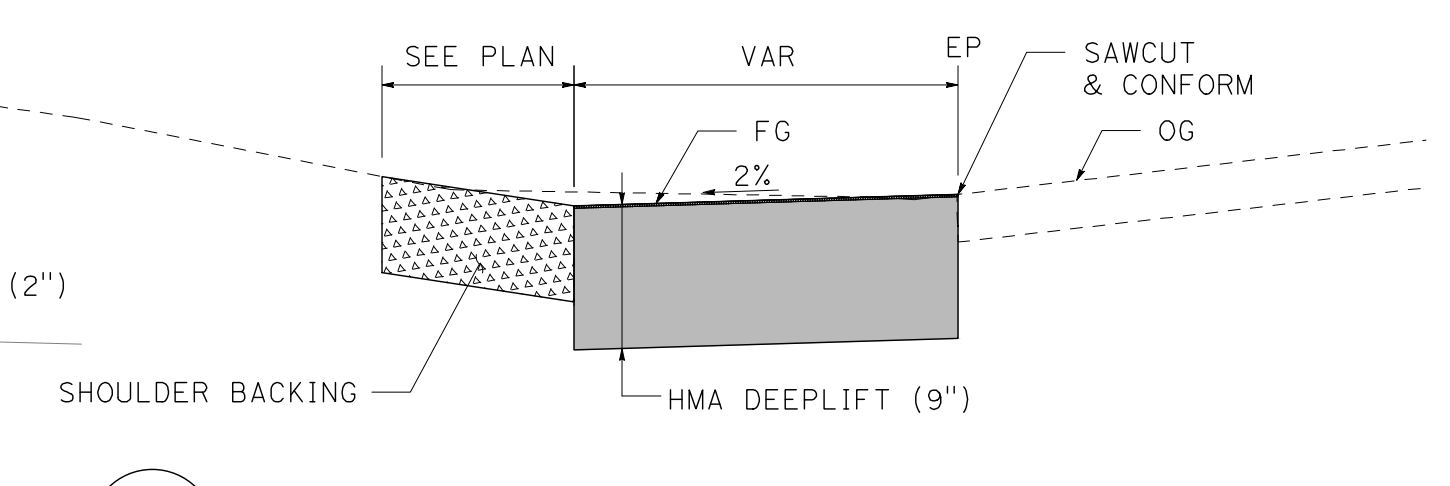
Know what's below.
Call before you dig.



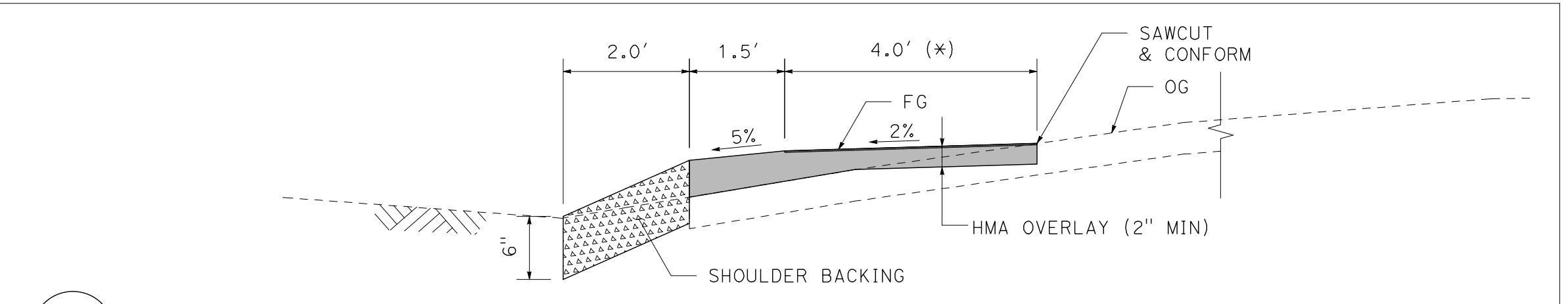
1 ALMOND AVE / EL MONTE AVE CURB RAMP DETAIL
SCALE: 1"=10'



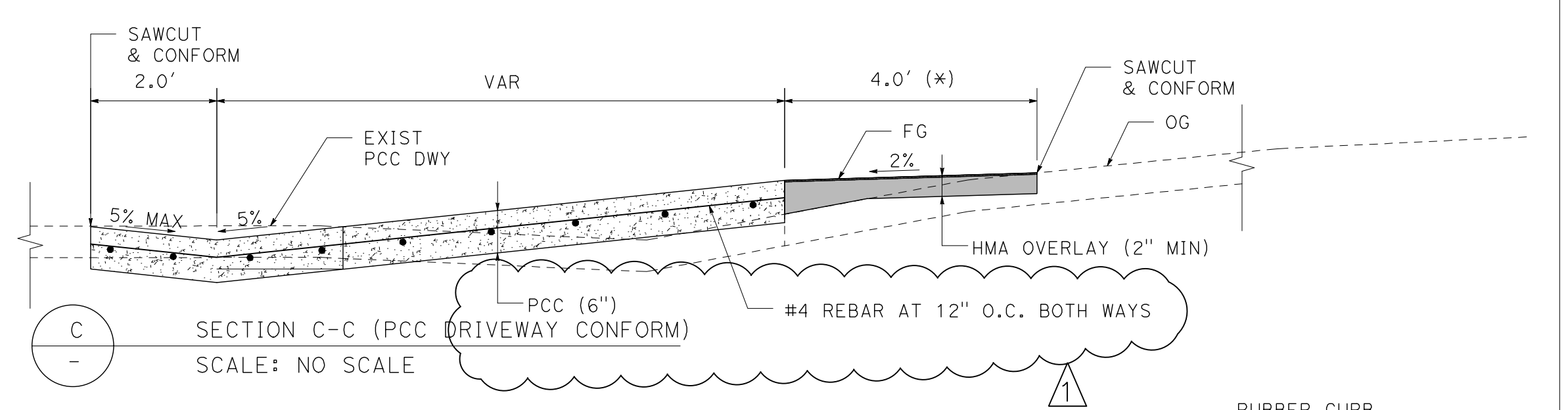
A SECTION A-A
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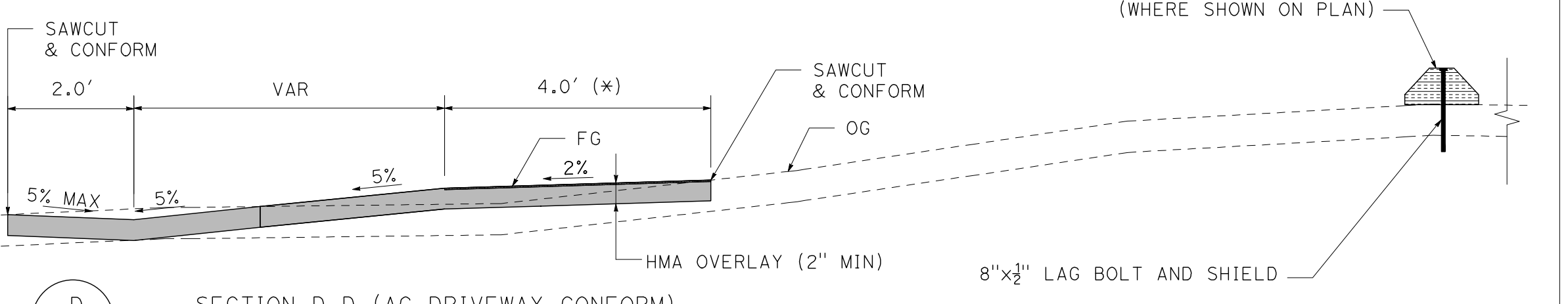
H SECTION H-H
SCALE: NO SCALE



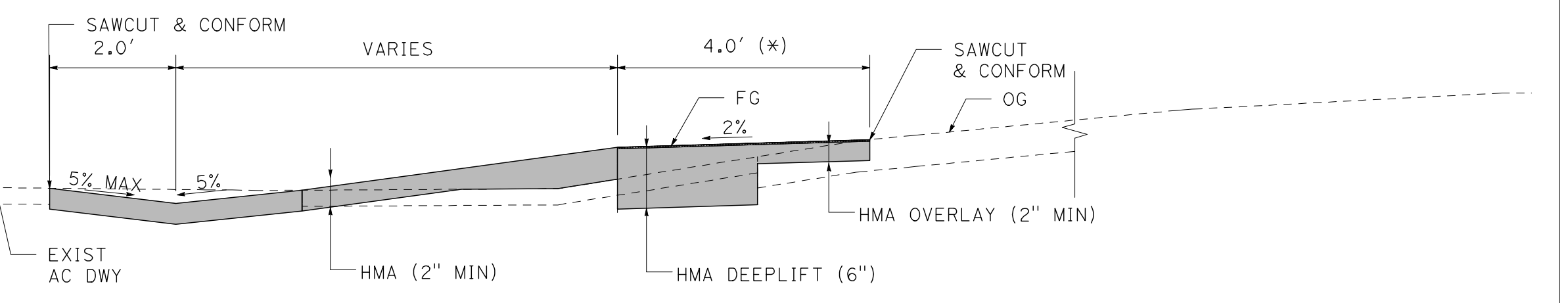
B SECTION B-B
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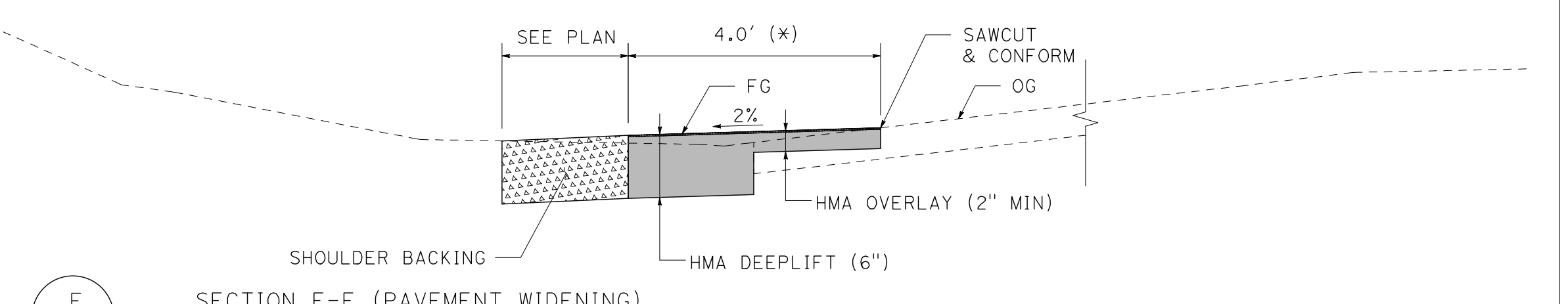
C SECTION C-C (PCC DRIVEWAY CONFORM)
SCALE: NO SCALE



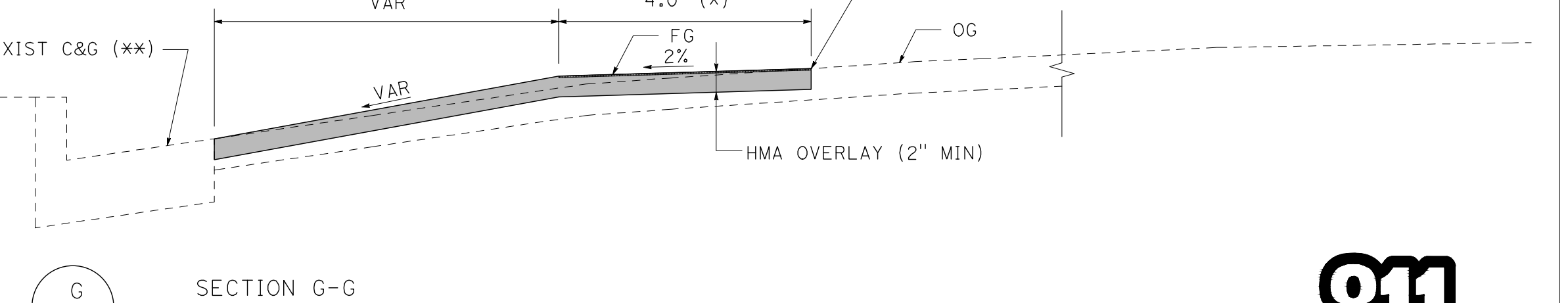
D SECTION D-D (AC DRIVEWAY CONFORM)
SCALE: NO SCALE



E SECTION E-E (AC DRIVEWAY CONFORM WITH PAVEMENT WIDENING)
SCALE: NO SCALE

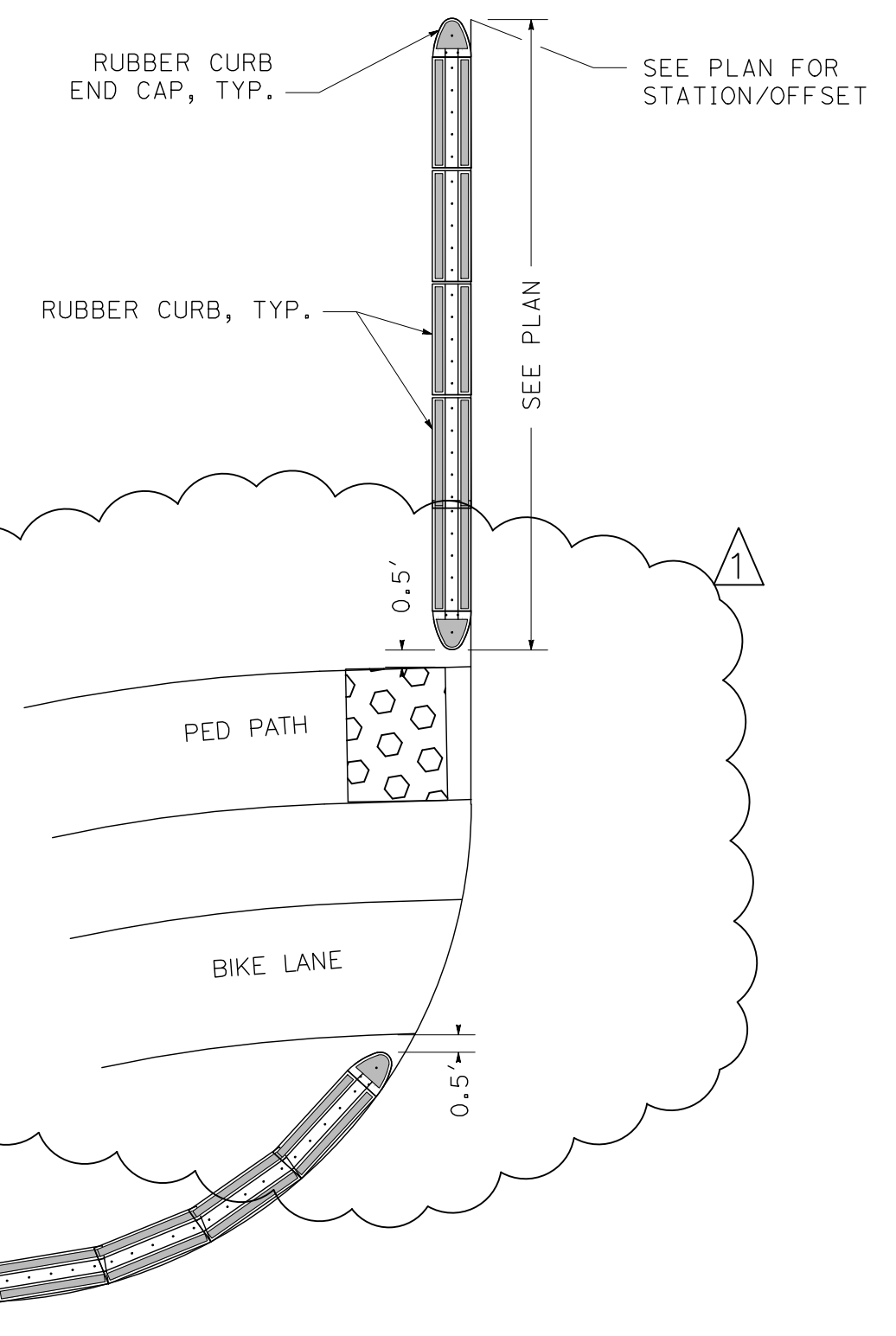


F SECTION F-F (PAVEMENT WIDENING)
SCALE: NO SCALE



G SECTION G-G
SCALE: NO SCALE

| Curve Table | | | | |
|-------------|--------|-----------|--------|--------|
| No. | R | Δ | T | L |
| C6 | 20.00' | 31°50'12" | 5.70' | 11.11' |
| C7 | 20.00' | 45°51'05" | 8.46' | 16.01' |
| C8 | 45.00' | 39°30'57" | 16.16' | 31.04' |
| C9 | 20.00' | 23°33'17" | 4.17' | 8.22' |
| C10 | 20.00' | 20°36'04" | 3.63' | 7.19' |
| C11 | 25.52' | 53°14'32" | 12.79' | 23.72' |



2 RUBBER CURB CORNER BULB-OUT
SCALE: NO SCALE

RUBBER CURB AND END CAP SHALL BE "BUS LANE CURB" MANUFACTURED BY RUBBERFORM RECYCLED PRODUCTS, LLC., OR APPROVED EQUAL BY CITY ENGINEER. THE COLOR OF THE REFLECTORS ON THE RUBBER CURB SHALL BE WHITE.

- NOTES:
- FOR NOTES, LEGEND, AND ABBREVIATIONS, SEE SHEET 2.
 - FOR "E" LINE ALIGNMENT INFORMATION, SEE SHEETS 3 AND 4.
 - ALL CONCRETE IMPROVEMENTS WITHIN THE LIMITS OF THE RESPECTIVE PROPOSED CONCRETE WORK SHALL BE REMOVED.
 - COUNTER SLOPE OF ADJOINING GUTTERS AND ROAD SURFACES IMMEDIATELY ADJACENT TO AND WITHIN 24 INCHES OF THE CURB RAMP SHALL NOT BE STEEPER THAN 5%.

* APPLY METHYL METHACRYLATE RESIN WITH HARDWEARING AGGREGATE ON WALKWAY.

** EXTEND HMA OVERLAY OVER GUTTER PAN WHERE SHOWN ON PLAN. ADJUST OVERLAY DEPTH TO MAINTAIN POSITIVE DRAINAGE IN GUTTER. GRIND GUTTER AT CONFORMS AS NEEDED.



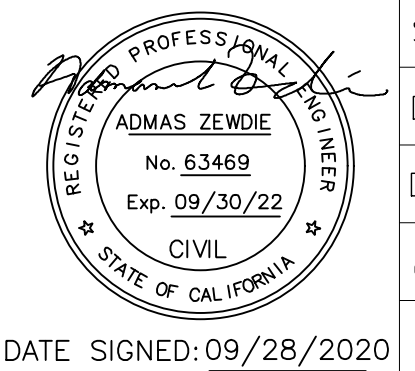
Know what's below.
Call before you dig.

| 01 | Bid Set | 09/28/2020 |
|------|-------------|------------|
| ▲ | Addendum 1 | 10/07/2020 |
| Rev. | Description | Date |



7901 Oakport St, Suite 4225
Oakland, CA 94621
www.activewayzengineering.com
(510) 989-2420

R.C.E. 63469

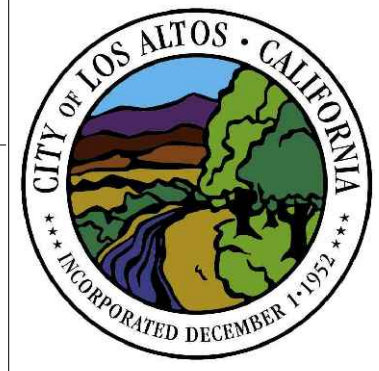


DATE SIGNED: 09/28/2020

| | |
|-------------|----------|
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| DESIGN BY: | AZ |
| DRAWING BY: | AZ |
| CHECKED BY: | DA |

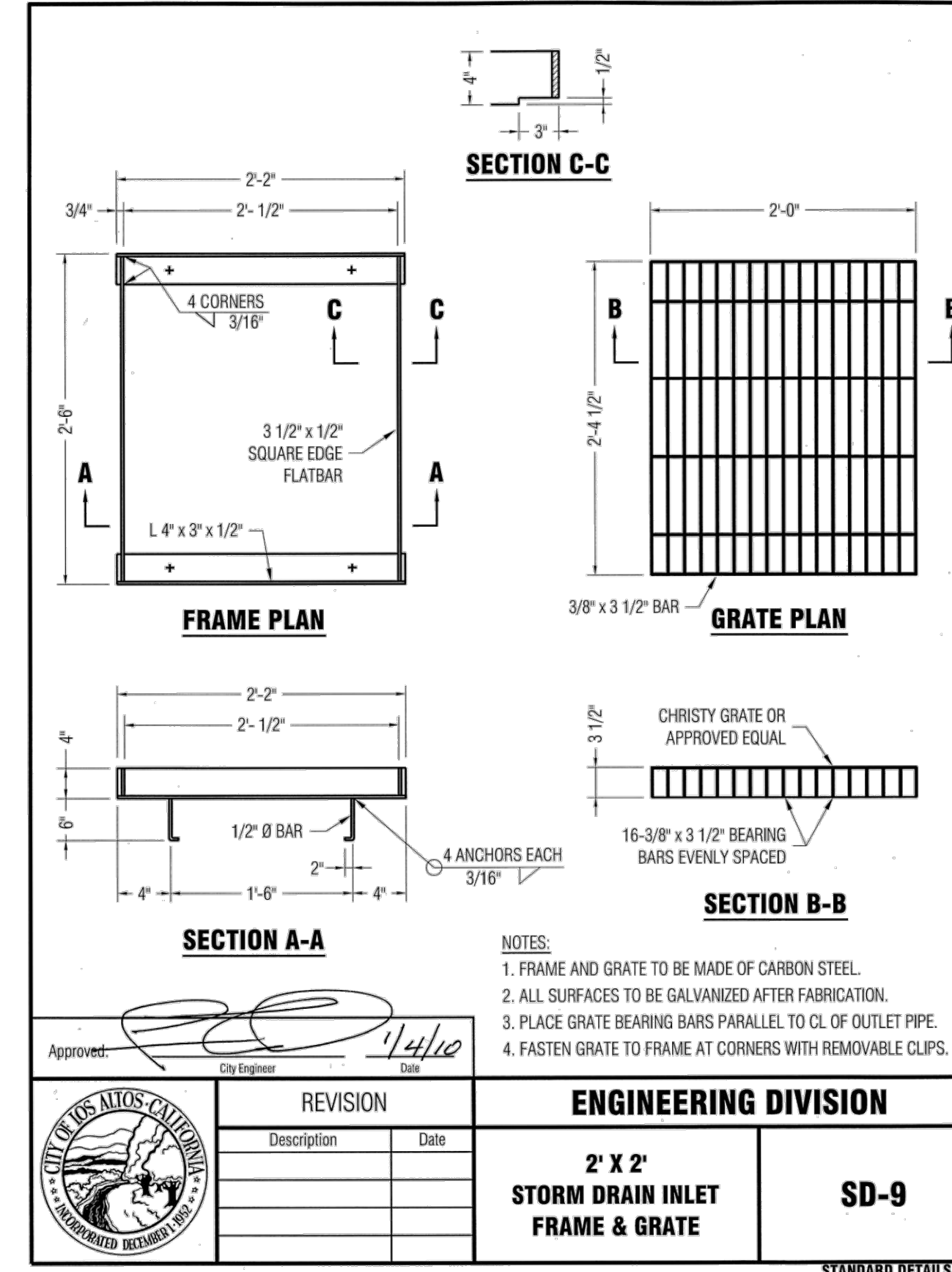
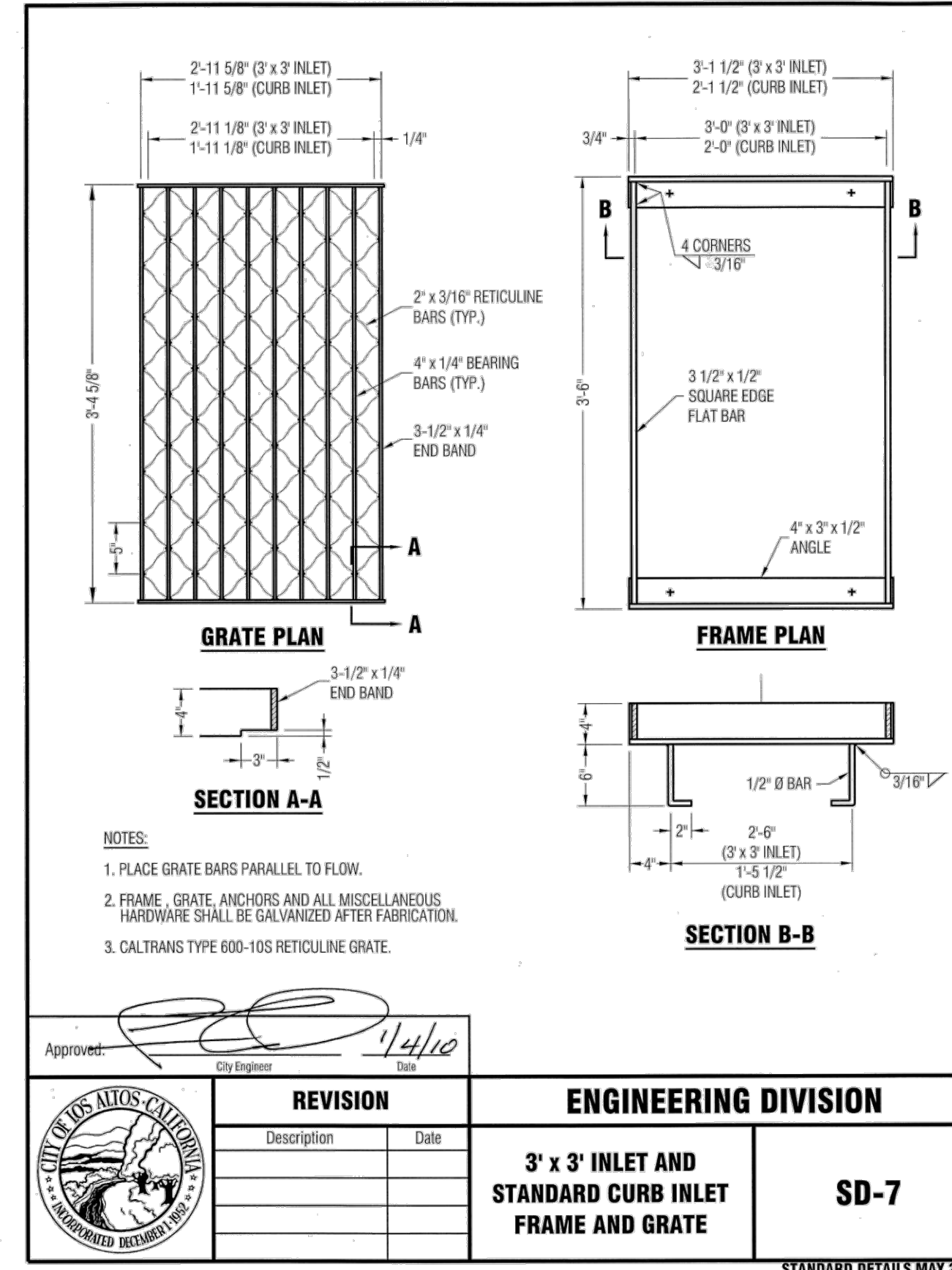
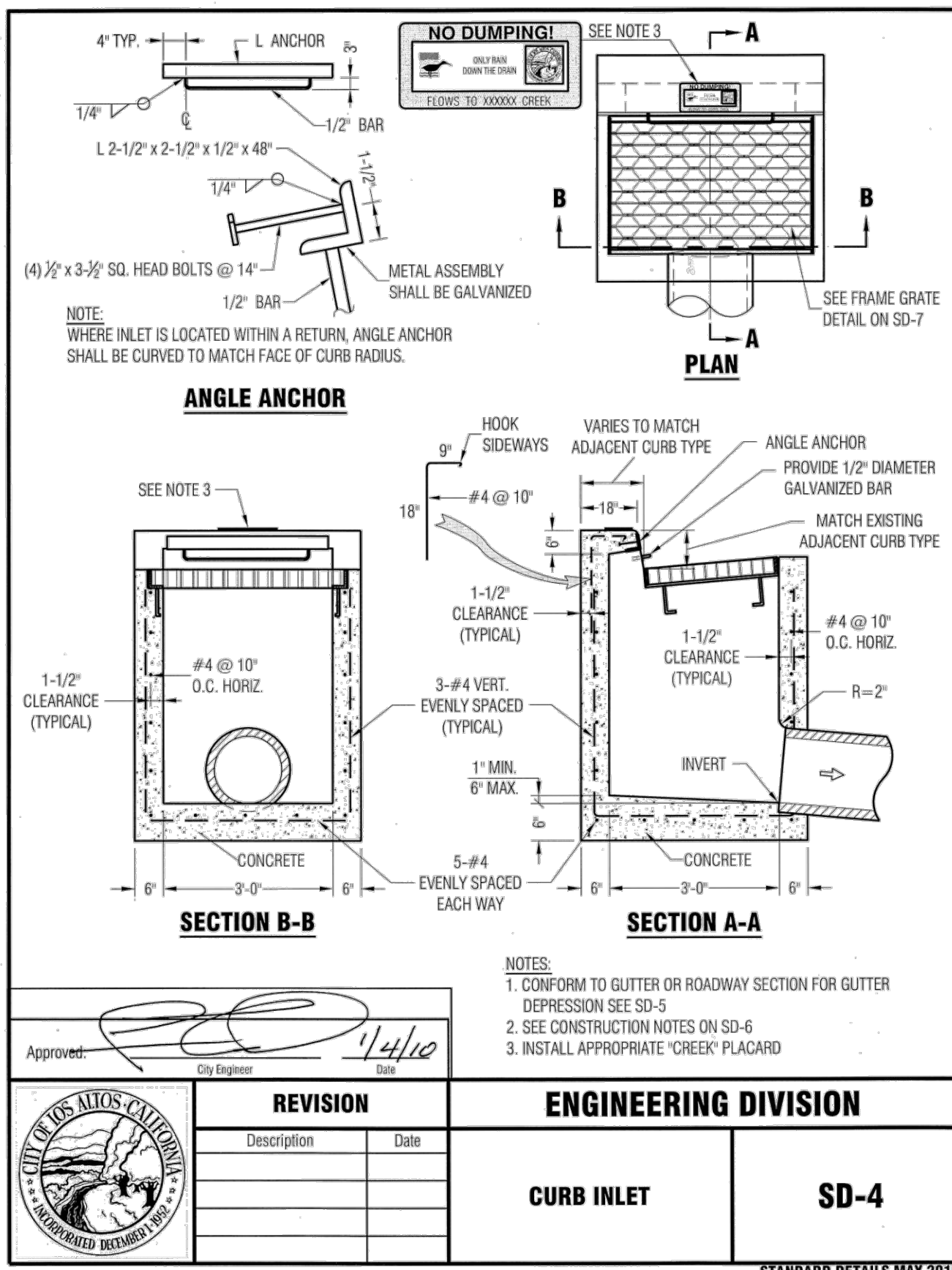
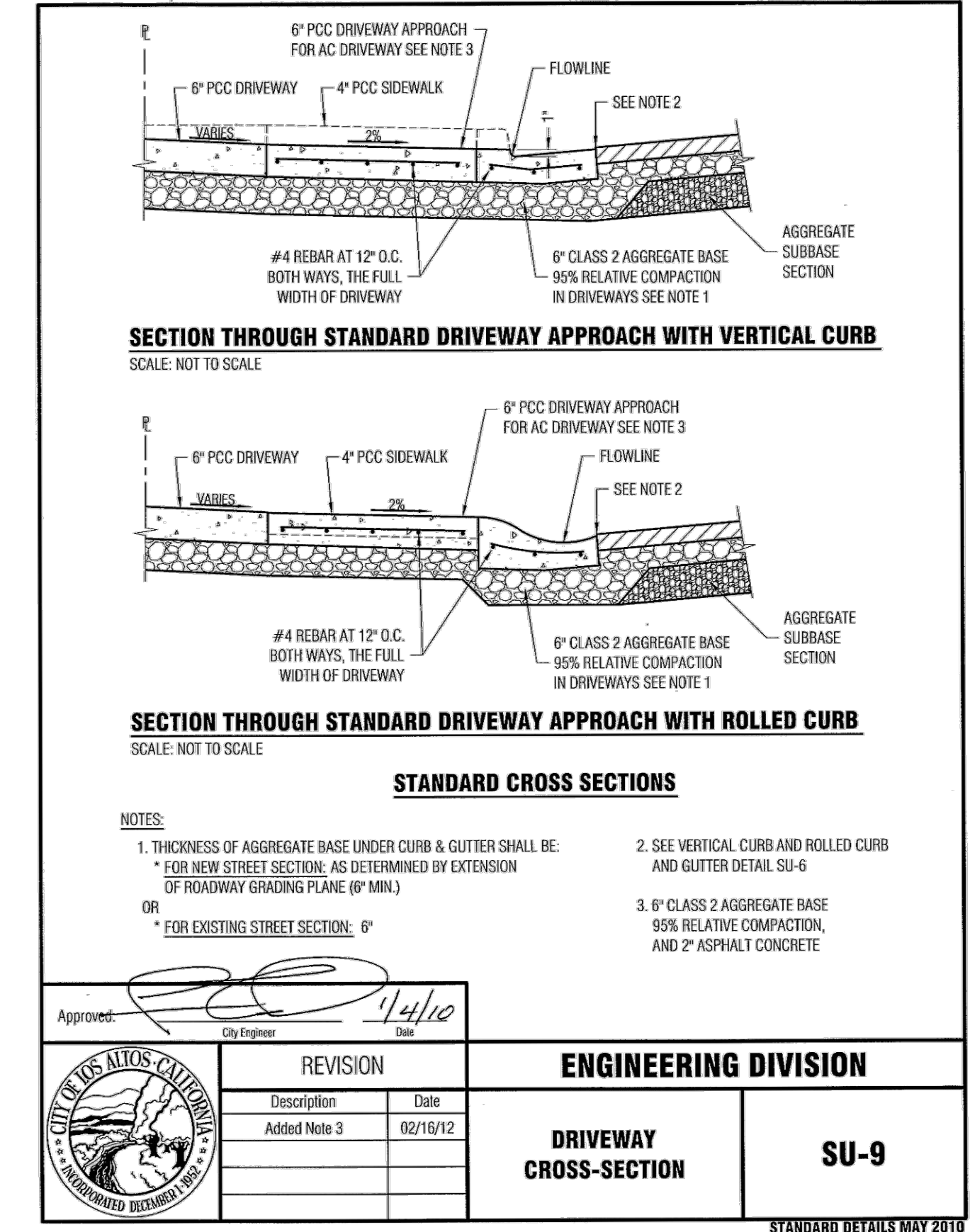
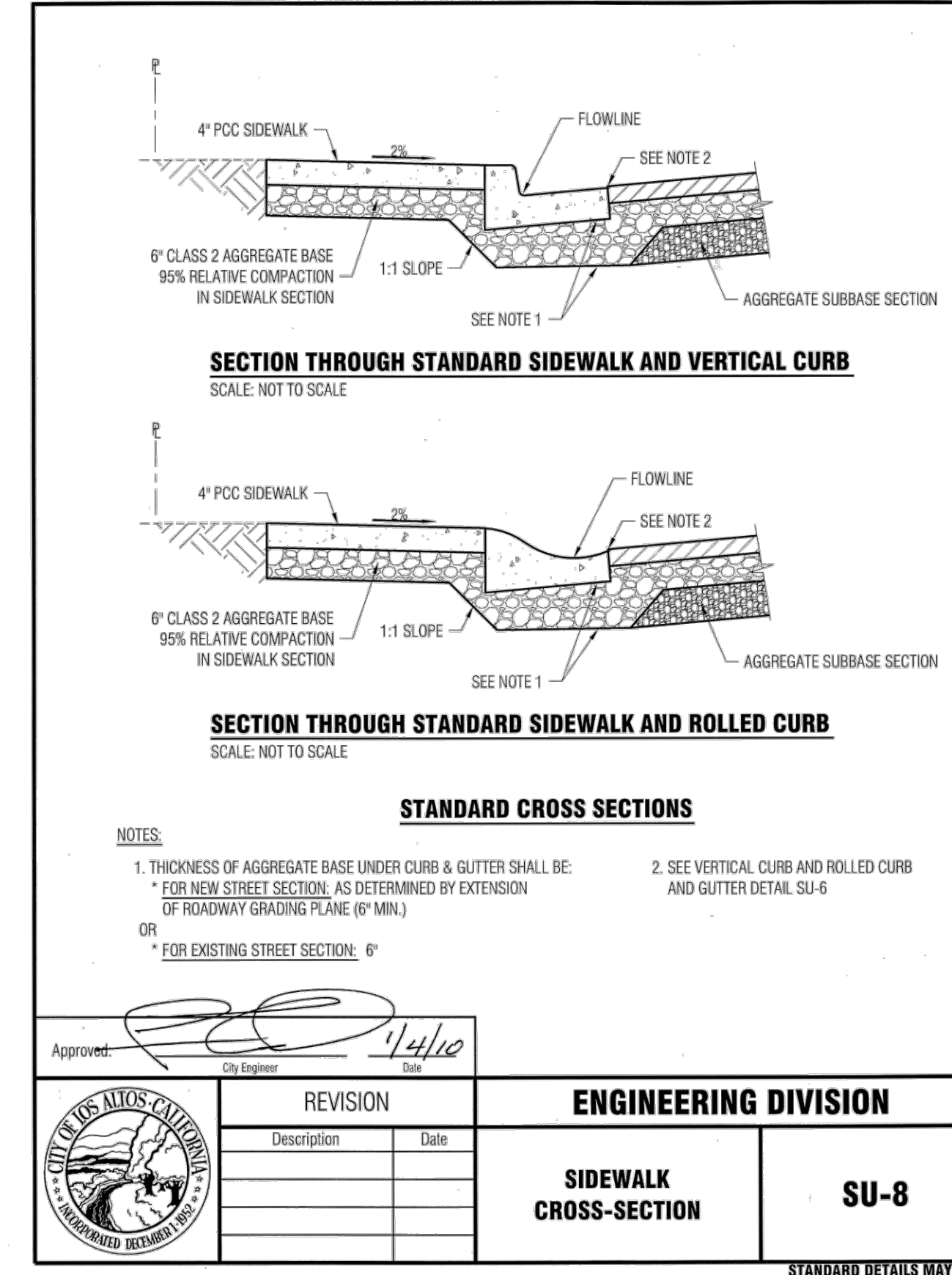
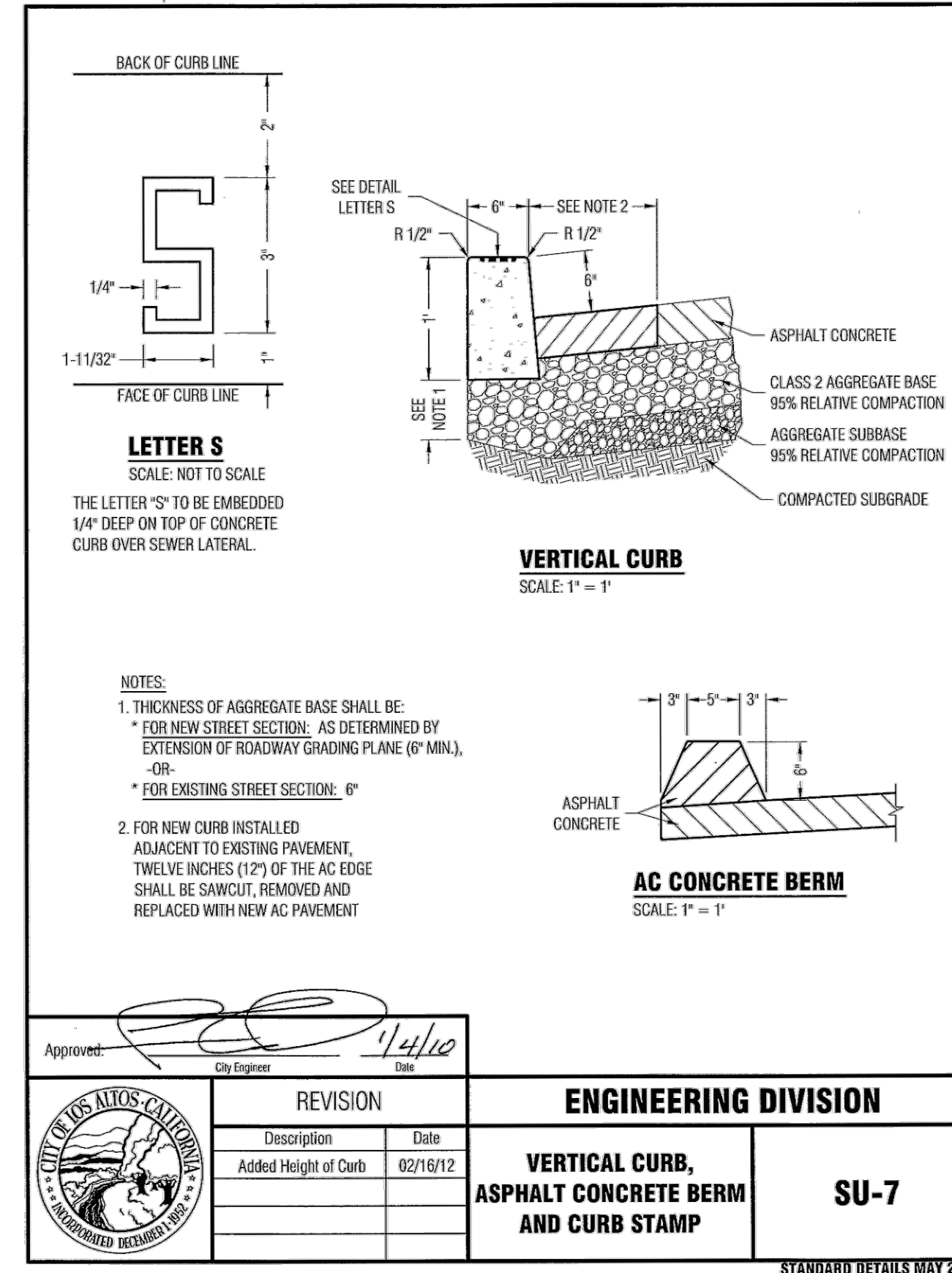
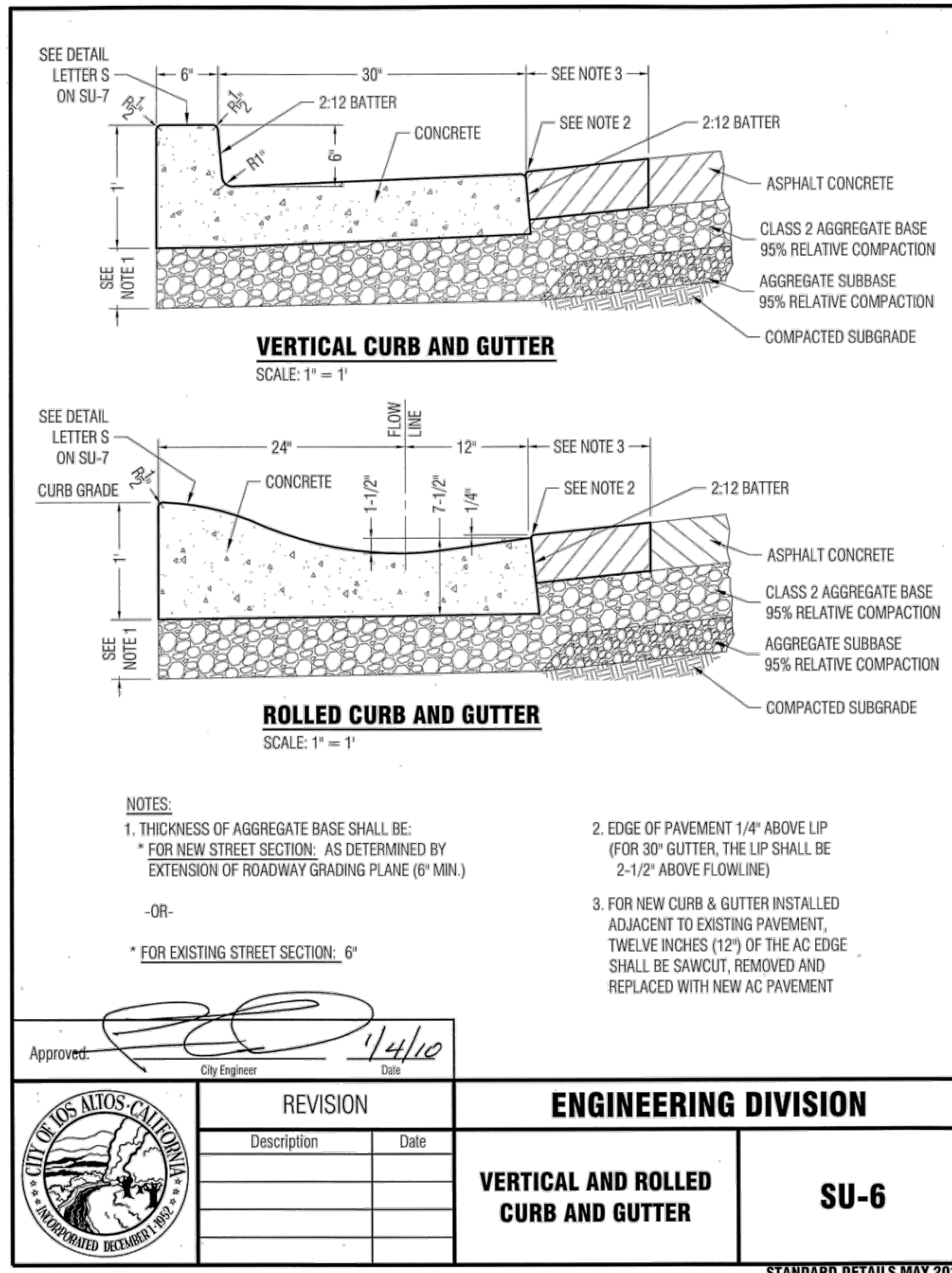
EL MONTE AVE SIDEWALK GAP CLOSURE PROJECT
TS-01038

CONSTRUCTOIN DETAILS



City of Los Altos
Santa Clara County
California
Engineering Services
Department
1 N. San Antonio Rd
Los Altos, CA
94022-3000

City of Los Altos
Project No.
TS-01038
Drawing No.
SHT 6 OF 11

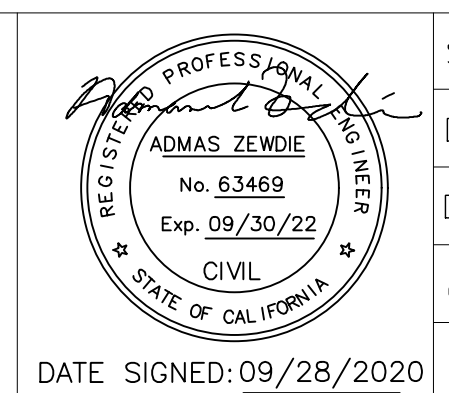


Know what's below.
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| Rev. | Description | Date |
|------|-------------|------------|
| 01 | Bid Set | 09/28/2020 |

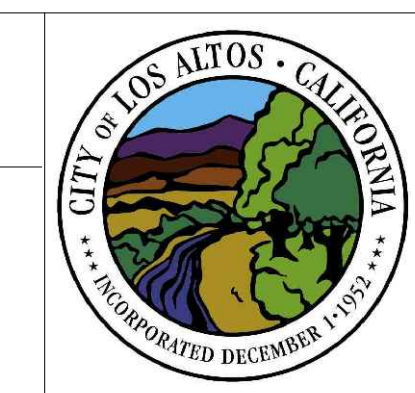


7901 Oakport St, Suite 4225
Oakland, CA 94621
www.activewayzengineering.com
(510) 989-2420



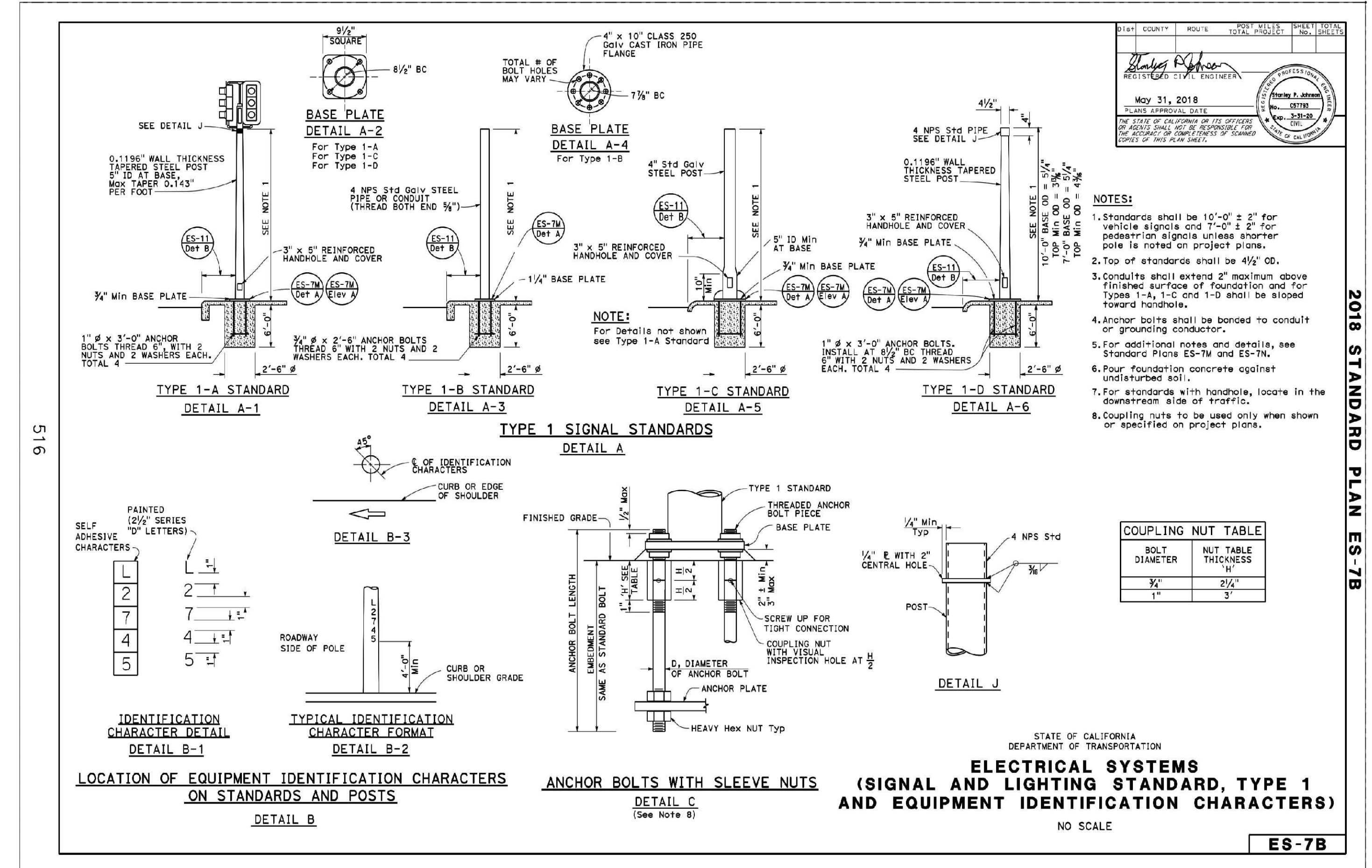
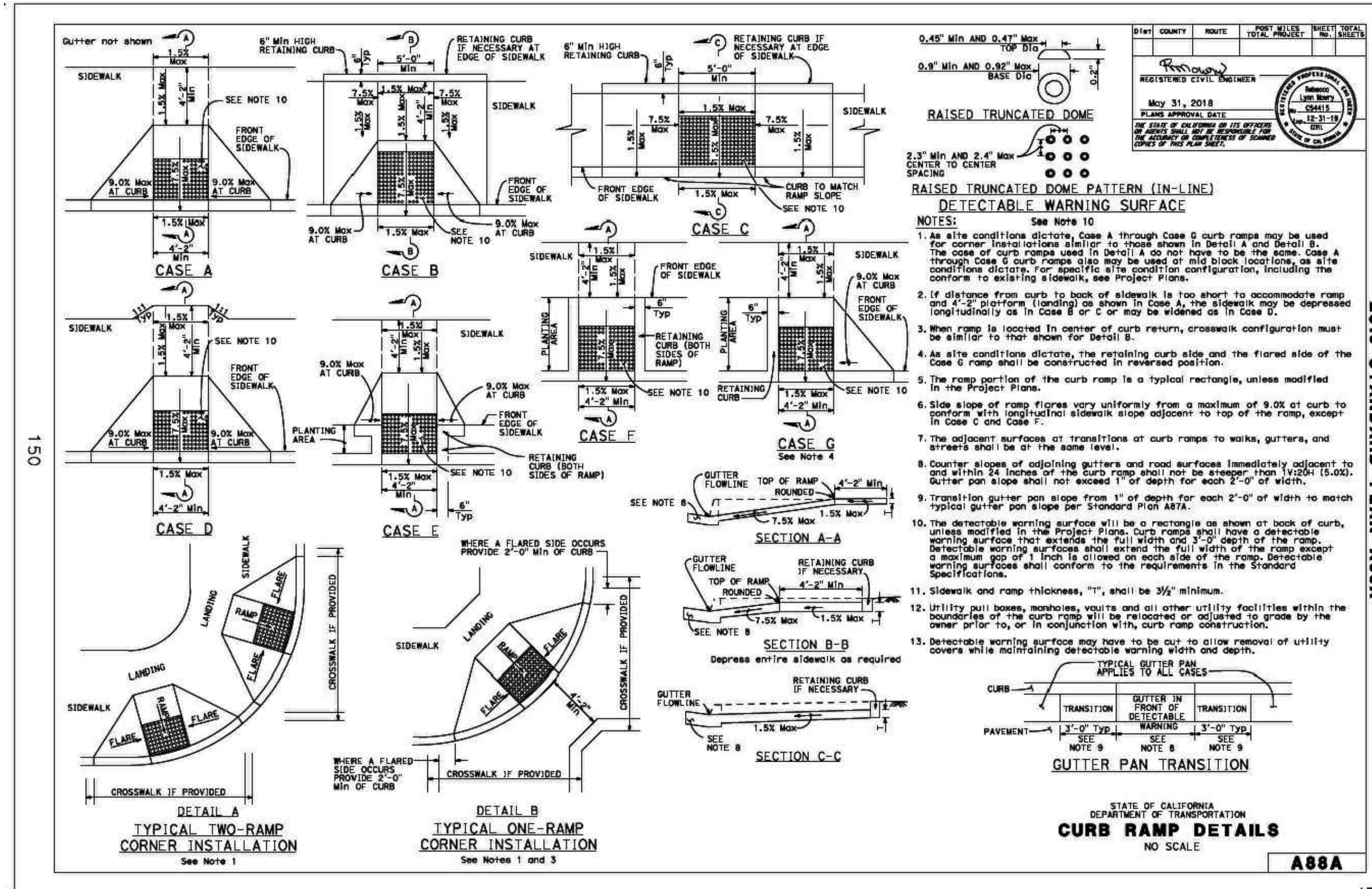
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DESIGN BY: AZ
DRAWING BY: AZ
CHECKED BY: DA

EL MONTE AVE SIDEWALK GAP CLOSURE PROJECT
TS-01038
CITY STANDARD DETAILS



City of Los Altos
Santa Clara County
California
Engineering Services
Department
1 N. San Antonio Rd
Los Altos, CA
94022-3000

City of Los Altos
Project No.
TS-01038
Drawing No.
SHT 7 OF 11

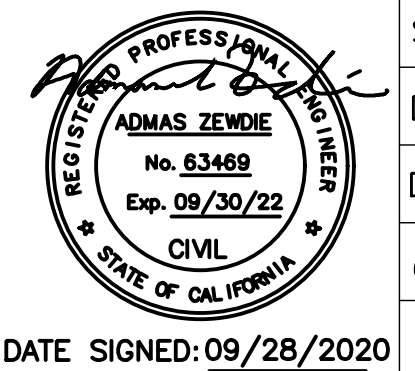


| Rev. | Description | Date |
|------|-------------|------------|
| 01 | Bid Set | 09/28/2020 |

ActiveWayz Engineering

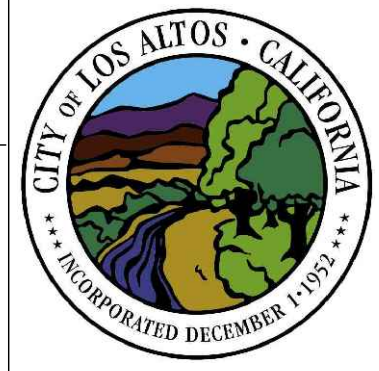
7901 Oakport St, Suite 4225
 Oakland, CA 94621
 www.activewayz.engineering
 (510) 989-2420

R.C.E. 63469 DATE SIGNED: 09/28/2020



| | |
|-------------|----------|
| SCALE: | AS SHOWN |
| DESIGN BY: | AZ |
| DRAWING BY: | AZ |
| CHECKED BY: | DA |

EL MONTE AVE SIDEWALK GAP CLOSURE PROJECT
 TS-01038
 CALTRANS STANDARD DETAILS

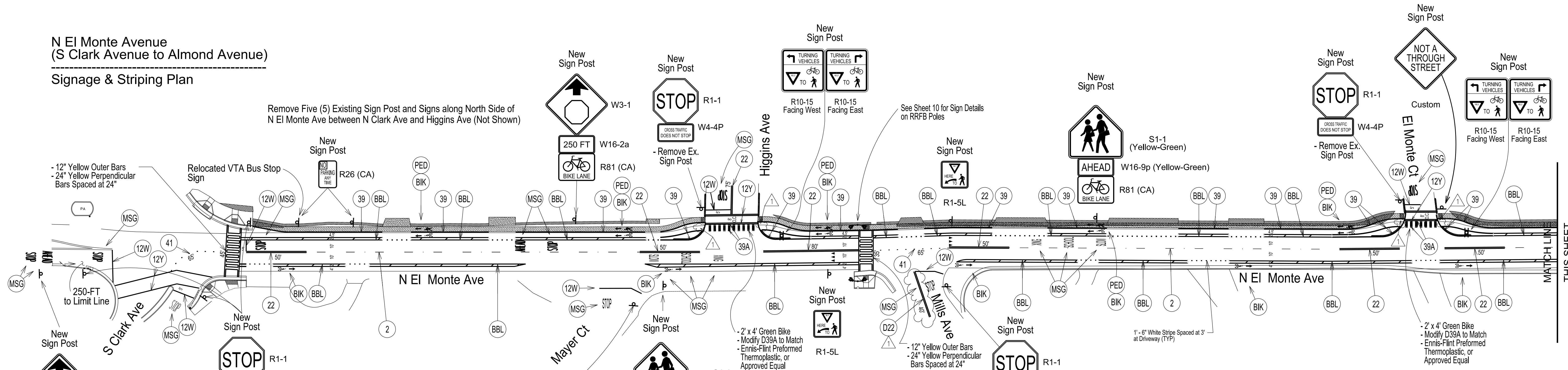


City of Los Altos
 Santa Clara County
 California
 Engineering Services
 Department
 1 N. San Antonio Rd
 Los Altos, CA
 94022-3000

City of Los Altos
 Project No.
 TS-01038
 Drawing No.
 SHT 8 OF 11



N El Monte Avenue
(S Clark Avenue to Almond Avenue)
Signage & Striping Plan



- 12" Yellow Outer Bars
- 24" Yellow Perpendicular Bars Spaced at 24"

Relocated VTA Bus Stop Sign

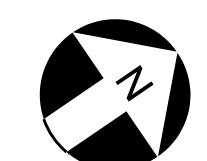
Remove Five (5) Existing Sign Post and Signs along North Side of N El Monte Ave between N Clark Ave and Higgins Ave (Not Shown)

New Sign Post
W3-1

STOP R1-1
ALL WAY R1-4

250 FT W16-2a
BIKE LANE R81 (CA)

Identify Sign and Legend Locations with City Staff



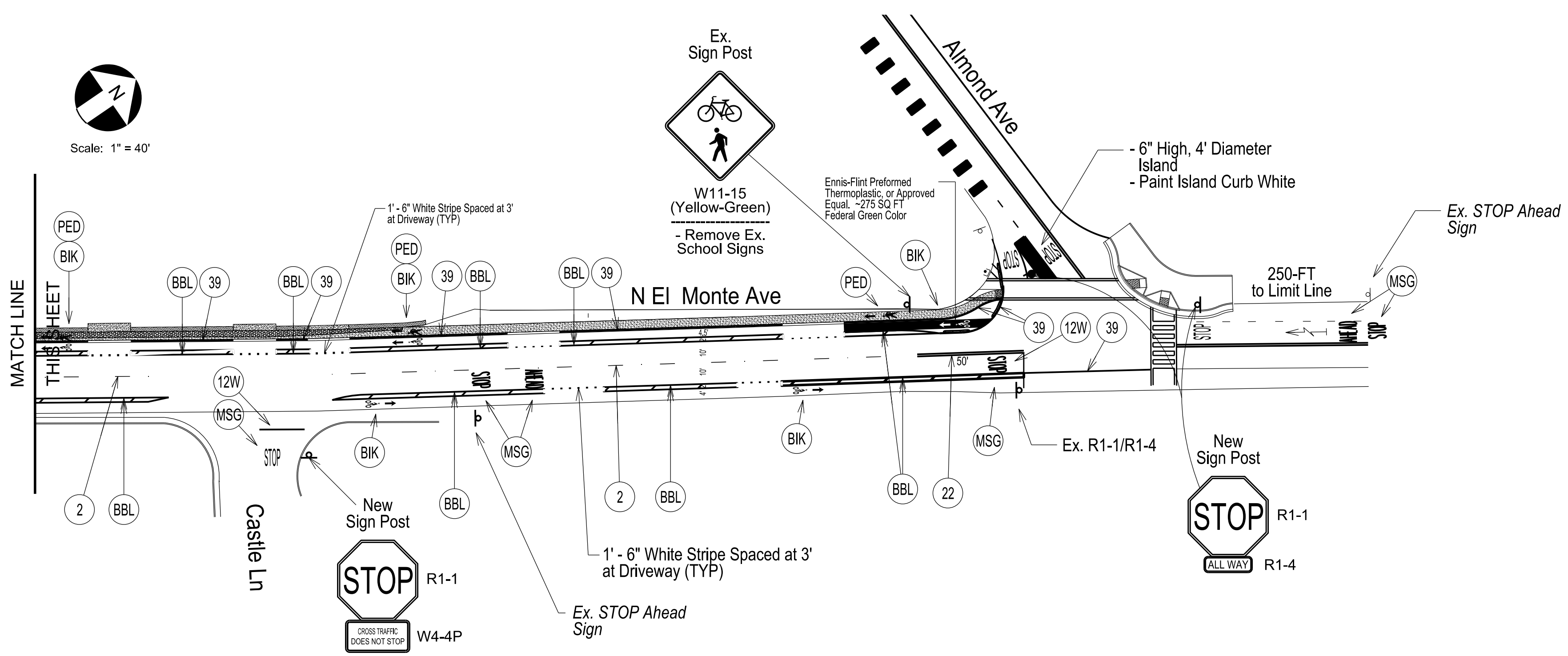
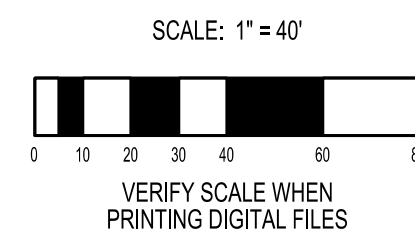
Scale: 1" = 40'



Scale: 1" = 40'

| STRIPING LEGEND | | | | | |
|-----------------|------------------|---|------------------|--------------|--|
| IDEN. NUMBER | STRIPING ELEMENT | IDEN. NUMBER | STRIPING ELEMENT | IDEN. NUMBER | STRIPING ELEMENT |
| (2) | STATE DETAIL 2 | (32) | STATE DETAIL 32 | (46) | SOLID 24" BIKE GREEN |
| (9) | STATE DETAIL 9 | (38) | STATE DETAIL 38 | (47) | SOLID 8" WHITE |
| (21) | STATE DETAIL 21 | (39A) | STATE DETAIL 39A | (48) | SOLID 12" WHITE |
| (22) | STATE DETAIL 22 | (39B) | STATE DETAIL 39B | (49) | SOLID 24" WHITE |
| (24) | STATE DETAIL 22 | (39) | STATE DETAIL 39 | (50) | SOLID 12" YELLOW |
| (27B) | STATE DETAIL 27B | (39A MODIFIED TO 24" X 48" SPACED AT 24") | | (51) | SOLID 24" YELLOW |
| (29) | STATE DETAIL 29 | (40) | STATE DETAIL 40 | (52) | PAVEMENT MESSAGE (MESSAGE SHOWN) |
| | | | | (53) | GREENBACK SHARED LANE MARKING MUTCD FIGURE 9C-9 (4X10) |
| | | | | (54) | BIKE LANE STENCIL WITH STRAIGHT ARROW MUTCD FIGURE 9C-3(B) |
| | | | | (55) | PEDESTRIAN LANE STENCIL WITH STRAIGHT ARROW |
| | | | | (56) | Buffered Bike Lane. Two D39 Spaced at 24-Inch O.C. with 4" White Hash Spaced at 15-FT O.C. |

NOTES:
- All new Lane Lines and Pavement Messages shall be Thermoplastic unless noted otherwise.
- All New Bicycle Facility Markings and Legends shall be Preformed Thermoplastic as Manufactured by Ennis-Flint or Approved Equal.
- Contractor Shall Remove any Roadway Striping or Markings that are in Conflict with this Plan.



| Rev. | Description | Date |
|------|---|------------|
| 01 | Bid Set | 09/28/2020 |
| | Bid Set - Addendum 1 Partial Removal of Rubber Curbs/Call Outs | 10/7/2020 |

Traffic Patterns
6701 Koll Center Pkwy
Suite 250
Pleasanton, CA 94566
O: (408) 916-8141
info@trafficpatterns.net

DATE SIGNED: 10/8/2020

| | |
|-------------|-------------------|
| SCALE: | AS SHOWN |
| DESIGN BY: | JOR |
| DRAWING BY: | JOR |
| CHECKED BY: | City of Los Altos |

EL MONTE AVE SIDEWALK GAP CLOSURE PROJECT
TS-01038

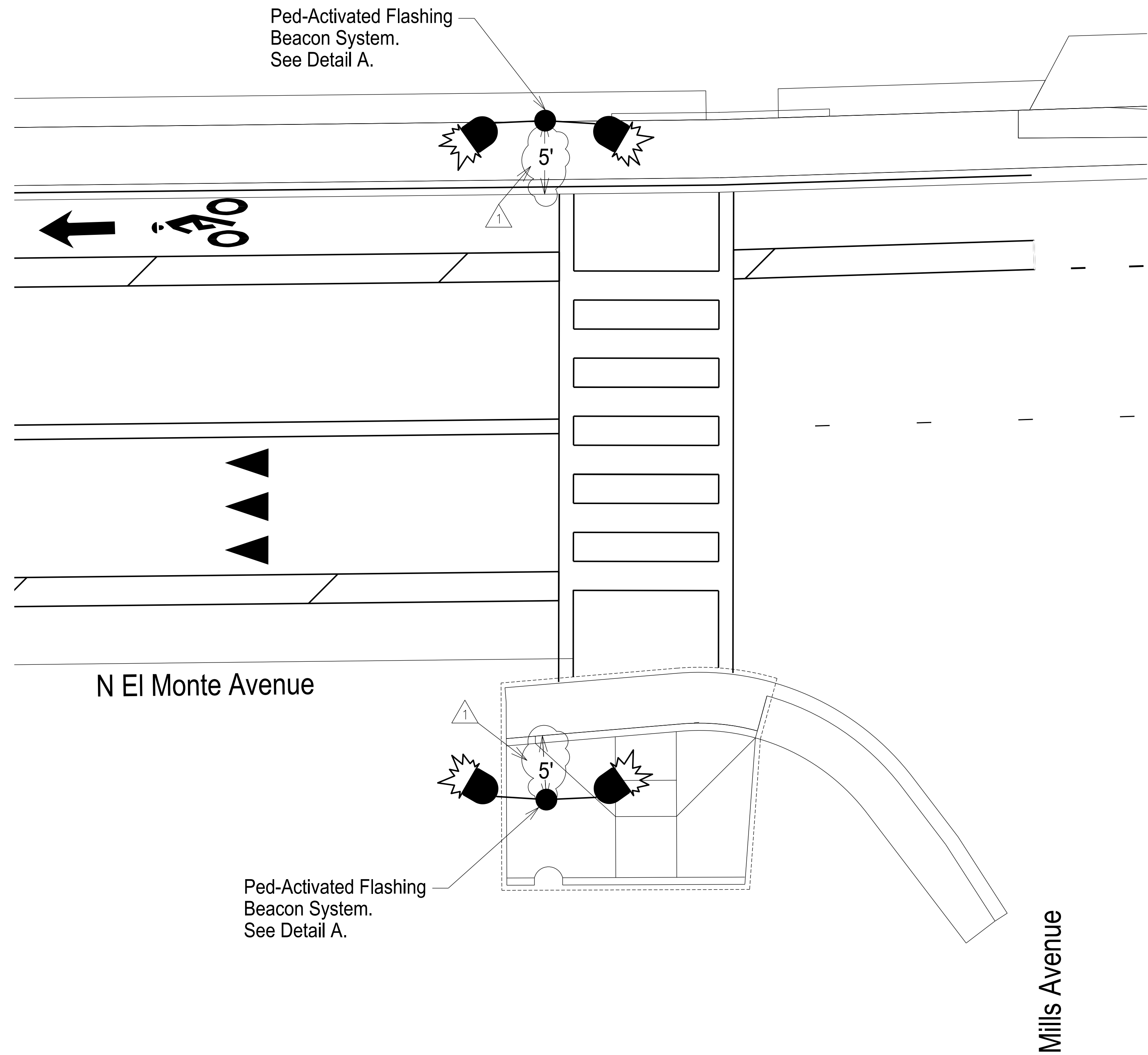
SIGNAGE & STRIPING PLAN

| | |
|---|--|
| City of Los Altos Santa Clara County California | City of Los Altos Project No. TS-01038 |
| Engineering Services Department 1 N. San Antonio Rd Los Altos, CA 94022-3000 | Drawing No. SHT 9 OF 11 |

N El Monte Avenue & Mills Avenue
Intersection Improvements

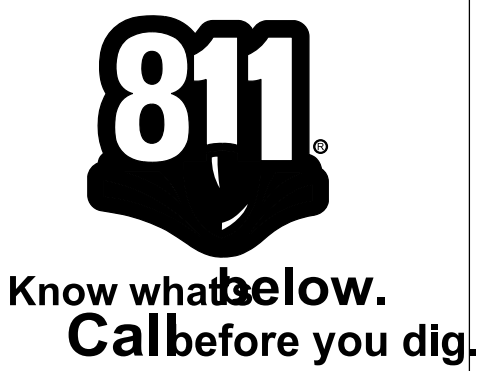
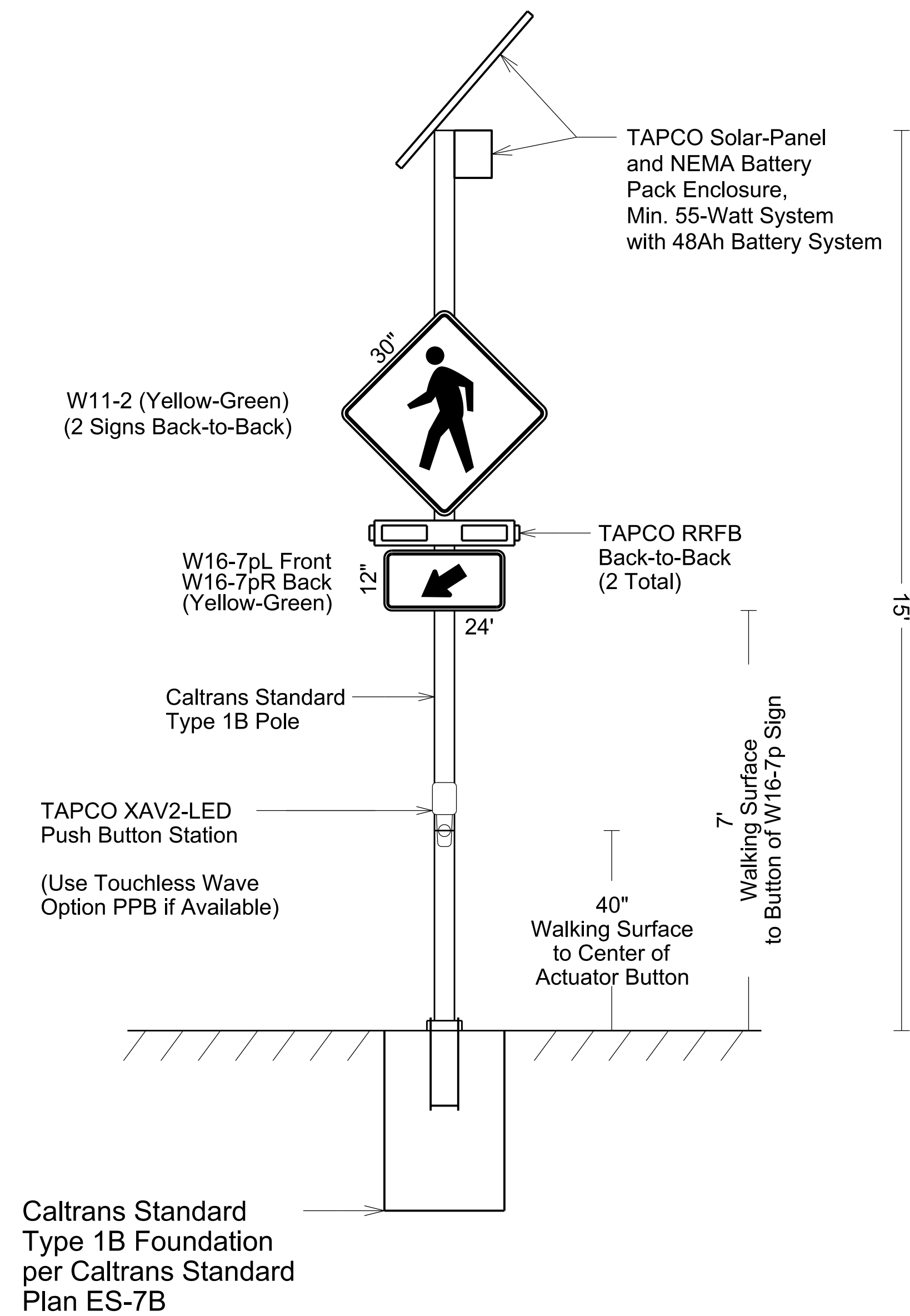
Ped-Activated RRFB Installation

Scale: None



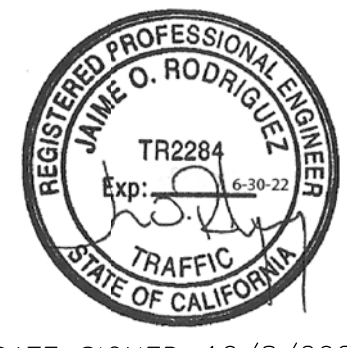
DETAIL A
TAPCO PEDESTRIAN-ACTIVATED
HIGH-VISIBILITY WARNING SYSTEM
ON TYPE 1B POLE

Scale: None



| Rev. | Description | Date |
|------|---|------------|
| 01 | Bid Set | 09/28/2020 |
| | Bid Set - Addendum 1 Partial Removal of Rubber Curbs/Call Outs | 10/7/2020 |

Traffic Patterns
6701 Koll Center Pkwy
Suite 250
Pleasanton, CA 94566
O: (408) 916-8141
info@trafficpatterns.net



DATE SIGNED: 10/8/2020

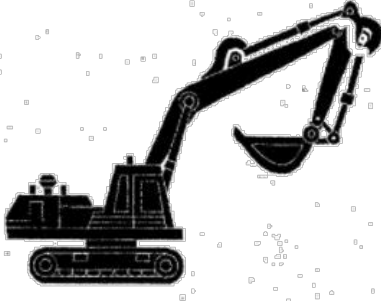
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| SCALE: | AS SHOWN |
| DESIGN BY: | JOR |
| DRAWING BY: | JOR |
| CHECKED BY: | City of Los Altos |

| |
|---|
| EL MONTE AVE SIDEWALK GAP CLOSURE PROJECT TS-01038 |
| RRFB INSTALLATION AT N EL MONTE AVENUE & MILLS AVENUE |

| | |
|---|--|
| City of Los Altos Santa Clara County California | City of Los Altos Project No. TS-01038 |
| Engineering Services Department 1 N. San Antonio Rd Los Altos, CA 94022-3000 | Drawing No. SHT 10 OF 11 |

Heavy Equipment Operation

Best Management Practices for the Construction Industry



Doing the Job Right

Site Planning and Preventive Vehicle Maintenance

- Maintain all vehicles and heavy equipment. Inspect frequently for and repair leaks.
- Schedule excavation and grading work during dry weather.
- Never hose down "dirty" pavement or impermeable surfaces where fluids have spilled. Use dry cleanup methods (absorbent materials, cat litter, and/or rags) whenever possible and properly dispose of absorbent materials.
- Always use spilled dry materials immediately. Never attempt to "wash them away" with water, or bury them whenever possible.
- Do not use diesel oil to lubricate equipment parts, or clean equipment. Use only water for any credible cleaning.
- Cover exposed fifth wheel hitch and other oily or greasy equipment during rain events.

Storm Water Pollution from Heavy Equipment on Construction Sites


Poorly maintained vehicles and heavy equipment that leak fuel, oil, antifreeze or other fluids on the construction site are common sources of storm drain pollution. Prevent spills and leaks by testing equipment for leaks, and by watching for leaks and other maintenance problems. Remove construction equipment from the site as soon as possible.

Best Management Practices for the

- Vehicle and equipment operators
- Site supervisors
- General contractors
- Home builders
- Developers

Roadwork and Paving

Best Management Practices for the Construction Industry



Doing the Job Right

General Business Practices

- Develop and implement erosion/sediment control plans for roadway embankments.
- Schedule excavation and grading work during dry weather.
- Check for and repair leaking equipment.
- Perform major equipment repairs at designated areas in your maintenance yard, where cleanups are used. Avoid performing equipment repairs at construction sites.
- When refueling or when vehicle/equipment maintenance must be done on site, designate a location away from storm drains and creeks.
- Do not use diesel oil to lubricate equipment parts or clean equipment.
- Recycle used oil, concrete, broken asphalt, etc. whenever possible, or dispose of properly.

During Construction

- Avoid paving and seal coating in wet weather, or when rain is forecast, to prevent fresh materials from contacting stormwater runoff.
- Cover and seal catch basins and manholes when applying seal coat, slurry seal, fog seal, or similar materials.
- Protect drainage ways by using earth dikes, sand bags, or other controls to divert or trap and filter runoff.

Storm Drain Pollution from Roadwork

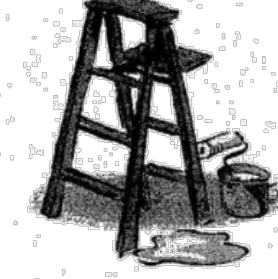
Road paving, surfacing, and pavement removal happen right in the street, where there are numerous opportunities for misapplied, saw-cut slurry or excavated material to illegally enter storm drains. Extra planning is required to store and dispose of materials properly and guard against pollution of storm drains, creeks, and the Bay.

Best Management Practices for the

- Road crews
- Driver/vehicle/parking lot construction crews
- Seal coat contractors
- Operators of grading equipment, paving machines, dump trucks, concrete mixers
- Construction inspectors
- General contractors
- Home builders
- Developers

Landscaping, Gardening, and Pool Maintenance

Best Management Practices for the Construction Industry



Doing the Job Right

General Business Practices

- Protect pesticides and landscaping materials from being washed into your yard, street, and storm drains. Liquid residues from paints, thinners, solvents, glues, and cleaning fluids are hazardous wastes and must be disposed of at a hazardous waste collection facility (contact your local stormwater program listed on the back of this brochure).
- When thoroughly dry, empty paint cans, used brushes, rags, and drop cloths may be disposed of as garbage in a sanitary landfill. Empty, dry paint cans also may be recycled as metal.
- Wash water from painted buildings conducted through 12" or larger downspouts of lead even if paint chips are not present. Before you begin stripping paint or cleaning pre-1970 building exteriors with water under high pressure, test paint for lead by taking paint samples to a local laboratory. See Yellow Pages for a state-certified laboratory.
- If there is loose paint on the building, or if the paint tests positive for lead, block storm drains. Check with the wastewater treatment plant to determine whether you may discharge water to the sanitary sewer, or if you must send it offsite for disposal as hazardous waste.

Paint Removal

- Never clean a filter in the street or near a storm drain. Clean filters in a bucket of water, and dispose of them in a sealed container.
- If there is no suitable dirt area, call your local wastewater treatment plant for instructions on discharging filter backwash or rinse water to the sanitary sewer.

Filter Cleaning

- Never clean a filter in the street or near a storm drain. Clean filters in a bucket of water, and dispose of them in a sealed container.
- If there is no suitable dirt area, call your local wastewater treatment plant for instructions on discharging filter backwash or rinse water to the sanitary sewer.

Storm Drain Pollution from Landscaping and Swimming Pool Maintenance

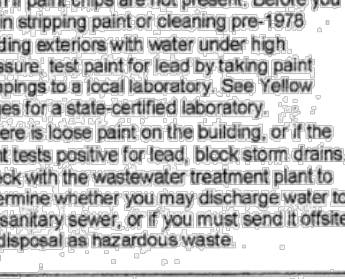
Many landscaping activities expose soils and increase the likelihood that lawn and garden chemicals will run off into the storm drains during irrigation or when it rains. Swimming pool water containing chlorine and copper-based algaecides should never be discharged to storm drains. These chemicals are toxic to aquatic life.

Best Management Practices for the

- Landscapers
- Gardeners
- Swimming pool/spa service and repair workers
- General contractors
- Home builders
- Developers
- Homeowners

Painting and Application of Solvents and Adhesives

Best Management Practices for the Construction Industry



Doing the Job Right

General Business Practices

- Never clean brushes or rinse paint containers into a street, gutter, storm drain, French drain, or other storm drain. Wash brushes in the street, gutter, or storm drain. Wash paint containers in the street, gutter, or storm drain.
- For water-based paints, paint out brushes to the extent possible, and rinse them in a bucket of water. Never pour paint down the drain.
- For oil-based paints, paint out brushes to the extent possible and clean with thinner or mineral spirits. Never pour thinner or mineral spirits down the drain.
- Chemical paint stripping residue and chips and dust from marine paints or paints containing lead, mercury or bismuth (in) must be disposed of as hazardous waste. Lead based paint removal requires a state-certified contractor.
- When stripping or cleaning building exteriors with high-pressure water, block storm drains. Direct wash water onto a dirt area and spill it into soil. Check with the local wastewater treatment authority to find out if you can collect (or vacuum) building cleaning water and dispose of it at the sanitary sewer. Sampling of the water may be required to assist the wastewater treatment authority in making its decision.

Recycle or Donate Leftover Paints Whenever Possible

- Recycle or donate water-based (latex) paint, or return to supplier.
- Recycle or donate oil-based paint. Dispose of non-recyclable thinners, sludge and unwanted paint, seal hazardous waste in a container.
- Unopened cans of paint may be able to be returned to the paint vendor. Check with the vendor regarding its "buy-back" policy.

Storm Drain Pollution from Paints, Solvents, and Adhesives

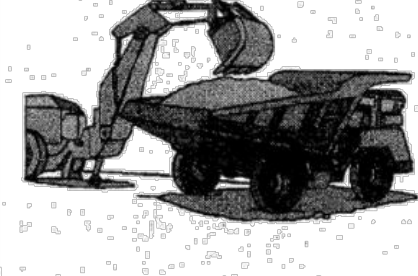
All paints, solvents, and adhesives contain chemicals that are harmful to wildlife in local streams, San Francisco Bay, and the Pacific Ocean. Toxic chemicals may come from liquid or solid products or from cleaning residues or rags. Paint materials and wastes, solvents and cleaning fluids should be recycled when possible, or disposed of properly to prevent them from flowing into storm drains and watercourses.

Best Management Practices for the

- Homeowners
- Painters
- Plumbers
- Painters
- Graphic artists
- Dry wall crews
- Floor covering installers
- General contractors
- Home builders
- Developers

Earth-Moving and Dewatering Activities

Best Management Practices for the Construction Industry



Doing the Job Right

General Business Practices

- Schedule excavation and grading work during dry weather.
- Perform major equipment repairs away from the dirt.
- When refueling or vehicle/equipment maintenance must be done on site, designate a location away from storm drains.
- Do not use diesel oil to lubricate equipment parts, or clean equipment.

Practices During Construction

- Remove existing vegetation only when absolutely necessary. Plant temporary vegetation for erosion control on slopes or drainage swales. Use check dams or ditches to divert runoff around excavations. Refer to the Regional Water Quality Control Board's Erosion and Sediment Control Field Manual for proper erosion and sediment control measures.

Storm Drain Pollution from Earth-Moving Activities and Dewatering

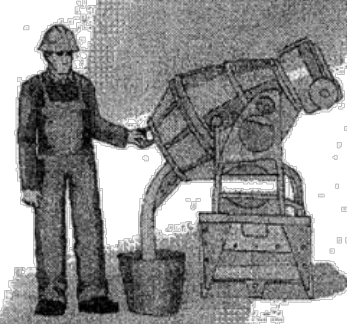
Soil excavation and grading operations loosen large amounts of soil that can flow or blow into storm drains when handled improperly. Sediments in runoff can clog storm drains, another aquatic life, and destroy habitats in creeks and the Bay. Effective erosion control practices reduce the amount of runoff causing a site and slow the flow with check dams or roughened ground surface.

Best Management Practices for the

- Bulldozer, back hoe, and grading machine operators
- Dump truck drivers
- Site supervisors
- General contractors
- Home builders
- Developers

Fresh Concrete and Mortar Application

Best Management Practices for the Construction Industry



Doing the Job Right

General Business Practices

- Wash out concrete mixers only in designated wash-out areas in your yard, away from storm drains and waterways, where the water will flow into a stormwater system. Let water percolate through soil and dispose of wet, hardened concrete as garbage. Whenever possible, recycle washout by pumping back into mixers for reuse.
- Wash out chutes onto dirt areas at site that do not flow to streets or drains.
- Always store both dry and wet materials under cover, protected from rainfall and runoff and away from storm drains or waterways. Protect dry materials from wind.
- Secure bags of cement after they are open. Be sure to keep wind-blown cement powder away from streets, gutters, storm drains, rainfall, and runoff.
- Do not use diesel fuel as a lubricant on concrete forms, tools, or trailers.

Storm Drain Pollution from Fresh Concrete and Mortar Applications

Fresh concrete and cement-related mortars that wash into lakes, streams, or estuaries are toxic to fish and the aquatic environment. Disposing of these materials in a storm drain, gutter, or other storm drain, causes serious problems, and is prohibited by law.

Best Management Practices for the

- Masons and bricklayers
- Sidewalk construction crews
- Plato construction workers
- Construction inspectors
- General contractors
- Home builders
- Developers
- Concrete delivery/pumping workers

Preventing Pollution: It's Up to Us

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Thirteen valley municipalities have joined together with Santa Clara County and the Santa Clara Valley Water District to educate local residents and businesses and fight storm water pollution. To comply with this program, contractors most comply with the practices described in this drawing sheet.

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State Office of Emergency Services Warning Center (24 hours): 800-852-7550
Santa Clara County Environmental Health Services: (408) 299-6930

Local Pollution Control Agencies

County of Santa Clara Pollution Prevention Program: (408) 441-1195
County of Santa Clara Integrated Waste Management Program: (408) 441-1198
County of Santa Clara District Attorney Environmental Crimes Hotline: (408) 299-TIPS

Santa Clara County Recycling Hotline: 1-800-533-8414
Santa Clara Valley Water District: (408) 265-2600
Santa Clara Valley Water District Pollution Hotline: 1-888-510-5151
Regional Water Quality Control Board San Francisco Bay Region: (510) 622-2300
Palo Alto Regional Water Quality Control Plant: (650) 329-2598
Serving East Palo Alto Sanitary District, Los Altos, Los Altos Hills, Mountain View, Palo Alto, Stanford

City of Los Altos
Building Department: (650) 947-2752
Engineering Department: (650) 947-2780

General Construction And Site Supervision

Best Management Practices For Construction



Doing the Job Right

General Principles

- Keep an orderly site and ensure good housekeeping practices are used.
- Maintain equipment properly.
- Cover materials when they are not in use.
- Keep materials away from streets, storm drains and drainage channels.
- Ensure dust control water doesn't leave site or discharge to storm drains.

Advance Planning To Prevent Pollution

- Schedule excavation and grading activities for dry weather periods. To reduce soil erosion, plant temporary vegetation or place other erosion controls before rain begins. Use the Erosion and Sediment Control Manual, available from the Regional Water Quality Control Board, as a reference.
- Control the amount of runoff covering your site by using berms or temporary or permanent drainage ditches to divert water flow around the site. Reduce storm water runoff velocities by constructing temporary check dams or berms where appropriate.
- Train your employees and subcontractors. Make these best management practices available to employees and subcontractors on the construction site. Inform subcontractors about the storm water requirements and their own responsibilities.

Good Housekeeping Practices

- Designate one area of the site for auto parking, vehicle refueling, and routine equipment maintenance. The designated area should be well away from streams or storm drain inlets, berms if necessary. Make major repairs off site.
- Keep materials out of the rain - prevent runoff from entering at the source. Cover excess pile of soil or construction materials with plastic sheeting or temporary roof. Before rain starts, sweep and remove materials from surfaces that drain to storm drains, creeks, or other waterways.
- Keep pollutants off exposed surfaces. Discharge and recycle/reuse materials around the site to minimize litter.

Storm Drain Pollution from Construction Activities

Construction sites are common sources of storm water pollution. Materials and wastes that flow or wash into a storm drain, gutter, or ditch have a direct impact on local creeks and the Bay.

Best Management Practices for the

- General contractors
- Site supervisors
- Inspectors
- Home builders
- Developers

Los Altos Municipal Code Requirements

Los Altos Municipal Code Chapter 10.08.390 Non-storm water discharges

A. Unlawful discharges. It shall be unlawful to discharge any domestic waste or industrial waste into storm drains, gutters, creeks, or San Francisco Bay. Unlawful discharges to storm drains shall include, but not be limited to, discharge from toilets; industrial processes; cooling systems; boilers; fabric cleaning; equipment cleaning; vehicle cleaning; construction activities, including, but not limited to, painting, pavement placement, saw cutting and grading; swimming pools; spas; and fountains, unless specifically permitted by a discharge permit or exempt pursuant to guidelines published by the superintendent.

B. Threatened discharges. It shall be unlawful to cause hazardous materials, domestic waste, or industrial waste to be deposited in such a manner or location as to constitute a threatened discharge into storm drains, gutters, creeks or San Francisco Bay. A "threatened discharge" is a condition creating a substantial probability of harm, when the probability and potential extent of harm make it reasonably necessary to take immediate action to prevent, reduce or mitigate damages to persons, property or natural resources. Domestic or industrial wastes that are no longer contained in a pipe, tank or other container are considered to be threatened discharges unless they are actively being cleaned up.

Los Altos Municipal Code Section 10.08.430 Requirements for construction operations.

A. A spill response plan for hazardous waste, hazardous materials and uncontained construction materials shall be prepared and available at the construction sites for all projects where the proposed construction site is equal to or greater than one acre of disturbed soil and for any other projects for which the city engineer determines it is necessary to protect surface waters. Preparation of the plan shall be in accordance with guidelines published by the city engineer.

B. A storm water pollution prevention plan shall be prepared and available at the construction sites for all projects greater than one acre of disturbed soil and for any other projects for which the city engineer determines that a storm water management plan is necessary to protect surface waters. Preparation of the plan shall be in accordance with guidelines published by the city engineer.

C. Prior approval shall be obtained from the city engineer or designee to discharge water pumped from construction sites to the storm drain. The city engineer or designee may require gravity settling and filtration upon a determination that either or both would improve the water quality of the discharge. Contaminated groundwater or water that exceeds state or federal requirements for discharge to navigable waters may not be discharged to the storm drain. Such water may be discharged to the sewer, provided that the requirements of Section 10.08.240 are met and the approval of the superintendent is obtained prior to discharge.

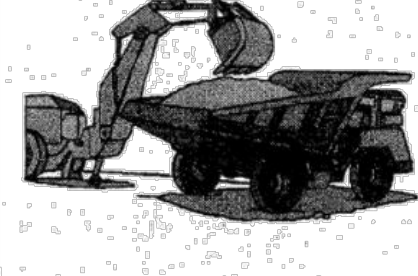
D. No cleanup of construction debris from the streets shall result in the discharge of water to the storm drain system; nor shall any construction debris be deposited or allowed to be deposited in the storm drain system. (Prior code § 5-5.643)

Crimes and judicial penalties can be assessed for non-compliance.

Blueprint for a Clean Bay

Remember: The property owner and the contractor share ultimate responsibility for the activities that occur on a construction site. You may be held responsible for any environmental damage caused by your subcontractors or employees.

Best Management Practices for the Construction Industry



Santa Clara Urban Runoff Pollution Prevention Program

DESIGNED BY: LARRY LIND
DRAWN BY: VICTOR CHEN
CHECKED BY: JIM GUSTAFSON

APPROVED BY: [Signature]
CITY ENGINEER

CITY OF LOS ALTOS
18056
R.C.E.

DATE: OCTOBER, 2003
SCALE: N.T.S.
DRAWING NO:

Landscaping, Gardening, and Pool Maintenance

Best Management Practices for the Construction Industry

Doing the Job Right

General Business Practices

- Protect pesticides and landscaping materials from being washed into your yard, street, and storm drains. Liquid residues from paints, thinners, solvents, glues, and cleaning fluids are hazardous wastes and must be disposed of at a hazardous waste collection facility (contact your local stormwater program listed on the back of this brochure).
- When thoroughly dry, empty paint cans, used brushes, rags, and drop cloths may be disposed of as garbage in a sanitary landfill. Empty, dry paint cans also may be recycled as metal.
- Wash water from painted buildings conducted through 12" or larger downspouts of lead even if paint chips are not present. Before you begin stripping paint or cleaning pre-1970 building exteriors with water under high pressure, test paint for lead by taking paint samples to a local laboratory. See Yellow Pages for a state-certified laboratory.
- If there is loose paint on the building, or if the paint tests positive for lead, block storm drains. Check with the wastewater treatment plant to determine whether you may discharge water to the sanitary sewer, or if you must send it offsite for disposal as hazardous waste.

Paint Removal

- Never clean a filter in the street or near a storm drain. Clean filters in a bucket of water, and dispose of them in a sealed container.
- If there is no suitable dirt area, call your local wastewater treatment plant for instructions on discharging filter backwash or rinse water to the sanitary sewer.

Filter Cleaning

- Never clean a filter in the street or near a storm drain. Clean filters in a bucket of water, and dispose of them in a sealed container.
- If there is no suitable dirt area, call your local wastewater treatment plant for instructions on discharging filter backwash or rinse water to the sanitary sewer.

Storm Drain Pollution from Landscaping and Swimming Pool Maintenance

Many landscaping activities expose soils and increase the likelihood that lawn and garden chemicals will run off into the storm drains during irrigation or when it rains. Swimming pool water containing chlorine and copper-based algaecides should never be discharged to storm drains. These chemicals are toxic to aquatic life.

Best Management Practices for the

- Landscapers
- Gardeners
- Swimming pool/spa service and repair workers
- General contractors
- Home builders
- Developers
- Homeowners

Painting and Application of Solvents and Adhesives

Best Management Practices for the Construction Industry

Doing the Job Right

General Business Practices

- Never clean brushes or rinse paint containers into a street, gutter, storm drain, French drain, or other storm drain. Wash brushes in the street, gutter, or storm drain. Wash paint containers in the street, gutter, or storm drain.
- For water-based paints, paint out brushes to the extent possible, and rinse them in a bucket of water. Never pour paint down the drain.
- For oil-based paints, paint out brushes to the extent possible and clean with thinner or mineral spirits. Never pour thinner or mineral spirits down the drain.
- Chemical paint stripping residue and chips and dust from marine paints or paints containing lead, mercury or bismuth (in) must be disposed of as hazardous waste. Lead based paint removal requires a state-certified contractor.
- When stripping or cleaning building exteriors with high-pressure water, block storm drains. Direct wash water onto a dirt area and spill it into soil. Check with the local wastewater treatment authority to find out if you can collect (or vacuum) building cleaning water and dispose of it at the sanitary sewer. Sampling of the water may be required to assist the wastewater treatment authority in making its decision.

Recycle or Donate Leftover Paints Whenever Possible

- Recycle or donate water-based (latex) paint, or return to supplier.
- Recycle or donate oil-based paint. Dispose of non-recyclable thinners, sludge and unwanted paint, seal hazardous waste in a container.
- Unopened cans of paint may be able to be returned to the paint vendor. Check with the vendor regarding its "buy-back" policy.

Storm Drain Pollution from Paints, Solvents, and Adhesives

All paints, solvents, and adhesives contain chemicals that are harmful to wildlife in local streams, San Francisco Bay, and the Pacific Ocean. Toxic chemicals may come from liquid or solid products or from cleaning residues or rags. Paint materials and wastes, solvents and cleaning fluids should be recycled when possible, or disposed of properly to prevent them from flowing into storm drains and watercourses.

Best Management Practices for the

- Homeowners
- Painters
- Plumbers
- Painters
- Graphic artists
- Dry wall crews
- Floor covering installers
- General contractors
- Home builders
- Developers

Earth-Moving and Dewatering Activities

Best Management Practices for the Construction Industry

Doing the Job Right

General Business Practices

- Schedule excavation and grading work during dry weather.
- Perform major equipment repairs away from the dirt.
- When refueling or vehicle/equipment maintenance must be done on site, designate a location away from storm drains.
- Do not use diesel oil to lubricate equipment parts, or clean equipment.

Practices During Construction

- Remove existing vegetation only when absolutely necessary. Plant temporary vegetation for erosion control on slopes or drainage swales. Use check dams or ditches to divert runoff around excavations. Refer to the Regional Water Quality Control Board's Erosion and Sediment Control Field Manual for proper erosion and sediment control measures.

Storm Drain Pollution from Earth-Moving Activities and Dewatering

Soil excavation and grading operations loosen large amounts of soil that can flow or blow into storm drains when handled improperly. Sediments in runoff can clog storm drains, another aquatic life, and destroy habitats in creeks and the Bay. Effective erosion control practices reduce the amount of runoff causing a site and slow the flow with check dams or roughened ground surface.

Best Management Practices for the

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- Dump truck drivers
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- Developers

Fresh Concrete and Mortar Application

Best Management Practices for the Construction Industry

Doing the Job Right

General Business Practices

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Best Management Practices for the

- Masons and bricklayers
- Sidewalk construction crews
- Plato construction workers
- Construction inspectors
- General contractors
- Home builders
- Developers
- Concrete delivery/pumping workers

Roadwork and Paving

Best Management Practices for the Construction Industry

Doing the Job Right

General Business Practices

- Develop and implement erosion/sediment control plans for roadway embankments.
- Schedule excavation and grading work during dry weather.
- Check for and repair leaking equipment.
- Perform major equipment repairs at designated areas in your maintenance yard, where cleanups are used. Avoid performing equipment repairs at construction sites.
- When refueling or when vehicle/equipment maintenance must be done on site, designate a location away from storm drains and creeks.
- Do not use diesel oil to lubricate equipment parts or clean equipment.
- Recycle used oil, concrete, broken asphalt, etc. whenever possible, or dispose of properly.

During Construction

- Avoid paving and seal coating in wet weather, or when rain is forecast, to prevent fresh materials from contacting stormwater runoff.
- Cover and seal catch basins and manholes when applying seal coat, slurry seal, fog seal, or similar materials.
- Protect drainage ways by using earth dikes, sand bags, or other controls to divert or trap and filter runoff.

Storm Drain Pollution from Roadwork

Road paving, surfacing, and pavement removal happen right in the street, where there are numerous opportunities for misapplied, saw-cut slurry or excavated material to illegally enter storm drains. Extra planning is required to store and dispose of materials properly and guard against pollution of storm drains, creeks, and the Bay.

Best Management Practices for the

- Road crews
- Driver/vehicle/parking lot construction crews
- Seal coat contractors
- Operators of grading equipment, paving machines, dump trucks, concrete mixers
- Construction inspectors
- General contractors
- Home builders
- Developers

Heavy Equipment Operation

Best Management Practices for the Construction Industry

Doing the Job Right

Site Planning and Preventive Vehicle Maintenance

- Maintain all vehicles and heavy equipment. Inspect frequently for and repair leaks.
- Schedule excavation and grading work during dry weather.
- Never hose down "dirty" pavement or impermeable surfaces where fluids have spilled. Use dry cleanup methods (absorbent materials, cat litter, and/or rags) whenever possible and properly dispose of absorbent materials.
- Always use spilled dry materials immediately. Never attempt to "wash them away" with water, or bury them whenever possible.
- Do not use diesel oil to lubricate equipment parts, or clean equipment. Use only water for any credible cleaning.
- Cover exposed fifth wheel hitch and other oily or greasy equipment during rain events.

Storm Water Pollution from Heavy Equipment on Construction Sites

Poorly maintained vehicles and heavy equipment that leak fuel, oil, antifreeze or other fluids on the construction site are common sources of storm drain pollution. Prevent spills and leaks by testing equipment for leaks, and by watching for leaks and other maintenance problems. Remove construction equipment from the site as soon as possible.

Best Management Practices for the

- Vehicle and equipment operators
- Site supervisors
- General contractors
- Home builders
- Developers

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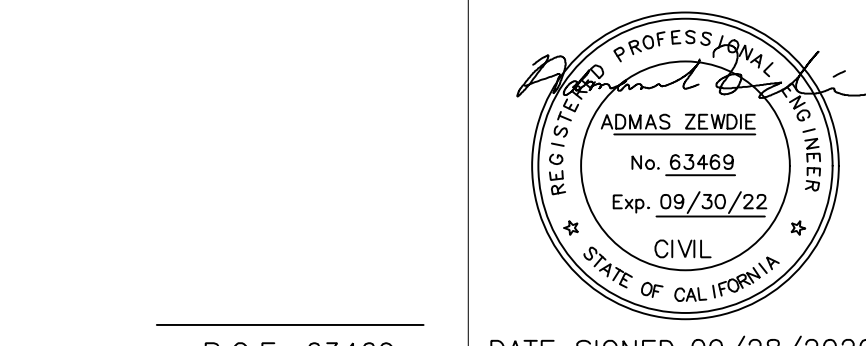
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|------|-------------|------------|
| Rev. | Description | Date |

7901 Oakport St, Suite 4225
Oakland, CA 94621
www.activewayz.engineering
(510) 989-2420



R.C.E. 63469

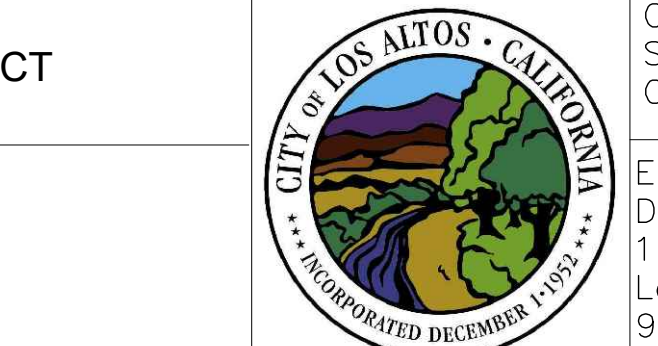
DATE SIGNED: 09/28/2020



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| SCALE: | AS SHOWN |
| DESIGN BY: | AZ |
| DRAWING BY: | AZ |
| CHECKED BY: | DA |

EL MONTE AVE SIDEWALK GAP CLOSURE PROJECT
TS-01038

BLUEPRINT FOR A CLEAN BAY



City of Los Altos
Santa Clara County
California

Engineering Services
Department
1 N. San Antonio Rd
Los Altos, CA
94022-3000

City of Los Altos
Project No.
TS-01038

Drawing No.
SHT 11 OF 11



Know what's below.
Call before you dig.



CONSENT CALENDAR

Agenda Item # 4

AGENDA REPORT SUMMARY

Meeting Date: November 10, 2020

Subject: Adopt resolution No: 2020 – 38 summary vacating an easement at 2020 El Sereno Avenue

Prepared by: Harun Musaefendic, Assistant Engineer

Reviewed by: Jim Sandoval, Engineering Services Director

Approved by: Chris Jordan, City Manager

Attachments:

1. Resolution No: 2020-38
2. Plat map and legal description

Initiated by:

Property owner of 2020 El Sereno Avenue

Previous Council Consideration:

None

Fiscal Impact:

None

Environmental Review:

Not applicable

Policy Question(s) for Council Consideration:

None

Summary:

- Property owner of 2020 El Sereno Avenue has requested the City vacate an easement that was reserved for future roadway in private property
- The property owner will be able to proceed with future remodel based on the new property line and setback compliance

Staff Recommendation:

Move to adopt Resolution No. 2020-38 summary vacating a portion of right-of-way at 2020 El Sereno Avenue.



Subject: Adopt resolution No: 2020 – 38X summary vacating an easement at 2020 El Sereno Avenue

Purpose

Summary vacation of an easement at 2020 El Sereno Avenue

Background

Property owner of 2020 El Sereno Avenue has requested that City vacate an easement that was reserved for future roadway on the northwestern side of 2020 El Sereno Avenue. This portion of the easement is located at the property side yard. Based on the parcel map, the property line at the north-west corner angles and makes it non-compliant with setback requirements prohibiting future remodel efforts.

Discussion/Analysis

Staff has reviewed the site and researched the history of the easement. The area of easement to be vacated is at the northwestern side of 2020 El Sereno Avenue and backing up to properties at 2039, 2047, and 2055 Crist Drive. The easement as shown in Tract 696 is described as reserved for future road, public road was not built in this location. Crist Drive was built approximately 140 feet northwest of said easement and is serving properties that the easement is backing up to. Staff recommends this summary vacation. A resolution ordering the vacation is attached.

Options

- 1) Adopt Resolution No. 2020-38

Advantages: The property owner will be able to proceed with remodel efforts based on the new property line and setback compliance.

Disadvantages: None, the area being vacated serves no benefit other than to the property owner of 2020 El Sereno Avenue.

- 2) Not adopt Resolution No. 2020-38

Advantages: None

Disadvantages: The property owner will not be able to perform a remodel.

Recommendation

The staff recommends Option 1

When recorded return to:

City Engineer
City of Los Altos
One North San Antonio Road
Los Altos, California 94022

RECORD WITHOUT FEE UNDER §§
27383 & 27388.1 GOVERNMENT CODE

SPACE ABOVE THIS LINE FOR RECORDERS USE ONLY

RESOLUTION NO. 2020-38

**A RESOLUTION OF THE CITY COUNCIL OF THE CITY OF LOS ALTOS
APPROVING THE VACATION OF AN EASEMENT ON THE PROPERTY AT
2020 EL SERENO AVENUE**

WHEREAS, the City of Los Altos (the “City”) received an application from property owner Shay Dunevich to vacate an easement previously acquired by the City for right of way purposes, and located along the northwestern border of his property at 2020 El Sereno Avenue, as more particularly described and depicted in **Exhibit A** hereto (the “Excess ROW”); and

WHEREAS, the Excess ROW was never developed into a street, and the City has no plans to use the easement for street or highway purposes in the future; and

WHEREAS, all the applicable public utilities, including Pacific Gas and Electric, California Water Service Company, AT&T, Comcast and Los Altos Public Works have confirmed that there is no existing or planned use for the Excess ROW; and

WHEREAS, the City Council held a public meeting on November 10, 2020.

NOW THEREFORE, BE IT RESOLVED, that:

1. The City Council hereby finds as follows:
 - a. That the foregoing recitals are true and correct;
 - b. That the vacation of the Excess ROW ordered herein is made under and in conformance with Division 9, Part 3, Chapter 4 of the Streets & Highways Code;
 - c. That the Excess ROW is not required for street or highway purposes, as set forth in Streets & Highways Code Section 8334, and that the necessity for a street or highway to be constructed within the Excess ROW has been superseded as set forth in Streets & Highways Code Section 8330 by the location of Crist Drive approximately 140 feet northwest of the Excess ROW, and vacating the Excess ROW will not cut off access to any person’s property or terminate a public service easement that is being used for the purpose for which it was dedicated;

- d. That the Excess ROW is not useful as a nonmotorized transportation facility, as set forth in Streets & Highways Code Section 892;
 - e. That, pursuant to Streets & Highways Code Section 8313, the vacation of Excess ROW ordered herein is consistent with the City's General Plan in that the Excess ROW is not depicted in Figure C-1 of the Circulation Element to the General Plan as being part of the City's Circulation Plan; nor is the Excess ROW described in the Circulation Element as being needed for future use; and
 - f. The vacation of the Excess ROW is exempt from review under the California Environmental Quality Act ("CEQA") pursuant to CEQA Guidelines Section 15061(b)(3) in that it can be seen with certainty that abandoning an unused easement not being used for right of way or utility purposes will not have a significant impact on the environment.
2. The Excess ROW is hereby ordered vacated so that from and after the date of this Resolution, it shall no longer constitute a right of way, street, highway, or public service easement of the City.
 3. As set forth in Streets and Highways Code Section 8336, the City Clerk is hereby directed to cause a certified copy of this Resolution, attested by the City Clerk under seal, to be recorded in the Official Records of Santa Clara County.
 4. The location and custodian of the documents or other materials that constitute the record of proceedings upon which the City Council's decision is hereby made shall be in the Office of the City Clerk.

I HEREBY CERTIFY that the foregoing is a true and correct copy of a Resolution passed and adopted by the City Council of the City of Los Altos at a meeting thereof on the 10th day of November 2020 by the following vote:

AYES:
NOES:
ABSENT:
ABSTAIN:

Janis C. Pepper, MAYOR

Attest:

Andrea Chelemengos, MMC, CITY CLERK

EXHIBIT "A"
LEGAL DESCRIPTION

FOR VACATION OF 15.75' RIGHT OF WAY
EASEMENT OVER LOT 15
BOOK 26 OF MAPS, AT PAGE 30,

2020 EL SERENO AVENUE
LOS ALTOS, CALIF.

REAL PROPERTY in the County of Santa Clara, State of California, described as follows:

Being the southeasterly 15.75 feet wide portion of the 20 foot wide Right Of Way which was described in that certain indenture which was recorded in Book 249 of Deeds, at Page 420, on December 2, 1901 in Santa Clara County Official Records, lying contiguous to and southeasterly of the northwesterly line of Lot 15 as shown on Tract No. 696, "El Sereno Homesites", filed for record on February 27, 1950, in Book 26 of Maps, at Page 30, Santa Clara County Records, and being more particularly described as follows:

Beginning at the most northerly corner of Lot 15 also being on the southwesterly line of El Sereno Avenue (60' in width) as shown on said tract map; Thence, southeasterly along said line being a non-tangent curve to the right, the center of which bears $S43^{\circ}57'00''W$, having a radius of 98.00 feet, through a central angle of $09^{\circ}15'02''$, an arc distance of 15.82 feet; Thence, leaving said southwesterly line of El Sereno Avenue, across said Lot 15, parallel with and southeasterly 15.75 feet (measured at right angles), with the northwesterly line of said Lot 15, $S43^{\circ}57'00''W$, 169.58 feet to the southwesterly line of said Lot 15; Thence, along said line, $N46^{\circ}03'00''W$, 15.75 feet to the most westerly corner of said Lot 15; Thence, along the northwesterly line of said Lot 15, $N43^{\circ}57'00''E$, 170.60 feet to the Point of Beginning.

Containing 2,685 square feet of land, more or less

End of Description

This description was prepared by me or under my direction in conformance with the requirements of the Professional Land Surveyors Act.

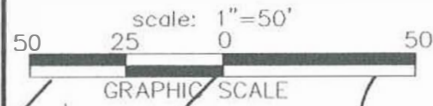

Brian L. Stockinger LS6995

Dated:

SEP 19, 2020

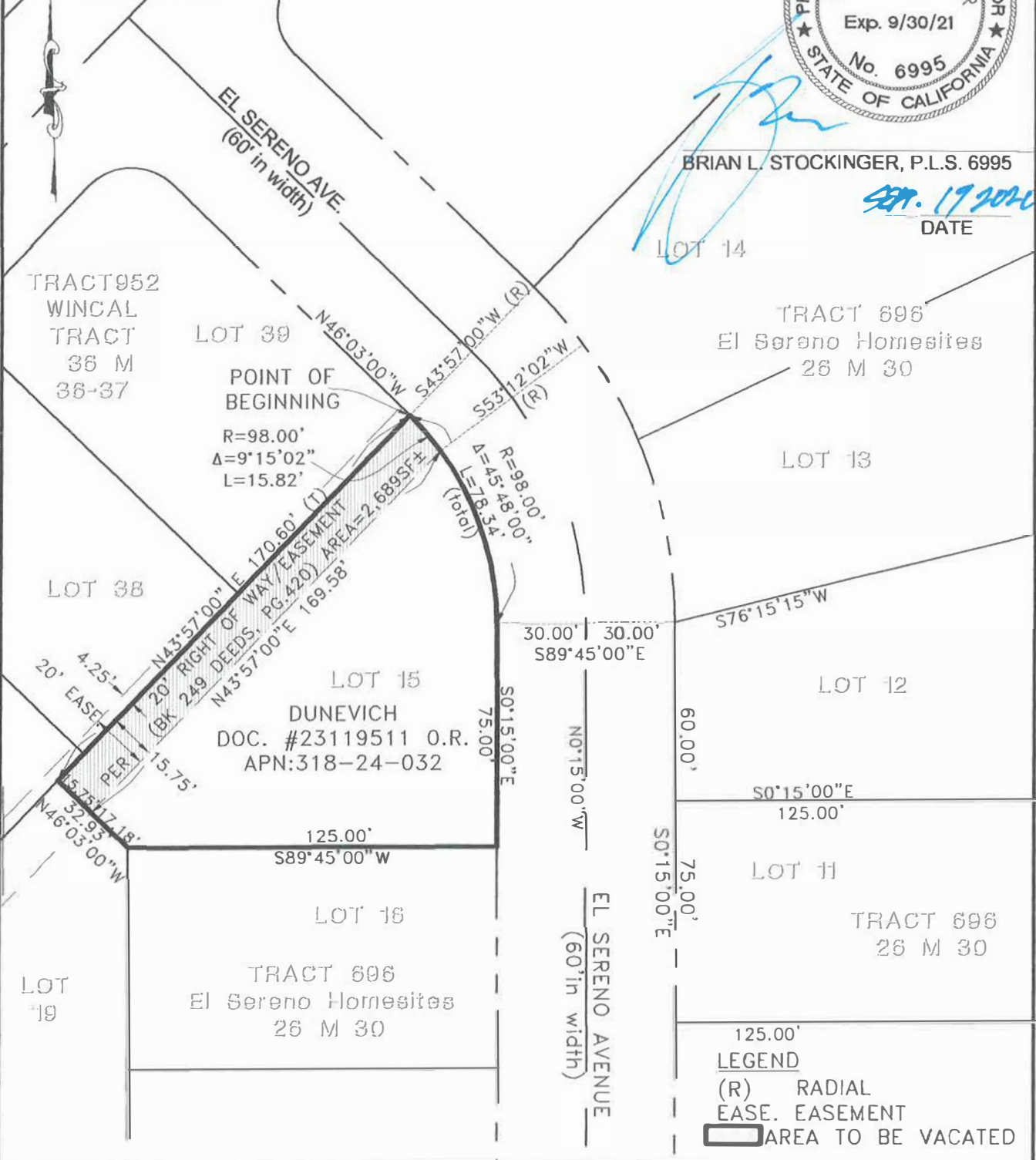


EXHIBIT "A"



BRIAN L. STOCKINGER, P.L.S. 6995

SEP. 17 2020
DATE



RIGHT OF WAY/EASEMENT VACATION

2020 EL SERENO AVE. LOS ALTOS CA 94024
DATE: SEPTEMBER 18, 2020 rev

BLS SURVEYING and MAPPING

BRIAN L STOCKINGER LS 6995
1531 GRANDVIEW AVE. MARTINEZ CA 94553
(925) 451 1644 goodsurveys6995@pacbell.net

Parcel Map Check Report

Date: 9/19/2020 6:53:13 AM

Parcel Name: 2020 El Sereno

Description:

Process segment order counterclockwise: False

Enable mapcheck across chord: False

"North:5,296.0348" "East:5,393.7701"

Segment# 1: Line

"Course: N43°57'00"E" Length: 170.90'
 "North: 5,419.0735" "East: 5,512.3799"

Segment# 2: Curve

Length: 15.82' Radius: 98.00'
 "Delta: 9°15'02" Tangent: 7.93'
 Chord: 15.81' "Course: S41°15'13"E"
 "Course In: S44°07'16"W" "Course Out: N53°22'19"E"
 "RP North: 5,348.7223" "East: 5,444.1545"
 "End North: 5,407.1909" "East: 5,522.8020"

Segment# 3: Line

"Course: S43°57'00"W" Length: 169.58'
 "North: 5,285.1025" "East: 5,405.1083"

Segment# 4: Line

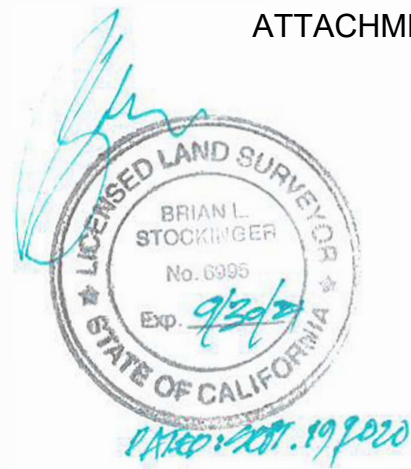
"Course: N46°03'00"W" Length: 15.75'
 "North: 5,296.0334" "East: 5,393.7692"

Perimeter: 372.05' "Area: 2,684.60Sq.Ft."

Error Closure: 0.0017 "Course: S33°27'40"W"

Error North : -0.00138 East: -0.00091

"Precision 1: 218,852.94"





CONSENT CALENDAR

Agenda Item # 5

AGENDA REPORT SUMMARY

Meeting Date: November 10, 2020

Subject: Civic Center Lands Protection

Prepared by: Jon Biggs, Community Development Director

Approved by: Chris Jordan, City Manager

Attachment(s):

1. Draft Public Lands Protection Ordinance

Initiated by:

City Council

Previous Council Consideration:

- The City Council considered this at its priority setting meetings for 2020.
- September 8, 2020

Fiscal Impact:

No fiscal impact is anticipated as work on ordinance is being developed using existing resources.

Environmental Review:

This draft amendment to Title 14 of the Los Altos Municipal has been assessed in accordance with the California Environmental Quality Act (Cal. Pub. Res. Code, § 21000 et seq.) (“CEQA”) and the State CEQA Guidelines (14 Cal. Code Regs. § 15000 et seq.) and is found to be categorically exempt from CEQA under CEQA Guidelines, § 15061(b)(3), which exempts from CEQA any project where it can be seen with certainty that there is no possibility that the activity in question may have a significant effect on the environment. In addition, the adoption of Amendments to Title 14 of the Los Altos Municipal Code would not be an activity with potential to cause significant adverse effect on the environment because the proposed changes relate to organizational or administrative activities of the City that will not result in direct or indirect physical changes in the environment, and therefore is exempt from CEQA.

Policy Question(s) for Council Consideration:

- Does the City Council agree with the staff’s suggested municipal code change that will put in place regulations that, if applied, will preserve park and open space areas within the Civic Center Complex.



Subject: Civic Center Lands Protection

Summary:

Staff is suggesting the addition of a Public Land Protection (PLP) overlay district to Title 14, Zoning, of the Los Altos Municipal Code that will provide for the protection of City owned property by requiring voter approval of the sale or transfer of title of any City-owned land to which this overlay designation is applied and voter approval to remove the PLP designation once it has been applied.

Staff Recommendation:

Concur with staff's proposal.

Purpose

The City Council has expressed an interest in enacting rules that would limit the City's ability to sell, transfer fee ownership, or re-designate lands of the Los Altos Civic Center.

Background

At its meeting of September 9, 2020, the City Council considered some options that would limit the City's ability to sell, transfer fee ownership, or re-designate lands of the Los Altos Civic Center. Staff recommended that a new zoning or land use designation and/or possibly an overlay district to the entire Civic Center complex be developed. Following a deliberation, the City Council voted to direct staff to proceed with developing a change to the zoning or land use designation to achieve the desired protection. The City Council also asked that staff check in once the code amendments to achieve this were developed, prior to taking the amendments through the zoning ordinance amendment process.

Attached with this agenda report is a draft ordinance that adds a Public Land Protection overlay district to the Municipal Code. This overlay district will work in conjunction with the underlying zone district of a property but provides that those properties with this overlay designation would require 1. Voter approval of the sale or transfer of title of any City-owned land to which this overlay designation is applied and 2. Voter approval to remove the PLP designation once applied.

This new overlay district will provide a City Council with the ability to protect other City owned properties with a precision that could not be achieved by amending the standards or language of an entire zone district. This is achievable because the PLP overlay designation can be applied to specific sites and memorialized on the City's zoning map.



Subject: Civic Center Lands Protection

If Council concurs with the addition of this code amendment, staff will proceed with the review of the code by the Planning Commission, and an amendment to the Zoning Map that reflects this overlay district applies to the Civic Center complex.

Options

- 1) Agree with the suggestion of staff.

Advantages: Provides a path that provides for the protection of the Civic Center complex.

Disadvantages: None identified.

- 2) Decline suggestion by staff.

Advantages: Other alternatives may seem more appropriate.

Disadvantages: Maintains current status.

Recommendation

Staff recommends Option 1.

ORDINANCE NO. 2020-XX

**AN ORDINANCE OF THE CITY COUNCIL OF THE CITY OF LOS ALTOS
 ADDING CHAPTER, 14.64, A PUBLIC LAND PRESERVATION (PLP)
 OVERLAY DISTRICT TO TITLE 14, ZONING, OF THE LOS ALTOS
 MUNICIPAL CODE THAT PROHIBITS: (1) THE SALE OR TRANSFER OF
 TITLE OF CITY-OWNED LAND WITH THE PLP OVERLAY
 DESIGNATION; AND (2) THE REMOVAL OF A PLP DESIGNATION
 WITHOUT VOTER APPROVAL**

WHEREAS, the City of Los Altos has a unique arrangement of land uses that require regulations and standards that preserve the character of the community and provide for compatibility of adjacent uses; and

WHEREAS, under the City’s police power, the City may enact comprehensive land-use and zoning regulations to promote health, safety and welfare; and

WHEREAS, the Open Space, Conservation, and Community Facilities Element of the Los Altos General Plan provide for public facilities and services and ensure a high quality of living for residents of and visitors to Los Altos; and

WHEREAS, the “Public and Institutional” General Plan Land Use designations provide for appropriate land uses and certain site development standards that help protect and maintain public parks, open space, facilities and services; and

WHEREAS, the City Council desires to amend the City of Los Altos Municipal Code to prohibit the sale, transfer of title, or re-designation of certain City owned lands without voter approval, except that voter approval shall not be required for leases (including ground leases), licenses and/or any other instruments which do not convey fee title interest; and

WHEREAS, Chapter 14.64, Public Property Preservation Overlay District (PLP), would require 1. Voter approval of the sale or transfer of title of any City-owned land to which this overlay designation is applied, except that voter approval shall not be required for leases (including ground leases), licenses and/or any other instruments which do not convey fee title interest; and 2. Voter approval to remove the PLP designation once applied; and

WHEREAS, at its XXXXX meeting the Planning Commission of the City of Los Altos reviewed the proposed addition of Chapter 14.64, to the Los Altos Municipal Code and voted to recommend their approval to the City Council.

NOW THEREFORE, the City Council of the City of Los Altos does hereby ordain as follows:

SECTION 1. FINDINGS. After considering the record before it, including but not limited to the agenda report, presentation of staff, public comment, and discussion, the City Council hereby finds that adoption of this Ordinance will help protect and promote public health, safety, comfort, convenience, prosperity and welfare by adding this Chapter to the City’s existing regulations.

SECTION 2. AMENDMENT OF CODE. The following Chapter, 14.64, Public Property Preservation Overlay District, is hereby added to Title 14, Zoning, of the Los Altos Municipal Code.

14.64.010. Public Land Preservation Overlay District (PLP). The purpose of the PLP district is to require voter approval for the sale or transfer of title of any City-owned land to which this overlay designation is applied, except that voter approval shall not be required for leases (including ground leases), licenses and/or any other instruments which do not convey fee title interest.

The regulations set forth in this chapter shall apply to all properties to which this overlay designation has been applied and shall supplement and be used in conjunction with the standards and requirements of the underlying zoning district.

14.66.020. Voter approval shall be required for the sale or transfer of title of any City-owned land to another party, whether public or private, with a PLP overlay designation, except that voter approval shall not be required for leases (including ground leases), licenses and/or any other instruments which do not convey fee title interest.

14.66.030. Once adopted, the PLP overlay designation shall not be removed unless by voter approval. The PLP shall be as set forth in the PLP Map Exhibit “A” and incorporated by this reference.

14.66.040. For purposes of this Ordinance, voter approval is accomplished when a City measure is placed on the ballot at a general or special election as authorized by the California Elections Code, and a majority of the voters voting on the measure vote in favor of it.

14.66.050. The voter approval requirement may be waived by the City Council when it is necessary to comply with State or Federal law governing the provision of housing, including but not limited to affordable housing requirements.

SECTION 3. SEVERABILITY. If any section, subsection, sentence, clause or phrase of this Ordinance is for any reason held to be invalid, such decision or decisions shall not affect the validity of the remaining portions of this Ordinance. The City Council hereby declares that it would have passed this Ordinance, and each section, subsection, sentence, clause and phrase thereof irrespective of the fact that any one or more sections, subsections, sentences, clauses or phrases be declared invalid.

SECTION 4. COMPLIANCE WITH THE CALIFORNIA ENVIRONMENTAL QUALITY ACT. Based on all the evidence presented in the administrative record, including but not limited to the staff reports, the proposed Ordinance relates to organizational or administrative activities of governments that will not result in direct or indirect physical changes in the environment, and therefore is exempt from California Environmental Quality Act (“CEQA”) CEQA Guidelines Section 15061(b)(3), which states the general rule that CEQA applies only to projects which have the potential for causing a significant effect on the environment” as the Ordinance has no potential to result in a direct, or reasonably foreseeable, indirect impact on the environment.

SECTION 5. CUSTODIAN OF RECORDS. The documents and materials associated with this Ordinance that constitute the record of proceedings on which the City Council’s findings and determinations are based are located at Los Altos City Hall, One North San Antonio Road, Los Altos, California. The City Clerk is the custodian of the record of proceedings.

SECTION 6. NOTICE OF EXEMPTION. The City Council hereby directs City staff to prepare and file a Notice of Exemption with the Santa Clara County Clerk.

SECTION 7. PUBLICATION. This Ordinance shall be published as provided in Government Code section 36933.

SECTION 8. EFFECTIVE DATE. This Ordinance shall be effective upon the commencement of the thirty-first day following the adoption date.

The foregoing Ordinance was duly and properly introduced at a regular meeting of the City Council of the City of Los Altos held on XXXXXX and was thereafter, at a regular meeting held on XXXXXX passed and adopted by the following vote:

AYES:

NOES:

ABSENT:

ABSTAIN:

Jan Pepper, MAYOR

Attest:

Andrea Chelemengos, CMC, CITY CLERK



CONSENT CALENDAR

Agenda Item #s 6,7,8, & 9

AGENDA REPORT SUMMARY

Meeting Date: November 10, 2020

Subject: Building Electrification and Electric Vehicle Infrastructure Reach Codes – Proposed Reach Codes for 2019 Energy Code

Prepared by: Environmental Commission and Staff

Reviewed by: Jon Biggs, Community Development Director

Approved by: Chris Jordan, City Manager

Attachment(s):

1. Ordinance No. 2020-470A
2. Ordinance No. 2020-470B
3. Ordinance No. 2020-470C
4. Ordinance No. 2020-471

Initiated by:

Environmental Commission

Previous Council Consideration:

November 19, 2019; September 22, 2020, October 27, 2020

Fiscal Impact:

None

Environmental Review:

The City Council hereby finds and determines that this Ordinance has been assessed in accordance with the California Environmental Quality Act (Cal. Pub. Res. Code, § 21000 et seq.) (“CEQA”) and the State CEQA Guidelines (14 Cal. Code Regs. § 15000 et seq.) and is categorically exempt from CEQA under CEQA Guidelines, § 15061(b)(3), which exempts from CEQA any project where it can be seen with certainty that there is no possibility that the activity in question may have a significant effect on the environment. Adoption of the proposed Ordinance would not be an activity with potential to cause significant adverse effect on the environment because the changes made to the California Energy Code are to provide more protection to the environment, and therefore is exempt from CEQA. It is also exempt from CEQA pursuant to CEQA Guidelines, § 15308 which exempts actions taken by regulatory agencies for the enhancement and protection of the environment. As such, the Ordinance is categorically exempt from CEQA.

Reviewed By:

City Manager

CJ

City Attorney

JH

Finance Director

SE



Subject: Building Electrification and Electric Vehicle Infrastructure Reach Codes – Proposed Reach Codes for 2019 Energy Code and the 2019 Green Building Standards Code

Policy Question(s) for Council Consideration:

- Does the Council wish to adopt Building Electrification and Electric Vehicle Infrastructure Codes containing requirements that limits power sources to principally electric appliances, fixtures, and equipment?

Summary:

Every three years, the State of California adopts new building standards that are organized in Title 24 of the California Code of Regulations, referred to as the California Building Standards Code. The City has adopted the 2019 building codes, which became effective statewide on January 1, 2020. Cities and counties can adopt amendments to building codes that have requirements that exceed minimum building code requirements. Reach codes provide requirements that exceed the standards for the energy and green building standards codes and require the installation of electric vehicle infrastructure in new construction. The energy reach codes must be approved by the California Energy Commission (“CEC”) before they can be enforced by a local government. To obtain CEC approval, a local government must find that the energy reach code is cost-effective, and the CEC must find that the reach code will require the diminution of energy consumption levels permitted by the state code.

Recommendation:

The Environmental Commission recommends the City Council adopt building electrification and electric vehicle reach codes, which amend the 2019 California Building Standards Code that was adopted, and became effective on January 1, 2020; to help reduce carbon emissions associated with new construction, reduce costs in new construction, improve indoor air quality and safety of our building stock, support affordable housing, and increase adoption of electric vehicles.

Purpose

The ordinance will put into effect requirements that mandate newly constructed buildings be all-electric with exceptions, and the installation of electric vehicle charging infrastructure for new construction.

Background

On November 19, 2019, the Environmental Commission presented the City Council with a Mixed-Fuel Reach Code Ordinance. During the first reading of the Ordinance, Council directed the Environmental Commission to pursue an All-Electric Reach Code Ordinance and to conduct community outreach.

On September 22, 2020, a public hearing of this ordinance was held, at which time the Environmental Commission and staff provided an overview of the reach code measures proposed in the ordinance, described the reach code development process, and explained findings that the energy reach code is cost-effective and will require the diminution of energy consumption levels permitted by the state



Subject: Building Electrification and Electric Vehicle Infrastructure Reach Codes – Proposed Reach Codes for 2019 Energy Code and the 2019 Green Building Standards Code

Energy Code. Council by motion directed staff to make modifications to the Building and Electrification Reach Code ordinance building type/use and reintroduce the ordinances.

On October 27, 2020, Council introduced the Building Electrification Reach Codes ordinance and waived its reading. No changes have been done since the introduction of the ordinance and we recommend its adoption.

Discussion/Analysis

On October 27, 2020, by motion Council directed staff to modify the Electric Vehicle Infrastructure Reach Code ordinances, introduced the ordinances, as amended, and waived their reading. Changes have been made and incorporated since the introduction of the ordinance per Council’s direction and we recommend their adoption. Substantive changes or modifications to the code may not be made between the introduction of an ordinance and its adoption. Any substantive change to the ordinance would require its re-introduction.

Options

- 1) Adopt Ordinance No. 2020-470A, Ordinance No. 2020-470B, and Ordinance No. 2020-470C, in the recommended sequence, amending chapter 12.22 Energy Code of Title 12 of the Los Altos Municipal code relating to amendments to the 2019 California Energy Code for All-Electric Buildings and adopt Ordinance No. 2020-471 amending chapter 12.26 Green Building Standards Code for Electric Vehicle Infrastructure.

Advantages: Reduce carbon emissions associated with new construction, improve indoor air quality and building safety, support affordable housing, and increase adoption of electric vehicles.

Disadvantages: Fail to follow PCE and SVCE member agencies that have already adopted reach codes to reduce carbon emissions associated with new construction, Fail to adopt a policy that advances the City’s sustainability and GHG emission reductions in line with Council Strategic Goals and Objectives 7. Do not take advantage of an opportunity to improve new building indoor air quality and safety, support affordable housing, and increase adoption of electric vehicles.

- 2) Do not adopt the Ordinance(s) and provide staff direction on changes to the Ordinance(s).

Advantages: Modifications can be made to the Ordinance(s) as necessary before being reintroduced



Subject: Building Electrification and Electric Vehicle Infrastructure Reach Codes – Proposed Reach Codes for 2019 Energy Code and the 2019 Green Building Standards Code

Disadvantages: Implementation will be delayed and allow for continued environmental harm and action to further environmental goals will be delayed

Recommendation

The staff recommends Option 1.

ORDINANCE NO. 2020-470A

**AN ORDINANCE OF THE CITY COUNCIL OF THE CITY OF LOS ALTOS
AMENDING CHAPTER 12.22 ENERGY CODE OF TITLE 12 OF THE LOS ALTOS
MUNICIPAL CODE RELATING TO AMENDMENTS TO THE 2019 CALIFORNIA
ENERGY CODE FOR ALL-ELECTRIC SINGLE-FAMILY BUILDINGS, MULTI-
FAMILY BUILDINGS HAVING FROM TWO TO NINE RESIDENTIAL UNITS, AND
DETACHED ACCESSORY DWELLING UNIT BUILDINGS**

WHEREAS, the California Building Standards Commission adopted and published an updated Title 24 of the California Code of Regulations, known as the 2019 California Building Standards Code, that became effective statewide on January 1, 2020; and

WHEREAS, California Health and Safety Code Sections 17958.5, 17958.7 and 18941.5 authorize cities to adopt the California Building Standards Code with modifications determined to be reasonably necessary because of local climatic, geological, or topographical conditions; and

WHEREAS, the City of Los Altos has adopted the 2019 California Building Standards Code with local amendments; and

WHEREAS, the City has adopted the 2019 California Energy Code in the 2019 California Building Standards Code, Part 6 of Title 24 of the California Code of Regulations, which implements minimum energy efficiency standards in buildings through mandatory requirements, prescriptive standards, and performances standards; and

WHEREAS, Public Resources Code Section 25402.1(h)(2) and Section 10-106 Locally Adopted Energy Standards of the California Administrative Code, Title 24 of the California Code of Regulations, Part I, establish a process which allows local adoption of energy standards that are more stringent than the statewide standards, provided that such local standards are cost effective and the California Energy Commission finds that the standards will require buildings to be designed to consume no more energy than permitted by the California Energy Code; and

WHEREAS, the City Council wishes to amend portions of the California Energy Code and affirms that such local modifications are cost effective and will result in designs that consume no more energy than that permitted under the 2019 California Energy Code; and

WHEREAS, the City's Climate Action Plan sets forth the goal to support initiatives that promote environmental sustainability and reduce the City's greenhouse gas emissions.

NOW THEREFORE, the City Council of the City of Los Altos does hereby ordain as follows:

SECTION 1. AMENDMENT OF CODE. Chapter 12.22 of Title 12 of the Los Altos Municipal Code is hereby amended in its entirety to read as follows:

Chapter 12.22 ENERGY CODE

Section 12.22.010 Adoption of the California Energy Code.

There is hereby adopted by reference as if fully set forth herein, the 2019 California Energy Code, contained in the California Code of Regulations, Title 24, Part 6, published by the International Code Council, and each and all of its regulations and provisions. One copy is on file for use and examination by the public in the office of the Building Official.

Section 12.22.020 Amendments for All-Electric Buildings.

- A. Amend Section 100.1(b) of the Energy Code by adding the following definitions to read as follows:

ALL-ELECTRIC BUILDING is a building that has no natural gas or propane plumbing installed within the building.

NEWLY CONSTRUCTED BUILDING (Applicable to Chapter 12.22 Energy Code Section 12.22.020 Amendments) is a building that has never been used or occupied for any purpose and supported by 1) a new structural foundation, 2) an existing, structural foundation where a building has been demolished and removed to floor or below, or 3) a combination of 1) and 2).

PUBLIC BUILDING is a building used by the public for any purpose, such as assembly, education, entertainment, or worship.

SCIENTIFIC LABORATORY BUILDING is a building or area where research, experiments, and measurement in medical, life, and physical sciences are performed and/or stored requiring examination of fine details. The building may include workbenches, countertops, scientific instruments, and supporting offices.

Subchapter 1 Section 100.0(e)2. A. is deleted and replaced to read as follows, based on express finding of necessity set forth of this Ordinance.

- B. Amend Section 100.0(e)2. A. of the Energy Code to read as follows:

2. Newly constructed buildings.

- A. Sections 110.0 through 110.12 apply to all newly constructed buildings within the scope of Section 100.0(a). In addition, newly constructed buildings shall meet the requirements of Subsections B, C, D or E, as applicable and shall be an all-electric building as defined in Section 100.1(b).

Exception 1: Residential Single-Family Dwellings, Detached ADUs (Accessory Dwelling Units), Multifamily Dwellings with two to nine units may install non-electric (natural gas-fueled) cooking and fireplace appliances if the applicant complies with the prewiring provisions, Subsection 12.22.020 B.3.

3. Wiring to accommodate future electric appliances or equipment.

(a) If a non-electric appliance or piece of equipment is allowed to be installed, the appliance or equipment location must also be electrically pre-wired for future electric appliance or equipment installation, including:

- i. A dedicated circuit, phased appropriately, with a minimum amperage requirement for a comparable electric appliance with an electrical receptacle or junction box that is connected to the electric panel with conductors of adequate capacity, extending to within 3 feet of the appliance and accessible with no obstructions. Appropriately sized conduit may be installed in lieu of conductors; and
- ii. Both ends of the unused conductor or conduit shall be labeled with the words “For Future Electric appliance or equipment” and be electrically isolated; and
- iii. A reserved circuit breaker space shall be installed in the electrical panel adjacent to the circuit breaker for the branch circuit and labeled for each circuit, an example is as follows (i.e. “For Future Electric Range;”); and,
- iv. All electrical components, including conductors, receptacles, junction boxes, or blank covers, related to this section shall be installed in accordance with the California Electrical Code.

SECTION 2.

The following findings support that the above amendments and modifications are reasonably necessary because of local climatic, geological or topographical conditions:

The City of Los Altos is located in Climate Zone 4 as established in the 2019 California Energy Code. Climate Zone 4 includes Santa Clara County, San Benito County, portions of Monterey County and San Luis Obispo. The City experiences an average of 19 inches of precipitation per year. In Los Altos, January is the rainiest month of the year while July is the driest month of the year. Temperatures average about 80 degrees Fahrenheit in the summer and about 40 degrees Fahrenheit in the winter. These climatic conditions along with the effects of climate change caused by Green House Gas (GHG) emissions generated from burning natural gas to heat buildings and emissions from Vehicle Miles Traveled results in an overall increase in global average temperature. Higher global temperatures are contributing to rising sea levels, record heat waves, droughts, wildfires and floods.

The above local amendments to the 2019 California Energy Code are necessary to combat the ever-increasing harmful effects of global climate change. Implementation of the proposed code amendments will achieve decarbonization and provide an accelerated path to reduce GHG emissions. The proposed Ordinance containing these amendments would ensure that new buildings use cleaner sources of energy which helps meet the goal of cutting carbon emissions in half by 2030.

All-electric building design benefits the health, welfare, and resiliency of Los Altos and its residents.

SECTION 3. CONSTITUTIONALITY.

If any section, subsection, sentence, clause or phrase of this code is for any reason held to be invalid or unconstitutional, such decision shall not affect the validity of the remaining portions of this code.

SECTION 4. CEQA.

The City Council hereby finds and determines that this Ordinance has been assessed in accordance with the California Environmental Quality Act (Cal. Pub. Res. Code, § 21000 et seq.) (“CEQA”) and the State CEQA Guidelines (14 Cal. Code Regs. § 15000 et seq.) and is categorically exempt from CEQA under CEQA Guidelines, § 15061(b)(3), which exempts from CEQA any project where it can be seen with certainty that there is no possibility that the activity in question may have a significant effect on the environment. Adoption of the proposed Ordinance would not be an activity with potential to cause significant adverse effect on the environment because the changes made to the California Energy Code within are enacted to provide more protection to the environment, and therefore is exempt from CEQA. It is also exempt from CEQA pursuant to CEQA Guidelines, § 15308 which exempts actions taken by regulatory agencies for the enhancement and protection of the environment. As such, the Ordinance is categorically exempt from CEQA.

SECTION 5. PUBLICATION.

This Ordinance shall be published as provided in Government Code section 36933.

SECTION 6. EFFECTIVE DATE.

This Ordinance shall be effective upon the commencement of the thirty-first (31st) day following the adoption date. The City Council’s findings of cost-effectiveness and energy savings will be filed with the California Energy Commission pursuant to Title 24 Chapter 10-106 before this ordinance takes effect.

The foregoing Ordinance was duly and properly introduced at a regular meeting of the City Council of the City of Los Altos held on _____, 2020 and was thereafter, at a regular meeting held on _____, 2020 passed and adopted by the following vote:

AYES:

NOES:

ABSENT:

ABSTAIN:

Janis C. Pepper, Mayor

ATTEST

Andrea Chelemengos MMC, City Clerk

ORDINANCE NO. 2020-470B

**AN ORDINANCE OF THE CITY COUNCIL OF THE CITY OF LOS ALTOS
AMENDING CHAPTER 12.22 ENERGY CODE OF TITLE 12 OF THE LOS ALTOS
MUNICIPAL CODE RELATING TO AMENDMENTS TO THE 2019 CALIFORNIA
ENERGY CODE FOR ALL-ELECTRIC MULTI-FAMILY RESIDENTIAL
DEVELOPMENTS HAVING TEN (10) OR MORE UNITS**

WHEREAS, the California Building Standards Commission adopted and published an updated Title 24 of the California Code of Regulations, known as the 2019 California Building Standards Code, that became effective statewide on January 1, 2020; and

WHEREAS, California Health and Safety Code Sections 17958.5, 17958.7 and 18941.5 authorize cities to adopt the California Building Standards Code with modifications determined to be reasonably necessary because of local climatic, geological, or topographical conditions; and

WHEREAS, the City of Los Altos has adopted the 2019 California Building Standards Code with local amendments; and

WHEREAS, the City has adopted the 2019 California Energy Code in the 2019 California Building Standards Code, Part 6 of Title 24 of the California Code of Regulations, which implements minimum energy efficiency standards in buildings through mandatory requirements, prescriptive standards, and performances standards; and

WHEREAS, Public Resources Code Section 25402.1(h)(2) and Section 10-106 Locally Adopted Energy Standards of the California Administrative Code, Title 24 of the California Code of Regulations, Part I, establish a process which allows local adoption of energy standards that are more stringent than the statewide standards, provided that such local standards are cost effective and the California Energy Commission finds that the standards will require buildings to be designed to consume no more energy than permitted by the California Energy Code; and

WHEREAS, the City Council wishes to amend portions of the California Energy Code and affirms that such local modifications are cost effective and will result in designs that consume no more energy than that permitted under the 2019 California Energy Code; and

WHEREAS, the City's Climate Action Plan sets forth the goal to support initiatives that promote environmental sustainability and reduce the City's greenhouse gas emissions.

NOW THEREFORE, the City Council of the City of Los Altos does hereby ordain as follows:

SECTION 1. AMENDMENT OF CODE. Chapter 12.22 of Title 12 of the Los Altos Municipal Code is hereby amended in its entirety to read as follows:

Chapter 12.22 ENERGY CODE

Section 12.22.010 Adoption of the California Energy Code.

There is hereby adopted by reference as if fully set forth herein, the 2019 California Energy Code, contained in the California Code of Regulations, Title 24, Part 6, published by the International Code Council, and each and all of its regulations and provisions. One copy is on file for use and examination by the public in the office of the Building Official.

Section 12.22.020 Amendments for All-Electric Buildings.

A. Amend Section 100.0(e)2. A. of the Energy Code to include the underlined language as follows:

2. Newly constructed buildings.

A. Sections 110.0 through 110.12 apply to all newly constructed buildings within the scope of Section 100.0(a). In addition, newly constructed buildings shall meet the requirements of Subsections B, C, D or E, as applicable and shall be an all-electric building as defined in Section 100.1(b).

Exception 1: Residential Single-Family Dwellings, Detached ADUs (Accessory Dwelling Units), Multifamily Dwellings with two to nine units may install non-electric (natural gas-fueled) cooking and fireplace appliances if the applicant complies with the prewiring provisions, Subsection 12.22.020 B.3.

SECTION 2.

The following findings support that the above amendments and modifications are reasonably necessary because of local climatic, geological or topographical conditions:

The City of Los Altos is located in Climate Zone 4 as established in the 2019 California Energy Code. Climate Zone 4 includes Santa Clara County, San Benito County, portions of Monterey County and San Luis Obispo. The City experiences an average of 19 inches of precipitation per year. In Los Altos, January is the rainiest month of the year while July is the driest month of the year. Temperatures average about 80 degrees Fahrenheit in the summer and about 40 degrees Fahrenheit in the winter. These climatic conditions along with the effects of climate change caused by Green House Gas (GHG) emissions generated from burning natural gas to heat buildings and emissions from Vehicle Miles Traveled results in an overall increase in global average temperature. Higher global temperatures are contributing to rising sea levels, record heat waves, droughts, wildfires and floods.

The above local amendments to the 2019 California Energy Code are necessary to combat the ever-increasing harmful effects of global climate change. Implementation of the proposed code amendments will achieve decarbonization and provide an accelerated path to reduce GHG emissions. The proposed Ordinance containing these amendments would ensure that new buildings use cleaner sources of energy which helps meet the goal of cutting carbon emissions in half by 2030.

All-electric building design benefits the health, welfare, and resiliency of Los Altos and its residents.

SECTION 3. CONSTITUTIONALITY.

If any section, subsection, sentence, clause or phrase of this code is for any reason held to be invalid or unconstitutional, such decision shall not affect the validity of the remaining portions of this code.

SECTION 4. CEQA.

The City Council hereby finds and determines that this Ordinance has been assessed in accordance with the California Environmental Quality Act (Cal. Pub. Res. Code, § 21000 et seq.) (“CEQA”) and the State CEQA Guidelines (14 Cal. Code Regs. § 15000 et seq.) and is categorically exempt from CEQA under CEQA Guidelines, § 15061(b)(3), which exempts from CEQA any project where it can be seen with certainty that there is no possibility that the activity in question may have a significant effect on the environment. Adoption of the proposed Ordinance would not be an activity with potential to cause significant adverse effect on the environment because the changes made to the California Energy Code within are enacted to provide more protection to the environment, and therefore is exempt from CEQA. It is also exempt from CEQA pursuant to CEQA Guidelines, § 15308 which exempts actions taken by regulatory agencies for the enhancement and protection of the environment. As such, the Ordinance is categorically exempt from CEQA.

SECTION 5. PUBLICATION.

This Ordinance shall be published as provided in Government Code section 36933.

SECTION 6. EFFECTIVE DATE.

This Ordinance shall be effective upon the commencement of the thirty-first (31st) day following the adoption date. The City Council’s findings of cost-effectiveness and energy savings will be filed with the California Energy Commission pursuant to Title 24 Chapter 10-106 before this ordinance takes effect.

The foregoing Ordinance was duly and properly introduced at a regular meeting of the City Council of the City of Los Altos held on _____, 2020 and was thereafter, at a regular meeting held on _____, 2020 passed and adopted by the following vote:

- AYES:
- NOES:
- ABSENT:
- ABSTAIN:

Janis C. Pepper, Mayor

ATTEST

Andrea Chelemengos MMC, City Clerk

ORDINANCE NO. 2020-470C

**AN ORDINANCE OF THE CITY COUNCIL OF THE CITY OF LOS ALTOS
AMENDING CHAPTER 12.22 ENERGY CODE OF TITLE 12 OF THE LOS ALTOS
MUNICIPAL CODE RELATING TO AMENDMENTS TO THE 2019 CALIFORNIA
ENERGY CODE FOR ALL-ELECTRIC NON-RESIDENTIAL BUILDINGS,
SCIENTIFIC LABORATORY BUILDINGS, AND PUBLIC BUILDINGS**

WHEREAS, the California Building Standards Commission adopted and published an updated Title 24 of the California Code of Regulations, known as the 2019 California Building Standards Code, that became effective statewide on January 1, 2020; and

WHEREAS, California Health and Safety Code Sections 17958.5, 17958.7 and 18941.5 authorize cities to adopt the California Building Standards Code with modifications determined to be reasonably necessary because of local climatic, geological, or topographical conditions; and

WHEREAS, the City of Los Altos has adopted the 2019 California Building Standards Code with local amendments; and

WHEREAS, the City has adopted the 2019 California Energy Code in the 2019 California Building Standards Code, Part 6 of Title 24 of the California Code of Regulations, which implements minimum energy efficiency standards in buildings through mandatory requirements, prescriptive standards, and performances standards; and

WHEREAS, Public Resources Code Section 25402.1(h)(2) and Section 10-106 Locally Adopted Energy Standards of the California Administrative Code, Title 24 of the California Code of Regulations, Part I, establish a process which allows local adoption of energy standards that are more stringent than the statewide standards, provided that such local standards are cost effective and the California Energy Commission finds that the standards will require buildings to be designed to consume no more energy than permitted by the California Energy Code; and

WHEREAS, the City Council wishes to amend portions of the California Energy Code and affirms that such local modifications are cost effective and will result in designs that consume no more energy than that permitted under the 2019 California Energy Code; and

WHEREAS, the City's Climate Action Plan sets forth the goal to support initiatives that promote environmental sustainability and reduce the City's greenhouse gas emissions.

NOW THEREFORE, the City Council of the City of Los Altos does hereby ordain as follows:

SECTION 1. AMENDMENT OF CODE. Chapter 12.22 of Title 12 of the Los Altos Municipal Code is hereby amended in its entirety to read as follows:

Chapter 12.22 ENERGY CODE

Section 12.22.010 Adoption of the California Energy Code.

There is hereby adopted by reference as if fully set forth herein, the 2019 California Energy Code, contained in the California Code of Regulations, Title 24, Part 6, published by the International Code Council, and each and all of its regulations and provisions. One copy is on file for use and examination by the public in the office of the Building Official.

A. Amend Section 100.0(e) 2. A. of the Energy Code is amended to include the underlined language as follows:

2. Newly constructed buildings.

A. Sections 110.0 through 110.12 apply to all newly constructed buildings within the scope of Section 100.0(a). In addition, newly constructed buildings shall meet the requirements of Subsections B, C, D or E, as applicable and shall be an all-electric building as defined in Section 100.1(b).

Exception 1: Residential Single-Family Dwellings, Detached ADUs (Accessory Dwelling Units), Multifamily Dwellings with two to nine units may install non-electric (natural gas-fueled) cooking and fireplace appliances if the applicant complies with the prewiring provisions, Subsection 12.22.020 B.3.

Exception 2: Non-residential Buildings containing for-profit restaurant open to the public may install gas-fueled cooking appliances. The applicant shall comply with the pre-wiring provision of Subsection 12.22.020 B. 3.

Exception 3: Non-residential buildings, Scientific Laboratory Buildings and Public Buildings may apply to the Building Division of the Los Altos Community Development Department for an exception to install a non-electric fueled appliance or piece of equipment. The Building Division of the Los Altos Community Development Department shall grant an exception if they find the following conditions are met:

- i. The applicant shows that there is a public or business-related need that cannot be reasonably met with an electric fueled appliance or piece of equipment.
- ii. The applicant complies with the pre-wiring provisions to the non-electric appliance or piece of equipment noted at Subsection 12.22.020 B. 3.

The decision of the Building Division of the Los Altos Community Development Department shall be final unless the applicant appeals the decision to the City Manager or his or her designee within 15 days of the date of the decision. The City Manager's or his or her designee's decision on the appeal shall be final.

SECTION 2.

The following findings support that the above amendments and modifications are reasonably necessary because of local climatic, geological or topographical conditions:

The City of Los Altos is located in Climate Zone 4 as established in the 2019 California Energy Code. Climate Zone 4 includes Santa Clara County, San Benito County, portions of Monterey County and San Luis Obispo. The City experiences an average of 19 inches of precipitation per year. In Los Altos, January is the rainiest month of the year while July is the driest month of the year. Temperatures average about 80 degrees Fahrenheit in the summer and about 40 degrees Fahrenheit in the winter. These climatic conditions along with the effects of climate change caused by Green House Gas (GHG) emissions generated from burning natural gas to heat buildings and emissions from Vehicle Miles Traveled results in an overall increase in global average temperature. Higher global temperatures are contributing to rising sea levels, record heat waves, droughts, wildfires and floods.

The above local amendments to the 2019 California Energy Code are necessary to combat the ever-increasing harmful effects of global climate change. Implementation of the proposed code amendments will achieve decarbonization and provide an accelerated path to reduce GHG emissions. The proposed Ordinance containing these amendments would ensure that new buildings use cleaner sources of energy which helps meet the goal of cutting carbon emissions in half by 2030.

All-electric building design benefits the health, welfare, and resiliency of Los Altos and its residents.

SECTION 3. CONSTITUTIONALITY.

If any section, subsection, sentence, clause or phrase of this code is for any reason held to be invalid or unconstitutional, such decision shall not affect the validity of the remaining portions of this code.

SECTION 4. CEQA.

The City Council hereby finds and determines that this Ordinance has been assessed in accordance with the California Environmental Quality Act (Cal. Pub. Res. Code, § 21000 et seq.) (“CEQA”) and the State CEQA Guidelines (14 Cal. Code Regs. § 15000 et seq.) and is categorically exempt from CEQA under CEQA Guidelines, § 15061(b)(3), which exempts from CEQA any project where it can be seen with certainty that there is no possibility that the activity in question may have a significant effect on the environment. Adoption of the proposed Ordinance would not be an activity with potential to cause significant adverse effect on the environment because the changes made to the California Energy Code within are enacted to provide more protection to the environment, and therefore is exempt from CEQA. It is also exempt from CEQA pursuant to CEQA Guidelines, § 15308 which exempts actions taken by regulatory agencies for the enhancement and protection of the environment. As such, the Ordinance is categorically exempt from CEQA.

SECTION 5. PUBLICATION.

This Ordinance shall be published as provided in Government Code section 36933.

SECTION 6. EFFECTIVE DATE.

This Ordinance shall be effective upon the commencement of the thirty-first (31st) day following the adoption date. The City Council's findings of cost-effectiveness and energy savings will be filed with the California Energy Commission pursuant to Title 24 Chapter 10-106 before this ordinance takes effect.

The foregoing Ordinance was duly and properly introduced at a regular meeting of the City Council of the City of Los Altos held on _____, 2020 and was thereafter, at a regular meeting held on _____, 2020 passed and adopted by the following vote:

AYES:

NOES:

ABSENT:

ABSTAIN:

Janis C. Pepper, Mayor

ATTEST

Andrea Chelemengos MMC, City Clerk

ORDINANCE NO. 2020-471
AN ORDINANCE OF THE CITY COUNCIL OF THE CITY OF LOS ALTOS
AMENDING CHAPTER 12.26 GREEN BUILDING STANDARDS CODE OF TITLE 12
OF THE LOS ALTOS MUNICIPAL CODE RELATING TO AMENDMENTS TO THE
2019 CALIFORNIA GREEN BUILDING STANDARDS CODE FOR ELECTRIC
VEHICLE (EV) INFRASTRUCTURE

WHEREAS, the City of Los Altos has seen significant sales of both electric vehicles (EV) and plug-in hybrid electric vehicles (“PHEV”); and

WHEREAS, the interest in EVs has grown alongside greater EV model availability, increased vehicle range, and expanded EV charging infrastructure in the region; and

WHEREAS, EV charging infrastructure available at locations they frequent, including one-and two-family dwellings, multi-family residences, and commercial properties is important for continued adoption of EVs; and

WHEREAS, the installation of the electric vehicle supply equipment (EVSE) is made cost effective when the infrastructure is installed during the initial construction phase as opposed to retrofitting existing buildings to accommodate the new electrical equipment; and

WHEREAS, the City of Los Altos supports this nascent industry for plug-in electric vehicles and its efforts in constructing EV charging infrastructure as this further supports the City’s sustainability goals; and

WHEREAS, the California Building Standards Commission adopted and published an updated Title 24 of the California Code of Regulations, known as the 2019 California Building Standards Code, that became effective statewide on January 1, 2020; and

WHEREAS, California Health and Safety Code Sections 17958.5, 17958.7 and 18941.5 authorize cities to adopt the California Building Standards Code with modifications determined to be reasonably necessary because of local climatic, geological or topographical conditions; and

WHEREAS, the City of Los Altos has adopted the 2019 California Building Standards Code with local amendments; and

WHEREAS, the City has adopted the 2019 California Green Building Standards Code in the 2019 California Building Standards Code, Title 24, Part 11, which enhances the design and construction of buildings through the use of building concepts having a reduced negative impact or positive environmental impact and encouraging sustainable construction practices; and

WHEREAS, the City Council wishes to amend portions of the California Green Building Standards Code and affirms the modifications are determined to be reasonably necessary because of local climatic, geological or topographical conditions, ensure that new buildings can charge a greater number of electric vehicles beyond state code requirements and reduce greenhouse gas emissions.

NOW THEREFORE, the City Council of the City of Los Altos does hereby ordain as follows:

SECTION 1. AMENDMENT OF CODE. Chapter 12.26 of Title 12 of the Los Altos Municipal Code is hereby amended in its entirety to read as follows:

Chapter 12.26 CALIFORNIA GREEN BUILDING STANDARDS CODE

Section 12.26.010 Adoption of the California Green Building Standards Code

Section 12.26.020 Amendments, Additions or Deletions

Section 12.26.030 Definitions

Section 12.26.010 Adoption of the California Green Building Standards Code

There is hereby adopted by reference as if fully set forth herein, the 2019 California Green Building Standards Code, contained in the California Code of Regulations, Title 24, Part 11, published by the International Code Council, and each and all of its regulations and provisions. One copy is on file for use and examination by the public in the office of the Building Official.

Section 12.26.020 Amendments, Additions or Deletions

The 2019 California Green Building Standards Code referred to in Section 12.26.010 is adopted, together with Chapters 1 Administration, 4 Residential Mandatory Measures, and 5 Nonresidential Mandatory Measures, of the 2019 California Green Building Standards Code, with the following amendments as follows:

Chapter 1 Section 102.4 Scope and Mandatory Compliance is hereby added to read as follows.

Section 102.4 Scope and Mandatory Compliance

- A. This code contains both mandatory and voluntary green building measures. Mandatory and voluntary measures are identified in the appropriate chapters contained in this code. Compliance measures and methods shall be by one of the following measures approved by the Building Official.

The means by which compliance measures are achieved shall be mandatory measures with appendix sections voluntarily applied, building division mandatory check list, whole house Build it Green GreenPoint check list, LEED, other recognized point systems, Title 24 Part 6 Energy Efficiency Standards, or equivalent approved methods. Green Building Compliance measures in addition to checklists shall be incorporated into the project drawings approved by the Building

Official prior to building permit submittal.

Prior to issuance of a building permit, the owner or responsible Registered Design Professional acting as the owner's agent shall employ and/or retain a Qualified Green Building Professional to the satisfaction of the Building Official, and prior to final inspection shall submit verification that the project is in compliance with this ordinance.

Chapter 4 Section 4.106.4 Electric vehicle (EV) charging for new construction thru 4.106.4.2.5 are deleted and replaced to read as follows, based upon express findings set forth in this Ordinance

Section 4.106.4, 4.106.4.1 and 4.106.2 are amended to read as follows:

4.106.4 Electric vehicle (EV) charging for new construction.

New construction shall comply with Sections 4.106.4.1, 4.106.4.2, or 4.106.4.3 to facilitate future installation and use of EV chargers. Electric vehicle supply equipment (EVSE) shall be installed in accordance with the *California Electrical Code, Article 625*.

Exceptions:

1. Where there is no commercial power supply.
2. If no additional parking facilities are provided, then Accessory Dwelling Units (ADU) and Junior Accessory Dwelling Units (JADU).

4.106.4.1 New one- and two-family dwellings and townhouses with attached or detached private garages.

For each dwelling unit, install at least one Level 2 EV Ready Space in the garage. If multiple (two or more) garage parking spaces are provided for a dwelling unit, install at least two Level 2 EV Ready Spaces.

4.106.4.1.1 Identification.

The raceway termination location shall be permanently and visibly marked as "Level 2 EV-Ready".

4.106.4.2 New multifamily dwellings.

The following requirements apply to all new multifamily dwellings:

1. For multifamily buildings with less than or equal to 20 dwelling units, install at least one Level 2 EV Ready Space for each dwelling unit.
2. When more than 20 multifamily dwelling units are constructed on a building site
 - a. 25% of the dwelling units with parking space(s) shall be provided with at least one Level 2 EV Ready Space. Calculations for the required minimum number of Level 2 EV Ready spaces shall be rounded up to the nearest whole number and not less than 21 spaces.

- b. In addition, each remaining dwelling unit with parking space(s) shall be provided with at least one Level 1 EV Ready Space.

Exception: For all multifamily Affordable Housing, 10% of dwelling units with parking space(s) shall be provided with at least one Level 2 EV Ready Space. Calculations for the required minimum number of Level 2 EV Ready spaces shall be rounded up to the nearest whole number. The remaining dwelling units with parking space(s) shall each be provided with at least one Level 1 EV Ready Space.

Notes:

1. ALMS may be installed to decrease electrical service and transformer costs associated with EV Charging Equipment subject to review of the authority having jurisdiction.
2. Installation of Level 2 EV Ready Spaces above the minimum number required level may offset the minimum number Level 1 EV Ready Spaces required on a 1:1 basis.
3. The requirements apply to multifamily buildings with parking spaces including: a) assigned or leased to individual dwelling units, and b) unassigned residential parking.
4. Local jurisdictions may consider allowing exceptions through their local process, on a case by case basis, if a building permit applicant provides documentation detailing that the increased cost of utility service or on-site transformer capacity would exceed an average of \$4,500 among parking spaces with Level 2 EV Ready Spaces and Level 1 EV Ready Spaces. If costs are found to exceed this level, the applicant shall provide EV infrastructure up to a level that would not exceed this cost for utility service or on-site transformer capacity.
5. In order to adhere to accessibility requirements in accordance with California Building Code Chapters 11A and/or 11B, it is recommended that all accessible parking spaces for covered newly constructed multifamily dwellings are provided with at least a Level 1 or Level 2 EV Ready Spaces.

4.106.4.2.1.1 Electric vehicle charging stations (EVCS).

When EV chargers are installed, EV spaces required by Section 4.106.4.2.2, Item 3, shall comply with at least one of the following options:

1. The EV space shall be located adjacent to an accessible parking space meeting the requirements of the California Building Code, Chapter 11A, to allow use of the EV charger from the accessible parking space.
2. The EV space shall be located on an accessible route, as defined in the California Building Code, Chapter 2, to the building.

Exception: Electric vehicle charging stations designed and constructed in compliance with the California Building Code, Chapter 11B, are not required to comply with Section 4.106.4.2.1.1 and Section 4.106.4.2.2, Item 3.

Note: Electric vehicle charging stations serving public housing are required to comply with the California Building Code, Chapter 11 B.

Section 4.106.4.2.2 Electric vehicle charging space (EV space) dimensions.

Refer to local authority having jurisdiction for parking dimension requirements.

4.106.4.2.3 Deleted

4.106.4.2.4 Deleted

4.106.4.2.5 Deleted

Chapter 5 Section 5.106.5.3 Electric vehicle (EV) charging thru 5.106.5.3.5 are deleted and replaced to read as follows, based upon express findings set forth in this Ordinance

Section 5.106.5.3 thru 5.106.5.3.5 are amended to read as follows:

5.106.5.3 Electric vehicle (EV) charging.

[N] New construction shall comply with Section 5.106.5.3.1 or Section 5.106.5.3.2 to facilitate future installation and use of EV.

Exceptions:

1. Where there is no commercial power supply.

5.106.5.3.1 Office and Institutional buildings.

In nonresidential new construction buildings designated primarily for office use and institutional buildings, with parking:

1. When 10 or more parking spaces are constructed, 50% of the available parking spaces on site shall be equipped with Level 2 EVCS;
2. An additional 20% shall be provided with at least Level 1 EV Ready Spaces; and
3. An additional 30% shall be at least Level 2 EV Capable.

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

Construction plans and specifications shall demonstrate that all raceways shall be a minimum of 1” and sufficient for installation of EVCS at all required Level 1 EV Ready and EV Capable spaces; Electrical calculations shall substantiate the design of the electrical system to include the rating of equipment and any on-site distribution transformers, and have sufficient capacity to simultaneously charge EVs at all required EV spaces including Level 1 EV Ready and EV Capable spaces; and service panel or subpanel(s) shall have sufficient capacity to accommodate the required number of dedicated branch circuit(s) for the future installation of the EVSE.

Notes:

1. ALMS may be installed to increase the number of EV chargers or the amperage or voltage beyond the minimum requirements in this code. The option does not allow for installing less electrical panel capacity than would be required without ALMS.

5.106.5.3.2 Other nonresidential buildings.

In nonresidential new construction buildings that are not designated primarily for office use, such as those for retail uses:

1. When 10 or more parking spaces are constructed, 6% of the available parking spaces on site shall be equipped with Level 2 EVCS;
2. An additional 5% shall be at least Level 1 EV Ready.
Calculations for the required minimum number of spaces equipped with Level 2 EVCS and Level 1 EV Ready spaces shall be rounded up to the nearest whole number

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

5.106.5.3.3 Clean Air Vehicle Parking Designation.

EVCS qualify as designated parking as described in Section 5.106.5.2 Designated parking for clean air vehicles.

Notes:

1. The California Department of Transportation adopts and publishes the California Manual on Uniform Traffic Control Devices (California MUTCD) to provide uniform standards and specifications for all official traffic control devices in California. Zero Emission Vehicle Signs and Pavement Markings can be found in the New Policies & Directives number 13-01. www.dot.ca.gov/hq/traffops/policy/13-01.pdf.
2. See Vehicle Code Section 22511 for EV charging spaces signage in off-street parking facilities and for use of EV charging spaces.
3. The Governor's Office of Planning and Research published a Zero-Emission Vehicle Community Readiness Guidebook which provides helpful information for local governments, residents and businesses. www.opr.ca.gov/docs/ZEV_Guidebook.pdf.
4. Section 11B-812 of the California Building Code requires that a facility providing EVCS for public and common use also provide one or more accessible EVCS as specified in Table 11B-228.3.2.1.
5. It is encouraged that shared parking, EV Ready are designated as "EV preferred."

5.106.5.3.4 [N] Identification.

The raceway termination location shall be permanently and visibly marked as "EV Ready".

5.106.5.3.5 Deleted.**Section 12.26.030 Definitions.**

For the purpose of this chapter, certain words and phrases used herein are defined as follows:

“Affordable Housing” means a housing development project, as defined in Government Code Section 65589.5(h)(2), in which at least forty percent (40%) of the units within the project are required by deed, regulatory restriction contained in an agreement with a government agency, or other recorded document, to be made available at an affordable housing cost as defined in Health and Safety Code Section 50052.5, or at an affordable rent as defined in Health and Safety Code Section 50053, to persons and families of low or moderate income as defined by Section 50093 of the Health and Safety Code, lower income households as defined by Section 50079.5 of the Health and Safety Code, very low income households as defined by Section 50105 of the Health and Safety Code, or extremely low income households as defined by Section 50106 of the Health and Safety Code, for a period of 55 years for rental housing or 45 years for owner-occupied housing.

“Automatic Load Management Systems (ALMS)” means a control system which allows multiple EV chargers or EV-Ready electric vehicle outlets to share a circuit or panel and automatically reduce power at each charger, providing the opportunity to reduce electrical infrastructure costs and/or provide demand response capability. ALMS systems must be designed to deliver at least 1.4kW to each EV Capable, EV Ready or EVCS space served by the ALMS. The connected amperage on-site shall not be lower than the required connected amperage per Part 11, 2019 California Green Building Code for the relevant building types.

“Build It Green” means the Build It Green organization. Build It Green is a California professional non-profit membership organization whose mission is to promote healthy, energy and resource-efficient buildings.

“Direct Current Fast Chargers” capable of charging at 20-400kW and delivers DC power directly to the battery and therefore able to charge faster. Examples of this type of charger include Superchargers and DC Fast Chargers currently used at some public and commercial sites.

“Electric Vehicle Charging Station (EVCS)” means a parking space that includes installation of electric vehicle supply equipment (EVSE) with a minimum capacity of 30 amperes connected to a circuit serving a Level 2 EV Ready Space. EVCS installation may be used to satisfy a Level 2 EV Ready Space requirement.

“EV Capable” means a parking space linked to a listed electrical panel with sufficient capacity to provide at least 110/120 volts and 20 amperes to the parking space. Raceways linking the electrical panel and parking space only need to be installed in spaces that will be inaccessible in the future, either trenched underground or where penetrations to walls, floors, or other partitions would otherwise be required for future installation of branch circuits. Raceways must be at least 1” in diameter and may be sized for multiple circuits as allowed by the California Electrical Code. The panel circuit directory shall identify the overcurrent protective device space(s) reserved for EV charging as “EV CAPABLE.” Construction documents shall indicate future completion of raceway from the panel to the parking space, via the installed inaccessible raceways.

“Green Point Rated” means the rating system developed by Build It Green.

“LEED” means the “Leadership in Energy and Environmental Design” program developed by the U.S. Green Building Council. The U.S. Green Building Council is a National professional non-profit membership organization whose mission is to promote buildings that are environmentally responsible.

“LEED Accredited Professional” means a person or organization determined by the Building Official to be qualified to perform inspections and provide documentation to assure compliance with the U.S. Green Building Council LEED requirements.

“Level 1 EV Ready Space” means a parking space served by a complete electric circuit with a minimum of 110/120 volt, 20-ampere capacity including electrical panel capacity, overprotection device, a minimum 1” diameter raceway that may include multiple circuits as allowed by the California Electrical Code, wiring, and either a) a receptacle labelled “Electric Vehicle Outlet” with at least a ½” font adjacent to the parking space, or b) electric vehicle supply equipment (EVSE).

“Level 2 EV Ready Space” means a parking space served by a complete electric circuit with 208/240 volt, 40-ampere capacity including electrical panel capacity, overprotection device, a minimum 1” diameter raceway that may include multiple circuits as allowed by the California Electrical Code, wiring, and either a) a receptacle labelled “Electric Vehicle Outlet” with at least a ½” font adjacent to the parking space, or b) electric vehicle supply equipment (EVSE) with a minimum output of 30 amperes.

“Qualified Green Building Professional” means a person trained through the USGBC as a “LEED AP” (accredited professional), or through Build It Green as a GreenPoint Rater, or other qualifications when acceptable to the Building Official. A certified green building professional, architect, designer, builder, or building inspector may be considered a qualified green building professional when determined appropriate by the Building Official.

“Structural Renovations” means existing portions of roof framing and/or exterior walls removed for the purpose of rebuilding and remodeling.

SECTION 3. CONSTITUTIONALITY.

If any section, subsection, sentence, clause or phrase of this code is for any reason held to be invalid or unconstitutional, such decision shall not affect the validity of the remaining portions of this code.

SECTION 4. CEQA.

The City Council hereby finds and determines that this Ordinance has been assessed in accordance with the California Environmental Quality Act (Cal. Pub. Res. Code, § 21000 et seq.) (“CEQA”) and the State CEQA Guidelines (14 Cal. Code Regs. § 15000 et seq.) and is categorically exempt from CEQA under CEQA Guidelines, § 15061(b)(3), which exempts from CEQA any project where it can be seen with certainty that there is no possibility that the activity in question may have a significant effect on the environment. Adoption of the proposed Ordinance would not be an activity with potential to cause significant adverse effect on the environment because the changes made to the California Green Buildings Standards Code within are enacted to provide more protection to the environment, and therefore is exempt from CEQA. It is also exempt from CEQA pursuant to CEQA Guidelines, § 15308 which exempts actions taken by regulatory agencies for the

enhancement and protection of the environment. As such, the Ordinance is categorically exempt from CEQA.

SECTION 5. PUBLICATION.

This Ordinance shall be published as provided in Government Code section 36933.

SECTION 6. EFFECTIVE DATE.

This Ordinance shall be effective upon the commencement of the thirty-first (31st) day following the adoption date.

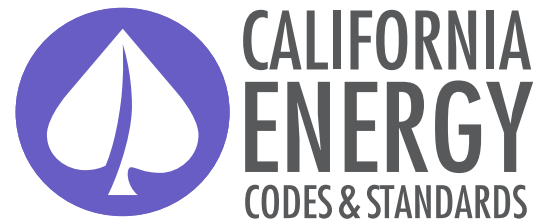
The foregoing Ordinance was duly and properly introduced at a regular meeting of the City Council of the City of Los Altos held on _____, 2020 and was thereafter, at a regular meeting held on _____, 2020 passed and adopted by the following vote:

- AYES:
- NOES:
- ABSENT:
- ABSTAIN:

Jan Pepper, Mayor

ATTEST

Andrea Chelemengos MMC, City Clerk



A STATEWIDE UTILITY PROGRAM

Title 24, Parts 6 and 11
Local Energy Efficiency Ordinances

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

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

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

Last Modified: August 01, 2019

LEGAL NOTICE

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

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Acronyms

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

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

1 Introduction

The California Building Energy Efficiency Standards Title 24, Part 6 (Title 24) (Energy Commission, 2018b) is maintained and updated every three years by two state agencies, the California Energy Commission (Energy Commission) and the Building Standards Commission (BSC). In addition to enforcing the code, local jurisdictions have the authority to adopt local energy efficiency ordinances, or reach codes, that exceed the minimum standards defined by Title 24 (as established by Public Resources Code Section 25402.1(h)2 and Section 10-106 of the Building Energy Efficiency Standards). Local jurisdictions must demonstrate that the requirements of the proposed ordinance are cost-effective and do not result in buildings consuming more energy than is permitted by Title 24. In addition, the jurisdiction must obtain approval from the Energy Commission and file the ordinance with the BSC for the ordinance to be legally enforceable.

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

2 Methodology and Assumptions

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

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

2.1 Building Prototypes

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



Table 1: Prototype Characteristics

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

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

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

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

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

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

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

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



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

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

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

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

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

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

2.2 Measure Analysis

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

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

³ Developed by Ken Nittler of Enercomp, Inc.

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

2.2.1 Federal Preemption

The Department of Energy (DOE) sets minimum efficiency standards for equipment and appliances that are federally regulated under the National Appliance Energy Conservation Act (NAECA), including heating, cooling, and water heating equipment. Since state and local governments are prohibited from adopting policies that mandate higher minimum efficiencies than the federal standards require, the focus of this study is to identify and evaluate cost-effective packages that do not include high efficiency equipment. While this study is limited by federal preemption, in practice builders may use any package of compliant measures to achieve the performance goals, including high efficiency appliances. Often, these measures are the simplest and most affordable measures to increase energy performance.

2.2.2 Energy Design Rating

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

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

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

For a building to comply, two criteria are required:

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

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

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

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

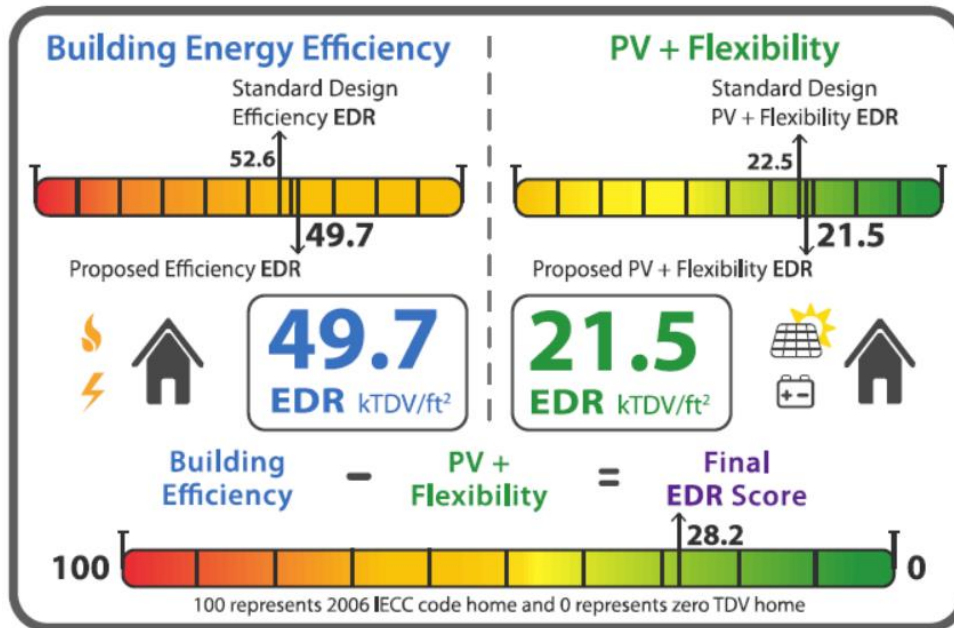


Figure 1: Graphical description of EDR scores (courtesy of Energy Code Ace⁵)

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

Equation 1

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

Equation 2

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

2.2.3 Energy Efficiency Measures

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

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

⁵ <https://energycodeace.com/>

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

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

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

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

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

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

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

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

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

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

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

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



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

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

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

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

Federally Preempted Measures:

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

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

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

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

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

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

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



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

2.3 Package Development

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

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

2.3.1 Solar Photovoltaics (PV)

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

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

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

2.3.2 Energy Storage (Batteries)

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

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

⁹ NEM rules apply to the IOU territories only.

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

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

2.4 Incremental Costs

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

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

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

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

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

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

¹² <http://www.deeresources.com>

Table 4: Incremental Cost Assumptions

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



Table 4: Incremental Cost Assumptions

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



Table 4: Incremental Cost Assumptions

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



2.5 Cost-effectiveness

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

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

Equation 3

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

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

Equation 4

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

Where:

- n = analysis term
- r = discount rate

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

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

2.5.1 On-Bill Customer Lifecycle Cost

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

¹³ Under NEM rulings by the CPUC (D-16-01-144, 1/28/16), all new PV customers shall be in an approved TOU rate structure. <https://www.cpuc.ca.gov/General.aspx?id=3800>



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

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

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

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

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

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

Table 5: IOU Utility Tariffs Applied Based on Climate Zone

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

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

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

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

2.5.2 TDV Lifecycle Cost

Cost-effectiveness was also assessed using the Energy Commission’s TDV LCC methodology. TDV is a normalized monetary format developed and used by the Energy Commission for comparing electricity and natural gas savings, and it considers the cost of electricity and natural gas consumed during different times of the day and year. The 2019 TDV values are based on long term discounted costs of 30 years for all residential measures. The CBEC-Res simulation software outputs are in terms of TDV kBTUs. The present value of the energy cost savings in dollars is calculated by multiplying the TDV kBTU savings by a net present value (NPV) factor, also developed by the Energy Commission. The NPV factor is \$0.173/TDV kBtu for residential buildings.

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

Equation 5

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

2.6 Electrification Evaluation

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

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

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

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



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

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

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

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

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

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

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

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

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

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



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

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

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

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

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

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

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

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

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



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

2.7 Greenhouse Gas Emissions

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

3 Results

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

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

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

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

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

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

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

3.1 PV and Battery System Sizing

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

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

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



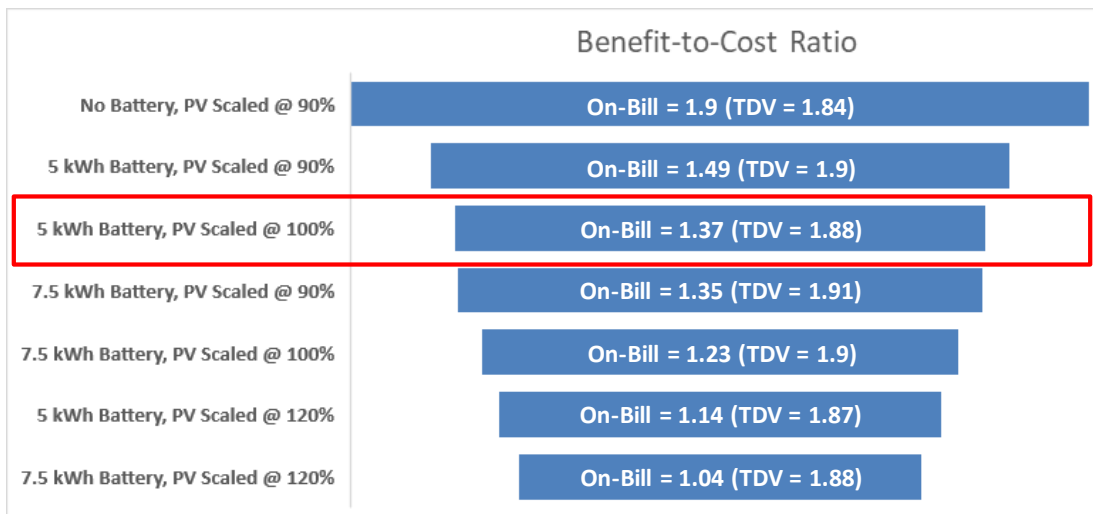
Table 7: PV & Battery Sizing Details by Package Type

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

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

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

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

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

3.2 Single Family Results

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

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

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

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

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

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



Table 8: Single Family Package Lifetime Incremental Costs

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



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

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

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

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



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

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

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

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



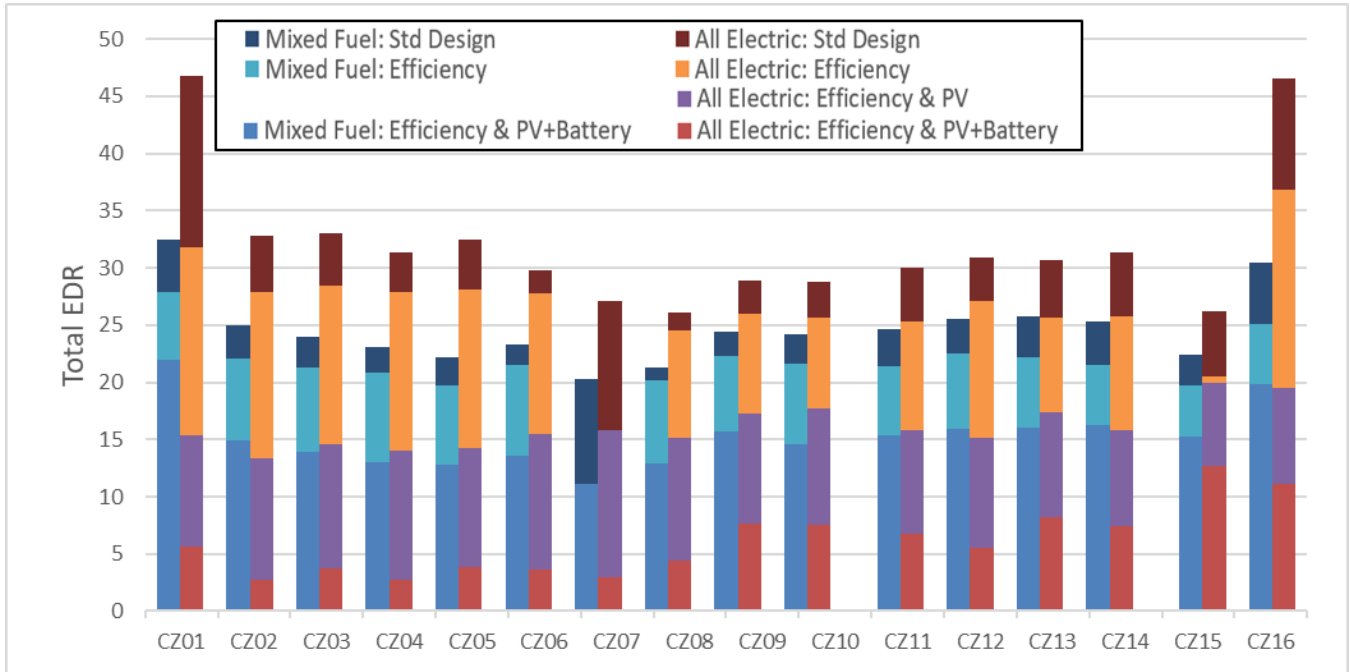


Figure 3: Single family Total EDR comparison

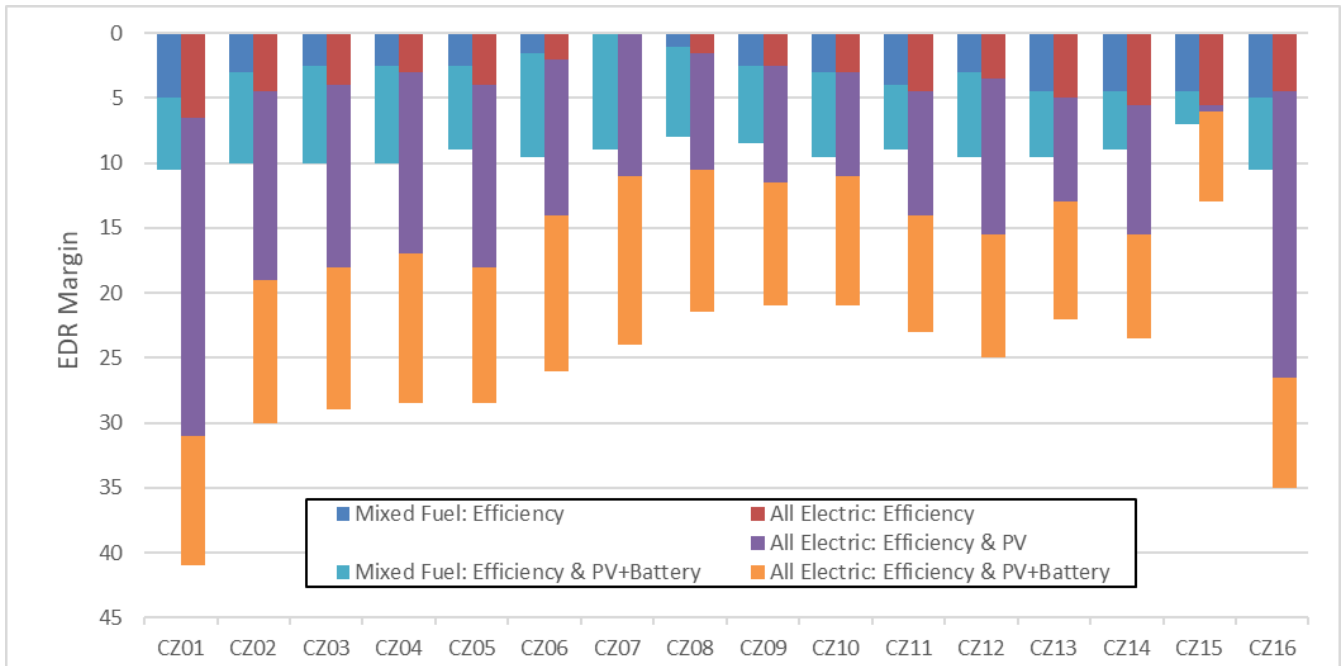


Figure 4: Single family EDR Margin comparison (based on Efficiency EDR Margin for the Efficiency packages and the Total EDR Margin for the Efficiency & PV and Efficiency & PV/Battery packages)



3.2.1 GHG Emission Reductions

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

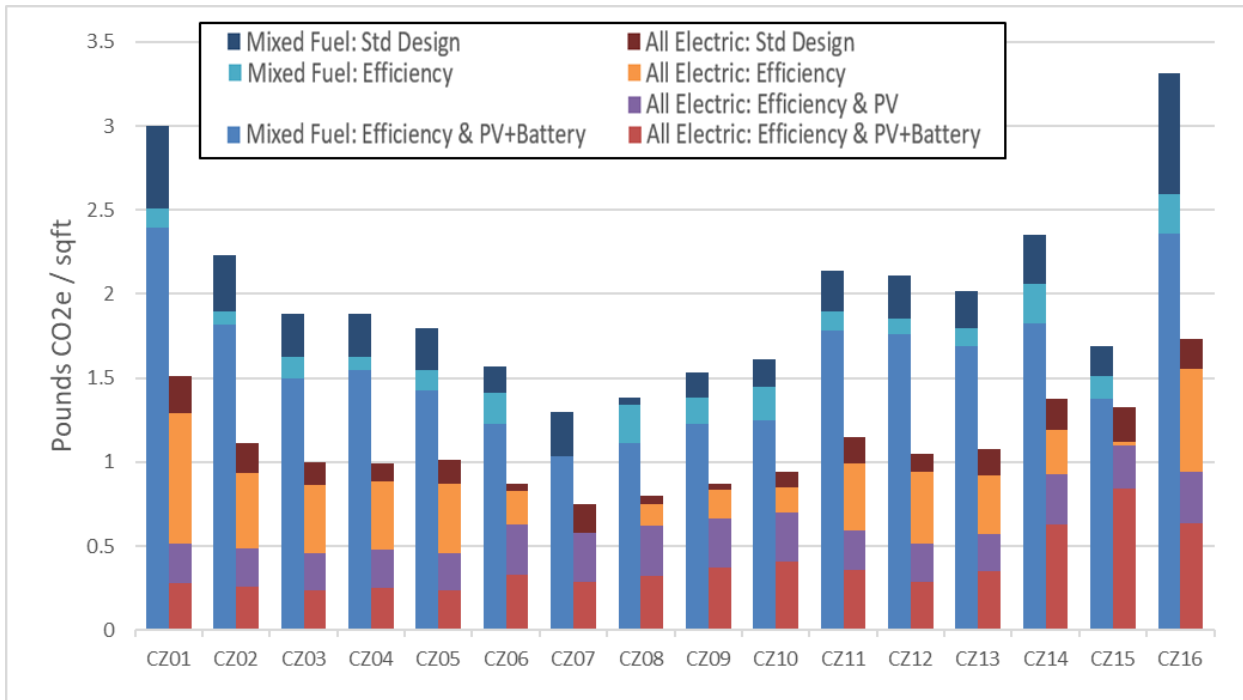


Figure 5: Single family greenhouse gas emissions comparison

3.3 Multifamily Results

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

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

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



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

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

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

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

Table 11: Multifamily Package Incremental Costs per Dwelling Unit

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



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

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

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

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



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

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

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

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



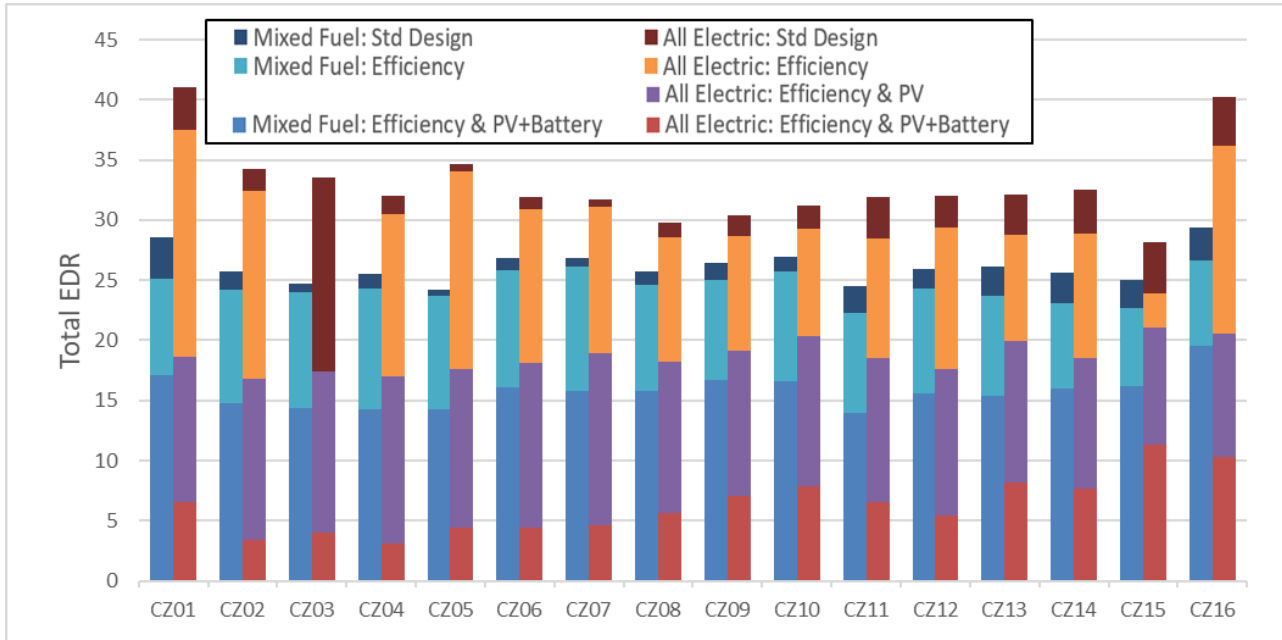


Figure 6: Multifamily Total EDR comparison

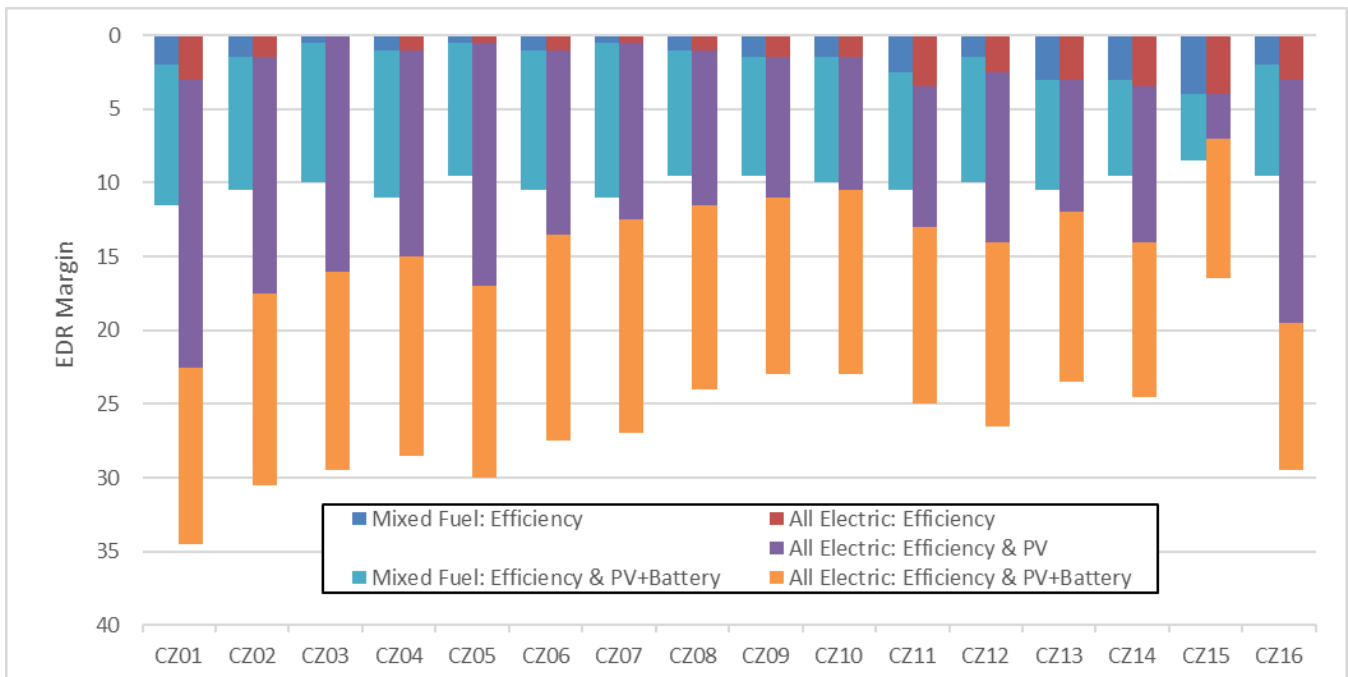


Figure 7: Multifamily EDR Margin comparison (based on Efficiency EDR Margin for the Efficiency packages and the Total EDR Margin for the Efficiency & PV and Efficiency & PV/Battery packages)



3.3.1 GHG Emission Reductions

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

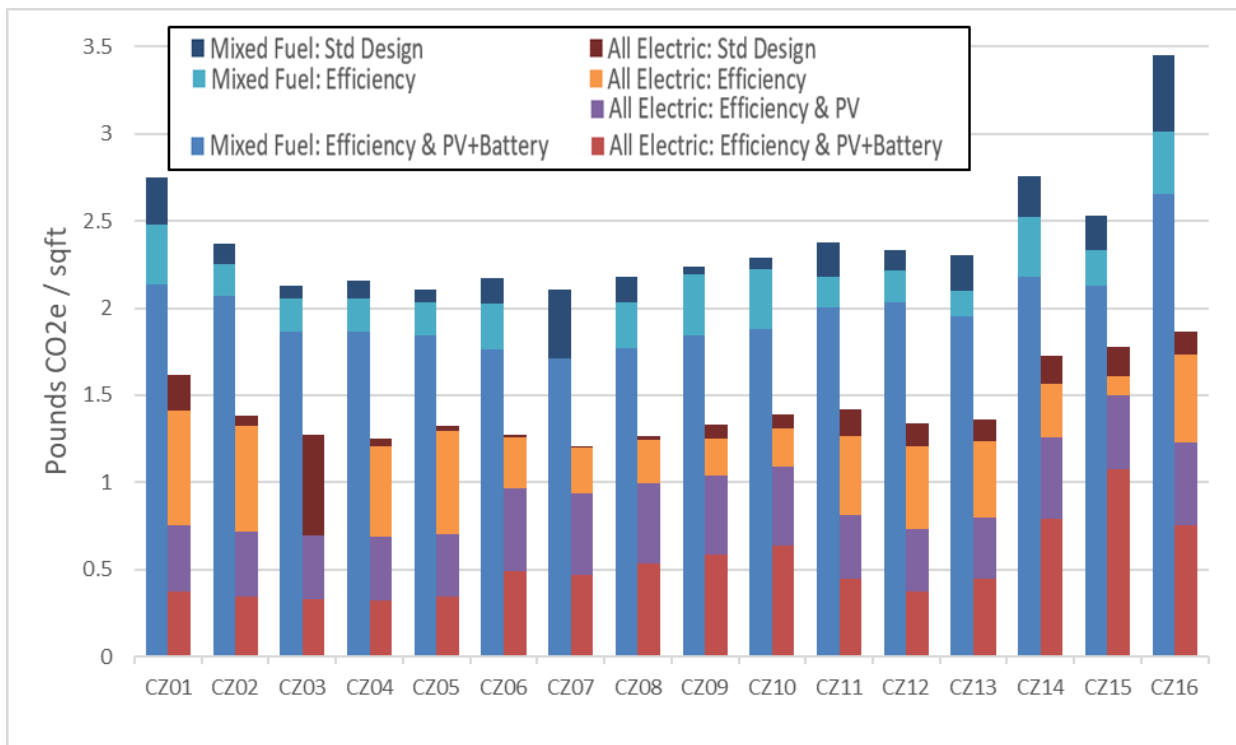


Figure 8: Multifamily greenhouse gas emissions comparison

3.4 Electrification Results

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



Three scenarios were evaluated:

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

3.4.1 Single Family

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

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

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

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

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

3.4.2 Multifamily

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



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

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

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

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

Table 14: Single Family Electrification Results

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



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

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

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



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

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

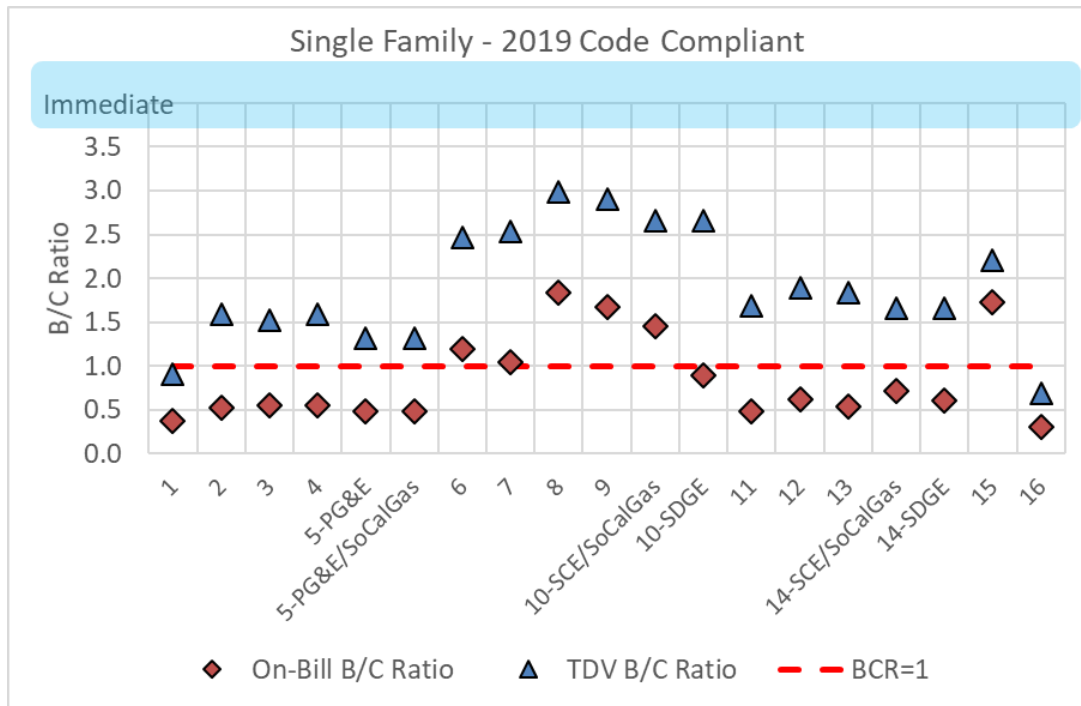


Figure 9: B/C ratio results for a single family all-electric code compliant home versus a mixed fuel code compliant home



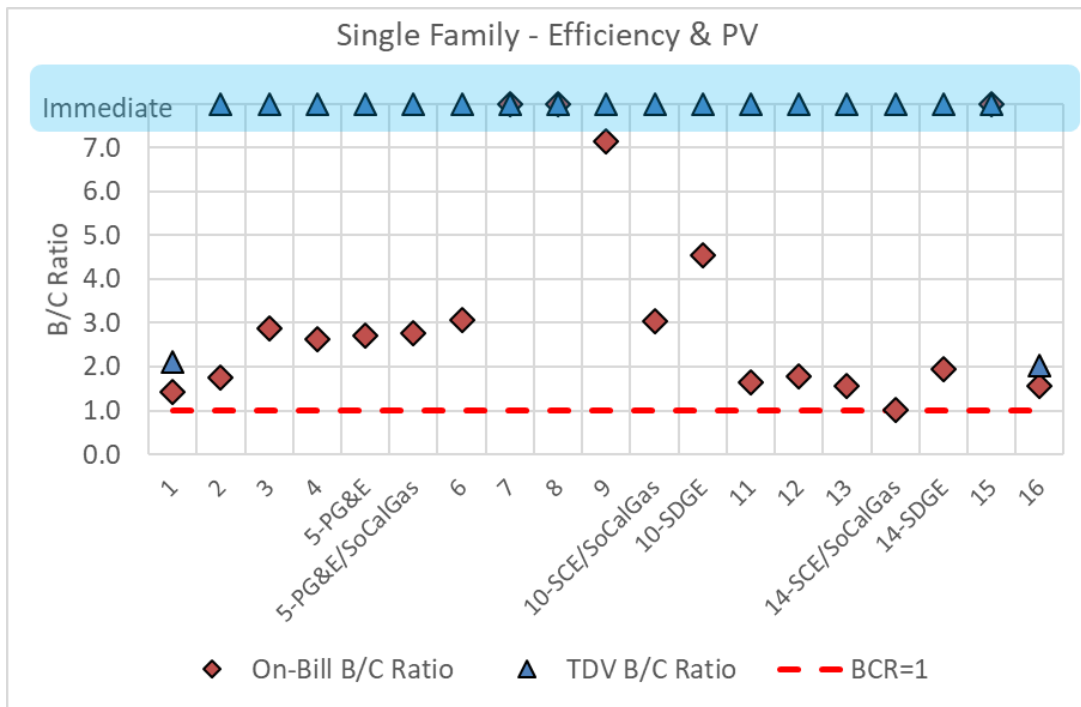


Figure 10: B/C ratio results for the single family Efficiency & PV all-electric home versus a mixed fuel code compliant home

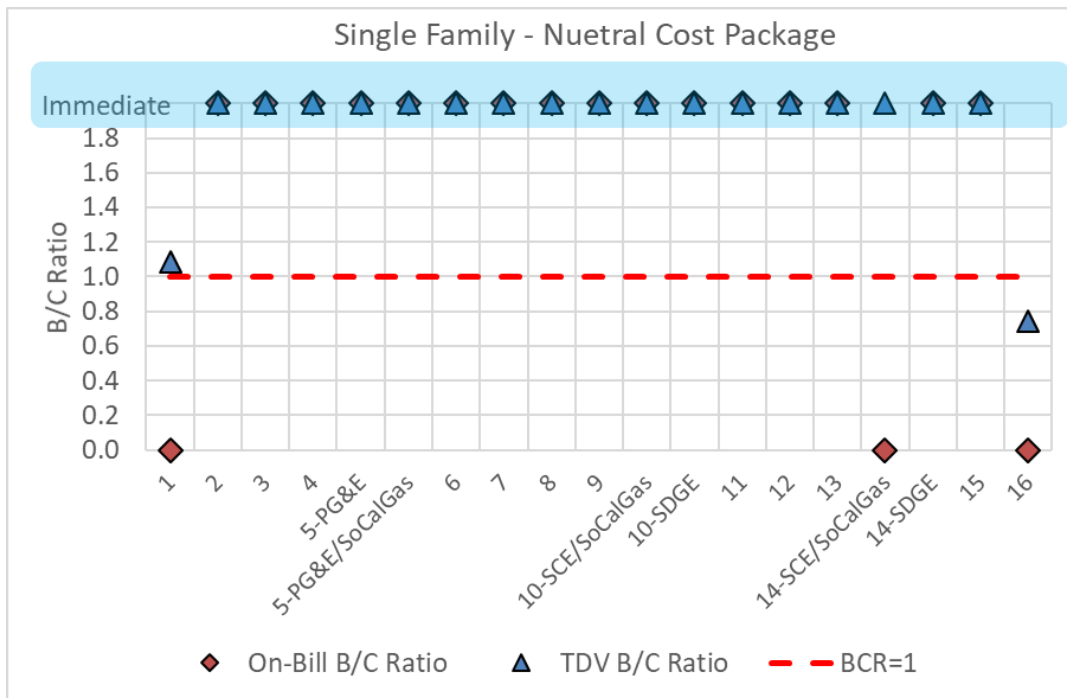


Figure 11: B/C ratio results for the single family neutral cost package all-electric home versus a mixed fuel code compliant home



Table 16: Multifamily Electrification Results (Per Dwelling Unit)

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



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

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

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

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

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



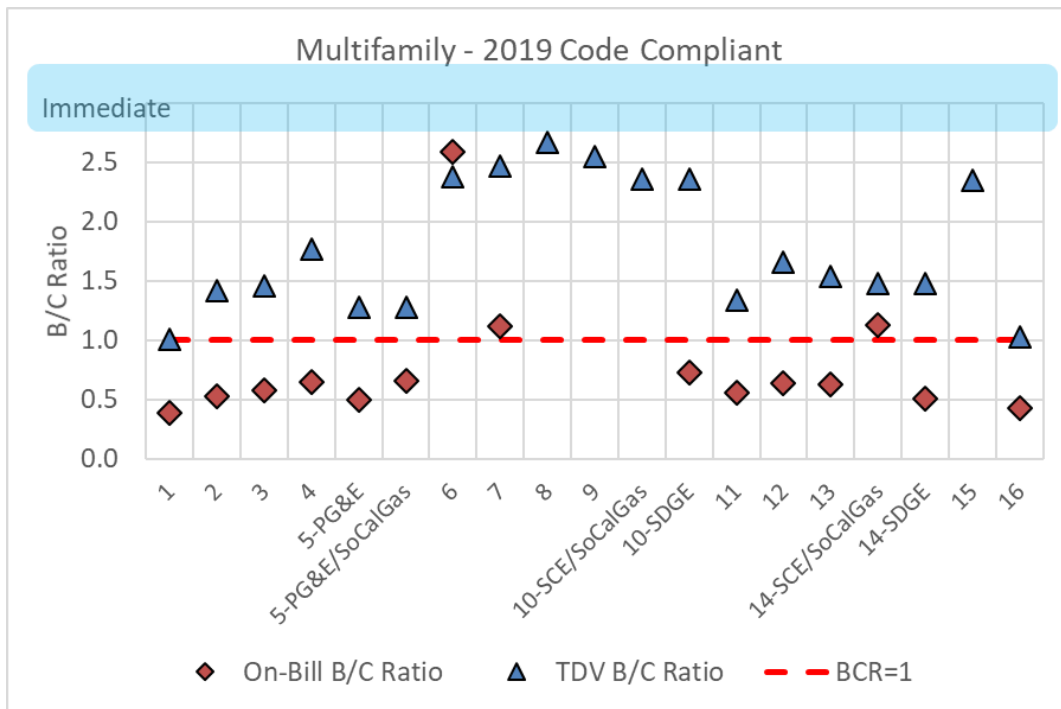


Figure 12: B/C ratio results for a multifamily all-electric code compliant home versus a mixed fuel code compliant home

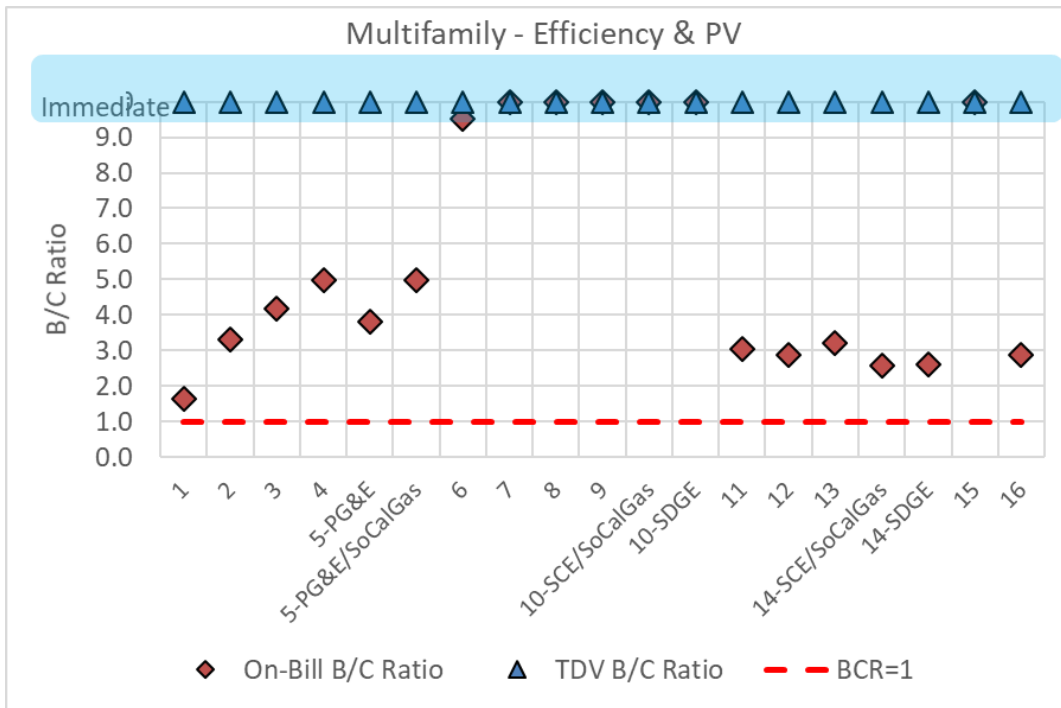


Figure 13: B/C ratio results for the multifamily Efficiency & PV all-electric home versus a mixed fuel code compliant home



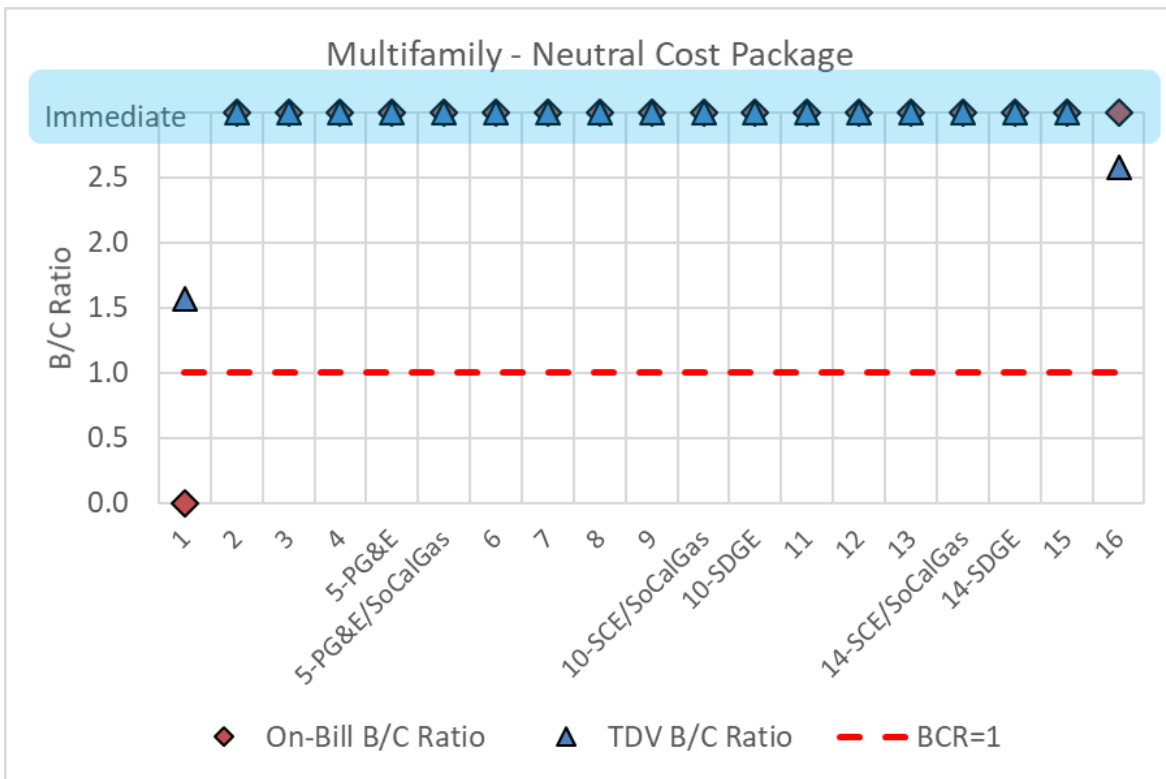


Figure 14: B/C ratio results for the multifamily neutral cost package all-electric home versus a mixed fuel code compliant home

4 Conclusions & Summary

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

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

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



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

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

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

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

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

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

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

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



Table 18: Summary of Single Family Target EDR Margins

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

Table 19: Summary of Multifamily Target EDR Margins

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



5 References

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Appendix A - California Climate Zone Map

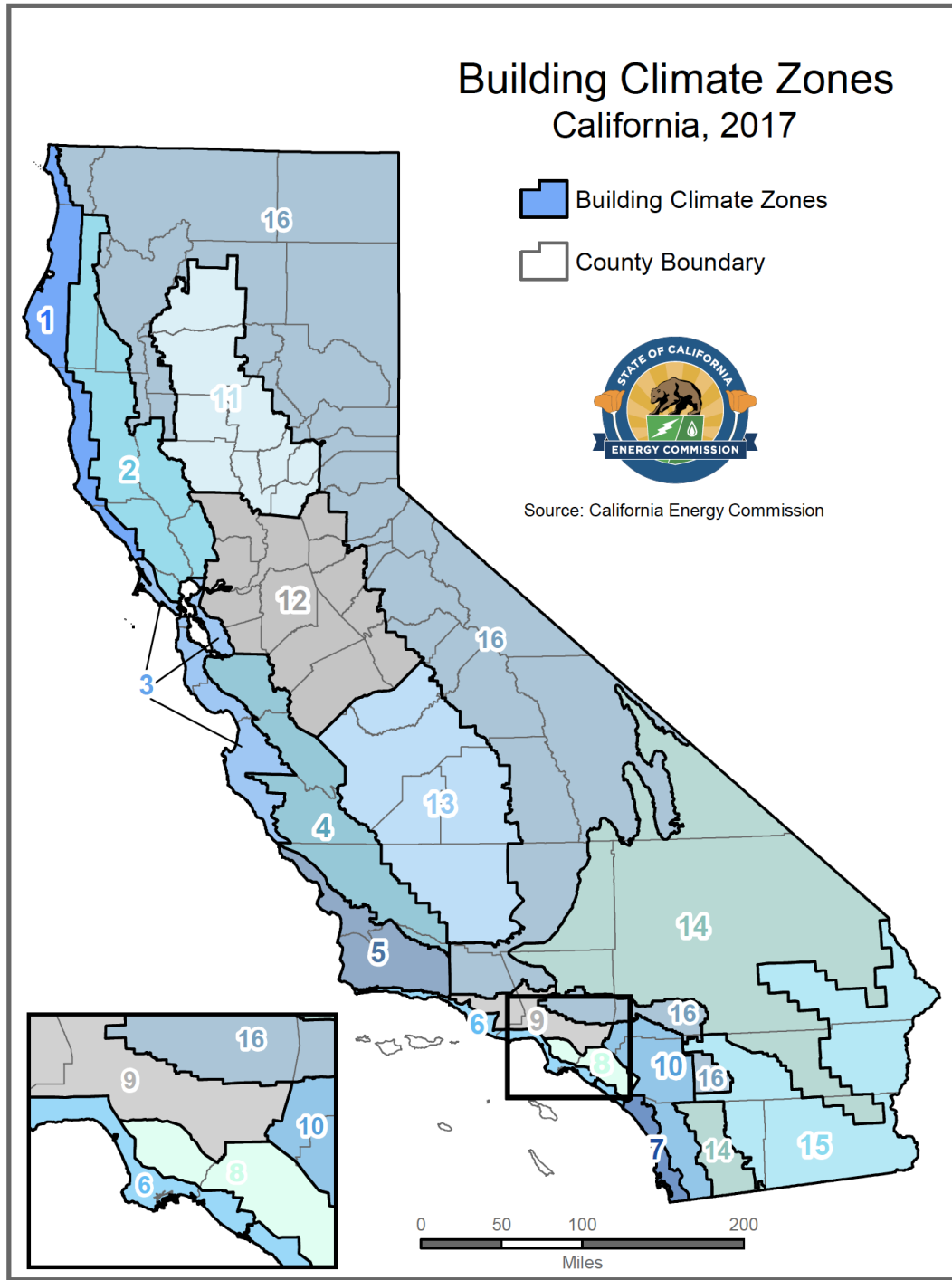


Figure 15: Map of California Climate Zones (courtesy of the California Energy Commission¹⁷)

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



Appendix B – Utility Tariff Details

| | |
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| SoCalGas | 53 |
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PG&E

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

Table 20: PG&E Baseline Territory by Climate Zone

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

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

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

^{1/} Unless otherwise noted
^{2/} Effective July 1, 2005, the Transportation Charge will be no less than the Minimum Transportation Charge of \$0.09863 (per day). Applicable to Rate Schedule G-1 only and does not apply to submetered tenants of master-metered customers served under gas Rate Schedule GS and GT.
^{3/} Schedule G-PPPS (Public Purpose Program Surcharge) needs to be added to the TOTAL Non-CARE Charge and TOTAL CARE Charge for bill calculation. See Schedule G-PPPS for details and exempt customers.
^{4/} CARE Schedules include California Solar Initiative (CSI) Exemption in accordance with Advice Letter 3257-G-A.
^{5/} Per dwelling unit per day (Multifamily Service)
^{6/} Per installed space per day (Mobilehome Park Service)
^{7/} This procurement rate includes a charge of \$0.03686 per therm to reflect account balance amortizations in accordance with Advice Letter 3157-G.
^{8/} Residential bill credit of (\$29.85) per household, annual bill credit occurring in the October 2018 bill cycle, thereafter in the April bill cycle.
Seasons: Winter = Nov-Mar Summer = April-Oct





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

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

Sheet 4

RATES:
 (Cont'd.)

OPTION B TOTAL RATES

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

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

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

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

UNBUNDLING OF OPTION B TOTAL RATES

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

* Transmission, Transmission Rate Adjustments and Reliability Service charges are combined for presentation on customer bills.
 ** Distribution and New System Generation Charges are combined for presentation on customer bills.
 *** This same assignment of revenues applies to direct access and community choice aggregation customers.

(Continued)

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





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

**GAS SCHEDULE G-1
RESIDENTIAL SERVICE**

Sheet 1

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

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

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

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

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

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

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

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

¹ PG&E's gas tariffs are available online at www.pge.com.
² Covered entities are not exempt from paying costs associated with LUAF Gas and Gas used by Company Facilities.
³ The exemption credit will be equal to the effective non-exempt AB 32 GHG Compliance Cost Rate (\$ per therm) included in Preliminary Statement – Part B, multiplied by the customer's billed volumes (therms) for each billing period.
⁴ PG&E will update its billing system annually to reflect newly exempt or newly excluded customers to conform with lists of Directly Billed Customers provided annually by the ARB.
⁵ The Minimum Transportation charge does not apply to submetered tenants of master-metered customers served under gas rate Schedules GS and GT.

(Continued)

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



SCE

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

Table 21: SCE Baseline Territory by Climate Zone

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

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



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

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

PROPOSED
(7 Year Average 2010-2016)

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



SoCalGas

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

Table 22: SoCalGas Baseline Territory by Climate Zone

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

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

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

(TO BE INSERTED BY UTILITY)
ADVICE LETTER NO. 5410
DECISION NO.
106

ISSUED BY
Dan Skopec
Vice President
Regulatory Affairs

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



SDG&E

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

Table 23: SDG&E Baseline Territory by Climate Zone

| | |
|------|---------------------------|
| | Baseline Territory |
| CZ07 | Coastal |
| CZ10 | Inland |
| CZ14 | Mountain |



San Diego Gas & Electric Company
San Diego, California

Revised Cal. P.U.C. Sheet No. 31320-E
Canceling Revised Cal. P.U.C. Sheet No. 31103-E

| SCHEDULE TOU-DR1 | | | | | Sheet 2 | |
|--|----------------|-------------|------------------------|-------------|---------------------------|---|
| RESIDENTIAL TIME-OF-USE | | | | | | |
| <u>RATES</u> | | | | | | |
| <u>Total Rates:</u> | | | | | | |
| Description – TOU DR1 | UDC Total Rate | DWR-BC Rate | EECC Rate + DWR Credit | Total Rate | | |
| Summer: | | | | | | |
| On-Peak | 0.29562 | R 0.00503 | R 0.35013 | R 0.65078 | R | |
| Off-Peak | 0.29562 | R 0.00503 | R 0.11235 | R 0.41300 | R | |
| Super Off-Peak | 0.29562 | R 0.00503 | R 0.05739 | R 0.35804 | R | |
| Winter: | | | | | | |
| On-Peak | 0.32037 | R 0.00503 | R 0.07618 | R 0.40158 | R | |
| Off-Peak | 0.32037 | R 0.00503 | R 0.06762 | R 0.39302 | R | |
| Super Off-Peak | 0.32037 | R 0.00503 | R 0.05812 | R 0.38352 | R | |
| Summer Baseline Adjustment Credit up to 130% of Baseline | (0.19921) | I | | (0.19921) | I | |
| Winter Baseline Adjustment Credit up to 130% of Baseline | (0.16853) | I | | (0.16853) | I | |
| Minimum Bill (\$/day) | 0.329 | | | 0.329 | | |
| Description – TOU DR1 | UDC Total Rate | DWR-BC Rate | EECC Rate + DWR Credit | Total Rate | Total Effective Care Rate | |
| Summer – CARE | | | | | | |
| Rates: | | | | | | |
| On-Peak | 0.29494 | R 0.00000 | 0.35013 R | 0.64507 R | 0.41628 | R |
| Off-Peak | 0.29494 | R 0.00000 | 0.11235 R | 0.40729 R | 0.26077 | R |
| Super Off-Peak | 0.29494 | R 0.00000 | 0.05739 R | 0.35233 R | 0.22483 | R |
| Winter – CARE | | | | | | |
| Rates: | | | | | | |
| On-Peak | 0.31989 | R 0.00000 | 0.07618 R | 0.39587 R | 0.25330 | R |
| Off-Peak | 0.31989 | R 0.00000 | 0.06762 R | 0.38731 R | 0.24770 | R |
| Super Off-Peak | 0.31989 | R 0.00000 | 0.05812 R | 0.37781 R | 0.24149 | R |
| Summer Baseline Adjustment Credit up to 130% of Baseline | (0.19921) | I | | (0.19921) I | (0.13028) | I |
| Winter Baseline Adjustment Credit up to 130% of Baseline | (0.16853) | I | | (0.16853) I | (0.11022) | I |
| Minimum Bill (\$/day) | 0.164 | | | 0.164 | 0.164 | |
| Note: | | | | | | |
| (1) Total Rates consist of UDC, Schedule DWR-BC (Department of Water Resources Bond Charge), and Schedule EECC (Electric Energy Commodity Cost) rates, with the EECC rates reflecting a DWR Credit. | | | | | | |
| (2) Total Rates presented are for customers that receive commodity supply and delivery service from Utility. | | | | | | |
| (3) DWR-BC charges do not apply to CARE customers. | | | | | | |
| (4) As identified in the rates tables, customer bills will also include line-item summer and winter credits for usage up to 130% of baseline to provide the rate capping benefits adopted by Assembly Bill 1X and Senate Bill 695. | | | | | | |

(Continued)

2C11

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Revised Cal. P.U.C. Sheet No. 23614-G
Canceling Revised Cal. P.U.C. Sheet No. 23601-G

SCHEDULE GR

Sheet 1

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

APPLICABILITY

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

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

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

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

TERRITORY

Within the entire territory served natural gas by the utility.

RATES

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

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

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

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

(Continued)

1C5
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Escalation Assumptions

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

Table 24: Real Utility Rate Escalation Rate Assumptions

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



Appendix C – Single Family Detailed Results

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

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

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



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

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

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



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

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



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

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

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



Appendix D – Single Family Measure Summary

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

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

VLLDCS – Verified Low Leakage Ducts in Conditioned Space



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

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

LLAHU - Low Leakage Air Handling Unit

VLLDCS – Verified Low Leakage Ducts in Conditioned Space



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

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

VLLDCS – Verified Low Leakage Ducts in Conditioned Space



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

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

VLLDCS – Verified Low Leakage Ducts in Conditioned Space



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

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

LLAHU - Low Leakage Air Handling Unit

VVLDCS – Verified Low Leakage Ducts in Conditioned Space



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

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

VLLDCS – Verified Low Leakage Ducts in Conditioned Space



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

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

VLLDCS – Verified Low Leakage Ducts in Conditioned Space



Appendix E - Multifamily Detailed Results

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

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

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



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

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

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



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

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

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



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

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

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



Appendix F – Multifamily Measure Summary

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

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

VLLDCS – Verified Low-Leakage Ducts in Conditioned Space



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

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

VLLDCS – Verified Low-Leakage Ducts in Conditioned Space



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

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

VLLDCS – Verified Low-Leakage Ducts in Conditioned Space



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

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

VLLDCS – Verified Low-Leakage Ducts in Conditioned Space



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

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

VLLDCS – Verified Low-Leakage Ducts in Conditioned Space



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

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

VLLDCS – Verified Low-Leakage Ducts in Conditioned Space



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

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

VLLDCS – Verified Low-Leakage Ducts in Conditioned Space



Appendix G – Results by Climate Zone

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



Climate Zone 1

Table 47: Single Family Climate Zone 1 Results Summary

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

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

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

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

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

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



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

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

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

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

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

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

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



Climate Zone 2

Table 49: Single Family Climate Zone 2 Results Summary

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

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

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

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

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

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



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

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

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

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

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

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

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



Climate Zone 3

Table 51: Single Family Climate Zone 3 Results Summary

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

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

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

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

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

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



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

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

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

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

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

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

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



Climate Zone 4

Table 53: Single Family Climate Zone 4 Results Summary

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

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

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

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

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

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



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

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

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

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

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

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

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



Climate Zone 5 PG&E

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

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

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

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

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

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

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



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

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

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

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

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

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

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



Climate Zone 5 PG&E/SoCalGas

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

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

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

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

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

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

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



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

| Climate Zone 5 PG&E/SoCalGas Multifamily | | Annual Net kWh | Annual therms | EDR Margin ⁴ | PV Size Change (kW) ⁵ | CO2-Equivalent Emissions (lbs/sf) | | NPV of Lifetime Incremental Cost (\$) | Benefit to Cost Ratio (B/C) | |
|--|--------------------------|----------------------|------------------|----------------------------|--|--------------------------------------|-----------|--|--------------------------------|-------|
| | | | | | | Total | Reduction | | On-Bill | TDV |
| Mixed Fuel ¹ | Code Compliant | 0 | 131 | n/a | n/a | 2.10 | n/a | n/a | n/a | n/a |
| | Efficiency-Non-Preempted | (0) | 126 | 0.5 | (0.00) | 2.03 | 0.07 | \$180 | 0.85 | 1.03 |
| | Efficiency-Equipment | (0) | 117 | 1.5 | (0.00) | 1.92 | 0.19 | \$358 | 1.09 | 1.34 |
| | Efficiency & PV/Battery | (7) | 126 | 9.5 | 0.05 | 1.84 | 0.26 | \$2,273 | 0.14 | 1.38 |
| All-Electric ² | Code Compliant | 2,044 | 0 | n/a | n/a | 1.32 | n/a | n/a | n/a | n/a |
| | Efficiency-Non-Preempted | 1,990 | 0 | 0.5 | 0.00 | 1.30 | 0.03 | \$247 | 1.09 | 0.86 |
| | Efficiency-Equipment | 1,738 | 0 | 3.5 | 0.00 | 1.15 | 0.17 | \$795 | 2.15 | 2.03 |
| | Efficiency & PV | 465 | 0 | 17.0 | 0.91 | 0.70 | 0.62 | \$3,293 | 2.53 | 1.82 |
| | Efficiency & PV/Battery | (6) | 0 | 30.0 | 1.24 | 0.34 | 0.98 | \$6,314 | 1.44 | 1.69 |
| Mixed Fuel to All-Electric ³ | Code Compliant | 2,044 | 0 | 0.0 | 0.00 | 1.32 | 0.78 | (\$2,337) | 0.65 | 1.28 |
| | Efficiency & PV | 58 | 0 | 17.0 | 0.91 | 0.70 | 1.40 | \$956 | 4.98 | >1 |
| | Neutral Cost | 874 | 0 | 12.5 | 0.70 | 0.87 | 1.23 | \$0 | >1 | 23.44 |

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

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

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

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

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



Climate Zone 6

Table 59: Single Family Climate Zone 6 Results Summary

| Climate Zone 6 SCE/SoCalGas Single Family | | Annual Net kWh | Annual therms | EDR Margin ⁴ | PV Size Change (kW) ⁵ | CO2-Equivalent Emissions (lbs/sf) | | NPV of Lifetime Incremental Cost (\$) | Benefit to Cost Ratio (B/C) | |
|---|--------------------------|----------------------|------------------|----------------------------|--|--------------------------------------|-----------|--|--------------------------------|------|
| | | | | | | Total | Reduction | | On-Bill | TDV |
| | | | | | | | | | | |
| Mixed Fuel ¹ | Code Compliant | (0) | 249 | n/a | n/a | 1.57 | n/a | n/a | n/a | n/a |
| | Efficiency-Non-Preempted | 0 | 229 | 2.0 | (0.02) | 1.47 | 0.10 | \$1,003 | 0.66 | 1.15 |
| | Efficiency-Equipment | (0) | 218 | 1.5 | (0.01) | 1.41 | 0.15 | \$581 | 1.58 | 2.04 |
| | Efficiency & PV/Battery | (13) | 229 | 9.5 | 0.08 | 1.22 | 0.34 | \$4,889 | 0.84 | 1.27 |
| All-Electric ² | Code Compliant | 3,099 | 0 | n/a | n/a | 0.87 | n/a | n/a | n/a | n/a |
| | Efficiency-Non-Preempted | 2,885 | 0 | 2.0 | 0.00 | 0.83 | 0.05 | \$926 | 1.31 | 1.41 |
| | Efficiency-Equipment | 2,746 | 0 | 2.5 | 0.00 | 0.80 | 0.08 | \$846 | 2.20 | 2.29 |
| | Efficiency & PV | 722 | 0 | 14.0 | 1.37 | 0.63 | 0.24 | \$6,341 | 1.19 | 1.48 |
| | Efficiency & PV/Battery | (6) | 0 | 26.0 | 1.93 | 0.33 | 0.55 | \$12,036 | 1.15 | 1.43 |
| Mixed Fuel to All-Electric ³ | Code Compliant | 3,099 | 0 | 0.0 | 0.00 | 0.87 | 0.69 | (\$5,349) | 1.19 | 2.46 |
| | Efficiency & PV | 722 | 0 | 14.0 | 1.37 | 0.63 | 0.93 | \$992 | 3.07 | >1 |
| | Neutral Cost | 959 | 0 | 12.0 | 1.36 | 0.67 | 0.89 | \$0 | >1 | >1 |

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

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

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

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

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



Table 60: Multifamily Climate Zone 6 Results Summary (Per Dwelling Unit)

| Climate Zone 6 SCE/SoCalGas Multifamily | | Annual Net kWh | Annual therms | EDR Margin ⁴ | PV Size Change (kW) ⁵ | CO2-Equivalent Emissions (lbs/sf) | | NPV of Lifetime Incremental Cost (\$) | Benefit to Cost Ratio (B/C) | |
|---|--------------------------|----------------------|------------------|----------------------------|--|--------------------------------------|-----------|--|--------------------------------|------|
| | | | | | | Total | Reduction | | On-Bill | TDV |
| Mixed Fuel ¹ | Code Compliant | (0) | 114 | n/a | n/a | 2.17 | n/a | n/a | n/a | n/a |
| | Efficiency-Non-Preempted | (0) | 112 | 1.0 | (0.01) | 2.14 | 0.03 | \$190 | 0.65 | 1.49 |
| | Efficiency-Equipment | (0) | 103 | 1.0 | (0.00) | 2.03 | 0.15 | \$213 | 1.43 | 1.74 |
| | Efficiency & PV/Battery | (6) | 112 | 10.5 | 0.04 | 1.76 | 0.41 | \$2,294 | 0.56 | 1.35 |
| All-Electric ² | Code Compliant | 1,558 | 0 | n/a | n/a | 1.28 | n/a | n/a | n/a | n/a |
| | Efficiency-Non-Preempted | 1,531 | 0 | 1.0 | 0.00 | 1.26 | 0.02 | \$231 | 0.65 | 1.34 |
| | Efficiency-Equipment | 1,430 | 0 | 2.0 | 0.00 | 1.20 | 0.08 | \$361 | 1.62 | 1.91 |
| | Efficiency & PV | 427 | 0 | 13.5 | 0.70 | 0.97 | 0.31 | \$2,580 | 1.24 | 1.71 |
| | Efficiency & PV/Battery | (5) | 0 | 27.5 | 1.02 | 0.49 | 0.79 | \$5,590 | 1.22 | 1.58 |
| Mixed Fuel to All-Electric ³ | Code Compliant | 1,558 | 0 | 0.0 | 0.00 | 1.28 | 0.90 | (\$2,337) | 2.59 | 2.38 |
| | Efficiency & PV | 53 | 0 | 13.5 | 0.70 | 0.97 | 1.20 | \$243 | 9.50 | >1 |
| | Neutral Cost | 459 | 0 | 12.5 | 0.70 | 0.99 | 1.18 | \$0 | >1 | >1 |

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

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

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

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

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



Climate Zone 7

Table 61: Single Family Climate Zone 7 Results Summary

| Climate Zone 7 SDG&E Single Family | | Annual Net kWh | Annual therms | EDR Margin ⁴ | PV Size Change (kW) ⁵ | CO2-Equivalent Emissions (lbs/sf) | | NPV of Lifetime Incremental Cost (\$) | Benefit to Cost Ratio (B/C) | |
|--|--------------------------|----------------------|------------------|----------------------------|--|--------------------------------------|-----------|--|--------------------------------|------|
| | | | | | | Total | Reduction | | On-Bill | TDV |
| | | | | | | | | | | |
| Mixed Fuel ¹ | Code Compliant | (0) | 196 | n/a | n/a | 1.30 | n/a | n/a | n/a | n/a |
| | Efficiency-Non-Preempted | (0) | 196 | 0.0 | 0.00 | 1.30 | 0.00 | \$0 | - | - |
| | Efficiency-Equipment | 0 | 171 | 1.5 | (0.00) | 1.18 | 0.12 | \$606 | 1.50 | 1.40 |
| | Efficiency & PV/Battery | (12) | 189 | 9.0 | 0.10 | 1.04 | 0.26 | \$4,028 | 0.06 | 1.32 |
| All-Electric ² | Code Compliant | 2,479 | 0 | n/a | n/a | 0.75 | n/a | n/a | n/a | n/a |
| | Efficiency-Non-Preempted | 2,479 | 0 | 0.0 | 0.00 | 0.75 | 0.00 | \$0 | - | - |
| | Efficiency-Equipment | 2,222 | 0 | 2.0 | 0.00 | 0.69 | 0.06 | \$846 | 1.60 | 1.65 |
| | Efficiency & PV | 674 | 0 | 11.0 | 1.10 | 0.58 | 0.17 | \$4,436 | 1.87 | 1.55 |
| | Efficiency & PV/Battery | (6) | 0 | 24.0 | 1.61 | 0.29 | 0.46 | \$9,936 | 1.25 | 1.47 |
| Mixed Fuel to All-Electric ³ | Code Compliant | 2,479 | 0 | 0.0 | 0.00 | 0.75 | 0.55 | (\$5,349) | 1.04 | 2.54 |
| | Efficiency & PV | 674 | 0 | 11.0 | 1.10 | 0.58 | 0.72 | (\$912) | >1 | >1 |
| | Neutral Cost | 267 | 0 | 13.5 | 1.35 | 0.55 | 0.75 | \$0 | >1 | >1 |

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

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

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

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

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



Table 62: Multifamily Climate Zone 7 Results Summary (Per Dwelling Unit)

| Climate Zone 7 SDG&E Multifamily | | Annual Net kWh | Annual therms | EDR Margin ⁴ | PV Size Change (kW) ⁵ | CO2-Equivalent Emissions (lbs/sf) | | NPV of Lifetime Incremental Cost (\$) | Benefit to Cost Ratio (B/C) | |
|--|--------------------------|----------------------|------------------|----------------------------|--|--------------------------------------|-----------|--|--------------------------------|------|
| | | | | | | Total | Reduction | | On-Bill | TDV |
| Mixed Fuel ¹ | Code Compliant | (0) | 110 | n/a | n/a | 2.11 | n/a | n/a | n/a | n/a |
| | Efficiency-Non-Preempted | (0) | 108 | 0.5 | (0.01) | 2.08 | 0.03 | \$90 | 0.73 | 2.24 |
| | Efficiency-Equipment | (0) | 99 | 2.0 | (0.00) | 1.96 | 0.15 | \$366 | 1.07 | 1.41 |
| | Efficiency & PV/Battery | (6) | 108 | 11.0 | 0.05 | 1.71 | 0.40 | \$2,188 | 0.03 | 1.40 |
| All-Electric ² | Code Compliant | 1,434 | 0 | n/a | n/a | 1.21 | n/a | n/a | n/a | n/a |
| | Efficiency-Non-Preempted | 1,416 | 0 | 0.5 | 0.00 | 1.20 | 0.01 | \$202 | 0.60 | 1.02 |
| | Efficiency-Equipment | 1,319 | 0 | 1.5 | 0.00 | 1.14 | 0.07 | \$361 | 1.59 | 1.71 |
| | Efficiency & PV | 412 | 0 | 12.5 | 0.61 | 0.94 | 0.27 | \$2,261 | 2.08 | 1.76 |
| | Efficiency & PV/Battery | (5) | 0 | 27.0 | 0.92 | 0.47 | 0.74 | \$5,203 | 1.19 | 1.62 |
| Mixed Fuel to All-Electric ³ | Code Compliant | 1,434 | 0 | 0.0 | 0.00 | 1.21 | 0.90 | (\$2,337) | 1.12 | 2.47 |
| | Efficiency & PV | 51 | 0 | 12.5 | 0.61 | 0.94 | 1.17 | (\$75) | >1 | >1 |
| | Neutral Cost | 294 | 0 | 13.5 | 0.70 | 0.91 | 1.20 | \$0 | >1 | >1 |

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

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

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

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

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



Climate Zone 8

Table 63: Single Family Climate Zone 8 Results Summary

| Climate Zone 8 SCE/SoCalGas Single Family | | Annual Net kWh | Annual therms | EDR Margin ⁴ | PV Size Change (kW) ⁵ | CO2-Equivalent Emissions (lbs/sf) | | NPV of Lifetime Incremental Cost (\$) | Benefit to Cost Ratio (B/C) | |
|---|--------------------------|----------------------|------------------|----------------------------|--|--------------------------------------|-----------|--|--------------------------------|------|
| | | | | | | Total | Reduction | | On-Bill | TDV |
| | | | | | | | | | | |
| Mixed Fuel ¹ | Code Compliant | (0) | 206 | n/a | n/a | 1.38 | n/a | n/a | n/a | n/a |
| | Efficiency-Non-Preempted | (0) | 198 | 1.0 | (0.02) | 1.34 | 0.05 | \$581 | 0.57 | 1.41 |
| | Efficiency-Equipment | 0 | 181 | 1.5 | (0.01) | 1.27 | 0.12 | \$586 | 1.30 | 1.82 |
| | Efficiency & PV/Battery | (13) | 198 | 8.0 | 0.08 | 1.11 | 0.27 | \$4,466 | 0.90 | 1.31 |
| All-Electric ² | Code Compliant | 2,576 | 0 | n/a | n/a | 0.80 | n/a | n/a | n/a | n/a |
| | Efficiency-Non-Preempted | 2,483 | 0 | 1.5 | 0.00 | 0.78 | 0.02 | \$926 | 0.57 | 1.22 |
| | Efficiency-Equipment | 2,352 | 0 | 1.5 | 0.00 | 0.75 | 0.05 | \$412 | 2.82 | 3.03 |
| | Efficiency & PV | 703 | 0 | 10.5 | 1.13 | 0.62 | 0.18 | \$5,373 | 1.00 | 1.48 |
| | Efficiency & PV/Battery | (7) | 0 | 21.5 | 1.67 | 0.32 | 0.48 | \$11,016 | 1.09 | 1.42 |
| Mixed Fuel to All-Electric ³ | Code Compliant | 2,576 | 0 | 0.0 | 0.00 | 0.80 | 0.58 | (\$5,349) | 1.83 | 2.99 |
| | Efficiency & PV | 703 | 0 | 10.5 | 1.13 | 0.62 | 0.77 | \$25 | 107.93 | >1 |
| | Neutral Cost | 439 | 0 | 11.0 | 1.36 | 0.60 | 0.78 | \$0 | >1 | >1 |

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

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

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

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

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



Table 64: Multifamily Climate Zone 8 Results Summary (Per Dwelling Unit)

| Climate Zone 8 SCE/SoCalGas Multifamily | | Annual Net kWh | Annual therms | EDR Margin ⁴ | PV Size Change (kW) ⁵ | CO2-Equivalent Emissions (lbs/sf) | | NPV of Lifetime Incremental Cost (\$) | Benefit to Cost Ratio (B/C) | |
|---|--------------------------|----------------------|------------------|----------------------------|--|--------------------------------------|-----------|--|--------------------------------|------|
| | | | | | | Total | Reduction | | On-Bill | TDV |
| Mixed Fuel ¹ | Code Compliant | (0) | 109 | n/a | n/a | 2.18 | n/a | n/a | n/a | n/a |
| | Efficiency-Non-Preempted | (0) | 106 | 1.5 | (0.02) | 2.13 | 0.05 | \$250 | 0.70 | 1.36 |
| | Efficiency-Equipment | (0) | 99 | 1.0 | (0.00) | 2.04 | 0.14 | \$213 | 1.37 | 1.67 |
| | Efficiency & PV/Battery | (6) | 106 | 9.5 | 0.03 | 1.77 | 0.41 | \$2,353 | 0.74 | 1.32 |
| All-Electric ² | Code Compliant | 1,409 | 0 | n/a | n/a | 1.26 | n/a | n/a | n/a | n/a |
| | Efficiency-Non-Preempted | 1,373 | 0 | 1.0 | 0.00 | 1.24 | 0.02 | \$231 | 0.87 | 1.72 |
| | Efficiency-Equipment | 1,276 | 0 | 1.5 | 0.00 | 1.18 | 0.08 | \$361 | 1.63 | 1.75 |
| | Efficiency & PV | 426 | 0 | 11.5 | 0.60 | 0.99 | 0.27 | \$2,240 | 1.26 | 1.78 |
| | Efficiency & PV/Battery | (5) | 0 | 24.0 | 0.92 | 0.53 | 0.73 | \$5,249 | 1.24 | 1.59 |
| Mixed Fuel to All-Electric ³ | Code Compliant | 1,409 | 0 | 0.0 | 0.00 | 1.26 | 0.91 | (\$2,337) | 6.69 | 2.67 |
| | Efficiency & PV | 53 | 0 | 11.5 | 0.60 | 0.99 | 1.18 | (\$96) | >1 | >1 |
| | Neutral Cost | 309 | 0 | 12.0 | 0.70 | 0.98 | 1.20 | \$0 | >1 | >1 |

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

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

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

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

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



Climate Zone 9

Table 65: Single Family Climate Zone 9 Results Summary

| Climate Zone 9 SCE/SoCalGas Single Family | | Annual Net kWh | Annual therms | EDR Margin ⁴ | PV Size Change (kW) ⁵ | CO2-Equivalent Emissions (lbs/sf) | | NPV of Lifetime Incremental Cost (\$) | Benefit to Cost Ratio (B/C) | |
|---|--------------------------|----------------------|------------------|----------------------------|--|--------------------------------------|-----------|--|--------------------------------|------|
| | | | | | | Total | Reduction | | On-Bill | TDV |
| | | | | | | | | | | |
| Mixed Fuel ¹ | Code Compliant | 0 | 229 | n/a | n/a | 1.53 | n/a | n/a | n/a | n/a |
| | Efficiency-Non-Preempted | (0) | 216 | 2.5 | (0.04) | 1.46 | 0.07 | \$912 | 0.69 | 1.97 |
| | Efficiency-Equipment | 0 | 201 | 2.5 | (0.04) | 1.38 | 0.15 | \$574 | 1.80 | 3.66 |
| | Efficiency & PV/Battery | (14) | 216 | 8.5 | 0.05 | 1.23 | 0.30 | \$4,785 | 0.99 | 1.48 |
| All-Electric ² | Code Compliant | 2,801 | 0 | n/a | n/a | 0.87 | n/a | n/a | n/a | n/a |
| | Efficiency-Non-Preempted | 2,645 | 0 | 2.5 | 0.00 | 0.84 | 0.04 | \$1,180 | 0.78 | 1.96 |
| | Efficiency-Equipment | 2,460 | 0 | 3.0 | 0.00 | 0.80 | 0.07 | \$846 | 2.11 | 3.22 |
| | Efficiency & PV | 745 | 0 | 11.5 | 1.16 | 0.66 | 0.21 | \$5,778 | 1.08 | 1.64 |
| | Efficiency & PV/Battery | (9) | 0 | 21.0 | 1.72 | 0.37 | 0.50 | \$11,454 | 1.11 | 1.53 |
| Mixed Fuel to All-Electric ³ | Code Compliant | 2,801 | 0 | 0.0 | 0.00 | 0.87 | 0.66 | (\$5,349) | 1.67 | 2.90 |
| | Efficiency & PV | 745 | 0 | 11.5 | 1.16 | 0.66 | 0.87 | \$429 | 7.15 | >1 |
| | Neutral Cost | 594 | 0 | 10.0 | 1.36 | 0.67 | 0.86 | \$0 | >1 | >1 |

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

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

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

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

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



Table 66: Multifamily Climate Zone 9 Results Summary (Per Dwelling Unit)

| Climate Zone 9 SCE/SoCalGas Multifamily | | Annual Net kWh | Annual therms | EDR Margin ⁴ | PV Size Change (kW) ⁵ | CO2-Equivalent Emissions (lbs/sf) | | NPV of Lifetime Incremental Cost (\$) | Benefit to Cost Ratio (B/C) | |
|---|--------------------------|----------------------|------------------|----------------------------|--|--------------------------------------|----------------|--|--------------------------------|------|
| | | | | | | Total | Reduction | | On-Bill | TDV |
| | | | | | | Mixed Fuel ¹ | Code Compliant | | 0 | 111 |
| Efficiency-Non-Preempted | (0) | 109 | 1.5 | (0.03) | 2.19 | | 0.05 | \$136 | 1.46 | 3.35 |
| Efficiency-Equipment | (0) | 101 | 2.5 | (0.03) | 2.08 | | 0.16 | \$274 | 1.66 | 2.87 |
| Efficiency & PV/Battery | (7) | 109 | 9.5 | 0.03 | 1.84 | | 0.40 | \$2,234 | 0.90 | 1.49 |
| All-Electric ² | Code Compliant | 1,468 | 0 | n/a | n/a | 1.33 | n/a | n/a | n/a | n/a |
| | Efficiency-Non-Preempted | 1,414 | 0 | 1.5 | 0.00 | 1.30 | 0.03 | \$231 | 1.29 | 2.70 |
| | Efficiency-Equipment | 1,334 | 0 | 1.5 | 0.00 | 1.25 | 0.08 | \$361 | 1.63 | 1.58 |
| | Efficiency & PV | 441 | 0 | 11.0 | 0.60 | 1.04 | 0.29 | \$2,232 | 1.34 | 1.91 |
| | Efficiency & PV/Battery | (7) | 0 | 23.0 | 0.92 | 0.58 | 0.75 | \$5,236 | 1.28 | 1.67 |
| Mixed Fuel to All-Electric ³ | Code Compliant | 1,468 | 0 | 0.0 | 0.00 | 1.33 | 0.91 | (\$2,337) | 4.38 | 2.55 |
| | Efficiency & PV | 55 | 0 | 11.0 | 0.60 | 1.04 | 1.20 | (\$104) | >1 | >1 |
| | Neutral Cost | 331 | 0 | 11.0 | 0.70 | 1.03 | 1.21 | \$0 | >1 | >1 |

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

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

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

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

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



Climate Zone 10 SCE/SoCalGas

Table 67: Single Family Climate Zone 10 SCE/SoCalGas Results Summary

| Climate Zone 10 SCE/SoCalGas Single Family | | Annual Net kWh | Annual therms | EDR Margin ⁴ | PV Size Change (kW) ⁵ | CO2-Equivalent Emissions (lbs/sf) | | NPV of Lifetime Incremental Cost (\$) | Benefit to Cost Ratio (B/C) | |
|--|--------------------------|----------------------|------------------|----------------------------|--|--------------------------------------|-----------|--|--------------------------------|------|
| | | | | | | Total | Reduction | | On-Bill | TDV |
| Mixed Fuel ¹ | Code Compliant | (0) | 239 | n/a | n/a | 1.61 | n/a | n/a | n/a | n/a |
| | Efficiency-Non-Preempted | (0) | 217 | 3.0 | (0.07) | 1.48 | 0.13 | \$1,648 | 0.63 | 1.33 |
| | Efficiency-Equipment | (0) | 209 | 3.0 | (0.06) | 1.45 | 0.16 | \$593 | 2.05 | 3.84 |
| | Efficiency & PV/Battery | (12) | 217 | 9.5 | 0.03 | 1.25 | 0.36 | \$5,522 | 1.00 | 1.48 |
| All-Electric ² | Code Compliant | 2,981 | 0 | n/a | n/a | 0.94 | n/a | n/a | n/a | n/a |
| | Efficiency-Non-Preempted | 2,673 | 0 | 3.0 | 0.00 | 0.88 | 0.07 | \$1,773 | 0.92 | 1.52 |
| | Efficiency-Equipment | 2,563 | 0 | 3.0 | 0.00 | 0.85 | 0.10 | \$949 | 2.27 | 3.19 |
| | Efficiency & PV | 762 | 0 | 11.0 | 1.17 | 0.70 | 0.24 | \$6,405 | 1.08 | 1.50 |
| | Efficiency & PV/Battery | (6) | 0 | 21.0 | 1.74 | 0.41 | 0.53 | \$12,129 | 1.11 | 1.51 |
| Mixed Fuel to All-Electric ³ | Code Compliant | 2,981 | 0 | 0.0 | 0.00 | 0.94 | 0.67 | (\$5,349) | 1.45 | 2.66 |
| | Efficiency & PV | 762 | 0 | 11.0 | 1.17 | 0.70 | 0.91 | \$1,057 | 3.04 | >1 |
| | Neutral Cost | 770 | 0 | 9.0 | 1.36 | 0.74 | 0.87 | \$0 | >1 | >1 |

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

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

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

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

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



Table 68: Multifamily Climate Zone 10 SCE/SoCalGas Results Summary (Per Dwelling Unit)

| Climate Zone 10 SCE/SoCalGas Multifamily | | Annual Net kWh | Annual therms | EDR Margin ⁴ | PV Size Change (kW) ⁵ | CO ₂ -Equivalent Emissions (lbs/sf) | | NPV of Lifetime Incremental Cost (\$) | Benefit to Cost Ratio (B/C) | |
|---|--------------------------|----------------------|------------------|----------------------------|--|---|-----------|--|--------------------------------|------|
| | | | | | | Total | Reduction | | On-Bill | TDV |
| Mixed Fuel¹ | Code Compliant | (0) | 112 | n/a | n/a | 2.29 | n/a | n/a | n/a | n/a |
| | Efficiency-Non-Preempted | (0) | 108 | 1.5 | (0.02) | 2.23 | 0.06 | \$278 | 0.81 | 1.69 |
| | Efficiency-Equipment | (0) | 102 | 2.5 | (0.04) | 2.13 | 0.16 | \$250 | 1.96 | 3.27 |
| | Efficiency & PV/Battery | (6) | 108 | 10.0 | 0.03 | 1.88 | 0.41 | \$2,376 | 0.98 | 1.57 |
| All-Electric² | Code Compliant | 1,507 | 0 | n/a | n/a | 1.39 | n/a | n/a | n/a | n/a |
| | Efficiency-Non-Preempted | 1,425 | 0 | 1.5 | 0.00 | 1.34 | 0.05 | \$361 | 1.16 | 2.00 |
| | Efficiency-Equipment | 1,369 | 0 | 1.5 | 0.00 | 1.31 | 0.08 | \$361 | 1.71 | 1.98 |
| | Efficiency & PV | 450 | 0 | 10.5 | 0.60 | 1.09 | 0.30 | \$2,371 | 1.31 | 1.79 |
| | Efficiency & PV/Battery | (4) | 0 | 23.0 | 0.93 | 0.63 | 0.76 | \$5,395 | 1.27 | 1.69 |
| Mixed Fuel to All-Electric³ | Code Compliant | 1,507 | 0 | 0.0 | 0.00 | 1.39 | 0.90 | (\$2,337) | 3.35 | 2.36 |
| | Efficiency & PV | 56 | 0 | 10.5 | 0.60 | 1.09 | 1.20 | \$34 | 70.89 | >1 |
| | Neutral Cost | 372 | 0 | 10.5 | 0.70 | 1.10 | 1.19 | \$0 | >1 | >1 |

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

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

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

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

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



Climate Zone 10 SDGE

Table 69: Single Family Climate Zone 10 SDGE Results Summary

| Climate Zone 10 SDG&E Single Family | | Annual Net kWh | Annual therms | EDR Margin ⁴ | PV Size Change (kW) ⁵ | CO2-Equivalent Emissions (lbs/sf) | | NPV of Lifetime Incremental Cost (\$) | Benefit to Cost Ratio (B/C) | |
|--|--------------------------|----------------------|------------------|----------------------------|--|--------------------------------------|-----------|--|--------------------------------|------|
| | | | | | | Total | Reduction | | On-Bill | TDV |
| | | | | | | | | | | |
| Mixed Fuel ¹ | Code Compliant | (0) | 239 | n/a | n/a | 1.61 | n/a | n/a | n/a | n/a |
| | Efficiency-Non-Preempted | (0) | 217 | 3.0 | (0.07) | 1.48 | 0.13 | \$1,648 | 0.80 | 1.33 |
| | Efficiency-Equipment | (0) | 209 | 3.0 | (0.06) | 1.45 | 0.16 | \$593 | 2.64 | 3.84 |
| | Efficiency & PV/Battery | (12) | 217 | 9.5 | 0.03 | 1.25 | 0.36 | \$5,522 | 0.58 | 1.48 |
| All-Electric ² | Code Compliant | 2,981 | 0 | n/a | n/a | 0.94 | n/a | n/a | n/a | n/a |
| | Efficiency-Non-Preempted | 2,673 | 0 | 3.0 | 0.00 | 0.88 | 0.07 | \$1,773 | 1.08 | 1.52 |
| | Efficiency-Equipment | 2,563 | 0 | 3.0 | 0.00 | 0.85 | 0.10 | \$949 | 2.62 | 3.19 |
| | Efficiency & PV | 762 | 0 | 11.0 | 1.17 | 0.70 | 0.24 | \$6,405 | 1.68 | 1.50 |
| | Efficiency & PV/Battery | (6) | 0 | 21.0 | 1.74 | 0.41 | 0.53 | \$12,129 | 1.42 | 1.51 |
| Mixed Fuel to All-Electric ³ | Code Compliant | 2,981 | 0 | 0.0 | 0.00 | 0.94 | 0.67 | (\$5,349) | 0.90 | 2.66 |
| | Efficiency & PV | 762 | 0 | 11.0 | 1.17 | 0.70 | 0.91 | \$1,057 | 4.55 | >1 |
| | Neutral Cost | 770 | 0 | 9.0 | 1.36 | 0.74 | 0.87 | \$0 | >1 | >1 |

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

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

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

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

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



Table 70: Multifamily Climate Zone 10 SDGE Results Summary (Per Dwelling Unit)

| Climate Zone 10 SDG&E Multifamily | | Annual Net kWh | Annual therms | EDR Margin ⁴ | PV Size Change (kW) ⁵ | CO2-Equivalent Emissions (lbs/sf) | | NPV of Lifetime Incremental Cost (\$) | Benefit to Cost Ratio (B/C) | |
|--|--------------------------|----------------------|------------------|----------------------------|--|--------------------------------------|-----------|--|--------------------------------|------|
| | | | | | | Total | Reduction | | On-Bill | TDV |
| | | | | | | | | | | |
| Mixed Fuel ¹ | Code Compliant | (0) | 112 | n/a | n/a | 2.29 | n/a | n/a | n/a | n/a |
| | Efficiency-Non-Preempted | (0) | 108 | 1.5 | (0.02) | 2.23 | 0.06 | \$278 | 1.09 | 1.69 |
| | Efficiency-Equipment | (0) | 102 | 2.5 | (0.04) | 2.13 | 0.16 | \$250 | 2.60 | 3.27 |
| | Efficiency & PV/Battery | (6) | 108 | 10.0 | 0.03 | 1.88 | 0.41 | \$2,376 | 0.23 | 1.57 |
| All-Electric ² | Code Compliant | 1,507 | 0 | n/a | n/a | 1.39 | n/a | n/a | n/a | n/a |
| | Efficiency-Non-Preempted | 1,425 | 0 | 1.5 | 0.00 | 1.34 | 0.05 | \$361 | 1.53 | 2.00 |
| | Efficiency-Equipment | 1,369 | 0 | 1.5 | 0.00 | 1.31 | 0.08 | \$361 | 2.05 | 1.98 |
| | Efficiency & PV | 450 | 0 | 10.5 | 0.60 | 1.09 | 0.30 | \$2,371 | 2.12 | 1.79 |
| | Efficiency & PV/Battery | (4) | 0 | 23.0 | 0.93 | 0.63 | 0.76 | \$5,395 | 1.44 | 1.69 |
| Mixed Fuel to All-Electric ³ | Code Compliant | 1,507 | 0 | 0.0 | 0.00 | 1.39 | 0.90 | (\$2,337) | 0.73 | 2.36 |
| | Efficiency & PV | 56 | 0 | 10.5 | 0.60 | 1.09 | 1.20 | \$34 | 54.15 | >1 |
| | Neutral Cost | 372 | 0 | 10.5 | 0.70 | 1.10 | 1.19 | \$0 | >1 | >1 |

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

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

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

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

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



Climate Zone 11

Table 71: Single Family Climate Zone 11 Results Summary

| Climate Zone 11 PG&E Single Family | | Annual Net kWh | Annual therms | EDR Margin ⁴ | PV Size Change (kW) ⁵ | CO2-Equivalent Emissions (lbs/sf) | | NPV of Lifetime Incremental Cost (\$) | Benefit to Cost Ratio (B/C) | |
|--|--------------------------|----------------------|------------------|----------------------------|--|--------------------------------------|-----------|--|--------------------------------|------|
| | | | | | | Total | Reduction | | On-Bill | TDV |
| | | | | | | | | | | |
| Mixed Fuel ¹ | Code Compliant | (0) | 378 | n/a | n/a | 2.14 | n/a | n/a | n/a | n/a |
| | Efficiency-Non-Preempted | (0) | 333 | 4.0 | (0.19) | 1.90 | 0.24 | \$3,143 | 0.78 | 1.20 |
| | Efficiency-Equipment | 0 | 320 | 5.0 | (0.21) | 1.83 | 0.31 | \$1,222 | 2.50 | 3.68 |
| | Efficiency & PV/Battery | (18) | 333 | 9.0 | (0.09) | 1.78 | 0.36 | \$7,026 | 0.36 | 1.51 |
| All-Electric ² | Code Compliant | 4,585 | 0 | n/a | n/a | 1.15 | n/a | n/a | n/a | n/a |
| | Efficiency-Non-Preempted | 3,815 | 0 | 4.5 | 0.00 | 0.99 | 0.16 | \$3,735 | 1.24 | 1.47 |
| | Efficiency-Equipment | 3,533 | 0 | 5.5 | 0.00 | 0.93 | 0.22 | \$2,108 | 2.97 | 3.33 |
| | Efficiency & PV | 957 | 0 | 14.0 | 1.79 | 0.60 | 0.55 | \$10,827 | 1.84 | 1.55 |
| | Efficiency & PV/Battery | (13) | 0 | 23.0 | 2.49 | 0.36 | 0.79 | \$17,077 | 1.49 | 1.61 |
| Mixed Fuel to All-Electric ³ | Code Compliant | 4,585 | 0 | 0.0 | 0.00 | 1.15 | 0.99 | (\$5,349) | 0.49 | 1.69 |
| | Efficiency & PV | 957 | 0 | 14.0 | 1.79 | 0.60 | 1.54 | \$5,478 | 1.64 | >1 |
| | Neutral Cost | 2,429 | 0 | 7.0 | 1.36 | 0.85 | 1.29 | \$0 | >1 | >1 |

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

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

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

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

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



Table 72: Multifamily Climate Zone 11 Results Summary (Per Dwelling Unit)

| Climate Zone 11 PG&E Multifamily | | Annual Net kWh | Annual therms | EDR Margin ⁴ | PV Size Change (kW) ⁵ | CO2-Equivalent Emissions (lbs/sf) | | NPV of Lifetime Incremental Cost (\$) | Benefit to Cost Ratio (B/C) | |
|--|--------------------------|----------------------|------------------|----------------------------|--|--------------------------------------|-----------|--|--------------------------------|-------|
| | | | | | | Total | Reduction | | On-Bill | TDV |
| | | | | | | | | | | |
| Mixed Fuel ¹ | Code Compliant | (0) | 141 | n/a | n/a | 2.38 | n/a | n/a | n/a | n/a |
| | Efficiency-Non-Preempted | 0 | 127 | 2.5 | (0.05) | 2.18 | 0.20 | \$850 | 0.65 | 1.17 |
| | Efficiency-Equipment | (0) | 126 | 3.0 | (0.06) | 2.16 | 0.22 | \$317 | 1.84 | 3.29 |
| | Efficiency & PV/Battery | (9) | 127 | 10.5 | 0.01 | 2.00 | 0.38 | \$2,950 | 0.39 | 1.60 |
| All-Electric ² | Code Compliant | 1,974 | 0 | n/a | n/a | 1.42 | n/a | n/a | n/a | n/a |
| | Efficiency-Non-Preempted | 1,732 | 0 | 3.5 | 0.00 | 1.29 | 0.13 | \$1,011 | 1.40 | 1.64 |
| | Efficiency-Equipment | 1,707 | 0 | 3.5 | 0.00 | 1.26 | 0.16 | \$795 | 2.02 | 2.33 |
| | Efficiency & PV | 504 | 0 | 13.0 | 0.77 | 0.81 | 0.61 | \$3,601 | 2.22 | 1.81 |
| | Efficiency & PV/Battery | (6) | 0 | 25.0 | 1.14 | 0.45 | 0.98 | \$6,759 | 1.42 | 1.81 |
| Mixed Fuel to All-Electric ³ | Code Compliant | 1,974 | 0 | 0.0 | 0.00 | 1.42 | 0.96 | (\$2,337) | 0.56 | 1.33 |
| | Efficiency & PV | 63 | 0 | 13.0 | 0.77 | 0.81 | 1.56 | \$1,264 | 3.03 | >1 |
| | Neutral Cost | 866 | 0 | 9.0 | 0.70 | 0.99 | 1.38 | \$0 | >1 | 73.96 |

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

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

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

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

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



Climate Zone 12

Table 73: Single Family Climate Zone 12 Results Summary

| Climate Zone 12 PG&E Single Family | | Annual Net kWh | Annual therms | EDR Margin ⁴ | PV Size Change (kW) ⁵ | CO2-Equivalent Emissions (lbs/sf) | | NPV of Lifetime Incremental Cost (\$) | Benefit to Cost Ratio (B/C) | |
|--|--------------------------|----------------------|------------------|----------------------------|--|--------------------------------------|----------------|--|--------------------------------|------|
| | | | | | | Total | Reduction | | On-Bill | TDV |
| | | | | | | Mixed Fuel ¹ | Code Compliant | | (0) | 390 |
| Efficiency-Non-Preempted | (0) | 344 | 3.5 | (0.06) | 1.88 | | 0.23 | \$1,679 | 1.18 | 1.83 |
| Efficiency-Equipment | 0 | 338 | 3.0 | (0.05) | 1.85 | | 0.26 | \$654 | 3.31 | 4.65 |
| Efficiency & PV/Battery | (23) | 344 | 9.5 | 0.04 | 1.76 | | 0.35 | \$5,568 | 0.43 | 1.72 |
| All-Electric ² | Code Compliant | 4,492 | 0 | n/a | n/a | 1.05 | n/a | n/a | n/a | n/a |
| | Efficiency-Non-Preempted | 3,958 | 0 | 3.5 | 0.00 | 0.94 | 0.10 | \$3,735 | 0.78 | 1.06 |
| | Efficiency-Equipment | 3,721 | 0 | 5.0 | 0.00 | 0.90 | 0.15 | \$2,108 | 2.00 | 2.51 |
| | Efficiency & PV | 867 | 0 | 15.5 | 1.97 | 0.51 | 0.53 | \$11,520 | 1.69 | 1.41 |
| | Efficiency & PV/Battery | (15) | 0 | 25.0 | 2.62 | 0.29 | 0.76 | \$17,586 | 1.29 | 1.48 |
| Mixed Fuel to All-Electric ³ | Code Compliant | 4,492 | 0 | 0.0 | 0.00 | 1.05 | 1.07 | (\$5,349) | 0.63 | 1.89 |
| | Efficiency & PV | 867 | 0 | 15.5 | 1.97 | 0.51 | 1.60 | \$6,172 | 1.77 | >1 |
| | Neutral Cost | 2,374 | 0 | 8.0 | 1.35 | 0.76 | 1.36 | \$0 | >1 | >1 |

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

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

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

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

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



Table 74: Multifamily Climate Zone 12 Results Summary (Per Dwelling Unit)

| Climate Zone 12 PG&E Multifamily | | Annual Net kWh | Annual therms | EDR Margin ⁴ | PV Size Change (kW) ⁵ | CO2-Equivalent Emissions (lbs/sf) | | NPV of Lifetime Incremental Cost (\$) | Benefit to Cost Ratio (B/C) | |
|--|--------------------------|----------------------|------------------|----------------------------|--|--------------------------------------|-----------|--|--------------------------------|------|
| | | | | | | Total | Reduction | | On-Bill | TDV |
| | | | | | | | | | | |
| Mixed Fuel ¹ | Code Compliant | (0) | 143 | n/a | n/a | 2.33 | n/a | n/a | n/a | n/a |
| | Efficiency-Non-Preempted | (0) | 135 | 1.5 | (0.02) | 2.21 | 0.12 | \$291 | 1.10 | 2.22 |
| | Efficiency-Equipment | 0 | 128 | 2.5 | (0.03) | 2.12 | 0.21 | \$434 | 1.25 | 2.22 |
| | Efficiency & PV/Battery | (11) | 135 | 10.0 | 0.03 | 2.03 | 0.30 | \$2,394 | 0.30 | 1.75 |
| All-Electric ² | Code Compliant | 1,963 | 0 | n/a | n/a | 1.34 | n/a | n/a | n/a | n/a |
| | Efficiency-Non-Preempted | 1,792 | 0 | 2.5 | 0.00 | 1.24 | 0.09 | \$1,011 | 0.91 | 1.12 |
| | Efficiency-Equipment | 1,744 | 0 | 2.5 | 0.00 | 1.21 | 0.13 | \$795 | 1.56 | 1.63 |
| | Efficiency & PV | 472 | 0 | 14.0 | 0.84 | 0.73 | 0.60 | \$3,835 | 2.08 | 1.65 |
| | Efficiency & PV/Battery | (8) | 0 | 26.5 | 1.20 | 0.38 | 0.96 | \$6,943 | 1.26 | 1.68 |
| Mixed Fuel to All-Electric ³ | Code Compliant | 1,963 | 0 | 0.0 | 0.00 | 1.34 | 1.00 | (\$2,337) | 0.64 | 1.66 |
| | Efficiency & PV | 59 | 0 | 14.0 | 0.84 | 0.73 | 1.60 | \$1,498 | 2.88 | >1 |
| | Neutral Cost | 872 | 0 | 9.5 | 0.70 | 0.92 | 1.42 | \$0 | >1 | >1 |

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

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

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

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

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



Climate Zone 13

Table 75: Single Family Climate Zone 13 Results Summary

| Climate Zone 13 PG&E Single Family | | Annual Net kWh | Annual therms | EDR Margin ⁴ | PV Size Change (kW) ⁵ | CO2-Equivalent Emissions (lbs/sf) | | NPV of Lifetime Incremental Cost (\$) | Benefit to Cost Ratio (B/C) | |
|--|--------------------------|----------------------|------------------|----------------------------|--|--------------------------------------|-----------|--|--------------------------------|------|
| | | | | | | Total | Reduction | | On-Bill | TDV |
| | | | | | | | | | | |
| Mixed Fuel ¹ | Code Compliant | (0) | 352 | n/a | n/a | 2.02 | n/a | n/a | n/a | n/a |
| | Efficiency-Non-Preempted | (0) | 311 | 4.5 | (0.21) | 1.80 | 0.22 | \$3,060 | 0.76 | 1.28 |
| | Efficiency-Equipment | (0) | 292 | 5.5 | (0.24) | 1.70 | 0.32 | \$611 | 5.26 | 8.40 |
| | Efficiency & PV/Battery | (19) | 311 | 9.5 | (0.11) | 1.69 | 0.33 | \$6,954 | 0.36 | 1.56 |
| All-Electric ² | Code Compliant | 4,180 | 0 | n/a | n/a | 1.08 | n/a | n/a | n/a | n/a |
| | Efficiency-Non-Preempted | 3,428 | 0 | 5.0 | 0.00 | 0.92 | 0.15 | \$4,154 | 1.12 | 1.40 |
| | Efficiency-Equipment | 3,177 | 0 | 6.0 | 0.00 | 0.87 | 0.21 | \$2,108 | 2.88 | 3.30 |
| | Efficiency & PV | 934 | 0 | 13.0 | 1.61 | 0.57 | 0.50 | \$10,532 | 1.70 | 1.47 |
| | Efficiency & PV/Battery | (11) | 0 | 22.0 | 2.32 | 0.35 | 0.73 | \$16,806 | 1.40 | 1.54 |
| Mixed Fuel to All-Electric ³ | Code Compliant | 4,180 | 0 | 0.0 | 0.00 | 1.08 | 0.94 | (\$5,349) | 0.54 | 1.83 |
| | Efficiency & PV | 934 | 0 | 13.0 | 1.61 | 0.57 | 1.44 | \$5,184 | 1.56 | >1 |
| | Neutral Cost | 2,092 | 0 | 7.0 | 1.36 | 0.79 | 1.23 | \$0 | >1 | >1 |

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

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

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

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

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



Table 76: Multifamily Climate Zone 13 Results Summary (Per Dwelling Unit)

| Climate Zone 13 PG&E Multifamily | | Annual Net kWh | Annual therms | EDR Margin ⁴ | PV Size Change (kW) ⁵ | CO2-Equivalent Emissions (lbs/sf) | | NPV of Lifetime Incremental Cost (\$) | Benefit to Cost Ratio (B/C) | |
|--|--------------------------|----------------------|------------------|----------------------------|--|--------------------------------------|-----------|--|--------------------------------|------|
| | | | | | | Total | Reduction | | On-Bill | TDV |
| | | | | | | | | | | |
| Mixed Fuel ¹ | Code Compliant | (0) | 135 | n/a | n/a | 2.30 | n/a | n/a | n/a | n/a |
| | Efficiency-Non-Preempted | (0) | 123 | 3.0 | (0.05) | 2.12 | 0.18 | \$831 | 0.63 | 1.27 |
| | Efficiency-Equipment | (0) | 121 | 3.0 | (0.07) | 2.10 | 0.21 | \$290 | 1.95 | 3.75 |
| | Efficiency & PV/Battery | (9) | 123 | 10.5 | 0.00 | 1.95 | 0.35 | \$2,936 | 0.38 | 1.64 |
| All-Electric ² | Code Compliant | 1,849 | 0 | n/a | n/a | 1.36 | n/a | n/a | n/a | n/a |
| | Efficiency-Non-Preempted | 1,629 | 0 | 3.0 | 0.00 | 1.24 | 0.12 | \$1,011 | 1.31 | 1.56 |
| | Efficiency-Equipment | 1,590 | 0 | 3.5 | 0.00 | 1.21 | 0.16 | \$795 | 1.98 | 2.28 |
| | Efficiency & PV | 501 | 0 | 12.0 | 0.73 | 0.80 | 0.56 | \$3,462 | 2.12 | 1.71 |
| | Efficiency & PV/Battery | (5) | 0 | 23.5 | 1.11 | 0.44 | 0.92 | \$6,650 | 1.35 | 1.74 |
| Mixed Fuel to All-Electric ³ | Code Compliant | 1,849 | 0 | 0.0 | 0.00 | 1.36 | 0.94 | (\$2,337) | 0.63 | 1.54 |
| | Efficiency & PV | 63 | 0 | 12.0 | 0.73 | 0.80 | 1.50 | \$1,125 | 3.22 | >1 |
| | Neutral Cost | 773 | 0 | 8.5 | 0.70 | 0.94 | 1.36 | \$0 | >1 | >1 |

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

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

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

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

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



Climate Zone 14 SCE/SoCalGas

Table 77: Single Family Climate Zone 14 SCE/SoCalGas Results Summary

| Climate Zone 14 SCE/SoCalGas Single Family | | Annual Net kWh | Annual therms | EDR Margin ⁴ | PV Size Change (kW) ⁵ | CO2-Equivalent Emissions (lbs/sf) | | NPV of Lifetime Incremental Cost (\$) | Benefit to Cost Ratio (B/C) | |
|--|--------------------------|----------------------|------------------|----------------------------|--|--------------------------------------|-----------|--|--------------------------------|------|
| | | | | | | Total | Reduction | | On-Bill | TDV |
| Mixed Fuel ¹ | Code Compliant | (0) | 371 | n/a | n/a | 2.35 | n/a | n/a | n/a | n/a |
| | Efficiency-Non-Preempted | (0) | 319 | 4.5 | (0.17) | 2.06 | 0.29 | \$1,662 | 1.57 | 2.46 |
| | Efficiency-Equipment | (0) | 305 | 5.5 | (0.19) | 1.98 | 0.36 | \$799 | 3.95 | 6.14 |
| | Efficiency & PV/Battery | (5) | 319 | 9.0 | (0.08) | 1.83 | 0.52 | \$5,526 | 1.31 | 1.74 |
| All-Electric ² | Code Compliant | 4,725 | 0 | n/a | n/a | 1.38 | n/a | n/a | n/a | n/a |
| | Efficiency-Non-Preempted | 3,819 | 0 | 5.5 | 0.00 | 1.19 | 0.19 | \$4,154 | 0.95 | 1.46 |
| | Efficiency-Equipment | 3,676 | 0 | 6.0 | 0.00 | 1.16 | 0.22 | \$2,108 | 2.29 | 3.13 |
| | Efficiency & PV | 953 | 0 | 15.5 | 1.60 | 0.93 | 0.45 | \$10,459 | 1.21 | 1.62 |
| | Efficiency & PV/Battery | (2) | 0 | 23.5 | 2.21 | 0.63 | 0.75 | \$16,394 | 1.35 | 1.59 |
| Mixed Fuel to All-Electric ³ | Code Compliant | 4,725 | 0 | 0.0 | 0.00 | 1.38 | 0.97 | (\$5,349) | 0.72 | 1.67 |
| | Efficiency & PV | 953 | 0 | 15.5 | 1.60 | 0.93 | 1.42 | \$5,111 | 1.01 | >1 |
| | Neutral Cost | 2,299 | 0 | 8.5 | 1.35 | 1.15 | 1.19 | \$0 | 0.00 | >1 |
| | Min Cost Effectiveness | 1,853 | 0 | 10.0 | 1.61 | 1.12 | 1.23 | (\$1,000) | 1.24 | >1 |

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

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

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

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

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



Table 78: Multifamily Climate Zone 14 SCE/SoCalGas Results Summary (Per Dwelling Unit)

| Climate Zone 14 SCE/SoCalGas Multifamily | | Annual Net kWh | Annual therms | EDR Margin ⁴ | PV Size Change (kW) ⁵ | CO2-Equivalent Emissions (lbs/sf) | | NPV of Lifetime Incremental Cost (\$) | Benefit to Cost Ratio (B/C) | |
|--|--------------------------|----------------------|------------------|----------------------------|--|--------------------------------------|-----------|--|--------------------------------|------|
| | | | | | | Total | Reduction | | On-Bill | TDV |
| Mixed Fuel ¹ | Code Compliant | (0) | 141 | n/a | n/a | 2.76 | n/a | n/a | n/a | n/a |
| | Efficiency-Non-Preempted | (0) | 126 | 3.0 | (0.04) | 2.53 | 0.23 | \$874 | 0.73 | 1.21 |
| | Efficiency-Equipment | (0) | 126 | 3.0 | (0.05) | 2.52 | 0.23 | \$347 | 1.96 | 2.99 |
| | Efficiency & PV/Battery | (3) | 126 | 9.5 | 0.01 | 2.18 | 0.58 | \$2,957 | 1.09 | 1.39 |
| All-Electric ² | Code Compliant | 2,022 | 0 | n/a | n/a | 1.73 | n/a | n/a | n/a | n/a |
| | Efficiency-Non-Preempted | 1,759 | 0 | 3.5 | 0.00 | 1.58 | 0.15 | \$1,011 | 1.24 | 1.65 |
| | Efficiency-Equipment | 1,748 | 0 | 3.5 | 0.00 | 1.56 | 0.16 | \$795 | 1.59 | 2.20 |
| | Efficiency & PV | 504 | 0 | 14.0 | 0.70 | 1.26 | 0.47 | \$3,356 | 1.39 | 1.91 |
| | Efficiency & PV/Battery | (2) | 0 | 24.5 | 1.03 | 0.79 | 0.94 | \$6,380 | 1.36 | 1.77 |
| Mixed Fuel to All-Electric ³ | Code Compliant | 2,022 | 0 | 0.0 | 0.00 | 1.73 | 1.03 | (\$2,337) | 1.13 | 1.48 |
| | Efficiency & PV | 63 | 0 | 14.0 | 0.70 | 1.26 | 1.50 | \$1,019 | 2.57 | >1 |
| | Neutral Cost | 772 | 0 | 10.0 | 0.70 | 1.41 | 1.35 | \$0 | >1 | >1 |

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

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

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

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

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



Climate Zone 14 SDGE

Table 79: Single Family Climate Zone 14 SDGE Results Summary

| Climate Zone 14 SDG&E Single Family | | Annual Net kWh | Annual therms | EDR Margin ⁴ | PV Size Change (kW) ⁵ | CO2-Equivalent Emissions (lbs/sf) | | NPV of Lifetime Incremental Cost (\$) | Benefit to Cost Ratio (B/C) | |
|--|--------------------------|----------------------|------------------|----------------------------|--|--------------------------------------|-----------|--|--------------------------------|------|
| | | | | | | Total | Reduction | | On-Bill | TDV |
| | | | | | | | | | | |
| Mixed Fuel ¹ | Code Compliant | (0) | 371 | n/a | n/a | 2.35 | n/a | n/a | n/a | n/a |
| | Efficiency-Non-Preempted | (0) | 319 | 4.5 | (0.17) | 2.06 | 0.29 | \$1,662 | 1.92 | 2.46 |
| | Efficiency-Equipment | (0) | 305 | 5.5 | (0.19) | 1.98 | 0.36 | \$799 | 4.88 | 6.14 |
| | Efficiency & PV/Battery | (5) | 319 | 9.0 | (0.08) | 1.83 | 0.52 | \$5,526 | 1.23 | 1.74 |
| All-Electric ² | Code Compliant | 4,725 | 0 | n/a | n/a | 1.38 | n/a | n/a | n/a | n/a |
| | Efficiency-Non-Preempted | 3,819 | 0 | 5.5 | 0.00 | 1.19 | 0.19 | \$4,154 | 1.30 | 1.46 |
| | Efficiency-Equipment | 3,676 | 0 | 6.0 | 0.00 | 1.16 | 0.22 | \$2,108 | 2.92 | 3.13 |
| | Efficiency & PV | 953 | 0 | 15.5 | 1.60 | 0.93 | 0.45 | \$10,459 | 1.80 | 1.62 |
| | Efficiency & PV/Battery | (2) | 0 | 23.5 | 2.21 | 0.63 | 0.75 | \$16,394 | 1.67 | 1.59 |
| Mixed Fuel to All-Electric ³ | Code Compliant | 4,725 | 0 | 0.0 | 0.00 | 1.38 | 0.97 | (\$5,349) | 0.60 | 1.67 |
| | Efficiency & PV | 953 | 0 | 15.5 | 1.60 | 0.93 | 1.42 | \$5,111 | 1.94 | >1 |
| | Neutral Cost | 2,299 | 0 | 8.5 | 1.35 | 1.15 | 1.19 | \$0 | >1 | >1 |

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

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

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

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

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



Table 80: Multifamily Climate Zone 14 SDGE Results Summary (Per Dwelling Unit)

| Climate Zone 14 SDG&E Multifamily | | Annual Net kWh | Annual therms | EDR Margin ⁴ | PV Size Change (kW) ⁵ | CO ₂ -Equivalent Emissions (lbs/sf) | | NPV of Lifetime Incremental Cost (\$) | Benefit to Cost Ratio (B/C) | |
|--|--------------------------|----------------------|------------------|----------------------------|--|---|-----------|--|--------------------------------|------|
| | | | | | | Total | Reduction | | On-Bill | TDV |
| | | | | | | | | | | |
| Mixed Fuel ¹ | Code Compliant | (0) | 141 | n/a | n/a | 2.76 | n/a | n/a | n/a | n/a |
| | Efficiency-Non-Preempted | (0) | 126 | 3.0 | (0.04) | 2.53 | 0.23 | \$874 | 0.93 | 1.21 |
| | Efficiency-Equipment | (0) | 126 | 3.0 | (0.05) | 2.52 | 0.23 | \$347 | 2.48 | 2.99 |
| | Efficiency & PV/Battery | (3) | 126 | 9.5 | 0.01 | 2.18 | 0.58 | \$2,957 | 0.51 | 1.39 |
| All-Electric ² | Code Compliant | 2,022 | 0 | n/a | n/a | 1.73 | n/a | n/a | n/a | n/a |
| | Efficiency-Non-Preempted | 1,759 | 0 | 3.5 | 0.00 | 1.58 | 0.15 | \$1,011 | 1.47 | 1.65 |
| | Efficiency-Equipment | 1,748 | 0 | 3.5 | 0.00 | 1.56 | 0.16 | \$795 | 2.00 | 2.20 |
| | Efficiency & PV | 504 | 0 | 14.0 | 0.70 | 1.26 | 0.47 | \$3,356 | 2.16 | 1.91 |
| | Efficiency & PV/Battery | (2) | 0 | 24.5 | 1.03 | 0.79 | 0.94 | \$6,380 | 1.69 | 1.77 |
| Mixed Fuel to All-Electric ³ | Code Compliant | 2,022 | 0 | 0.0 | 0.00 | 1.73 | 1.03 | (\$2,337) | 0.51 | 1.48 |
| | Efficiency & PV | 63 | 0 | 14.0 | 0.70 | 1.26 | 1.50 | \$1,019 | 2.60 | >1 |
| | Neutral Cost | 772 | 0 | 10.0 | 0.70 | 1.41 | 1.35 | \$0 | >1 | >1 |

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

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

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

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

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



Climate Zone 15

Table 81: Single Family Climate Zone 15 Results Summary

| Climate Zone 15 SCE/SoCalGas Single Family | | Annual Net kWh | Annual therms | EDR Margin ⁴ | PV Size Change (kW) ⁵ | CO ₂ -Equivalent Emissions (lbs/sf) | | NPV of Lifetime Incremental Cost (\$) | Benefit to Cost Ratio (B/C) | |
|--|--------------------------|----------------------|------------------|----------------------------|--|---|-----------|--|--------------------------------|------|
| | | | | | | Total | Reduction | | On-Bill | TDV |
| | | | | | | | | | | |
| Mixed Fuel ¹ | Code Compliant | 0 | 149 | n/a | n/a | 1.69 | n/a | n/a | n/a | n/a |
| | Efficiency-Non-Preempted | 0 | 141 | 4.5 | (0.43) | 1.56 | 0.13 | \$2,179 | 1.00 | 1.58 |
| | Efficiency-Equipment | (0) | 132 | 4.5 | (0.45) | 1.51 | 0.18 | (\$936) | >1 | >1 |
| | Efficiency & PV/Battery | (3) | 141 | 7.0 | (0.34) | 1.38 | 0.32 | \$6,043 | 1.15 | 1.51 |
| All-Electric ² | Code Compliant | 2,149 | 0 | n/a | n/a | 1.32 | n/a | n/a | n/a | n/a |
| | Efficiency-Non-Preempted | 1,230 | 0 | 5.5 | 0.00 | 1.12 | 0.20 | \$4,612 | 1.12 | 1.58 |
| | Efficiency-Equipment | 866 | 0 | 7.0 | 0.00 | 1.04 | 0.28 | \$2,108 | 3.30 | 4.47 |
| | Efficiency & PV | 1,030 | 0 | 6.0 | 0.12 | 1.10 | 0.22 | \$5,085 | 1.12 | 1.57 |
| | Efficiency & PV/Battery | (2) | 0 | 13.0 | 0.83 | 0.84 | 0.48 | \$11,382 | 1.16 | 1.54 |
| Mixed Fuel to All-Electric ³ | Code Compliant | 2,149 | 0 | 0.0 | 0.00 | 1.32 | 0.37 | (\$5,349) | 1.73 | 2.21 |
| | Efficiency & PV | 1,030 | 0 | 6.0 | 0.12 | 1.10 | 0.59 | (\$264) | >1 | >1 |
| | Neutral Cost | 23 | 0 | 6.0 | 1.36 | 1.13 | 0.57 | \$0 | >1 | >1 |

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

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

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

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

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



Table 82: Multifamily Climate Zone 15 Results Summary (Per Dwelling Unit)

| Climate Zone 15 SCE/SoCalGas Multifamily | | Annual Net kWh | Annual therms | EDR Margin ⁴ | PV Size Change (kW) ⁵ | CO2-Equivalent Emissions (lbs/sf) | | NPV of Lifetime Incremental Cost (\$) | Benefit to Cost Ratio (B/C) | |
|--|--------------------------|----------------------|------------------|----------------------------|--|--------------------------------------|-----------|--|--------------------------------|------|
| | | | | | | Total | Reduction | | On-Bill | TDV |
| | | | | | | | | | | |
| Mixed Fuel ¹ | Code Compliant | 0 | 93 | n/a | n/a | 2.53 | n/a | n/a | n/a | n/a |
| | Efficiency-Non-Preempted | 0 | 92 | 4.0 | (0.15) | 2.42 | 0.11 | \$510 | 1.35 | 2.28 |
| | Efficiency-Equipment | 0 | 86 | 4.0 | (0.16) | 2.33 | 0.20 | (\$157) | >1 | >1 |
| | Efficiency & PV/Battery | (3) | 92 | 8.5 | (0.10) | 2.13 | 0.40 | \$2,604 | 1.29 | 1.70 |
| All-Electric ² | Code Compliant | 1,243 | 0 | n/a | n/a | 1.78 | n/a | n/a | n/a | n/a |
| | Efficiency-Non-Preempted | 954 | 0 | 4.0 | 0.00 | 1.61 | 0.17 | \$1,011 | 1.50 | 2.28 |
| | Efficiency-Equipment | 764 | 0 | 6.0 | 0.00 | 1.50 | 0.29 | \$1,954 | 1.24 | 1.72 |
| | Efficiency & PV | 548 | 0 | 7.0 | 0.24 | 1.50 | 0.28 | \$1,826 | 1.43 | 2.07 |
| | Efficiency & PV/Battery | (3) | 0 | 16.5 | 0.62 | 1.08 | 0.70 | \$5,020 | 1.34 | 1.80 |
| Mixed Fuel to All-Electric ³ | Code Compliant | 1,243 | 0 | 0.0 | 0.00 | 1.78 | 0.75 | (\$2,337) | 6.36 | 2.35 |
| | Efficiency & PV | 68 | 0 | 7.0 | 0.24 | 1.50 | 1.03 | (\$511) | >1 | >1 |
| | Neutral Cost | 78 | 0 | 7.5 | 0.70 | 1.48 | 1.05 | \$0 | >1 | >1 |

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

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

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

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

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



Climate Zone 16

Table 83: Single Family Climate Zone 16 Results Summary

| Climate Zone 16 PG&E Single Family | | Annual Net kWh | Annual therms | EDR Margin ⁴ | PV Size Change (kW) ⁵ | CO2-Equivalent Emissions (lbs/sf) | | NPV of Lifetime Incremental Cost (\$) | Benefit to Cost Ratio (B/C) | |
|--|--------------------------|----------------|---------------|-------------------------|----------------------------------|-----------------------------------|-----------|---------------------------------------|-----------------------------|------|
| | | | | | | Total | Reduction | | On-Bill | TDV |
| Mixed Fuel ¹ | Code Compliant | (0) | 605 | n/a | n/a | 3.31 | n/a | n/a | n/a | n/a |
| | Efficiency-Non-Preempted | 0 | 454 | 5.0 | 0.01 | 2.59 | 0.72 | \$3,542 | 1.62 | 1.46 |
| | Efficiency-Equipment | 0 | 474 | 6.0 | (0.08) | 2.66 | 0.65 | \$2,441 | 2.19 | 2.20 |
| | Efficiency & PV/Battery | (18) | 454 | 10.5 | 0.10 | 2.36 | 0.95 | \$7,399 | 0.87 | 1.37 |
| All-Electric ² | Code Compliant | 7,694 | 0 | n/a | n/a | 1.73 | n/a | n/a | n/a | n/a |
| | Efficiency-Non-Preempted | 5,696 | 0 | 9.5 | 0.00 | 1.38 | 0.35 | \$5,731 | 1.72 | 1.69 |
| | Efficiency-Equipment | 6,760 | 0 | 4.5 | 0.00 | 1.55 | 0.18 | \$2,108 | 2.36 | 2.32 |
| | Efficiency & PV | 1,032 | 0 | 26.5 | 2.75 | 0.94 | 0.79 | \$16,582 | 2.09 | 1.62 |
| | Efficiency & PV/Battery | (11) | 0 | 35.0 | 3.45 | 0.64 | 1.09 | \$22,838 | 1.71 | 1.55 |
| Mixed Fuel to All-Electric ³ | Code Compliant | 7,694 | 0 | 0.0 | 0.00 | 1.73 | 1.58 | (\$5,349) | 0.31 | 0.68 |
| | Efficiency & PV | 1,032 | 0 | 26.5 | 2.75 | 0.94 | 2.37 | \$11,234 | 1.55 | 2.02 |
| | Neutral Cost | 5,398 | 0 | 8.5 | 1.35 | 1.51 | 1.80 | \$0 | 0.00 | 0.74 |
| | Min Cost Effectiveness | 3,358 | 0 | 16.0 | 2.56 | 1.32 | 1.99 | (\$4,753) | 1.24 | 1.40 |

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

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

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

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

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



Table 84: Multifamily Climate Zone 16 Results Summary (Per Dwelling Unit)

| Climate Zone 16 PG&E Multifamily | | Annual Net kWh | Annual therms | EDR Margin ⁴ | PV Size Change (kW) ⁵ | CO2-Equivalent Emissions (lbs/sf) | | NPV of Lifetime Incremental Cost (\$) | Benefit to Cost Ratio (B/C) | |
|--|--------------------------|----------------------|------------------|----------------------------|--|--------------------------------------|-----------|--|--------------------------------|------|
| | | | | | | Total | Reduction | | On-Bill | TDV |
| | | | | | | | | | | |
| Mixed Fuel ¹ | Code Compliant | 0 | 206 | n/a | n/a | 3.45 | n/a | n/a | n/a | n/a |
| | Efficiency-Non-Preempted | (0) | 172 | 2.0 | 0.03 | 3.02 | 0.44 | \$937 | 1.11 | 1.19 |
| | Efficiency-Equipment | (0) | 183 | 2.5 | (0.02) | 3.12 | 0.33 | \$453 | 1.76 | 2.15 |
| | Efficiency & PV/Battery | (9) | 172 | 9.5 | 0.08 | 2.65 | 0.80 | \$3,028 | 0.47 | 1.28 |
| All-Electric ² | Code Compliant | 2,699 | 0 | n/a | n/a | 1.86 | n/a | n/a | n/a | n/a |
| | Efficiency-Non-Preempted | 2,329 | 0 | 4.0 | 0.00 | 1.70 | 0.16 | \$843 | 2.08 | 2.05 |
| | Efficiency-Equipment | 2,470 | 0 | 3.0 | 0.00 | 1.74 | 0.13 | \$795 | 1.59 | 1.70 |
| | Efficiency & PV | 518 | 0 | 19.5 | 1.07 | 1.23 | 0.63 | \$4,423 | 2.58 | 1.89 |
| | Efficiency & PV/Battery | (6) | 0 | 29.5 | 1.42 | 0.75 | 1.11 | \$7,533 | 1.65 | 1.69 |
| Mixed Fuel to All-Electric ³ | Code Compliant | 2,699 | 0 | 0.0 | 0.00 | 1.86 | 1.59 | (\$2,337) | 0.43 | 1.03 |
| | Efficiency & PV | 65 | 0 | 19.5 | 1.07 | 1.23 | 2.22 | \$2,087 | 2.87 | >1 |
| | Neutral Cost | 1,518 | 0 | 10.0 | 0.70 | 1.56 | 1.90 | \$0 | >1 | 2.58 |

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

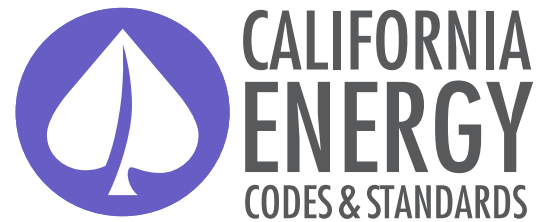
²All reductions and incremental costs relative to the **all-electric** code compliant home.

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

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

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





A STATEWIDE UTILITY PROGRAM

Title 24, Parts 6 and 11
Local Energy Efficiency Ordinances

2019 Nonresidential New Construction Reach Code Cost Effectiveness Study

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1 Introduction

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

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

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

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

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

Figure 1. Measure Category and Package Overview

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

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

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

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

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

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



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

2 Methodology and Assumptions

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

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

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

2.1 Building Prototypes

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

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

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

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

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

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

Figure 2. Prototype Characteristics Summary

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

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



2.2 Cost Effectiveness

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

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

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

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

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

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

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



Figure 3. Utility Tariffs used based on Climate Zone

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

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

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

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

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



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

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

3 Measure Description and Cost

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

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

3.1 Energy Efficiency Measures

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

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

3.1.1 Envelope

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

In all cases, the fenestration visible transmittance and U-factor remain at prescriptive values.

- ◆ **Fenestration as a function of orientation:** Limit the amount of fenestration area as a function of orientation. East-facing and west-facing windows are each limited to one-half of the average amount of north-facing and south-facing windows.

3.1.2 HVAC and SWH

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



3.1.3 Lighting

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

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



Figure 4. Energy Efficiency Measures - Specification and Cost

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



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

⁸ <http://www.csithermalstats.org/download.html>

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



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

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

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



3.2 Solar Photovoltaics and Battery Measures

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

3.2.1 Solar Photovoltaics

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

- ◆ 15 W/ft² covering 50 percent of the roof area, or
- ◆ Enough to nearly offset the annual energy consumption.

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

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

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

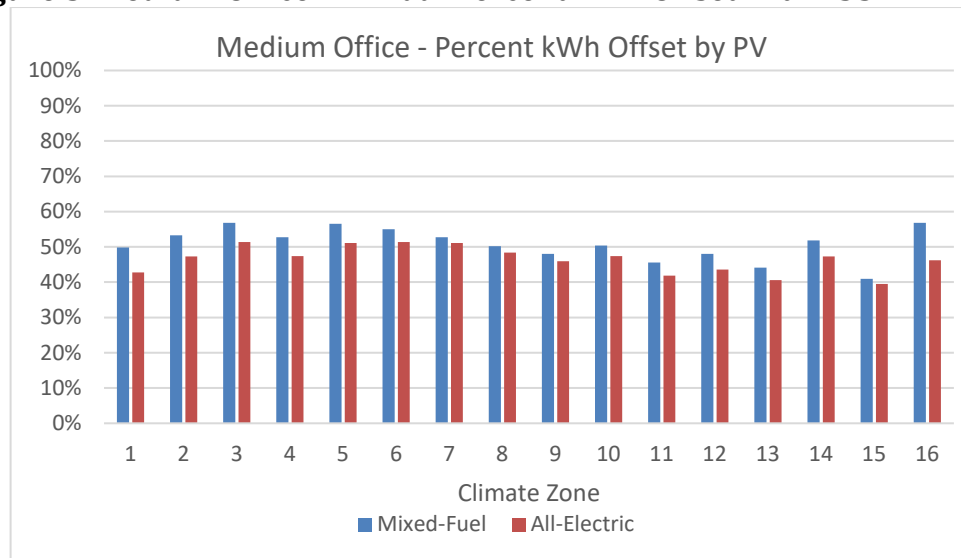


Figure 6. Medium Retail – Annual Percent kWh Offset with 110 kW Array

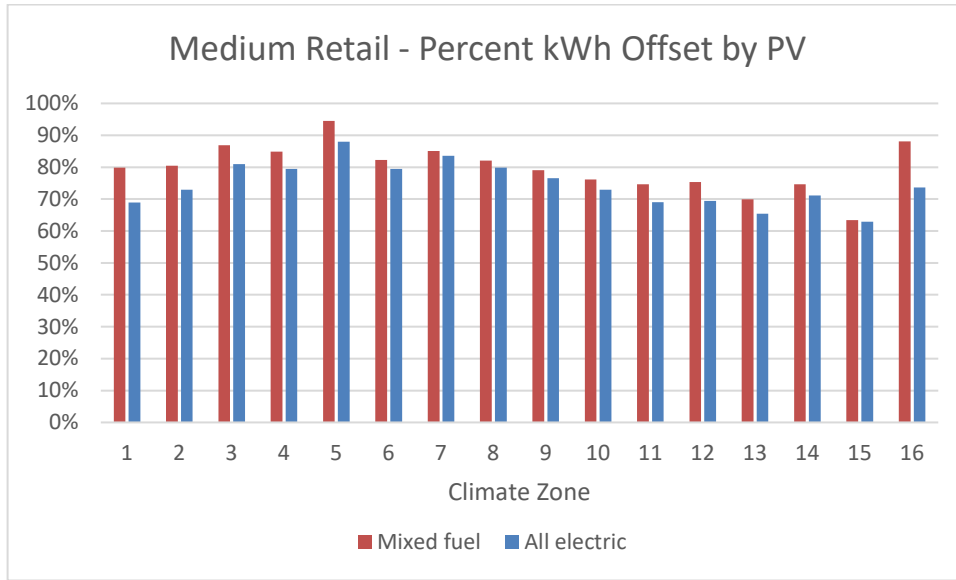
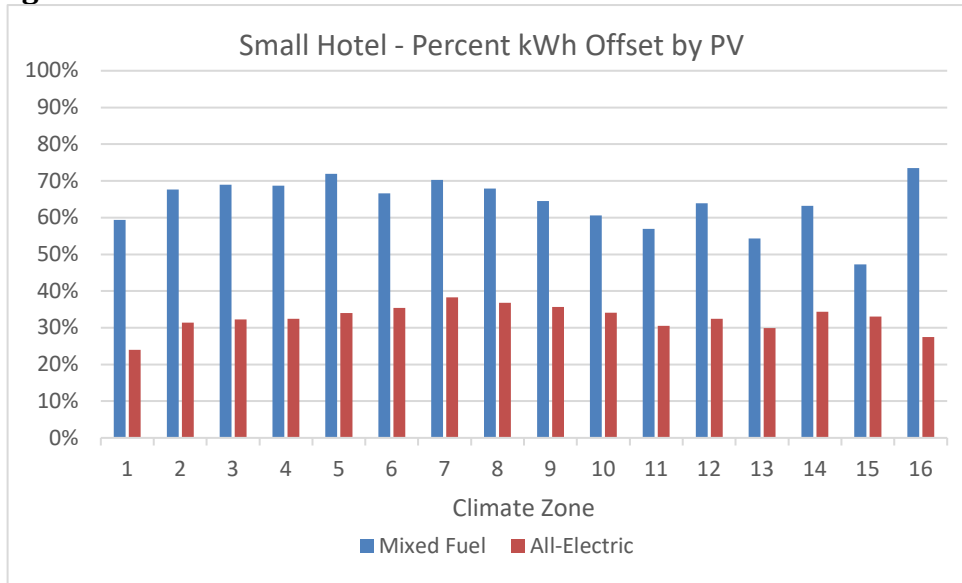


Figure 7. Small Hotel – Annual Percent kWh Offset with 80 kW Array



The costs for PV include first cost to purchase and install the system, inverter replacement costs, and annual maintenance costs. A summary of the medium office costs and sources is given in Figure 8. Upfront solar PV system costs are reduced by the federal income tax credit (ITC), approximately 19 percent due to a phased reduction in the credit through the year 2022.¹²

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



Figure 8. Medium Office Upfront PV Costs

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

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

3.2.2 Battery Storage

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

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

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

The Reach Code Team used costs of \$558 kWh based on a 2018 IOU Codes and Standards Program report, assuming a replacement is necessary in year 15.¹⁸ Batteries are also eligible for the ITC if they are installed at the same time as the renewable generation source and at least 75 percent of the energy used to charge

¹³ Available at: <https://www.nrel.gov/docs/fy16osti/66532.pdf>

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

¹⁵ More information available at: <https://pvwatts.nrel.gov/downloads/pvwattsv5.pdf>

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

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

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



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

3.2.3 PV-only and PV+Battery Packages

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

- ◆ **Small PV Size:** 3 kW, assumed to be the minimal PV system considered for installation in a nonresidential building.
- ◆ **Large PV Size:** PV capacity equal to 15 W/ft² over 50 percent of the roof area, or sized to nearly offset annual electricity consumption, as described in Section 3.2.1.
- ◆ **Small Battery Size:** 5 kWh, assumed to be the minimal battery system considered for installation in a nonresidential building, and representative of smaller products currently available on the market.
- ◆ **Large Battery Size:** 50 kWh, assumed to be a substantially large size for a nonresidential setting. Generally, the reach code team found diminishing on-bill and TDV benefits as the battery size increased.

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

3.3 All Electric Measures

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

3.3.1 HVAC and Water Heating

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



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

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

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

3.3.1.1 Medium Office

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

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

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

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



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

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

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

Figure 10. Medium Office HVAC System Costs

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

3.3.1.2 Medium Retail

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

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

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

Figure 11. Medium Retail HVAC System Costs

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

3.3.1.3 Small Hotel

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

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

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

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



Figure 12. Small Hotel HVAC and Water Heating System Costs

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

3.3.2 *Infrastructure Impacts*

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

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

3.3.2.1 *Electrical Panel Sizing and Wiring*

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

VAV terminal units with hot water reheat coils that are replaced with electric resistance reheat coils require additional electrical infrastructure. In the case of electric resistance coils, the Reach Code Team assumed that on average, a VAV terminal unit serves around 900 ft² of conditioned space and has a heating capacity of 5 kW (15 kBtu/hr/ft²). The incremental electrical infrastructure costs were determined based on RS Means. Calculations for the medium office shown in Figure 13 include the cost to add electrical panels as well as the cost to add electrical lines to each VAV terminal unit electric resistance coil in the medium office prototype. Additionally, the Reach Code Team subtracted the electrical infrastructure costs associated with hot water pumps required in the mixed fuel baseline, which are not required in the all-electric measures.



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

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

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

3.3.2.2 Natural Gas

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

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



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

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

3.4 Preempted High Efficiency Appliances

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

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

Figure 15. High Efficiency Appliance Assumptions

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

3.5 Greenhouse Gas Emissions

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

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

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



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

4 Results

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

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

Figure 16. Package Summary

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

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



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

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

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

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

4.1 Cost Effectiveness Results – Medium Office

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

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

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



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

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



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

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



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

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



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

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

*The Incremental Package Cost is equal to the sum of the incremental HVAC and water heating equipment costs from

Figure 10, the electrical infrastructure incremental cost of \$27,802 (see section 3.3.2.1), and the natural gas infrastructure incremental costs of \$(18,949) (see section 3.3.2.2).



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

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



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

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



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

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



4.2 Cost Effectiveness Results – Medium Retail

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

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



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

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



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

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



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

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



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

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

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



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

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



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

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



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

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



4.3 Cost Effectiveness Results – Small Hotel

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

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

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

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

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

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



◆ **2 – All-Electric Federal Code-Minimum Reference:**

◆ This all-electric design does not comply with the Energy Commission's TDV performance budget. Packages achieve between -50% and -4% compliance margins depending on climate zone. This may be because the modeled HW system is constrained to having an artificially low efficiency to avoid triggering federal pre-emption, and the heat pump space heating systems must operate overnight when operation is less efficient.

◆ All packages are cost effective in all climate zones.

◆ **3A – All-Electric + EE:** Packages achieve positive compliance margins in all CZs ranging from 0% to +17%, except CZ16 which had a -18% compliance margin. All packages are cost effective in all climate zones. The improved degree of cost effectiveness outcomes in Package 3A compared to Package 1A appear to be due to the significant incremental package cost savings.

◆ **3B – All-Electric + EE + PV + B:** All packages are cost effective. Packages improve in B/C ratio when compared to 3A and increase in magnitude of overall NPV savings. PV appears to be more cost-effective with higher building electricity loads.

◆ **3C – All-Electric + HE:**

◆ Packages do not comply with Title 24 in all CZs except CZ15 which resulted in a +0.04% compliance margin.

◆ All packages are cost effective.



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

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



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

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



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

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



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

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

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



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

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



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

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



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

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



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

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

Jurisdictions interested in adopting PV-only reach codes should reference the mixed-fuel cost effectiveness results because a mixed-fuel building is the baseline for the nonresidential prototypes analyzed in this study. PV or PV+Battery packages are added to all-electric federal code minimum reference which (in many scenarios) do not have a positive compliance margin compared to the mixed-fuel baseline model, and are solely provided for informational purposes. Jurisdictions interested in reach codes requiring all-electric+PV or all-electric+PV+battery should reference package 3B results in Sections 4.1 – 4.3.²⁵

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

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

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

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

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

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

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



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

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



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

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



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

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



5 Summary, Conclusions, and Further Considerations

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

5.1 Summary

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

- ◆ Cells highlighted in green depict a positive compliance margin and cost-effective results using both On-Bill and TDV approaches.
- ◆ Cells highlighted in yellow depict a positive compliance and cost-effective results using either the On-Bill or TDV approach.
- ◆ Cells not highlighted either depict a negative compliance margin or a package that was not cost effective using either the On-Bill or TDV approach.

For more detail on the results in the Figures, please refer to *Section 4 Results*. As described in Section 4.4, PV-only and PV+Battery packages in the mixed-fuel building were found to be cost effective across all prototypes, climate zones, and packages using the TDV approach, and results are not reiterated in the following figures.



Figure 41. Medium Office Summary of Compliance Margin and Cost Effectiveness

| CZ | Utility | Mixed Fuel | | | All Electric | | | |
|--------|---------|------------|-------------|----|--------------|------|-------------|------|
| | | EE | EE + PV + B | HE | Fed Code | EE | EE + PV + B | HE |
| CZ01 | PG&E | 18% | 18% | 3% | -15% | 7% | 7% | -14% |
| CZ02 | PG&E | 17% | 17% | 4% | -7% | 10% | 10% | -5% |
| CZ03 | PG&E | 20% | 20% | 3% | -7% | 16% | 16% | -6% |
| CZ04 | PG&E | 14% | 14% | 5% | -6% | 9% | 9% | -3% |
| CZ04-2 | CPAU | 14% | 14% | 5% | -6% | 9% | 9% | -3% |
| CZ05 | PG&E | 18% | 18% | 4% | -8% | 12% | 12% | -6% |
| CZ05-2 | SCG | 18% | 18% | 4% | NA | NA | NA | NA |
| CZ06 | SCE | 20% | 20% | 3% | -4% | 18% | 18% | -2% |
| CZ06-2 | LADWP | 20% | 20% | 3% | -4% | 18% | 18% | -2% |
| CZ07 | SDG&E | 20% | 20% | 4% | -2% | 20% | 20% | 1% |
| CZ08 | SCE | 18% | 18% | 4% | -2% | 18% | 18% | 1% |
| CZ08-2 | LADWP | 18% | 18% | 4% | -2% | 18% | 18% | 1% |
| CZ09 | SCE | 16% | 16% | 4% | -2% | 15% | 15% | 2% |
| CZ09-2 | LADWP | 16% | 16% | 4% | -2% | 15% | 15% | 2% |
| CZ10 | SDG&E | 17% | 17% | 4% | -4% | 13% | 13% | -1% |
| CZ10-2 | SCE | 17% | 17% | 4% | -4% | 13% | 13% | -1% |
| CZ11 | PG&E | 13% | 13% | 5% | -4% | 10% | 10% | 0% |
| CZ12 | PG&E | 14% | 14% | 5% | -5% | 10% | 10% | -1% |
| CZ12-2 | SMUD | 14% | 14% | 5% | -5% | 10% | 10% | -1% |
| CZ13 | PG&E | 13% | 13% | 5% | -4% | 9% | 9% | 0% |
| CZ14 | SDG&E | 14% | 14% | 5% | -5% | 9% | 9% | -1% |
| CZ14-2 | SCE | 14% | 14% | 5% | -5% | 9% | 9% | -1% |
| CZ15 | SCE | 12% | 12% | 5% | -2% | 10% | 10% | 3% |
| CZ16 | PG&E | 14% | 14% | 5% | -27% | -15% | -15% | -26% |
| CZ16-2 | LADWP | 14% | 14% | 5% | -27% | -15% | -15% | -26% |



Figure 42. Medium Retail Summary of Compliance Margin and Cost Effectiveness

| CZ | Utility | Mixed Fuel | | | All Electric | | | |
|--------|---------|------------|-------------|----|--------------|-----|-------------|-----|
| | | EE | EE + PV + B | HE | Fed Code | EE | EE + PV + B | HE |
| CZ01 | PG&E | 18% | 18% | 2% | -4.1% | 15% | 15% | -2% |
| CZ02 | PG&E | 13% | 13% | 3% | -1.0% | 13% | 13% | 3% |
| CZ03 | PG&E | 16% | 16% | 2% | -0.4% | 16% | 16% | 2% |
| CZ04 | PG&E | 14% | 14% | 3% | -0.1% | 14% | 14% | 3% |
| CZ04-2 | CPAU | 14% | 14% | 3% | -0.1% | 14% | 14% | 3% |
| CZ05 | PG&E | 16% | 16% | 1% | -1.2% | 15% | 15% | 1% |
| CZ05-2 | SCG | 16% | 16% | 1% | NA | NA | NA | NA |
| CZ06 | SCE | 10% | 10% | 3% | 0.5% | 11% | 11% | 3% |
| CZ06-2 | LADWP | 10% | 10% | 3% | 0.5% | 11% | 11% | 3% |
| CZ07 | SDG&E | 13% | 13% | 2% | 0.3% | 13% | 13% | 3% |
| CZ08 | SCE | 10% | 10% | 3% | 0.4% | 10% | 10% | 4% |
| CZ08-2 | LADWP | 10% | 10% | 3% | 0.4% | 10% | 10% | 4% |
| CZ09 | SCE | 10% | 10% | 4% | 0.4% | 10% | 10% | 4% |
| CZ09-2 | LADWP | 10% | 10% | 4% | 0.4% | 10% | 10% | 4% |
| CZ10 | SDG&E | 12% | 12% | 4% | 0.1% | 12% | 12% | 4% |
| CZ10-2 | SCE | 12% | 12% | 4% | 0.1% | 12% | 12% | 4% |
| CZ11 | PG&E | 13% | 13% | 4% | 0.5% | 12% | 12% | 5% |
| CZ12 | PG&E | 13% | 13% | 4% | -0.1% | 12% | 12% | 4% |
| CZ12-2 | SMUD | 13% | 13% | 4% | -0.1% | 12% | 12% | 4% |
| CZ13 | PG&E | 15% | 15% | 4% | -0.4% | 14% | 14% | 4% |
| CZ14 | SDG&E | 13% | 13% | 4% | 0.7% | 15% | 15% | 5% |
| CZ14-2 | SCE | 13% | 13% | 4% | 0.7% | 15% | 15% | 5% |
| CZ15 | SCE | 12% | 12% | 5% | 0.9% | 12% | 12% | 6% |
| CZ16 | PG&E | 13% | 13% | 3% | -12.2% | 3% | 3% | -8% |
| CZ16-2 | LADWP | 13% | 13% | 3% | -12.2% | 3% | 3% | -8% |



Figure 43. Small Hotel Summary of Compliance Margin and Cost Effectiveness

| CZ | Utility | Mixed Fuel | | | All Electric | | | |
|--------|---------|------------|-------------|----|--------------|------|-------------|-------|
| | | EE | EE + PV + B | HE | Fed Code | EE | EE + PV + B | HE |
| CZ01 | PG&E | 9% | 9% | 2% | -28% | 1% | 1% | -24% |
| CZ02 | PG&E | 7% | 7% | 3% | -12% | 4% | 4% | -11% |
| CZ03 | PG&E | 10% | 10% | 2% | -14% | 6% | 6% | -14% |
| CZ04 | PG&E | 6% | 6% | 2% | -13% | 0.2% | 0.2% | -13% |
| CZ04-2 | CPAU | 6% | 6% | 2% | -13% | 0.2% | 0.2% | -13% |
| CZ05 | PG&E | 9% | 9% | 2% | -15% | 5% | 5% | -15% |
| CZ05-2 | SCG | 9% | 9% | 2% | NA | NA | NA | NA |
| CZ06 | SCE | 8% | 8% | 2% | -5% | 7% | 7% | -15% |
| CZ06-2 | LADWP | 8% | 8% | 2% | -5% | 7% | 7% | -15% |
| CZ07 | SDG&E | 8% | 8% | 2% | -7% | 7% | 7% | -7% |
| CZ08 | SCE | 7% | 7% | 2% | -6% | 3% | 3% | -6% |
| CZ08-2 | LADWP | 7% | 7% | 2% | -6% | 3% | 3% | -6% |
| CZ09 | SCE | 6% | 6% | 3% | -6% | 2% | 2% | -4% |
| CZ09-2 | LADWP | 6% | 6% | 3% | -6% | 2% | 2% | -4% |
| CZ10 | SDG&E | 5% | 5% | 4% | -8% | 2% | 2% | -5% |
| CZ10-2 | SCE | 5% | 5% | 4% | -8% | 2% | 2% | -5% |
| CZ11 | PG&E | 4% | 4% | 4% | -10% | 1% | 1% | -7% |
| CZ12 | PG&E | 5% | 5% | 4% | -10% | 2% | 2% | -9% |
| CZ12-2 | SMUD | 5% | 5% | 4% | -10% | 2% | 2% | -9% |
| CZ13 | PG&E | 4% | 4% | 3% | -10% | 0.3% | 0.3% | -7% |
| CZ14 | SDG&E | 4% | 4% | 4% | -11% | 0.1% | 0.1% | -7% |
| CZ14-2 | SCE | 4% | 4% | 4% | -11% | 0.1% | 0.1% | -7% |
| CZ15 | SCE | 3% | 3% | 5% | -4% | 2% | 2% | 0.04% |
| CZ16 | PG&E | 6% | 6% | 3% | -50% | -14% | -14% | -39% |
| CZ16-2 | LADWP | 6% | 6% | 3% | -50% | -14% | -14% | -39% |

5.2 Conclusions and Further Considerations

Findings are specific to the scenarios analyzed under this specific methodology, and largely pertain to office, retail, and hotel-type occupancies. Nonresidential buildings constitute a wide variety of occupancy profiles and process loads, making findings challenging to generalize across multiple building types.

Findings indicate the following overall conclusions:

1. This study assumed that electrifying space heating and service water heating could eliminate natural gas infrastructure alone, because these were the only gas end-uses included the prototypes. Avoiding the installation of natural gas infrastructure results in significant cost savings and is a primary factor toward cost-effective outcomes in all-electric designs, even with necessary increases in electrical capacity.
2. There is ample opportunity for cost effective energy efficiency improvements, as demonstrated by the compliance margins achieved in many of the efficiency-only and efficiency + PV packages. Though much of the energy savings are attributable to lighting measures, efficiency measures selected for these prototypes are confined to the building systems that can be modeled. There is



likely further opportunity for energy savings through measures that cannot be currently demonstrated in compliance software, such as high-performance control sequences or variable speed parallel fan powered boxes.

3. High efficiency appliances triggering federal preemption do not achieve as high compliance margins as the other efficiency measures analyzed in this study. Cost effectiveness appears to be dependent on the system type and building type. Nonetheless, specifying high efficiency equipment will always be a key feature in integrated design.
4. Regarding the Small Hotel prototype:
 - a. The Small Hotel presents a challenging prototype to cost-effectively exceed the state's energy performance budget without efficiency measures. The Reach Code Team is uncertain of the precision of the results due to the inability to directly model either drain water heat recovery or a central heat pump water heater with a recirculation loop.
 - b. Hotel results may be applicable to high-rise (4 or more stories) multifamily buildings. Both hotel and multifamily buildings have the same or similar mandatory and prescriptive compliance options for hot water systems, lighting, and envelope. Furthermore, the Alternate Calculation Method Reference Manual specifies the same baseline HVAC system for both building types.
 - c. Hotel compliance margins were the lowest among the three building types analyzed, and thus the most conservative performance thresholds applicable to other nonresidential buildings not analyzed in this study. As stated previously, the varying occupancy and energy profiles of nonresidential buildings makes challenging to directly apply these results across all buildings.
5. Many all-electric and solar PV packages demonstrated greater GHG reductions than their mixed-fuel counterparts, contrary to TDV-based performance, suggesting a misalignment among the TDV metric and California's long-term GHG-reduction goals. The Energy Commission has indicated that they are aware of this issue and are seeking to address it.
6. Changes to the Nonresidential Alternative Calculation Method (ACM) Reference Manual can drastically impact results. Two examples include:
 - a. When performance modeling residential buildings, the Standard Design is electric if the Proposed Design is electric, which removes TDV-related penalties and associated negative compliance margins. This essentially allows for a compliance pathway for all-electric residential buildings. If nonresidential buildings were treated in the same way, all-electric cost effectiveness using the TDV approach would improve.
 - b. The baseline mixed-fuel system for a hotel includes a furnace in each guest room, which carries substantial plumbing costs and labor costs for assembly. A change in the baseline system would lead to different base case costs and different cost effectiveness outcomes.
7. All-electric federal code-minimum packages appear to be cost effective, largely due to avoided natural gas infrastructure, but in most cases do not comply with the Energy Commission's minimum performance budget (as described in item 7a above). For most cases it appears that adding cost-effective efficiency measures achieves compliance. All-electric nonresidential projects can leverage the initial cost savings of avoiding natural gas infrastructure by adding energy efficiency measures that would not be cost effective independently.



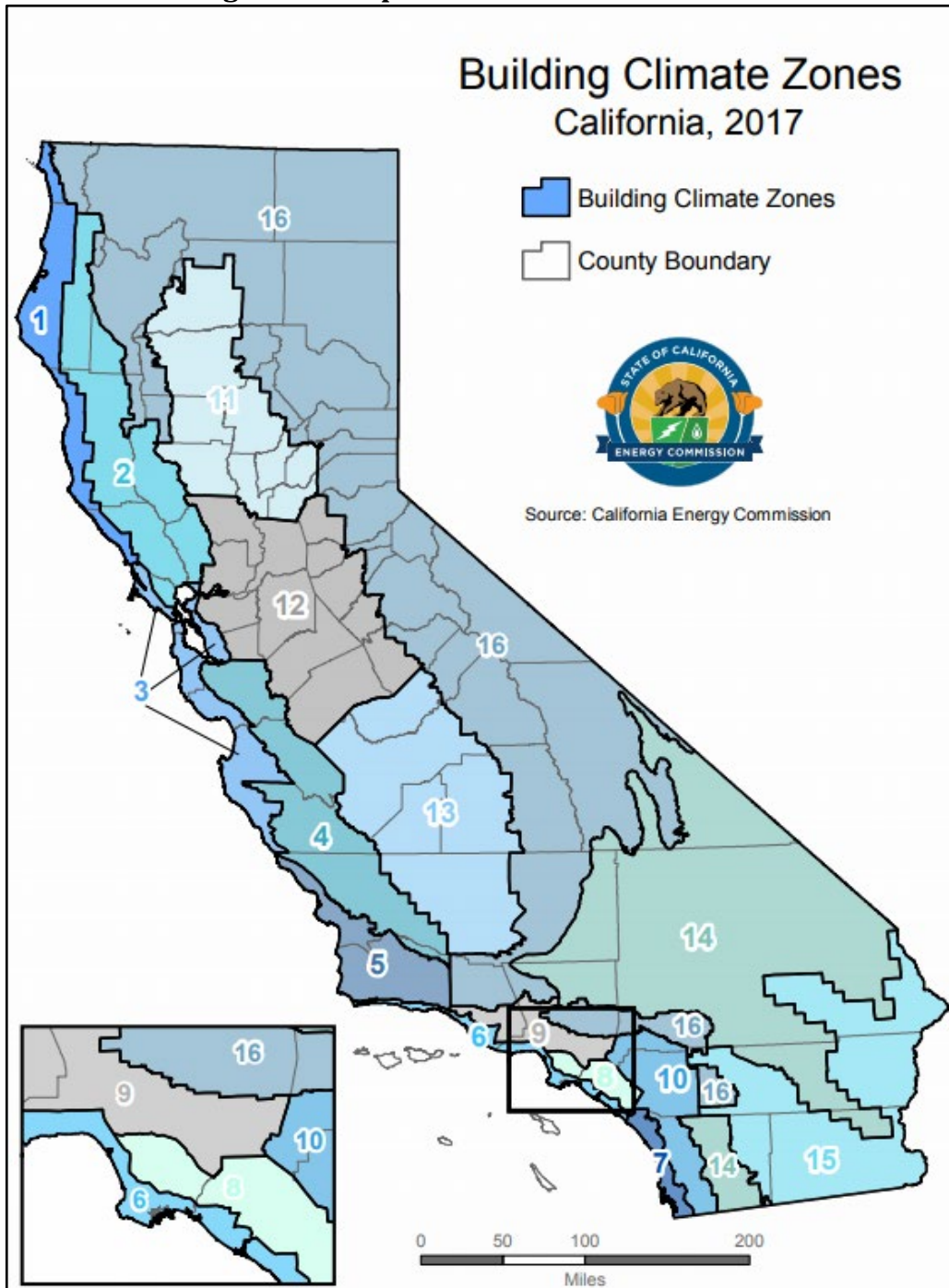
6 Appendices

6.1 Map of California Climate Zones

Climate zone geographical boundaries are depicted in Figure 44. The map in Figure 44 along with a zip-code search directory is available at:

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

Figure 44. Map of California Climate Zones



6.2 Lighting Efficiency Measures

Figure 45 details the applicability and impact of each lighting efficiency measure by prototype and space function and includes the resulting LPD that is modeled as the proposed by building type and by space function.

Figure 45. Impact of Lighting Measures on Proposed LPDs by Space Function

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

6.3 Drain Water Heat Recovery Measure Analysis

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

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



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

6.4 Utility Rate Schedules

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

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

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



6.5 Mixed Fuel Baseline Energy Figures

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

Figure 47. Medium Office – Mixed Fuel Baseline

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



Figure 48. Medium Retail – Mixed Fuel Baseline

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



Figure 49. Small Hotel – Mixed Fuel Baseline

| Climate Zone | Utility | Electricity Consumption (kWh) | Natural Gas Consumption (Therms) | Electricity Cost | Natural Gas Cost | Compliance TDV | GHG Emissions (lbs) |
|--|---------|-------------------------------|----------------------------------|------------------|------------------|----------------|---------------------|
| Small Hotel Mixed Fuel Baseline | | | | | | | |
| CZ01 | PG&E | 177,734 | 16,936 | 40,778 | 20,465 | 110 | 340,491 |
| CZ02 | PG&E | 189,319 | 12,696 | 53,396 | 15,664 | 110 | 293,056 |
| CZ03 | PG&E | 183,772 | 12,341 | 42,325 | 15,210 | 98 | 284,217 |
| CZ04 | PG&E | 187,482 | 11,945 | 52,118 | 14,806 | 106 | 281,851 |
| CZ04-2 | CPAU | 187,482 | 11,945 | 32,176 | 14,806 | 106 | 281,851 |
| CZ05 | PG&E | 187,150 | 11,979 | 43,182 | 14,733 | 98 | 281,183 |
| CZ05-2 | SCG | 187,150 | 11,979 | 43,182 | 10,869 | 98 | 281,183 |
| CZ06 | SCE | 191,764 | 8,931 | 28,036 | 8,437 | 98 | 244,664 |
| CZ06-2 | LA | 191,764 | 8,931 | 16,636 | 8,437 | 98 | 244,664 |
| CZ07 | SDG&E | 189,174 | 8,207 | 58,203 | 10,752 | 90 | 233,884 |
| CZ08 | SCE | 190,503 | 8,372 | 27,823 | 7,991 | 94 | 236,544 |
| CZ08-2 | LA | 190,503 | 8,372 | 16,555 | 7,991 | 94 | 236,544 |
| CZ09 | SCE | 198,204 | 8,421 | 30,262 | 8,030 | 103 | 242,296 |
| CZ09-2 | LA | 198,204 | 8,421 | 17,951 | 8,030 | 103 | 242,296 |
| CZ10 | SDG&E | 215,364 | 8,437 | 71,713 | 10,926 | 122 | 255,622 |
| CZ10-2 | SCE | 215,364 | 8,437 | 33,736 | 8,043 | 122 | 255,622 |
| CZ11 | PG&E | 219,852 | 10,271 | 63,724 | 12,882 | 131 | 282,232 |
| CZ12 | PG&E | 199,499 | 10,422 | 46,245 | 13,022 | 115 | 270,262 |
| CZ12-2 | SMUD | 199,499 | 10,422 | 26,872 | 13,022 | 115 | 270,262 |
| CZ13 | PG&E | 226,925 | 10,048 | 65,559 | 12,629 | 132 | 284,007 |
| CZ14 | SDG&E | 226,104 | 10,075 | 73,621 | 12,167 | 134 | 283,287 |
| CZ14-2 | SCE | 226,104 | 10,075 | 35,187 | 9,350 | 134 | 283,287 |
| CZ15 | SCE | 280,595 | 5,598 | 42,852 | 5,777 | 152 | 260,378 |
| CZ16 | PG&E | 191,231 | 17,618 | 51,644 | 21,581 | 127 | 358,590 |
| CZ16-2 | LA | 191,231 | 17,618 | 16,029 | 21,581 | 127 | 358,590 |

6.6 Hotel TDV Cost Effectiveness with Propane Baseline

The Reach Codes Team further analyzed TDV cost effectiveness of the all-electric packages with a mixed-fuel design baseline using propane instead of natural gas. Results for each package are shown in Figure 50. through Figure 53. below.

All electric models compared to a propane baseline have positive compliance margins in all climate zones when compared to results using a natural gas baseline. Compliance margin improvement is roughly 30 percent, which also leads to improved cost effectiveness for the all-electric packages. These outcomes are likely due to the TDV penalty associated with propane when compared to natural gas.



Across packages, TDV cost effectiveness with a propane baseline follows similar trends as the natural gas baseline. Adding efficiency measures increased compliance margins by 3 to 10 percent depending on climate zone, while adding high efficiency HVAC and SHW equipment alone increased compliance margins by smaller margins of about 2 to 4 percent compared to the All-Electric package.

Figure 50. TDV Cost Effectiveness for Small Hotel, Propane Baseline – Package 2 All-Electric Federal Code Minimum

| Climate Zone | Compliance Margin (%) | Incremental Package Cost | \$-TDV Savings | B/C Ratio (TDV) | NPV (TDV) |
|--------------|-----------------------|--------------------------|----------------|-----------------|-------------|
| CZ01 | -4% | (\$1,271,869) | (\$28,346) | 44.9 | \$1,243,523 |
| CZ02 | 27% | (\$1,272,841) | \$170,263 | >1 | \$1,443,104 |
| CZ03 | -3% | (\$1,275,114) | (\$16,425) | 77.6 | \$1,258,689 |
| CZ04 | 26% | (\$1,274,949) | \$155,466 | >1 | \$1,430,414 |
| CZ05 | 27% | (\$1,275,002) | \$154,709 | >1 | \$1,429,710 |
| CZ06 | 17% | (\$1,275,143) | \$126,212 | >1 | \$1,401,355 |
| CZ07 | 25% | (\$1,273,490) | \$117,621 | >1 | \$1,391,111 |
| CZ08 | 24% | (\$1,271,461) | \$122,087 | >1 | \$1,393,548 |
| CZ09 | 23% | (\$1,273,259) | \$123,525 | >1 | \$1,396,784 |
| CZ10 | 18% | (\$1,270,261) | \$109,522 | >1 | \$1,379,783 |
| CZ11 | 19% | (\$1,271,070) | \$129,428 | >1 | \$1,400,498 |
| CZ12 | -4% | (\$1,272,510) | (\$26,302) | 48.4 | \$1,246,208 |
| CZ13 | 18% | (\$1,270,882) | \$124,357 | >1 | \$1,395,239 |
| CZ14 | 17% | (\$1,271,241) | \$117,621 | >1 | \$1,388,861 |
| CZ15 | -7% | (\$1,269,361) | (\$45,338) | 28.0 | \$1,224,023 |
| CZ16 | 9% | (\$1,275,637) | \$68,272 | >1 | \$1,343,908 |



Figure 51. TDV Cost Effectiveness for Small Hotel, Propane Baseline – Package 3A (All-Electric + EE)

| Climate Zone | Compliance Margin (%) | Incremental Package Cost | -\$-TDV Savings | B/C Ratio (TDV) | NPV (TDV) |
|--------------|-----------------------|--------------------------|-----------------|-----------------|-------------|
| CZ01 | 35% | (\$1,250,898) | \$252,831 | >1 | \$1,503,729 |
| CZ02 | 34% | (\$1,251,870) | \$217,238 | >1 | \$1,469,108 |
| CZ03 | 37% | (\$1,254,142) | \$218,642 | >1 | \$1,472,784 |
| CZ04 | 31% | (\$1,250,769) | \$191,393 | >1 | \$1,442,162 |
| CZ05 | 36% | (\$1,254,031) | \$208,773 | >1 | \$1,462,804 |
| CZ06 | 25% | (\$1,250,964) | \$159,714 | >1 | \$1,410,677 |
| CZ07 | 32% | (\$1,249,311) | \$154,111 | >1 | \$1,403,422 |
| CZ08 | 29% | (\$1,247,282) | \$146,536 | >1 | \$1,393,818 |
| CZ09 | 27% | (\$1,249,080) | \$146,671 | >1 | \$1,395,751 |
| CZ10 | 22% | (\$1,246,081) | \$134,477 | >1 | \$1,380,559 |
| CZ11 | 23% | (\$1,246,891) | \$157,138 | >1 | \$1,404,029 |
| CZ12 | 27% | (\$1,248,330) | \$167,945 | >1 | \$1,416,276 |
| CZ13 | 22% | (\$1,246,703) | \$149,270 | >1 | \$1,395,973 |
| CZ14 | 21% | (\$1,247,061) | \$145,269 | >1 | \$1,392,331 |
| CZ15 | 14% | (\$1,245,182) | \$93,647 | >1 | \$1,338,829 |
| CZ16 | 20% | (\$1,254,665) | \$154,035 | >1 | \$1,408,701 |

Figure 52. TDV Cost Effectiveness for Small Hotel, Propane Baseline – Package 3B (All-Electric + EE + PV)

| Climate Zone | Compliance Margin (%) | Incremental Package Cost | -\$-TDV Savings | B/C Ratio (TDV) | NPV (TDV) |
|--------------|-----------------------|--------------------------|-----------------|-----------------|-------------|
| CZ01 | 35% | (\$1,043,528) | \$511,688 | >1 | \$1,555,215 |
| CZ02 | 34% | (\$1,044,500) | \$524,460 | >1 | \$1,568,960 |
| CZ03 | 37% | (\$1,046,772) | \$518,485 | >1 | \$1,565,257 |
| CZ04 | 31% | (\$1,043,399) | \$505,579 | >1 | \$1,548,978 |
| CZ05 | 36% | (\$1,046,660) | \$526,668 | >1 | \$1,573,328 |
| CZ06 | 25% | (\$1,043,594) | \$469,623 | >1 | \$1,513,216 |
| CZ07 | 32% | (\$1,041,941) | \$471,513 | >1 | \$1,513,454 |
| CZ08 | 29% | (\$1,039,912) | \$475,973 | >1 | \$1,515,885 |
| CZ09 | 27% | (\$1,041,710) | \$467,971 | >1 | \$1,509,681 |
| CZ10 | 22% | (\$1,038,711) | \$454,832 | >1 | \$1,493,543 |
| CZ11 | 23% | (\$1,039,521) | \$474,844 | >1 | \$1,514,364 |
| CZ12 | 27% | (\$1,040,960) | \$484,667 | >1 | \$1,525,627 |
| CZ13 | 22% | (\$1,039,333) | \$454,108 | >1 | \$1,493,441 |
| CZ14 | 21% | (\$1,039,691) | \$505,398 | >1 | \$1,545,090 |
| CZ15 | 14% | (\$1,037,811) | \$423,879 | >1 | \$1,461,691 |
| CZ16 | 20% | (\$1,047,295) | \$480,407 | >1 | \$1,527,702 |



Figure 53. TDV Cost Effectiveness for Small Hotel, Propane Baseline – Package 3C (All Electric + HE)

| Climate Zone | Compliance Margin (%) | Incremental Package Cost | -\$TDV Savings | B/C Ratio (TDV) | NPV (TDV) |
|--------------|-----------------------|--------------------------|----------------|-----------------|-------------|
| CZ01 | 27% | (\$1,256,423) | \$194,975 | >1 | \$1,451,398 |
| CZ02 | 28% | (\$1,258,328) | \$177,378 | >1 | \$1,435,706 |
| CZ03 | 28% | (\$1,263,867) | \$164,094 | >1 | \$1,427,961 |
| CZ04 | 26% | (\$1,262,963) | \$155,314 | >1 | \$1,418,277 |
| CZ05 | 26% | (\$1,263,327) | \$153,271 | >1 | \$1,416,598 |
| CZ06 | 17% | (\$1,263,779) | \$122,011 | >1 | \$1,385,790 |
| CZ07 | 24% | (\$1,260,844) | \$116,751 | >1 | \$1,377,594 |
| CZ08 | 25% | (\$1,256,326) | \$122,995 | >1 | \$1,379,321 |
| CZ09 | 24% | (\$1,260,223) | \$128,482 | >1 | \$1,388,706 |
| CZ10 | 20% | (\$1,253,181) | \$121,595 | >1 | \$1,374,776 |
| CZ11 | 21% | (\$1,254,613) | \$143,658 | >1 | \$1,398,271 |
| CZ12 | 23% | (\$1,257,919) | \$142,901 | >1 | \$1,400,820 |
| CZ13 | 21% | (\$1,254,386) | \$138,625 | >1 | \$1,393,011 |
| CZ14 | 20% | (\$1,254,978) | \$136,430 | >1 | \$1,391,407 |
| CZ15 | 14% | (\$1,251,932) | \$96,087 | >1 | \$1,348,019 |
| CZ16 | 15% | (\$1,263,534) | \$122,011 | >1 | \$1,385,545 |



6.7 PV-only and PV+Battery-only Cost Effectiveness Results Details

The Reach Code Tea evaluated cost effectiveness of installing a PV system and battery storage in six different measure combinations over a 2019 code-compliant baseline for all climate zones. The baseline for all nonresidential buildings is a mixed-fuel design.

All mixed fuel models are compliant with 2019 Title24, whereas all electric models can show negative compliance. The compliance margin is the same as that of their respective federal minimum design and is not affected by addition of solar PV or battery. These scenarios evaluate the cost effectiveness of PV and/or battery measure individually. The climate zones where all-electric design is not compliant will have the flexibility to ramp up the efficiency of appliance or add another measure to be code compliant, as per package 1B and 3B in main body of the report. The large negative lifecycle costs in all electric packages are due to lower all-electric HVAC system costs and avoided natural gas infrastructure costs. This is commonly applied across all climate zones and packages over any additional costs for PV and battery.

6.7.1 Cost Effectiveness Results – Medium Office

Figure 54 through Figure 61 contain the cost-effectiveness findings for the Medium Office packages. Notable findings for each package include:

- ◆ **Mixed-Fuel + 3 kW PV Only:** All packages are cost effective using the On-Bill and TDV approaches.
- ◆ **Mixed-Fuel + 3 kW PV + 5 kWh Battery:** The packages are mostly cost effective on a TDV basis except in CZ1. As compared to the 3 kW PV only package, battery reduces cost effectiveness. This package is not cost effective for LADWP and SMUD territories using an On-Bill approach.
- ◆ **Mixed-Fuel + PV only:** The packages are less cost effective as compared to 3 kW PV packages in most climate zones. In areas served by LADWP, the B/C ratio is narrowly less than 1 and not cost effective.
- ◆ **Mixed-Fuel + PV + 50 kWh Battery:** The packages are cost effective in all climate zones except for in the areas served by LADWP. On-Bill and TDV B/C ratios are slightly lower compared to the PV only package.
- ◆ **All-Electric + 3 kW PV:** Packages are on-bill cost effective in ten of sixteen climate zones. Climate zones 1,2,4,12, and 16 were not found to be cost-effective from an on-bill perspective. These zones are within PG&E’s service area. Packages are cost effective using TDV in all climate zones except CZ16.
- ◆ **All-Electric + 3 kW PV + 5 kWh Battery:** Packages are slightly more cost effective than the previous minimal PV only package. Packages are on-bill cost effective in most climate zones except for 1,2 and 16 from an on-bill perspective. These zones are within PG&E’s service area. Packages are cost effective using TDV in all climate zones except CZ16.
- ◆ **All-Electric + PV only:** All packages are cost effective and achieve savings using the On-Bill and TDV approaches.



- ◆ **All-Electric + PV + 50 kWh Battery:** All packages are cost effective and achieve savings using the On-Bill and TDV approaches. On-Bill and TDV B/C ratios are slightly lower compared to the PV only package.



Figure 54. Cost Effectiveness for Medium Office - Mixed Fuel + 3kW PV

| CZ | IOU territory | Elec Savings (kWh) | Gas Savings (therms) | GHG savings (tons) | Incremental Package Cost | Lifecycle Energy Cost Savings | Lifecycle \$-TDV Savings | B/C Ratio (On-bill) | B/C Ratio (TDV) | NPV (On-bill) | NPV (TDV) |
|----------------------------|---------------|--------------------|----------------------|--------------------|--------------------------|-------------------------------|--------------------------|---------------------|-----------------|---------------|-----------|
| Mixed Fuel + 3kW PV | | | | | | | | | | | |
| CZ01 | PG&E | 3,941 | 0 | 0.8 | \$5,566 | \$15,743 | \$8,448 | 2.8 | 1.5 | \$10,177 | \$2,882 |
| CZ02 | PG&E | 4,785 | 0 | 0.9 | \$5,566 | \$20,372 | \$10,500 | 3.7 | 1.9 | \$14,806 | \$4,934 |
| CZ03 | PG&E | 4,660 | 0 | 0.9 | \$5,566 | \$20,603 | \$9,975 | 3.7 | 1.8 | \$15,037 | \$4,409 |
| CZ04 | PG&E | 5,056 | 0 | 1.0 | \$5,566 | \$20,235 | \$11,073 | 3.6 | 2.0 | \$14,669 | \$5,507 |
| CZ04-2 | CPAU | 5,056 | 0 | 1.0 | \$5,566 | \$11,945 | \$11,073 | 2.1 | 2.0 | \$6,379 | \$5,507 |
| CZ05 | PG&E | 5,027 | 0 | 1.0 | \$5,566 | \$23,159 | \$10,834 | 4.2 | 1.9 | \$17,593 | \$5,268 |
| CZ06 | SCE | 4,853 | 0 | 0.9 | \$5,566 | \$10,968 | \$10,930 | 2.0 | 2.0 | \$5,402 | \$5,364 |
| CZ06-2 | LADWP | 4,853 | 0 | 0.9 | \$5,566 | \$6,575 | \$10,930 | 1.2 | 2.0 | \$1,009 | \$5,364 |
| CZ07 | SDG&E | 4,960 | 0 | 1.0 | \$5,566 | \$17,904 | \$11,025 | 3.2 | 2.0 | \$12,338 | \$5,459 |
| CZ08 | SCE | 4,826 | 0 | 0.9 | \$5,566 | \$10,768 | \$11,359 | 1.9 | 2.0 | \$5,202 | \$5,793 |
| CZ08-2 | LADWP | 4,826 | 0 | 0.9 | \$5,566 | \$6,503 | \$11,359 | 1.2 | 2.0 | \$937 | \$5,793 |
| CZ09 | SCE | 4,889 | 0 | 1.0 | \$5,566 | \$10,622 | \$11,216 | 1.9 | 2.0 | \$5,056 | \$5,650 |
| CZ09-2 | LADWP | 4,889 | 0 | 1.0 | \$5,566 | \$6,217 | \$11,216 | 1.1 | 2.0 | \$651 | \$5,650 |
| CZ10 | SDG&E | 4,826 | 0 | 0.9 | \$5,566 | \$21,280 | \$10,787 | 3.8 | 1.9 | \$15,714 | \$5,221 |
| CZ10-2 | SCE | 4,826 | 0 | 0.9 | \$5,566 | \$11,598 | \$10,787 | 2.1 | 1.9 | \$6,032 | \$5,221 |
| CZ11 | PG&E | 4,701 | 0 | 0.9 | \$5,566 | \$19,869 | \$10,644 | 3.6 | 1.9 | \$14,303 | \$5,078 |
| CZ12 | PG&E | 4,707 | 0 | 0.9 | \$5,566 | \$19,643 | \$10,644 | 3.5 | 1.9 | \$14,077 | \$5,078 |
| CZ12-2 | SMUD | 4,707 | 0 | 0.9 | \$5,566 | \$8,005 | \$10,644 | 1.4 | 1.9 | \$2,439 | \$5,078 |
| CZ13 | PG&E | 4,633 | 0 | 0.9 | \$5,566 | \$19,231 | \$10,262 | 3.5 | 1.8 | \$13,665 | \$4,696 |
| CZ14 | SDG&E | 5,377 | 0 | 1.0 | \$5,566 | \$18,789 | \$12,600 | 3.4 | 2.3 | \$13,223 | \$7,034 |
| CZ14-2 | SCE | 5,377 | 0 | 1.0 | \$5,566 | \$10,512 | \$12,600 | 1.9 | 2.3 | \$4,946 | \$7,034 |
| CZ15 | SCE | 5,099 | 0 | 1.0 | \$5,566 | \$10,109 | \$11,550 | 1.8 | 2.1 | \$4,543 | \$5,984 |
| CZ16 | PG&E | 5,096 | 0 | 1.0 | \$5,566 | \$21,836 | \$10,882 | 3.9 | 2.0 | \$16,270 | \$5,316 |
| CZ16-2 | LADWP | 5,096 | 0 | 1.0 | \$5,566 | \$6,501 | \$10,882 | 1.2 | 2.0 | \$935 | \$5,316 |



Figure 55. Cost Effectiveness for Medium Office - Mixed Fuel + 3kW PV + 5 kWh Battery

| CZ | IOU territory | Elec Savings (kWh) | Gas Savings (therms) | GHG savings (tons) | Incremental Package Cost | Lifecycle Energy Cost Savings | \$-TDV Savings | B/C Ratio (On-bill) | B/C Ratio (TDV) | NPV (On-bill) | NPV (TDV) |
|---|---------------|--------------------|----------------------|--------------------|--------------------------|-------------------------------|----------------|---------------------|-----------------|---------------|-----------|
| Mixed Fuel + 3kW PV + 5kWh Battery | | | | | | | | | | | |
| CZ01 | PG&E | 3,941 | 0 | 0.8 | \$9,520 | \$15,743 | \$8,448 | 1.7 | 0.9 | \$6,223 | (\$1,072) |
| CZ02 | PG&E | 4,785 | 0 | 0.9 | \$9,520 | \$20,372 | \$10,500 | 2.1 | 1.1 | \$10,852 | \$980 |
| CZ03 | PG&E | 4,660 | 0 | 0.9 | \$9,520 | \$20,603 | \$9,975 | 2.2 | 1.0 | \$11,083 | \$455 |
| CZ04 | PG&E | 5,056 | 0 | 1.0 | \$9,520 | \$20,235 | \$11,073 | 2.1 | 1.2 | \$10,714 | \$1,553 |
| CZ04-2 | CPAU | 5,056 | 0 | 1.0 | \$9,520 | \$11,945 | \$11,073 | 1.3 | 1.2 | \$2,425 | \$1,553 |
| CZ05 | PG&E | 5,027 | 0 | 1.0 | \$9,520 | \$23,159 | \$10,834 | 2.4 | 1.1 | \$13,639 | \$1,314 |
| CZ06 | SCE | 4,853 | 0 | 0.9 | \$9,520 | \$10,968 | \$10,930 | 1.2 | 1.1 | \$1,448 | \$1,410 |
| CZ06-2 | LADWP | 4,853 | 0 | 0.9 | \$9,520 | \$6,575 | \$10,930 | 0.7 | 1.1 | (\$2,945) | \$1,410 |
| CZ07 | SDG&E | 4,960 | 0 | 1.0 | \$9,520 | \$17,904 | \$11,025 | 1.9 | 1.2 | \$8,384 | \$1,505 |
| CZ08 | SCE | 4,826 | 0 | 0.9 | \$9,520 | \$10,768 | \$11,359 | 1.1 | 1.2 | \$1,248 | \$1,839 |
| CZ08-2 | LADWP | 4,826 | 0 | 0.9 | \$9,520 | \$6,503 | \$11,359 | 0.7 | 1.2 | (\$3,017) | \$1,839 |
| CZ09 | SCE | 4,889 | 0 | 1.0 | \$9,520 | \$10,622 | \$11,216 | 1.1 | 1.2 | \$1,102 | \$1,696 |
| CZ09-2 | LADWP | 4,889 | 0 | 1.0 | \$9,520 | \$6,217 | \$11,216 | 0.7 | 1.2 | (\$3,303) | \$1,696 |
| CZ10 | SDG&E | 4,826 | 0 | 0.9 | \$9,520 | \$21,280 | \$10,787 | 2.2 | 1.1 | \$11,760 | \$1,267 |
| CZ10-2 | SCE | 4,826 | 0 | 0.9 | \$9,520 | \$11,598 | \$10,787 | 1.2 | 1.1 | \$2,078 | \$1,267 |
| CZ11 | PG&E | 4,701 | 0 | 0.9 | \$9,520 | \$19,869 | \$10,644 | 2.1 | 1.1 | \$10,349 | \$1,123 |
| CZ12 | PG&E | 4,707 | 0 | 0.9 | \$9,520 | \$19,643 | \$10,644 | 2.1 | 1.1 | \$10,123 | \$1,123 |
| CZ12-2 | SMUD | 4,707 | 0 | 0.9 | \$9,520 | \$8,005 | \$10,644 | 0.8 | 1.1 | (\$1,515) | \$1,123 |
| CZ13 | PG&E | 4,633 | 0 | 0.9 | \$9,520 | \$19,231 | \$10,262 | 2.0 | 1.1 | \$9,711 | \$742 |
| CZ14 | SDG&E | 5,377 | 0 | 1.0 | \$9,520 | \$18,789 | \$12,600 | 2.0 | 1.3 | \$9,269 | \$3,080 |
| CZ14-2 | SCE | 5,377 | 0 | 1.0 | \$9,520 | \$10,512 | \$12,600 | 1.1 | 1.3 | \$992 | \$3,080 |
| CZ15 | SCE | 5,099 | 0 | 1.0 | \$9,520 | \$10,109 | \$11,550 | 1.1 | 1.2 | \$589 | \$2,030 |
| CZ16 | PG&E | 5,096 | 0 | 1.0 | \$9,520 | \$21,836 | \$10,882 | 2.3 | 1.1 | \$12,316 | \$1,362 |
| CZ16-2 | LADWP | 5,096 | 0 | 1.0 | \$9,520 | \$6,501 | \$10,882 | 0.7 | 1.1 | (\$3,019) | \$1,362 |



Figure 56. Cost Effectiveness for Medium Office – Mixed Fuel + 135kW PV

| CZ | IOU territory | Elec Savings (kWh) | Gas Savings (therms) | GHG savings (tons) | Incremental Package Cost | Lifecycle Energy Cost Savings | Lifecycle TDV Savings | B/C Ratio (On-bill) | B/C Ratio (TDV) | NPV (On-bill) | NPV (TDV) |
|-----------------------------|---------------|--------------------|----------------------|--------------------|--------------------------|-------------------------------|-----------------------|---------------------|-----------------|---------------|-----------|
| Mixed Fuel +135kW PV | | | | | | | | | | | |
| CZ01 | PG&E | 177,340 | 0 | 34.3 | \$302,856 | \$526,352 | \$380,399 | 1.7 | 1.3 | \$223,497 | \$77,544 |
| CZ02 | PG&E | 215,311 | 0 | 41.5 | \$302,856 | \$666,050 | \$471,705 | 2.2 | 1.6 | \$363,194 | \$168,849 |
| CZ03 | PG&E | 209,717 | 0 | 40.7 | \$302,856 | \$645,010 | \$449,797 | 2.1 | 1.5 | \$342,154 | \$146,942 |
| CZ04 | PG&E | 227,535 | 0 | 44.0 | \$302,856 | \$686,434 | \$497,431 | 2.3 | 1.6 | \$383,578 | \$194,575 |
| CZ04-2 | CPAU | 227,535 | 0 | 44.0 | \$302,856 | \$537,521 | \$497,431 | 1.8 | 1.6 | \$234,665 | \$194,575 |
| CZ05 | PG&E | 226,195 | 0 | 44.1 | \$302,856 | \$753,230 | \$486,596 | 2.5 | 1.6 | \$450,374 | \$183,741 |
| CZ06 | SCE | 218,387 | 0 | 42.3 | \$302,856 | \$401,645 | \$492,515 | 1.3 | 1.6 | \$98,789 | \$189,659 |
| CZ06-2 | LADWP | 218,387 | 0 | 42.3 | \$302,856 | \$233,909 | \$492,515 | 0.8 | 1.6 | (\$68,947) | \$189,659 |
| CZ07 | SDG&E | 223,185 | 0 | 43.3 | \$302,856 | \$623,078 | \$496,667 | 2.1 | 1.6 | \$320,223 | \$193,811 |
| CZ08 | SCE | 217,171 | 0 | 42.0 | \$302,856 | \$389,435 | \$510,270 | 1.3 | 1.7 | \$86,579 | \$207,414 |
| CZ08-2 | LADWP | 217,171 | 0 | 42.0 | \$302,856 | \$222,066 | \$510,270 | 0.7 | 1.7 | (\$80,790) | \$207,414 |
| CZ09 | SCE | 220,010 | 0 | 43.2 | \$302,856 | \$387,977 | \$505,783 | 1.3 | 1.7 | \$85,122 | \$202,928 |
| CZ09-2 | LADWP | 220,010 | 0 | 43.2 | \$302,856 | \$226,516 | \$505,783 | 0.7 | 1.7 | (\$76,340) | \$202,928 |
| CZ10 | SDG&E | 217,148 | 0 | 42.5 | \$302,856 | \$632,726 | \$485,451 | 2.1 | 1.6 | \$329,870 | \$182,595 |
| CZ10-2 | SCE | 217,148 | 0 | 42.5 | \$302,856 | \$394,884 | \$485,451 | 1.3 | 1.6 | \$92,028 | \$182,595 |
| CZ11 | PG&E | 211,556 | 0 | 40.9 | \$302,856 | \$671,691 | \$478,912 | 2.2 | 1.6 | \$368,835 | \$176,056 |
| CZ12 | PG&E | 211,824 | 0 | 40.9 | \$302,856 | \$653,242 | \$478,101 | 2.2 | 1.6 | \$350,386 | \$175,245 |
| CZ12-2 | SMUD | 211,824 | 0 | 40.9 | \$302,856 | \$345,255 | \$478,101 | 1.1 | 1.6 | \$42,399 | \$175,245 |
| CZ13 | PG&E | 208,465 | 0 | 40.5 | \$302,856 | \$651,952 | \$462,732 | 2.2 | 1.5 | \$349,096 | \$159,876 |
| CZ14 | SDG&E | 241,965 | 0 | 46.7 | \$302,856 | \$659,487 | \$566,351 | 2.2 | 1.9 | \$356,632 | \$263,496 |
| CZ14-2 | SCE | 241,965 | 0 | 46.7 | \$302,856 | \$401,712 | \$566,351 | 1.3 | 1.9 | \$98,856 | \$263,496 |
| CZ15 | SCE | 229,456 | 0 | 43.9 | \$302,856 | \$378,095 | \$520,102 | 1.2 | 1.7 | \$75,239 | \$217,246 |
| CZ16 | PG&E | 229,317 | 0 | 44.8 | \$302,856 | \$707,095 | \$489,508 | 2.3 | 1.6 | \$404,239 | \$186,652 |
| CZ16-2 | LADWP | 229,317 | 0 | 44.8 | \$302,856 | \$223,057 | \$489,508 | 0.7 | 1.6 | (\$79,799) | \$186,652 |



Figure 57. Cost Effectiveness for Medium Office – Mixed Fuel + 135kW PV + 50 kWh Battery

| CZ | IOU territory | Elec Savings (kWh) | Gas Savings (therms) | GHG savings (tons) | Incremental Package Cost | Lifecycle Energy Cost Savings | Lifecycle TDV Savings | B/C Ratio (On-bill) | B/C Ratio (TDV) | NPV (On-bill) | NPV (TDV) |
|---|---------------|--------------------|----------------------|--------------------|--------------------------|-------------------------------|-----------------------|---------------------|-----------------|---------------|-----------|
| Mixed Fuel + 135kW PV + 50 kWh Battery | | | | | | | | | | | |
| CZ01 | PG&E | 176,903 | 0 | 35.3 | \$330,756 | \$525,948 | \$381,450 | 1.6 | 1.2 | \$195,192 | \$50,694 |
| CZ02 | PG&E | 214,861 | 0 | 42.6 | \$330,756 | \$665,864 | \$472,898 | 2.0 | 1.4 | \$335,108 | \$142,142 |
| CZ03 | PG&E | 209,255 | 0 | 41.8 | \$330,756 | \$644,170 | \$451,611 | 1.9 | 1.4 | \$313,414 | \$120,855 |
| CZ04 | PG&E | 227,076 | 0 | 45.0 | \$330,756 | \$685,605 | \$502,108 | 2.1 | 1.5 | \$354,849 | \$171,352 |
| CZ04-2 | CPAU | 227,076 | 0 | 45.0 | \$330,756 | \$536,463 | \$502,108 | 1.6 | 1.5 | \$205,707 | \$171,352 |
| CZ05 | PG&E | 225,752 | 0 | 45.1 | \$330,756 | \$753,558 | \$487,742 | 2.3 | 1.5 | \$422,803 | \$156,986 |
| CZ06 | SCE | 217,939 | 0 | 43.4 | \$330,756 | \$401,356 | \$494,042 | 1.2 | 1.5 | \$70,601 | \$163,286 |
| CZ06-2 | LADWP | 217,939 | 0 | 43.4 | \$330,756 | \$233,673 | \$494,042 | 0.7 | 1.5 | (\$97,083) | \$163,286 |
| CZ07 | SDG&E | 222,746 | 0 | 44.4 | \$330,756 | \$628,383 | \$498,147 | 1.9 | 1.5 | \$297,627 | \$167,391 |
| CZ08 | SCE | 216,724 | 0 | 43.1 | \$330,756 | \$389,184 | \$511,511 | 1.2 | 1.5 | \$58,428 | \$180,755 |
| CZ08-2 | LADWP | 216,724 | 0 | 43.1 | \$330,756 | \$221,839 | \$511,511 | 0.7 | 1.5 | (\$108,917) | \$180,755 |
| CZ09 | SCE | 219,563 | 0 | 44.2 | \$330,756 | \$387,728 | \$506,929 | 1.2 | 1.5 | \$56,972 | \$176,173 |
| CZ09-2 | LADWP | 219,563 | 0 | 44.2 | \$330,756 | \$226,303 | \$506,929 | 0.7 | 1.5 | (\$104,453) | \$176,173 |
| CZ10 | SDG&E | 216,700 | 0 | 43.5 | \$330,756 | \$638,040 | \$486,644 | 1.9 | 1.5 | \$307,284 | \$155,888 |
| CZ10-2 | SCE | 216,700 | 0 | 43.5 | \$330,756 | \$394,633 | \$486,644 | 1.2 | 1.5 | \$63,877 | \$155,888 |
| CZ11 | PG&E | 211,129 | 0 | 41.9 | \$330,756 | \$670,932 | \$481,298 | 2.0 | 1.5 | \$340,177 | \$150,543 |
| CZ12 | PG&E | 211,386 | 0 | 41.9 | \$330,756 | \$652,465 | \$482,826 | 2.0 | 1.5 | \$321,709 | \$152,070 |
| CZ12-2 | SMUD | 211,386 | 0 | 41.9 | \$330,756 | \$344,668 | \$482,826 | 1.0 | 1.5 | \$13,913 | \$152,070 |
| CZ13 | PG&E | 208,045 | 0 | 41.5 | \$330,756 | \$651,191 | \$473,280 | 2.0 | 1.4 | \$320,435 | \$142,524 |
| CZ14 | SDG&E | 241,502 | 0 | 47.7 | \$330,756 | \$672,601 | \$569,454 | 2.0 | 1.7 | \$341,846 | \$238,698 |
| CZ14-2 | SCE | 241,502 | 0 | 47.7 | \$330,756 | \$401,450 | \$569,454 | 1.2 | 1.7 | \$70,694 | \$238,698 |
| CZ15 | SCE | 229,062 | 0 | 44.8 | \$330,756 | \$377,827 | \$521,963 | 1.1 | 1.6 | \$47,071 | \$191,208 |
| CZ16 | PG&E | 228,825 | 0 | 45.9 | \$330,756 | \$706,201 | \$496,190 | 2.1 | 1.5 | \$375,445 | \$165,434 |
| CZ16-2 | LADWP | 228,825 | 0 | 45.9 | \$330,756 | \$222,802 | \$496,190 | 0.7 | 1.5 | (\$107,953) | \$165,434 |



Figure 58. Cost Effectiveness for Medium Office– All-Electric + 3kW PV

| CZ | IOU territory | Elec Savings (kWh) | Gas Savings (therms) | GHG savings (tons) | Incremental Package Cost | Lifecycle Energy Cost Savings | Lifecycle TDV Savings | B/C Ratio (On-bill) | B/C Ratio (TDV) | NPV (On-bill) | NPV (TDV) |
|------------------------------|---------------|--------------------|----------------------|--------------------|--------------------------|-------------------------------|-----------------------|---------------------|-----------------|---------------|------------|
| All-Electric + 3kW PV | | | | | | | | | | | |
| CZ01 | PG&E | -49,716 | 4967 | 10.9 | (\$80,523) | (\$84,765) | (\$49,972) | 0.9 | 1.6 | (\$4,242) | \$30,551 |
| CZ02 | PG&E | -44,899 | 3868 | 6.0 | (\$66,965) | (\$83,115) | (\$30,928) | 0.8 | 2.2 | (\$16,150) | \$36,037 |
| CZ03 | PG&E | -31,226 | 3142 | 6.5 | (\$75,600) | (\$39,441) | (\$19,617) | 1.9 | 3.9 | \$36,159 | \$55,983 |
| CZ04 | PG&E | -43,772 | 3759 | 5.7 | (\$62,282) | (\$70,999) | (\$29,496) | 0.9 | 2.1 | (\$8,717) | \$32,786 |
| CZ04-2 | CPAU | -43,772 | 3759 | 5.7 | (\$62,282) | (\$8,050) | (\$29,496) | 7.7 | 2.1 | \$54,232 | \$32,786 |
| CZ05 | PG&E | -35,504 | 3240 | 5.5 | (\$77,773) | (\$42,559) | (\$29,162) | 1.8 | 2.7 | \$35,214 | \$48,611 |
| CZ06 | SCE | -21,321 | 2117 | 4.0 | (\$69,422) | \$35,862 | (\$9,641) | >1 | 7.2 | \$105,284 | \$59,781 |
| CZ06-2 | LADWP | -21,321 | 2117 | 4.0 | (\$69,422) | \$32,936 | (\$9,641) | >1 | 7.2 | \$102,358 | \$59,781 |
| CZ07 | SDG&E | -7,943 | 950 | 1.9 | (\$63,595) | \$64,781 | (\$382) | >1 | 166.6 | \$128,376 | \$63,214 |
| CZ08 | SCE | -10,854 | 1219 | 2.5 | (\$62,043) | \$28,651 | (\$1,289) | >1 | 48.1 | \$90,694 | \$60,755 |
| CZ08-2 | LADWP | -10,854 | 1219 | 2.5 | (\$62,043) | \$25,122 | (\$1,289) | >1 | 48.1 | \$87,165 | \$60,755 |
| CZ09 | SCE | -14,878 | 1605 | 3.3 | (\$56,372) | \$31,542 | (\$3,246) | >1 | 17.4 | \$87,913 | \$53,126 |
| CZ09-2 | LADWP | -14,878 | 1605 | 3.3 | (\$56,372) | \$28,145 | (\$3,246) | >1 | 17.4 | \$84,517 | \$53,126 |
| CZ10 | SDG&E | -22,588 | 2053 | 3.1 | (\$41,171) | \$59,752 | (\$12,553) | >1 | 3.3 | \$100,924 | \$28,619 |
| CZ10-2 | SCE | -22,588 | 2053 | 3.1 | (\$41,171) | \$32,039 | (\$12,553) | >1 | 3.3 | \$73,211 | \$28,619 |
| CZ11 | PG&E | -35,455 | 3062 | 4.5 | (\$57,257) | (\$53,776) | (\$22,194) | 1.1 | 2.6 | \$3,481 | \$35,063 |
| CZ12 | PG&E | -38,704 | 3327 | 5.0 | (\$61,613) | (\$66,808) | (\$24,819) | 0.9 | 2.5 | (\$5,195) | \$36,794 |
| CZ12-2 | SMUD | -38,704 | 3327 | 5.0 | (\$61,613) | \$2,897 | (\$24,819) | >1 | 2.5 | \$64,510 | \$36,794 |
| CZ13 | PG&E | -35,016 | 3063 | 4.7 | (\$55,996) | (\$52,159) | (\$22,146) | 1.1 | 2.5 | \$3,836 | \$33,849 |
| CZ14 | SDG&E | -38,945 | 3266 | 4.5 | (\$58,426) | \$24,867 | (\$25,821) | >1 | 2.3 | \$83,293 | \$32,605 |
| CZ14-2 | SCE | -38,945 | 3266 | 4.5 | (\$58,426) | \$15,338 | (\$25,821) | >1 | 2.3 | \$73,764 | \$32,605 |
| CZ15 | SCE | -14,818 | 1537 | 2.8 | (\$29,445) | \$22,852 | (\$3,914) | >1 | 7.5 | \$52,298 | \$25,532 |
| CZ16 | PG&E | -88,966 | 6185 | 6.6 | (\$57,366) | (\$193,368) | (\$139,989) | 0.3 | 0.4 | (\$136,002) | (\$82,623) |
| CZ16-2 | LADWP | -88,966 | 6185 | 6.6 | (\$57,366) | \$36,354 | (\$139,989) | >1 | 0.4 | \$93,720 | (\$82,623) |



Figure 59. Cost Effectiveness for Medium Office – All-Electric + 3kW PV + 5 kWh Battery

| CZ | IOU territory | Elec Savings (kWh) | Gas Savings (therms) | GHG savings (tons) | Incremental Package Cost | Lifecycle Energy Cost Savings | -\$TDV Savings | B/C Ratio (On-bill) | B/C Ratio (TDV) | NPV (On-bill) | NPV (TDV) |
|--|---------------|--------------------|----------------------|--------------------|--------------------------|-------------------------------|----------------|---------------------|-----------------|---------------|------------|
| All-Electric + 3kW PV + 5 kWh Battery | | | | | | | | | | | |
| CZ01 | PG&E | -49,716 | 4967 | 10.9 | (\$78,897) | (\$84,765) | (\$49,972) | 0.9 | 1.6 | (\$5,868) | \$28,925 |
| CZ02 | PG&E | -44,899 | 3868 | 6.0 | (\$78,897) | (\$83,115) | (\$30,928) | 0.9 | 2.6 | (\$4,218) | \$47,969 |
| CZ03 | PG&E | -31,226 | 3142 | 6.5 | (\$78,897) | (\$39,441) | (\$19,617) | 2.0 | 4.0 | \$39,456 | \$59,280 |
| CZ04 | PG&E | -43,772 | 3759 | 5.7 | (\$78,897) | (\$70,999) | (\$29,496) | 1.1 | 2.7 | \$7,898 | \$49,400 |
| CZ04-2 | CPAU | -43,772 | 3759 | 5.7 | (\$78,897) | (\$8,050) | (\$29,496) | 9.8 | 2.7 | \$70,847 | \$49,400 |
| CZ05 | PG&E | -35,504 | 3240 | 5.5 | (\$78,897) | (\$42,559) | (\$29,162) | 1.9 | 2.7 | \$36,338 | \$49,735 |
| CZ06 | SCE | -21,321 | 2117 | 4.0 | (\$78,897) | \$35,862 | (\$9,641) | >1 | 8.2 | \$114,759 | \$69,256 |
| CZ06-2 | LADWP | -21,321 | 2117 | 4.0 | (\$78,897) | \$32,936 | (\$9,641) | >1 | 8.2 | \$111,833 | \$69,256 |
| CZ07 | SDG&E | -7,943 | 950 | 1.9 | (\$78,897) | \$64,781 | (\$382) | >1 | 206.6 | \$143,678 | \$78,515 |
| CZ08 | SCE | -10,854 | 1219 | 2.5 | (\$78,897) | \$28,651 | (\$1,289) | >1 | 61.2 | \$107,548 | \$77,608 |
| CZ08-2 | LADWP | -10,854 | 1219 | 2.5 | (\$78,897) | \$25,122 | (\$1,289) | >1 | 61.2 | \$104,019 | \$77,608 |
| CZ09 | SCE | -14,878 | 1605 | 3.3 | (\$78,897) | \$31,542 | (\$3,246) | >1 | 24.3 | \$110,439 | \$75,651 |
| CZ09-2 | LADWP | -14,878 | 1605 | 3.3 | (\$78,897) | \$28,145 | (\$3,246) | >1 | 24.3 | \$107,042 | \$75,651 |
| CZ10 | SDG&E | -22,588 | 2053 | 3.1 | (\$78,897) | \$59,752 | (\$12,553) | >1 | 6.3 | \$138,649 | \$66,344 |
| CZ10-2 | SCE | -22,588 | 2053 | 3.1 | (\$78,897) | \$32,039 | (\$12,553) | >1 | 6.3 | \$110,936 | \$66,344 |
| CZ11 | PG&E | -35,455 | 3062 | 4.5 | (\$78,897) | (\$53,776) | (\$22,194) | 1.5 | 3.6 | \$25,121 | \$56,703 |
| CZ12 | PG&E | -38,704 | 3327 | 5.0 | (\$78,897) | (\$66,808) | (\$24,819) | 1.2 | 3.2 | \$12,089 | \$54,078 |
| CZ12-2 | SMUD | -38,704 | 3327 | 5.0 | (\$78,897) | \$2,897 | (\$24,819) | >1 | 3.2 | \$81,794 | \$54,078 |
| CZ13 | PG&E | -35,016 | 3063 | 4.7 | (\$78,897) | (\$52,159) | (\$22,146) | 1.5 | 3.6 | \$26,738 | \$56,751 |
| CZ14 | SDG&E | -38,945 | 3266 | 4.5 | (\$78,897) | \$24,867 | (\$25,821) | >1 | 3.1 | \$103,764 | \$53,076 |
| CZ14-2 | SCE | -38,945 | 3266 | 4.5 | (\$78,897) | \$15,338 | (\$25,821) | >1 | 3.1 | \$94,235 | \$53,076 |
| CZ15 | SCE | -14,818 | 1537 | 2.8 | (\$78,897) | \$22,852 | (\$3,914) | >1 | 20.2 | \$101,749 | \$74,983 |
| CZ16 | PG&E | -88,966 | 6185 | 6.6 | (\$78,897) | (\$193,368) | (\$139,989) | 0.4 | 0.6 | (\$114,472) | (\$61,092) |
| CZ16-2 | LADWP | -88,966 | 6185 | 6.6 | (\$78,897) | \$36,354 | (\$139,989) | >1 | 0.6 | \$115,250 | (\$61,092) |



Figure 60. Cost Effectiveness for Medium Office - All-Electric + 135kW PV

| CZ | IOU territory | Elec Savings (kWh) | Gas Savings (therms) | GHG savings (tons) | Incremental Package Cost | Lifecycle Energy Cost Savings | Lifecycle TDV Savings | B/C Ratio (On-bill) | B/C Ratio (TDV) | NPV (On-bill) | NPV (TDV) |
|--------------------------------|---------------|--------------------|----------------------|--------------------|--------------------------|-------------------------------|-----------------------|---------------------|-----------------|---------------|-----------|
| All-Electric + 135kW PV | | | | | | | | | | | |
| CZ01 | PG&E | 123,683 | 4967 | 44.5 | \$163,217 | \$405,731 | \$321,979 | 2.5 | 2.0 | \$242,514 | \$158,762 |
| CZ02 | PG&E | 165,627 | 3868 | 46.6 | \$176,775 | \$562,528 | \$430,276 | 3.2 | 2.4 | \$385,753 | \$253,501 |
| CZ03 | PG&E | 173,831 | 3142 | 46.3 | \$168,140 | \$575,864 | \$420,205 | 3.4 | 2.5 | \$407,725 | \$252,066 |
| CZ04 | PG&E | 178,706 | 3759 | 48.7 | \$181,458 | \$601,431 | \$456,861 | 3.3 | 2.5 | \$419,973 | \$275,403 |
| CZ04-2 | CPAU | 178,706 | 3759 | 48.7 | \$181,458 | \$517,526 | \$456,861 | 2.9 | 2.5 | \$336,069 | \$275,403 |
| CZ05 | PG&E | 185,664 | 3240 | 48.6 | \$165,967 | \$664,842 | \$446,600 | 4.0 | 2.7 | \$498,875 | \$280,633 |
| CZ06 | SCE | 192,214 | 2117 | 45.3 | \$174,317 | \$423,657 | \$471,944 | 2.4 | 2.7 | \$249,340 | \$297,626 |
| CZ06-2 | LADWP | 192,214 | 2117 | 45.3 | \$174,317 | \$259,270 | \$471,944 | 1.5 | 2.7 | \$84,953 | \$297,626 |
| CZ07 | SDG&E | 210,282 | 950 | 44.3 | \$180,145 | \$669,979 | \$485,260 | 3.7 | 2.7 | \$489,834 | \$305,115 |
| CZ08 | SCE | 201,491 | 1219 | 43.5 | \$181,696 | \$407,277 | \$497,622 | 2.2 | 2.7 | \$225,580 | \$315,925 |
| CZ08-2 | LADWP | 201,491 | 1219 | 43.5 | \$181,696 | \$240,657 | \$497,622 | 1.3 | 2.7 | \$58,960 | \$315,925 |
| CZ09 | SCE | 200,242 | 1605 | 45.6 | \$187,368 | \$408,922 | \$491,322 | 2.2 | 2.6 | \$221,554 | \$303,953 |
| CZ09-2 | LADWP | 200,242 | 1605 | 45.6 | \$187,368 | \$248,452 | \$491,322 | 1.3 | 2.6 | \$61,084 | \$303,953 |
| CZ10 | SDG&E | 189,734 | 2053 | 44.7 | \$202,568 | \$667,551 | \$462,111 | 3.3 | 2.3 | \$464,982 | \$259,543 |
| CZ10-2 | SCE | 189,734 | 2053 | 44.7 | \$202,568 | \$412,659 | \$462,111 | 2.0 | 2.3 | \$210,091 | \$259,543 |
| CZ11 | PG&E | 171,399 | 3062 | 44.5 | \$186,483 | \$597,807 | \$446,074 | 3.2 | 2.4 | \$411,324 | \$259,592 |
| CZ12 | PG&E | 168,413 | 3327 | 45.0 | \$182,127 | \$571,758 | \$442,638 | 3.1 | 2.4 | \$389,632 | \$260,511 |
| CZ12-2 | SMUD | 168,413 | 3327 | 45.0 | \$182,127 | \$343,602 | \$442,638 | 1.9 | 2.4 | \$161,475 | \$260,511 |
| CZ13 | PG&E | 168,817 | 3063 | 44.3 | \$187,744 | \$581,964 | \$430,324 | 3.1 | 2.3 | \$394,220 | \$242,580 |
| CZ14 | SDG&E | 197,643 | 3266 | 50.1 | \$185,314 | \$667,762 | \$527,930 | 3.6 | 2.8 | \$482,449 | \$342,616 |
| CZ14-2 | SCE | 197,643 | 3266 | 50.1 | \$185,314 | \$408,424 | \$527,930 | 2.2 | 2.8 | \$223,110 | \$342,616 |
| CZ15 | SCE | 209,539 | 1537 | 45.7 | \$214,294 | \$390,267 | \$504,638 | 1.8 | 2.4 | \$175,972 | \$290,343 |
| CZ16 | PG&E | 135,255 | 6185 | 50.4 | \$186,374 | \$470,199 | \$338,637 | 2.5 | 1.8 | \$283,825 | \$152,263 |
| CZ16-2 | LADWP | 135,255 | 6185 | 50.4 | \$186,374 | \$250,807 | \$338,637 | 1.3 | 1.8 | \$64,433 | \$152,263 |



Figure 61. Cost Effectiveness for Medium Office – All-Electric + 135kW PV + 50 kWh Battery

| CZ | IOU territory | Elec Savings (kWh) | Gas Savings (therms) | GHG savings (tons) | Incremental Package Cost | Lifecycle Energy Cost Savings | Lifecycle TDV Savings | B/C Ratio (On-bill) | B/C Ratio (TDV) | NPV (On-bill) | NPV (TDV) |
|---|---------------|--------------------|----------------------|--------------------|--------------------------|-------------------------------|-----------------------|---------------------|-----------------|---------------|-----------|
| All-Electric + 135kW PV + 50 kWh Battery | | | | | | | | | | | |
| CZ01 | PG&E | 123,280 | 4967 | 45.4 | \$191,117 | \$404,994 | \$323,077 | 2.1 | 1.7 | \$213,877 | \$131,960 |
| CZ02 | PG&E | 165,200 | 3868 | 47.7 | \$204,675 | \$561,747 | \$431,469 | 2.7 | 2.1 | \$357,072 | \$226,795 |
| CZ03 | PG&E | 173,384 | 3142 | 47.4 | \$196,040 | \$575,043 | \$422,019 | 2.9 | 2.2 | \$379,003 | \$225,979 |
| CZ04 | PG&E | 178,259 | 3759 | 49.8 | \$209,358 | \$600,621 | \$461,634 | 2.9 | 2.2 | \$391,263 | \$252,276 |
| CZ04-2 | CPAU | 178,259 | 3759 | 49.8 | \$209,358 | \$516,495 | \$461,634 | 2.5 | 2.2 | \$307,137 | \$252,276 |
| CZ05 | PG&E | 185,229 | 3240 | 49.7 | \$193,867 | \$664,046 | \$447,793 | 3.4 | 2.3 | \$470,179 | \$253,926 |
| CZ06 | SCE | 191,767 | 2117 | 46.5 | \$202,217 | \$423,369 | \$473,519 | 2.1 | 2.3 | \$221,152 | \$271,301 |
| CZ06-2 | LADWP | 191,767 | 2117 | 46.5 | \$202,217 | \$259,033 | \$473,519 | 1.3 | 2.3 | \$56,816 | \$271,301 |
| CZ07 | SDG&E | 209,848 | 950 | 45.4 | \$208,045 | \$675,307 | \$486,787 | 3.2 | 2.3 | \$467,262 | \$278,743 |
| CZ08 | SCE | 201,047 | 1219 | 44.7 | \$209,596 | \$407,027 | \$498,910 | 1.9 | 2.4 | \$197,430 | \$289,314 |
| CZ08-2 | LADWP | 201,047 | 1219 | 44.7 | \$209,596 | \$240,432 | \$498,910 | 1.1 | 2.4 | \$30,835 | \$289,314 |
| CZ09 | SCE | 199,802 | 1605 | 46.6 | \$215,268 | \$408,676 | \$492,515 | 1.9 | 2.3 | \$193,408 | \$277,246 |
| CZ09-2 | LADWP | 199,802 | 1605 | 46.6 | \$215,268 | \$248,242 | \$492,515 | 1.2 | 2.3 | \$32,974 | \$277,246 |
| CZ10 | SDG&E | 189,293 | 2053 | 45.7 | \$230,468 | \$672,867 | \$463,352 | 2.9 | 2.0 | \$442,399 | \$232,884 |
| CZ10-2 | SCE | 189,293 | 2053 | 45.7 | \$230,468 | \$412,412 | \$463,352 | 1.8 | 2.0 | \$181,944 | \$232,884 |
| CZ11 | PG&E | 170,987 | 3062 | 45.5 | \$214,383 | \$597,062 | \$448,509 | 2.8 | 2.1 | \$382,680 | \$234,126 |
| CZ12 | PG&E | 167,995 | 3327 | 46.0 | \$210,027 | \$571,002 | \$447,411 | 2.7 | 2.1 | \$360,975 | \$237,384 |
| CZ12-2 | SMUD | 167,995 | 3327 | 46.0 | \$210,027 | \$343,043 | \$447,411 | 1.6 | 2.1 | \$133,017 | \$237,384 |
| CZ13 | PG&E | 168,408 | 3063 | 45.3 | \$215,644 | \$581,225 | \$440,920 | 2.7 | 2.0 | \$365,580 | \$225,275 |
| CZ14 | SDG&E | 197,188 | 3266 | 51.2 | \$213,214 | \$680,893 | \$531,080 | 3.2 | 2.5 | \$467,679 | \$317,866 |
| CZ14-2 | SCE | 197,188 | 3266 | 51.2 | \$213,214 | \$408,166 | \$531,080 | 1.9 | 2.5 | \$194,952 | \$317,866 |
| CZ15 | SCE | 209,148 | 1537 | 46.6 | \$242,194 | \$390,000 | \$506,499 | 1.6 | 2.1 | \$147,806 | \$264,305 |
| CZ16 | PG&E | 134,809 | 6185 | 51.4 | \$214,274 | \$469,378 | \$341,978 | 2.2 | 1.6 | \$255,105 | \$127,704 |
| CZ16-2 | LADWP | 134,809 | 6185 | 51.4 | \$214,274 | \$250,580 | \$341,978 | 1.2 | 1.6 | \$36,306 | \$127,704 |



6.7.2 Cost Effectiveness Results – Medium Retail

Figure 62 through Figure 69 contain the cost-effectiveness findings for the Medium Retail packages. Notable findings for each package include:

- ◆ **Mixed-Fuel + 3 kW PV:** Packages are cost effective and achieve savings for all climate zones using the On-Bill and TDV approaches.
- ◆ **Mixed-Fuel + 3 kW PV + 5 kWh Battery:** The packages are less cost effective as compared to the 3 kW PV only package and not cost effective for LADWP and SMUD service area.
- ◆ **Mixed-Fuel + PV only:** Packages achieve positive energy cost savings and are cost effective using the On-Bill approach for all climate zones except for LADWP territory (CZs 6, 8, 9 and 16). Packages achieve positive savings and are cost effective using the TDV approach for all climate zones.
- ◆ **Mixed Fuel + PV + 5 kWh Battery:** Adding battery slightly reduces On-Bill B/C ratios but is still cost effective for all climate zones except for LADWP territory. Packages achieve savings and cost effective using the TDV approach for all climate zones.
- ◆ **All-Electric + 3 kW PV:** Packages are cost effective using the On-Bill and TDV approach for all climate zones except for CZ16 under PG&E service.
- ◆ **All-Electric + 3 kW PV + 5 kWh Battery:** Similar to minimal PV only package, adding battery is cost effective as well using the On-Bill and TDV approach for all climate zones except for CZ16 under PG&E service.
- ◆ **All-Electric + PV only:** Packages are cost effective and achieve savings in all climate zones for both the On-Bill and TDV approaches
- ◆ **All-Electric + PV + 50 kWh Battery:** Adding battery slightly reduces B/C ratios for both the On-Bill and TDV approaches. Packages are not cost effective for all climate zones except CZ6, CZ8 and CZ9 under LADWP service area.



Figure 62. Cost Effectiveness for Medium Retail – Mixed-Fuel + 3kW PV

| CZ | IOU territory | Elec Savings (kWh) | Gas Savings (therms) | GHG savings (tons) | Incremental Package Cost | Lifecycle Energy Cost Savings | Lifecycle TDV Savings | B/C Ratio (On-bill) | B/C Ratio (TDV) | NPV (On-bill) | NPV (TDV) |
|----------------------------|---------------|--------------------|----------------------|--------------------|--------------------------|-------------------------------|-----------------------|---------------------|-----------------|---------------|-----------|
| Mixed Fuel + 3kW PV | | | | | | | | | | | |
| CZ01 | PG&E | 3,941 | 0 | 0.76 | \$5,566 | \$12,616 | \$8,460 | 2.3 | 1.5 | \$7,050 | \$2,894 |
| CZ02 | PG&E | 4,685 | 0 | 0.91 | \$5,566 | \$17,635 | \$10,262 | 3.2 | 1.8 | \$12,069 | \$4,696 |
| CZ03 | PG&E | 4,733 | 0 | 0.92 | \$5,566 | \$15,146 | \$10,152 | 2.7 | 1.8 | \$9,580 | \$4,586 |
| CZ04 | PG&E | 4,834 | 0 | 0.94 | \$5,566 | \$18,519 | \$10,614 | 3.3 | 1.9 | \$12,953 | \$5,048 |
| CZ04-2 | CPAU | 4,834 | 0 | 0.94 | \$5,566 | \$11,507 | \$10,614 | 2.1 | 1.9 | \$5,941 | \$5,048 |
| CZ05 | PG&E | 4,910 | 0 | 0.95 | \$5,566 | \$15,641 | \$10,548 | 2.8 | 1.9 | \$10,075 | \$4,982 |
| CZ06 | SCE | 4,769 | 0 | 0.93 | \$5,566 | \$11,374 | \$10,724 | 2.0 | 1.9 | \$5,808 | \$5,158 |
| CZ06-2 | LA | 4,769 | 0 | 0.93 | \$5,566 | \$7,069 | \$10,724 | 1.3 | 1.9 | \$1,503 | \$5,158 |
| CZ07 | SDG&E | 4,960 | 0 | 0.96 | \$5,566 | \$22,452 | \$11,031 | 4.0 | 2.0 | \$16,886 | \$5,465 |
| CZ08 | SCE | 4,826 | 0 | 0.93 | \$5,566 | \$11,838 | \$11,339 | 2.1 | 2.0 | \$6,272 | \$5,773 |
| CZ08-2 | LA | 4,826 | 0 | 0.93 | \$5,566 | \$7,342 | \$11,339 | 1.3 | 2.0 | \$1,776 | \$5,773 |
| CZ09 | SCE | 4,889 | 0 | 0.96 | \$5,566 | \$11,187 | \$11,229 | 2.0 | 2.0 | \$5,621 | \$5,663 |
| CZ09-2 | LA | 4,889 | 0 | 0.96 | \$5,566 | \$6,728 | \$11,229 | 1.2 | 2.0 | \$1,162 | \$5,663 |
| CZ10 | SDG&E | 4,948 | 0 | 0.97 | \$5,566 | \$20,999 | \$10,987 | 3.8 | 2.0 | \$15,433 | \$5,421 |
| CZ10-2 | SCE | 4,948 | 0 | 0.97 | \$5,566 | \$11,384 | \$10,987 | 2.0 | 2.0 | \$5,818 | \$5,421 |
| CZ11 | PG&E | 4,718 | 0 | 0.91 | \$5,566 | \$15,381 | \$10,680 | 2.8 | 1.9 | \$9,815 | \$5,114 |
| CZ12 | PG&E | 4,707 | 0 | 0.91 | \$5,566 | \$16,442 | \$10,614 | 3.0 | 1.9 | \$10,876 | \$5,048 |
| CZ12-2 | SMUD | 4,707 | 0 | 0.91 | \$5,566 | \$8,247 | \$10,614 | 1.5 | 1.9 | \$2,681 | \$5,048 |
| CZ13 | PG&E | 4,750 | 0 | 0.92 | \$5,566 | \$16,638 | \$10,592 | 3.0 | 1.9 | \$11,072 | \$5,026 |
| CZ14 | SDG&E | 5,258 | 0 | 1.01 | \$5,566 | \$19,576 | \$12,218 | 3.5 | 2.2 | \$14,010 | \$6,652 |
| CZ14-2 | SCE | 5,258 | 0 | 1.01 | \$5,566 | \$10,227 | \$12,218 | 1.8 | 2.2 | \$4,661 | \$6,652 |
| CZ15 | SCE | 4,997 | 0 | 0.96 | \$5,566 | \$10,476 | \$11,339 | 1.9 | 2.0 | \$4,910 | \$5,773 |
| CZ16 | PG&E | 5,336 | 0 | 1.04 | \$5,566 | \$20,418 | \$11,361 | 3.7 | 2.0 | \$14,852 | \$5,795 |
| CZ16-2 | LA | 5,336 | 0 | 1.04 | \$5,566 | \$6,987 | \$11,361 | 1.3 | 2.0 | \$1,421 | \$5,795 |



Figure 63. Cost Effectiveness for Medium Retail – Mixed Fuel + 3kW PV + 5 kWh Battery

| CZ | IOU territory | Elec Savings (kWh) | Gas Savings (therms) | GHG savings (tons) | Incremental Package Cost | Lifecycle Energy Cost Savings | -\$TDV Savings | B/C Ratio (On-bill) | B/C Ratio (TDV) | NPV (On-bill) | NPV (TDV) |
|--|---------------|--------------------|----------------------|--------------------|--------------------------|-------------------------------|----------------|---------------------|-----------------|---------------|-----------|
| Mixed Fuel + 3kW PV + 5 kWh Battery | | | | | | | | | | | |
| CZ01 | PG&E | 3,941 | 0 | 0.76 | \$9,520 | \$12,616 | \$8,460 | 1.3 | 0.9 | \$3,096 | (\$1,060) |
| CZ02 | PG&E | 4,685 | 0 | 0.91 | \$9,520 | \$17,635 | \$10,262 | 1.9 | 1.1 | \$8,115 | \$742 |
| CZ03 | PG&E | 4,733 | 0 | 0.92 | \$9,520 | \$15,146 | \$10,152 | 1.6 | 1.1 | \$5,626 | \$632 |
| CZ04 | PG&E | 4,834 | 0 | 0.94 | \$9,520 | \$18,519 | \$10,614 | 1.9 | 1.1 | \$8,999 | \$1,094 |
| CZ04-2 | CPAU | 4,834 | 0 | 0.94 | \$9,520 | \$11,507 | \$10,614 | 1.2 | 1.1 | \$1,987 | \$1,094 |
| CZ05 | PG&E | 4,910 | 0 | 0.95 | \$9,520 | \$15,641 | \$10,548 | 1.6 | 1.1 | \$6,120 | \$1,028 |
| CZ05-2 | SCG | 4,910 | 0 | 0.95 | \$9,520 | \$15,641 | \$10,548 | 1.6 | 1.1 | \$6,120 | \$1,028 |
| CZ06 | SCE | 4,769 | 0 | 0.93 | \$9,520 | \$11,374 | \$10,724 | 1.2 | 1.1 | \$1,854 | \$1,204 |
| CZ06-2 | LA | 4,769 | 0 | 0.93 | \$9,520 | \$7,069 | \$10,724 | 0.7 | 1.1 | (\$2,452) | \$1,204 |
| CZ07 | SDG&E | 4,960 | 0 | 0.96 | \$9,520 | \$22,452 | \$11,031 | 2.4 | 1.2 | \$12,932 | \$1,511 |
| CZ08 | SCE | 4,826 | 0 | 0.93 | \$9,520 | \$11,838 | \$11,339 | 1.2 | 1.2 | \$2,317 | \$1,819 |
| CZ08-2 | LA | 4,826 | 0 | 0.93 | \$9,520 | \$7,342 | \$11,339 | 0.8 | 1.2 | (\$2,178) | \$1,819 |
| CZ09 | SCE | 4,889 | 0 | 0.96 | \$9,520 | \$11,187 | \$11,229 | 1.2 | 1.2 | \$1,667 | \$1,709 |
| CZ09-2 | LA | 4,889 | 0 | 0.96 | \$9,520 | \$6,728 | \$11,229 | 0.7 | 1.2 | (\$2,792) | \$1,709 |
| CZ10 | SDG&E | 4,948 | 0 | 0.97 | \$9,520 | \$20,999 | \$10,987 | 2.2 | 1.2 | \$11,479 | \$1,467 |
| CZ10-2 | SCE | 4,948 | 0 | 0.97 | \$9,520 | \$11,384 | \$10,987 | 1.2 | 1.2 | \$1,863 | \$1,467 |
| CZ11 | PG&E | 4,718 | 0 | 0.91 | \$9,520 | \$15,381 | \$10,680 | 1.6 | 1.1 | \$5,861 | \$1,160 |
| CZ12 | PG&E | 4,707 | 0 | 0.91 | \$9,520 | \$16,442 | \$10,614 | 1.7 | 1.1 | \$6,922 | \$1,094 |
| CZ12-2 | SMUD | 4,707 | 0 | 0.91 | \$9,520 | \$8,247 | \$10,614 | 0.9 | 1.1 | (\$1,273) | \$1,094 |
| CZ13 | PG&E | 4,750 | 0 | 0.92 | \$9,520 | \$16,638 | \$10,592 | 1.7 | 1.1 | \$7,117 | \$1,072 |
| CZ14 | SDG&E | 5,258 | 0 | 1.01 | \$9,520 | \$19,576 | \$12,218 | 2.1 | 1.3 | \$10,056 | \$2,698 |
| CZ14-2 | SCE | 5,258 | 0 | 1.01 | \$9,520 | \$10,227 | \$12,218 | 1.1 | 1.3 | \$707 | \$2,698 |
| CZ15 | SCE | 4,997 | 0 | 0.96 | \$9,520 | \$10,476 | \$11,339 | 1.1 | 1.2 | \$956 | \$1,819 |
| CZ16 | PG&E | 5,336 | 0 | 1.04 | \$9,520 | \$20,418 | \$11,361 | 2.1 | 1.2 | \$10,898 | \$1,841 |
| CZ16-2 | LA | 5,336 | 0 | 1.04 | \$9,520 | \$6,987 | \$11,361 | 0.7 | 1.2 | (\$2,533) | \$1,841 |



Figure 64. Cost Effectiveness for Medium Retail – Mixed-Fuel + 110kW PV

| CZ | IOU territory | Elec Savings (kWh) | Gas Savings (therms) | GHG savings (tons) | Incremental Package Cost | Lifecycle Energy Cost Savings | Lifecycle TDV Savings | B/C Ratio (On-bill) | B/C Ratio (TDV) | NPV (On-bill) | NPV (TDV) |
|------------------------------|---------------|--------------------|----------------------|--------------------|--------------------------|-------------------------------|-----------------------|---------------------|-----------------|---------------|-----------|
| Mixed Fuel + 110kW PV | | | | | | | | | | | |
| CZ01 | PG&E | 144,499 | 0 | 27.97 | \$201,904 | \$454,462 | \$309,935 | 2.3 | 1.5 | \$252,558 | \$108,031 |
| CZ02 | PG&E | 171,790 | 0 | 33.31 | \$201,904 | \$477,584 | \$376,300 | 2.4 | 1.9 | \$275,681 | \$174,396 |
| CZ03 | PG&E | 173,534 | 0 | 33.55 | \$201,904 | \$538,530 | \$372,146 | 2.7 | 1.8 | \$336,626 | \$170,243 |
| CZ04 | PG&E | 177,229 | 0 | 34.42 | \$201,904 | \$489,934 | \$389,067 | 2.4 | 1.9 | \$288,030 | \$187,163 |
| CZ04-2 | CPAU | 177,229 | 0 | 34.42 | \$201,904 | \$418,173 | \$389,067 | 2.1 | 1.9 | \$216,269 | \$187,163 |
| CZ05 | PG&E | 180,044 | 0 | 34.84 | \$201,904 | \$556,787 | \$386,958 | 2.8 | 1.9 | \$354,883 | \$185,054 |
| CZ06 | SCE | 174,855 | 0 | 33.92 | \$201,904 | \$288,188 | \$393,198 | 1.4 | 1.9 | \$86,284 | \$191,295 |
| CZ06-2 | LA | 174,855 | 0 | 33.92 | \$201,904 | \$165,538 | \$393,198 | 0.8 | 1.9 | (\$36,366) | \$191,295 |
| CZ07 | SDG&E | 181,854 | 0 | 35.32 | \$201,904 | \$373,974 | \$404,713 | 1.9 | 2.0 | \$172,070 | \$202,809 |
| CZ08 | SCE | 176,954 | 0 | 34.23 | \$201,904 | \$284,481 | \$415,789 | 1.4 | 2.1 | \$82,577 | \$213,885 |
| CZ08-2 | LA | 176,954 | 0 | 34.23 | \$201,904 | \$161,366 | \$415,789 | 0.8 | 2.1 | (\$40,538) | \$213,885 |
| CZ09 | SCE | 179,267 | 0 | 35.18 | \$201,904 | \$289,050 | \$412,097 | 1.4 | 2.0 | \$87,146 | \$210,193 |
| CZ09-2 | LA | 179,267 | 0 | 35.18 | \$201,904 | \$168,822 | \$412,097 | 0.8 | 2.0 | (\$33,082) | \$210,193 |
| CZ10 | SDG&E | 181,443 | 0 | 35.41 | \$201,904 | \$410,310 | \$402,999 | 2.0 | 2.0 | \$208,406 | \$201,095 |
| CZ10-2 | SCE | 181,443 | 0 | 35.41 | \$201,904 | \$291,236 | \$402,999 | 1.4 | 2.0 | \$89,332 | \$201,095 |
| CZ11 | PG&E | 172,983 | 0 | 33.46 | \$201,904 | \$464,776 | \$391,550 | 2.3 | 1.9 | \$262,872 | \$189,646 |
| CZ12 | PG&E | 172,597 | 0 | 33.33 | \$201,904 | \$467,870 | \$389,573 | 2.3 | 1.9 | \$265,966 | \$187,669 |
| CZ12-2 | SMUD | 172,597 | 0 | 33.33 | \$201,904 | \$267,086 | \$389,573 | 1.3 | 1.9 | \$65,182 | \$187,669 |
| CZ13 | PG&E | 174,151 | 0 | 33.81 | \$201,904 | \$478,857 | \$387,968 | 2.4 | 1.9 | \$276,953 | \$186,065 |
| CZ14 | SDG&E | 192,789 | 0 | 36.97 | \$201,904 | \$396,181 | \$448,268 | 2.0 | 2.2 | \$194,277 | \$246,364 |
| CZ14-2 | SCE | 192,789 | 0 | 36.97 | \$201,904 | \$288,782 | \$448,268 | 1.4 | 2.2 | \$86,878 | \$246,364 |
| CZ15 | SCE | 183,214 | 0 | 35.12 | \$201,904 | \$277,867 | \$415,789 | 1.4 | 2.1 | \$75,963 | \$213,885 |
| CZ16 | PG&E | 195,665 | 0 | 37.97 | \$201,904 | \$522,352 | \$416,558 | 2.6 | 2.1 | \$320,448 | \$214,654 |
| CZ16-2 | LA | 195,665 | 0 | 37.97 | \$201,904 | \$171,802 | \$416,558 | 0.9 | 2.1 | (\$30,101) | \$214,654 |



Figure 65. Cost Effectiveness for Medium Retail – Mixed-Fuel + 110 kW PV + 50 kWh Battery

| CZ | IOU territory | Elec Savings (kWh) | Gas Savings (therms) | GHG savings (tons) | Incremental Package Cost | Lifecycle Energy Cost Savings | Lifecycle TDV Savings | B/C Ratio (On-bill) | B/C Ratio (TDV) | NPV (On-bill) | NPV (TDV) |
|---|---------------|--------------------|----------------------|--------------------|--------------------------|-------------------------------|-----------------------|---------------------|-----------------|---------------|-----------|
| Mixed Fuel + 110kW PV + 50 kWh Battery | | | | | | | | | | | |
| CZ01 | PG&E | 143,423 | 0 | 29.48 | \$229,804 | \$452,119 | \$324,373 | 2.0 | 1.4 | \$222,315 | \$94,569 |
| CZ02 | PG&E | 170,542 | 0 | 35.14 | \$229,804 | \$486,704 | \$398,363 | 2.1 | 1.7 | \$256,900 | \$168,559 |
| CZ03 | PG&E | 172,266 | 0 | 35.66 | \$229,804 | \$535,974 | \$395,374 | 2.3 | 1.7 | \$306,170 | \$165,570 |
| CZ04 | PG&E | 175,940 | 0 | 36.32 | \$229,804 | \$525,788 | \$422,579 | 2.3 | 1.8 | \$295,984 | \$192,775 |
| CZ04-2 | CPAU | 175,940 | 0 | 36.32 | \$229,804 | \$416,019 | \$422,579 | 1.8 | 1.8 | \$186,216 | \$192,775 |
| CZ05 | PG&E | 178,728 | 0 | 36.91 | \$229,804 | \$554,968 | \$409,086 | 2.4 | 1.8 | \$325,164 | \$179,283 |
| CZ06 | SCE | 173,567 | 0 | 35.99 | \$229,804 | \$290,599 | \$412,690 | 1.3 | 1.8 | \$60,795 | \$182,886 |
| CZ06-2 | LA | 173,567 | 0 | 35.99 | \$229,804 | \$169,786 | \$412,690 | 0.7 | 1.8 | (\$60,018) | \$182,886 |
| CZ07 | SDG&E | 180,508 | 0 | 37.61 | \$229,804 | \$425,793 | \$427,040 | 1.9 | 1.9 | \$195,989 | \$197,236 |
| CZ08 | SCE | 175,616 | 0 | 36.29 | \$229,804 | \$296,318 | \$434,687 | 1.3 | 1.9 | \$66,514 | \$204,883 |
| CZ08-2 | LA | 175,616 | 0 | 36.29 | \$229,804 | \$170,489 | \$434,687 | 0.7 | 1.9 | (\$59,315) | \$204,883 |
| CZ09 | SCE | 177,966 | 0 | 36.74 | \$229,804 | \$300,540 | \$421,195 | 1.3 | 1.8 | \$70,736 | \$191,391 |
| CZ09-2 | LA | 177,966 | 0 | 36.74 | \$229,804 | \$178,852 | \$421,195 | 0.8 | 1.8 | (\$50,952) | \$191,391 |
| CZ10 | SDG&E | 180,248 | 0 | 36.91 | \$229,804 | \$459,486 | \$410,537 | 2.0 | 1.8 | \$229,683 | \$180,733 |
| CZ10-2 | SCE | 180,248 | 0 | 36.91 | \$229,804 | \$301,219 | \$410,537 | 1.3 | 1.8 | \$71,415 | \$180,733 |
| CZ11 | PG&E | 171,779 | 0 | 34.85 | \$229,804 | \$490,245 | \$417,679 | 2.1 | 1.8 | \$260,442 | \$187,875 |
| CZ12 | PG&E | 171,392 | 0 | 34.77 | \$229,804 | \$497,363 | \$417,371 | 2.2 | 1.8 | \$267,559 | \$187,567 |
| CZ12-2 | SMUD | 171,392 | 0 | 34.77 | \$229,804 | \$273,783 | \$417,371 | 1.2 | 1.8 | \$43,979 | \$187,567 |
| CZ13 | PG&E | 173,052 | 0 | 34.97 | \$229,804 | \$488,196 | \$397,791 | 2.1 | 1.7 | \$258,392 | \$167,987 |
| CZ14 | SDG&E | 191,703 | 0 | 38.31 | \$229,804 | \$420,241 | \$452,641 | 1.8 | 2.0 | \$190,437 | \$222,837 |
| CZ14-2 | SCE | 191,703 | 0 | 38.31 | \$229,804 | \$294,010 | \$452,641 | 1.3 | 2.0 | \$64,206 | \$222,837 |
| CZ15 | SCE | 182,299 | 0 | 36.01 | \$229,804 | \$279,036 | \$416,382 | 1.2 | 1.8 | \$49,232 | \$186,578 |
| CZ16 | PG&E | 194,293 | 0 | 40.00 | \$229,804 | \$535,137 | \$432,951 | 2.3 | 1.9 | \$305,333 | \$203,147 |
| CZ16-2 | LA | 194,293 | 0 | 40.00 | \$229,804 | \$175,573 | \$432,951 | 0.8 | 1.9 | (\$54,231) | \$203,147 |



Figure 66. Cost Effectiveness for Medium Retail – All-Electric + 3kW PV

| CZ | IOU territory | Elec Savings (kWh) | Gas Savings (therms) | GHG savings (tons) | Incremental Package Cost | Lifecycle Energy Cost Savings | Lifecycle TDV Savings | B/C Ratio (On-bill) | B/C Ratio (TDV) | NPV (On-bill) | NPV (TDV) |
|------------------------------|---------------|--------------------|----------------------|--------------------|--------------------------|-------------------------------|-----------------------|---------------------|-----------------|---------------|------------|
| All-Electric + 3kW PV | | | | | | | | | | | |
| CZ01 | PG&E | -25,214 | 3893 | 14.61 | (\$16,318) | \$4,288 | (\$5,450) | >1 | 3.0 | \$20,606 | \$10,868 |
| CZ02 | PG&E | -17,101 | 2448 | 8.40 | (\$20,734) | \$859 | \$5,779 | >1 | >1 | \$21,593 | \$26,513 |
| CZ03 | PG&E | -9,851 | 1868 | 7.18 | (\$17,381) | \$15,418 | \$8,702 | >1 | >1 | \$32,799 | \$26,083 |
| CZ04 | PG&E | -9,353 | 1706 | 6.24 | (\$16,166) | \$9,110 | \$10,394 | >1 | >1 | \$25,276 | \$26,560 |
| CZ04-2 | CPAU | -9,353 | 1706 | 6.24 | (\$16,166) | \$24,000 | \$10,394 | >1 | >1 | \$40,166 | \$26,560 |
| CZ05 | PG&E | -9,423 | 1746 | 6.42 | (\$18,776) | \$14,076 | \$6,351 | >1 | >1 | \$32,852 | \$25,127 |
| CZ06 | SCE | -2,759 | 1002 | 4.24 | (\$15,032) | \$29,710 | \$12,592 | >1 | >1 | \$44,741 | \$27,623 |
| CZ06-2 | LA | -2,759 | 1002 | 4.24 | (\$15,032) | \$26,292 | \$12,592 | >1 | >1 | \$41,324 | \$27,623 |
| CZ07 | SDG&E | 1,148 | 522 | 2.72 | (\$17,032) | \$76,810 | \$12,350 | >1 | >1 | \$93,842 | \$29,382 |
| CZ08 | SCE | -979 | 793 | 3.64 | (\$20,192) | \$28,576 | \$13,185 | >1 | >1 | \$48,768 | \$33,377 |
| CZ08-2 | LA | -979 | 793 | 3.64 | (\$20,192) | \$24,475 | \$13,185 | >1 | >1 | \$44,667 | \$33,377 |
| CZ09 | SCE | -2,352 | 970 | 4.28 | (\$25,383) | \$29,776 | \$13,207 | >1 | >1 | \$55,159 | \$38,590 |
| CZ09-2 | LA | -2,352 | 970 | 4.28 | (\$25,383) | \$25,823 | \$13,207 | >1 | >1 | \$51,207 | \$38,590 |
| CZ10 | SDG&E | -5,388 | 1262 | 4.95 | (\$20,541) | \$75,458 | \$11,493 | >1 | >1 | \$95,999 | \$32,034 |
| CZ10-2 | SCE | -5,388 | 1262 | 4.95 | (\$20,541) | \$32,394 | \$11,493 | >1 | >1 | \$52,936 | \$32,034 |
| CZ11 | PG&E | -14,533 | 2415 | 8.86 | (\$25,471) | \$7,618 | \$13,295 | >1 | >1 | \$33,090 | \$38,766 |
| CZ12 | PG&E | -14,764 | 2309 | 8.19 | (\$25,774) | \$2,210 | \$10,152 | >1 | >1 | \$27,984 | \$35,926 |
| CZ12-2 | SMUD | -14,764 | 2309 | 8.19 | (\$25,774) | \$21,215 | \$10,152 | >1 | >1 | \$46,988 | \$35,926 |
| CZ13 | PG&E | -12,069 | 1983 | 7.08 | (\$21,428) | \$5,647 | \$8,570 | >1 | >1 | \$27,075 | \$29,998 |
| CZ14 | SDG&E | -7,950 | 1672 | 6.45 | (\$19,926) | \$60,412 | \$16,679 | >1 | >1 | \$80,338 | \$36,605 |
| CZ14-2 | SCE | -7,950 | 1672 | 6.45 | (\$19,926) | \$28,631 | \$16,679 | >1 | >1 | \$48,557 | \$36,605 |
| CZ15 | SCE | 2,534 | 518 | 3.10 | (\$22,813) | \$27,271 | \$17,162 | >1 | >1 | \$50,084 | \$39,976 |
| CZ16 | PG&E | -36,081 | 4304 | 14.26 | (\$19,041) | (\$30,111) | (\$41,181) | 0.6 | 0.5 | (\$11,070) | (\$22,140) |
| CZ16-2 | LA | -36,081 | 4304 | 14.26 | (\$19,041) | \$45,706 | (\$41,181) | >1 | 0.5 | \$64,747 | (\$22,140) |



Figure 67. Cost Effectiveness for Medium Retail - All-Electric + 3kW PV + 5 kWh Battery

| CZ | IOU territory | Elec Savings (kWh) | Gas Savings (therms) | GHG savings (tons) | Incremental Package Cost | Lifecycle Energy Cost Savings | -\$TDV Savings | B/C Ratio (On-bill) | B/C Ratio (TDV) | NPV (On-bill) | NPV (TDV) |
|--|---------------|--------------------|----------------------|--------------------|--------------------------|-------------------------------|----------------|---------------------|-----------------|---------------|------------|
| All-Electric + 3kW PV + 5 kWh Battery | | | | | | | | | | | |
| CZ01 | PG&E | -25,214 | 3893 | 14.61 | (\$14,692) | \$4,288 | (\$5,450) | >1 | 2.7 | \$18,980 | \$9,242 |
| CZ02 | PG&E | -17,101 | 2448 | 8.40 | (\$14,692) | \$859 | \$5,779 | >1 | >1 | \$15,551 | \$20,472 |
| CZ03 | PG&E | -9,851 | 1868 | 7.18 | (\$14,692) | \$15,418 | \$8,702 | >1 | >1 | \$30,110 | \$23,394 |
| CZ04 | PG&E | -9,353 | 1706 | 6.24 | (\$14,692) | \$9,110 | \$10,394 | >1 | >1 | \$23,802 | \$25,086 |
| CZ04-2 | CPAU | -9,353 | 1706 | 6.24 | (\$14,692) | \$24,000 | \$10,394 | >1 | >1 | \$38,693 | \$25,086 |
| CZ05 | PG&E | -9,423 | 1746 | 6.42 | (\$14,692) | \$14,076 | \$6,351 | >1 | >1 | \$28,768 | \$21,043 |
| CZ06 | SCE | -2,759 | 1002 | 4.24 | (\$14,692) | \$29,710 | \$12,592 | >1 | >1 | \$44,402 | \$27,284 |
| CZ06-2 | LA | -2,759 | 1002 | 4.24 | (\$14,692) | \$26,292 | \$12,592 | >1 | >1 | \$40,984 | \$27,284 |
| CZ07 | SDG&E | 1,148 | 522 | 2.72 | (\$14,692) | \$76,810 | \$12,350 | >1 | >1 | \$91,502 | \$27,042 |
| CZ08 | SCE | -979 | 793 | 3.64 | (\$14,692) | \$28,576 | \$13,185 | >1 | >1 | \$43,268 | \$27,877 |
| CZ08-2 | LA | -979 | 793 | 3.64 | (\$14,692) | \$24,475 | \$13,185 | >1 | >1 | \$39,167 | \$27,877 |
| CZ09 | SCE | -2,352 | 970 | 4.28 | (\$14,692) | \$29,776 | \$13,207 | >1 | >1 | \$44,468 | \$27,899 |
| CZ09-2 | LA | -2,352 | 970 | 4.28 | (\$14,692) | \$25,823 | \$13,207 | >1 | >1 | \$40,516 | \$27,899 |
| CZ10 | SDG&E | -5,388 | 1262 | 4.95 | (\$14,692) | \$75,458 | \$11,493 | >1 | >1 | \$90,150 | \$26,185 |
| CZ10-2 | SCE | -5,388 | 1262 | 4.95 | (\$14,692) | \$32,394 | \$11,493 | >1 | >1 | \$47,086 | \$26,185 |
| CZ11 | PG&E | -14,533 | 2415 | 8.86 | (\$14,692) | \$7,618 | \$13,295 | >1 | >1 | \$22,310 | \$27,987 |
| CZ12 | PG&E | -14,764 | 2309 | 8.19 | (\$14,692) | \$2,210 | \$10,152 | >1 | >1 | \$16,902 | \$24,845 |
| CZ12-2 | SMUD | -14,764 | 2309 | 8.19 | (\$14,692) | \$21,215 | \$10,152 | >1 | >1 | \$35,907 | \$24,845 |
| CZ13 | PG&E | -12,069 | 1983 | 7.08 | (\$14,692) | \$5,647 | \$8,570 | >1 | >1 | \$20,339 | \$23,262 |
| CZ14 | SDG&E | -7,950 | 1672 | 6.45 | (\$14,692) | \$60,412 | \$16,679 | >1 | >1 | \$75,104 | \$31,371 |
| CZ14-2 | SCE | -7,950 | 1672 | 6.45 | (\$14,692) | \$28,631 | \$16,679 | >1 | >1 | \$43,323 | \$31,371 |
| CZ15 | SCE | 2,534 | 518 | 3.10 | (\$14,692) | \$27,271 | \$17,162 | >1 | >1 | \$41,963 | \$31,855 |
| CZ16 | PG&E | -36,081 | 4304 | 14.26 | (\$14,692) | (\$30,111) | (\$41,181) | 0.5 | 0.4 | (\$15,419) | (\$26,489) |
| CZ16-2 | LA | -36,081 | 4304 | 14.26 | (\$14,692) | \$45,706 | (\$41,181) | >1 | 0.4 | \$60,398 | (\$26,489) |



Figure 68. Cost Effectiveness for Medium Retail – All-Electric + 110kW PV

| CZ | IOU territory | Elec Savings (kWh) | Gas Savings (therms) | GHG savings (tons) | Incremental Package Cost | Lifecycle Energy Cost Savings | Lifecycle TDV Savings | B/C Ratio (On-bill) | B/C Ratio (TDV) | NPV (On-bill) | NPV (TDV) |
|--------------------------------|---------------|--------------------|----------------------|--------------------|--------------------------|-------------------------------|-----------------------|---------------------|-----------------|---------------|-----------|
| All-Electric + 110kW PV | | | | | | | | | | | |
| CZ01 | PG&E | 115,344 | 3893 | 41.82 | \$143,932 | \$454,277 | \$296,025 | 3.2 | 2.1 | \$310,345 | \$152,093 |
| CZ02 | PG&E | 150,004 | 2448 | 40.80 | \$139,516 | \$470,236 | \$371,817 | 3.4 | 2.7 | \$330,720 | \$232,301 |
| CZ03 | PG&E | 158,951 | 1868 | 39.82 | \$142,869 | \$544,095 | \$370,696 | 3.8 | 2.6 | \$401,226 | \$227,827 |
| CZ04 | PG&E | 163,043 | 1706 | 39.73 | \$144,084 | \$488,619 | \$388,847 | 3.4 | 2.7 | \$344,534 | \$244,763 |
| CZ04-2 | CPAU | 163,043 | 1706 | 39.73 | \$144,084 | \$432,905 | \$388,847 | 3.0 | 2.7 | \$288,821 | \$244,763 |
| CZ05 | PG&E | 165,711 | 1746 | 40.30 | \$141,473 | \$565,525 | \$382,760 | 4.0 | 2.7 | \$424,051 | \$241,287 |
| CZ06 | SCE | 167,328 | 1002 | 37.24 | \$145,218 | \$306,670 | \$395,066 | 2.1 | 2.7 | \$161,452 | \$249,848 |
| CZ06-2 | LA | 167,328 | 1002 | 37.24 | \$145,218 | \$184,797 | \$395,066 | 1.3 | 2.7 | \$39,579 | \$249,848 |
| CZ07 | SDG&E | 178,042 | 522 | 37.07 | \$143,218 | \$428,332 | \$406,032 | 3.0 | 2.8 | \$285,114 | \$262,814 |
| CZ08 | SCE | 171,149 | 793 | 36.94 | \$140,058 | \$301,219 | \$417,635 | 2.2 | 3.0 | \$161,161 | \$277,577 |
| CZ08-2 | LA | 171,149 | 793 | 36.94 | \$140,058 | \$178,419 | \$417,635 | 1.3 | 3.0 | \$38,361 | \$277,577 |
| CZ09 | SCE | 172,027 | 970 | 38.50 | \$134,867 | \$307,640 | \$414,075 | 2.3 | 3.1 | \$172,773 | \$279,208 |
| CZ09-2 | LA | 172,027 | 970 | 38.50 | \$134,867 | \$187,813 | \$414,075 | 1.4 | 3.1 | \$52,946 | \$279,208 |
| CZ10 | SDG&E | 171,107 | 1262 | 39.40 | \$139,708 | \$463,692 | \$403,505 | 3.3 | 2.9 | \$323,984 | \$263,796 |
| CZ10-2 | SCE | 171,107 | 1262 | 39.40 | \$139,708 | \$311,464 | \$403,505 | 2.2 | 2.9 | \$171,755 | \$263,796 |
| CZ11 | PG&E | 153,732 | 2415 | 41.41 | \$134,778 | \$467,356 | \$394,165 | 3.5 | 2.9 | \$332,578 | \$259,387 |
| CZ12 | PG&E | 153,126 | 2309 | 40.61 | \$134,476 | \$467,106 | \$389,111 | 3.5 | 2.9 | \$332,630 | \$254,635 |
| CZ12-2 | SMUD | 153,126 | 2309 | 40.61 | \$134,476 | \$283,343 | \$389,111 | 2.1 | 2.9 | \$148,867 | \$254,635 |
| CZ13 | PG&E | 157,332 | 1983 | 39.97 | \$138,822 | \$477,831 | \$385,947 | 3.4 | 2.8 | \$339,008 | \$247,124 |
| CZ14 | SDG&E | 179,582 | 1672 | 42.42 | \$140,324 | \$437,575 | \$452,729 | 3.1 | 3.2 | \$297,251 | \$312,405 |
| CZ14-2 | SCE | 179,582 | 1672 | 42.42 | \$140,324 | \$309,064 | \$452,729 | 2.2 | 3.2 | \$168,740 | \$312,405 |
| CZ15 | SCE | 180,751 | 518 | 37.26 | \$137,436 | \$294,877 | \$421,612 | 2.1 | 3.1 | \$157,440 | \$284,176 |
| CZ16 | PG&E | 154,248 | 4304 | 51.20 | \$141,209 | \$473,892 | \$364,016 | 3.4 | 2.6 | \$332,682 | \$222,807 |
| CZ16-2 | LA | 154,248 | 4304 | 51.20 | \$141,209 | \$211,677 | \$364,016 | 1.5 | 2.6 | \$70,467 | \$222,807 |



Figure 69. Cost Effectiveness for Medium Retail – All-Electric + 110kW PV + 50 kWh Battery

| CZ | IOU territory | Elec Savings (kWh) | Gas Savings (therms) | GHG savings (tons) | Incremental Package Cost | Lifecycle Energy Cost Savings | Lifecycle TDV Savings | B/C Ratio (On-bill) | B/C Ratio (TDV) | NPV (On-bill) | NPV (TDV) |
|--|---------------|--------------------|----------------------|--------------------|--------------------------|-------------------------------|-----------------------|---------------------|-----------------|---------------|-----------|
| All-Electric + 90kW PV + 50 kWh Battery | | | | | | | | | | | |
| CZ01 | PG&E | 114,356 | 3893 | 43.52 | \$171,832 | \$451,043 | \$310,265 | 2.6 | 1.8 | \$279,211 | \$138,433 |
| CZ02 | PG&E | 148,793 | 2448 | 42.89 | \$167,416 | \$475,081 | \$394,099 | 2.8 | 2.4 | \$307,664 | \$226,683 |
| CZ03 | PG&E | 157,707 | 1868 | 42.12 | \$170,769 | \$541,418 | \$394,034 | 3.2 | 2.3 | \$370,649 | \$223,265 |
| CZ04 | PG&E | 161,769 | 1706 | 41.82 | \$171,984 | \$523,603 | \$422,535 | 3.0 | 2.5 | \$351,618 | \$250,551 |
| CZ04-2 | CPAU | 161,769 | 1706 | 41.82 | \$171,984 | \$430,567 | \$422,535 | 2.5 | 2.5 | \$258,582 | \$250,551 |
| CZ05 | PG&E | 164,408 | 1746 | 42.68 | \$169,373 | \$561,966 | \$405,087 | 3.3 | 2.4 | \$392,592 | \$235,714 |
| CZ06 | SCE | 166,052 | 1002 | 39.48 | \$173,118 | \$306,697 | \$414,756 | 1.8 | 2.4 | \$133,579 | \$241,638 |
| CZ06-2 | LA | 166,052 | 1002 | 39.48 | \$173,118 | \$187,941 | \$414,756 | 1.1 | 2.4 | \$14,823 | \$241,638 |
| CZ07 | SDG&E | 176,705 | 522 | 39.47 | \$171,118 | \$479,038 | \$428,490 | 2.8 | 2.5 | \$307,920 | \$257,372 |
| CZ08 | SCE | 169,825 | 793 | 39.14 | \$167,958 | \$312,602 | \$436,709 | 1.9 | 2.6 | \$144,645 | \$268,751 |
| CZ08-2 | LA | 169,825 | 793 | 39.14 | \$167,958 | \$187,142 | \$436,709 | 1.1 | 2.6 | \$19,185 | \$268,751 |
| CZ09 | SCE | 170,747 | 970 | 40.23 | \$162,767 | \$318,113 | \$423,370 | 2.0 | 2.6 | \$155,346 | \$260,604 |
| CZ09-2 | LA | 170,747 | 970 | 40.23 | \$162,767 | \$197,006 | \$423,370 | 1.2 | 2.6 | \$34,240 | \$260,604 |
| CZ10 | SDG&E | 169,935 | 1262 | 41.08 | \$167,608 | \$503,504 | \$411,284 | 3.0 | 2.5 | \$335,896 | \$243,675 |
| CZ10-2 | SCE | 169,935 | 1262 | 41.08 | \$167,608 | \$317,927 | \$411,284 | 1.9 | 2.5 | \$150,319 | \$243,675 |
| CZ11 | PG&E | 152,559 | 2415 | 42.99 | \$162,678 | \$491,775 | \$420,667 | 3.0 | 2.6 | \$329,096 | \$257,989 |
| CZ12 | PG&E | 151,956 | 2309 | 42.21 | \$162,376 | \$494,703 | \$417,063 | 3.0 | 2.6 | \$332,327 | \$254,687 |
| CZ12-2 | SMUD | 151,956 | 2309 | 42.21 | \$162,376 | \$288,950 | \$417,063 | 1.8 | 2.6 | \$126,573 | \$254,687 |
| CZ13 | PG&E | 156,271 | 1983 | 41.25 | \$166,722 | \$485,422 | \$395,770 | 2.9 | 2.4 | \$318,699 | \$229,047 |
| CZ14 | SDG&E | 178,505 | 1672 | 43.94 | \$168,224 | \$452,456 | \$457,387 | 2.7 | 2.7 | \$284,232 | \$289,163 |
| CZ14-2 | SCE | 178,505 | 1672 | 43.94 | \$168,224 | \$311,520 | \$457,387 | 1.9 | 2.7 | \$143,296 | \$289,163 |
| CZ15 | SCE | 179,840 | 518 | 38.23 | \$165,336 | \$296,004 | \$422,293 | 1.8 | 2.6 | \$130,668 | \$256,957 |
| CZ16 | PG&E | 152,965 | 4304 | 53.53 | \$169,109 | \$483,205 | \$378,299 | 2.9 | 2.2 | \$314,096 | \$209,190 |
| CZ16-2 | LA | 152,965 | 4304 | 53.53 | \$169,109 | \$215,341 | \$378,299 | 1.3 | 2.2 | \$46,231 | \$209,190 |



6.7.3 Cost Effectiveness Results – Small Hotel

Figure 70 through Figure 77 contain the cost-effectiveness findings for the Small Hotel packages. Notable findings for each package include:

- ◆ **Mixed-Fuel + 3 kW PV:** Packages are cost effective and achieve savings for all climate zones for both the On-Bill and TDV approaches.
- ◆ **Mixed-Fuel + 3 kW PV + 5 kWh Battery:** The packages are less cost effective as compared to the previous minimal PV only package and not cost effective for LADWP and SMUD service area. The addition of battery reduces the cost effectiveness of packages.
- ◆ **Mixed-Fuel + PV only:** Packages are cost effective and achieve savings for the On-Bill approach for all climate zones except for LADWP territory. Packages are cost effective and achieve savings for the TDV approach for all climate zones.
- ◆ **Mixed-Fuel + PV + 50 kWh Battery:** Adding battery slightly reduces On-Bill B/C ratios. Packages are not cost effective for LADWP territory, SMUD territory as well as for climate zones 6,8,9 under PG&E service area.
- ◆ **All-Electric + 3 kW PV:** All packages are cost effective using the On-Bill approach. All packages are cost effective using the TDV approach but do not achieve positive energy cost savings.
- ◆ **All-Electric + 3 kW PV + 5 kWh Battery:** Similar to minimal PV only package, all packages are cost effective using the On-Bill approach. All packages are cost effective using the TDV approach but do not achieve positive energy cost savings.
- ◆ **All-Electric + PV only:** All packages are cost effective for both On-Bill and TDV approaches. Packages achieve on-bill savings for all climate zones.
- ◆ **All-Electric + PV + 50 kWh Battery:** Adding battery slightly reduces On-Bill B/C ratios but is still cost effective for all climate zones.



Figure 70. Cost Effectiveness for Small Hotel – Mixed Fuel + 3kW PV

| CZ | IOU territory | Elec Savings (kWh) | Gas Savings (therms) | GHG savings (tons) | Incremental Package Cost | Lifecycle Energy Cost Savings | Lifecycle \$-TDV Savings | B/C Ratio (On-bill) | B/C Ratio (TDV) | NPV (On-bill) | NPV (TDV) |
|----------------------------|---------------|--------------------|----------------------|--------------------|--------------------------|-------------------------------|--------------------------|---------------------|-----------------|---------------|-----------|
| Mixed Fuel + 3kW PV | | | | | | | | | | | |
| CZ01 | PG&E | 3,941 | 0 | 0.8 | \$5,566 | \$12,616 | \$8,326 | 2.3 | 1.5 | \$7,050 | \$2,760 |
| CZ02 | PG&E | 4,785 | 0 | 0.9 | \$5,566 | \$12,639 | \$10,332 | 2.3 | 1.9 | \$7,073 | \$4,766 |
| CZ03 | PG&E | 4,733 | 0 | 0.9 | \$5,566 | \$15,146 | \$9,991 | 2.7 | 1.8 | \$9,580 | \$4,425 |
| CZ04 | PG&E | 4,834 | 0 | 1.0 | \$5,566 | \$13,266 | \$10,445 | 2.4 | 1.9 | \$7,700 | \$4,879 |
| CZ04-2 | CPAU | 4,834 | 0 | 1.0 | \$5,566 | \$11,507 | \$10,445 | 2.1 | 1.9 | \$5,941 | \$4,879 |
| CZ05 | PG&E | 5,027 | 0 | 1.0 | \$5,566 | \$16,048 | \$10,634 | 2.9 | 1.9 | \$10,482 | \$5,068 |
| CZ06 | SCE | 4,769 | 0 | 0.9 | \$5,566 | \$10,276 | \$10,559 | 1.8 | 1.9 | \$4,710 | \$4,993 |
| CZ06-2 | LA | 4,769 | 0 | 0.9 | \$5,566 | \$6,307 | \$10,559 | 1.1 | 1.9 | \$741 | \$4,993 |
| CZ07 | SDG&E | 4,960 | 0 | 1.0 | \$5,566 | \$14,576 | \$10,861 | 2.6 | 2.0 | \$9,010 | \$5,295 |
| CZ08 | SCE | 4,824 | 0 | 0.9 | \$5,566 | \$10,837 | \$11,202 | 1.9 | 2.0 | \$5,271 | \$5,636 |
| CZ08-2 | LA | 4,824 | 0 | 0.9 | \$5,566 | \$6,505 | \$11,202 | 1.2 | 2.0 | \$939 | \$5,636 |
| CZ09 | SCE | 4,779 | 0 | 0.9 | \$5,566 | \$10,298 | \$10,824 | 1.9 | 1.9 | \$4,732 | \$5,258 |
| CZ09-2 | LA | 4,779 | 0 | 0.9 | \$5,566 | \$6,201 | \$10,824 | 1.1 | 1.9 | \$635 | \$5,258 |
| CZ10 | SDG&E | 4,905 | 0 | 1.0 | \$5,566 | \$16,302 | \$10,710 | 2.9 | 1.9 | \$10,736 | \$5,144 |
| CZ10-2 | SCE | 4,905 | 0 | 1.0 | \$5,566 | \$9,468 | \$10,710 | 1.7 | 1.9 | \$3,902 | \$5,144 |
| CZ11 | PG&E | 4,701 | 0 | 0.9 | \$5,566 | \$14,193 | \$10,483 | 2.6 | 1.9 | \$8,627 | \$4,917 |
| CZ12 | PG&E | 4,770 | 0 | 0.9 | \$5,566 | \$15,262 | \$10,596 | 2.7 | 1.9 | \$9,696 | \$5,030 |
| CZ12-2 | SMUD | 4,770 | 0 | 0.9 | \$5,566 | \$7,848 | \$10,596 | 1.4 | 1.9 | \$2,282 | \$5,030 |
| CZ13 | PG&E | 4,633 | 0 | 0.9 | \$5,566 | \$14,674 | \$10,105 | 2.6 | 1.8 | \$9,108 | \$4,539 |
| CZ14 | SDG&E | 5,377 | 0 | 1.1 | \$5,566 | \$16,615 | \$12,375 | 3.0 | 2.2 | \$11,049 | \$6,809 |
| CZ14-2 | SCE | 5,377 | 0 | 1.1 | \$5,566 | \$10,021 | \$12,375 | 1.8 | 2.2 | \$4,455 | \$6,809 |
| CZ15 | SCE | 4,997 | 0 | 1.0 | \$5,566 | \$9,542 | \$11,164 | 1.7 | 2.0 | \$3,976 | \$5,598 |
| CZ16 | PG&E | 5,240 | 0 | 1.0 | \$5,566 | \$14,961 | \$10,975 | 2.7 | 2.0 | \$9,395 | \$5,409 |
| CZ16-2 | LA | 5,240 | 0 | 1.0 | \$5,566 | \$5,670 | \$10,975 | 1.0 | 2.0 | \$104 | \$5,409 |



Figure 71. Cost Effectiveness for Small Hotel – Mixed Fuel + 3kW PV + 5 kWh Battery

| CZ | IOU territory | Elec Savings (kWh) | Gas Savings (therms) | GHG savings (tons) | Incremental Package Cost | Lifecycle Energy Cost Savings | -\$TDV Savings | B/C Ratio (On-bill) | B/C Ratio (TDV) | NPV (On-bill) | NPV (TDV) |
|---|---------------|--------------------|----------------------|--------------------|--------------------------|-------------------------------|----------------|---------------------|-----------------|---------------|-----------|
| Mixed Fuel + 3kW PV + 5kWh Battery | | | | | | | | | | | |
| CZ01 | PG&E | 3,941 | 0 | 0.8 | \$9,520 | \$12,616 | \$8,326 | 1.3 | 0.9 | \$3,096 | (\$1,194) |
| CZ02 | PG&E | 4,785 | 0 | 0.9 | \$9,520 | \$12,639 | \$10,332 | 1.3 | 1.1 | \$3,119 | \$811 |
| CZ03 | PG&E | 4,733 | 0 | 0.9 | \$9,520 | \$15,146 | \$9,991 | 1.6 | 1.0 | \$5,626 | \$471 |
| CZ04 | PG&E | 4,834 | 0 | 1.0 | \$9,520 | \$13,266 | \$10,445 | 1.4 | 1.1 | \$3,746 | \$925 |
| CZ04-2 | CPAU | 4,834 | 0 | 1.0 | \$9,520 | \$11,507 | \$10,445 | 1.2 | 1.1 | \$1,987 | \$925 |
| CZ05 | PG&E | 5,027 | 0 | 1.0 | \$9,520 | \$16,048 | \$10,634 | 1.7 | 1.1 | \$6,528 | \$1,114 |
| CZ05-2 | SCG | 5,027 | 0 | 1.0 | \$9,520 | \$16,048 | \$10,634 | 1.7 | 1.1 | \$6,528 | \$1,114 |
| CZ06 | SCE | 4,769 | 0 | 0.9 | \$9,520 | \$10,276 | \$10,559 | 1.1 | 1.1 | \$756 | \$1,039 |
| CZ06-2 | LA | 4,769 | 0 | 0.9 | \$9,520 | \$6,307 | \$10,559 | 0.7 | 1.1 | (\$3,213) | \$1,039 |
| CZ07 | SDG&E | 4,960 | 0 | 1.0 | \$9,520 | \$14,576 | \$10,861 | 1.5 | 1.1 | \$5,056 | \$1,341 |
| CZ08 | SCE | 4,824 | 0 | 0.9 | \$9,520 | \$10,837 | \$11,202 | 1.1 | 1.2 | \$1,317 | \$1,682 |
| CZ08-2 | LA | 4,824 | 0 | 0.9 | \$9,520 | \$6,505 | \$11,202 | 0.7 | 1.2 | (\$3,015) | \$1,682 |
| CZ09 | SCE | 4,779 | 0 | 0.9 | \$9,520 | \$10,298 | \$10,824 | 1.1 | 1.1 | \$778 | \$1,303 |
| CZ09-2 | LA | 4,779 | 0 | 0.9 | \$9,520 | \$6,201 | \$10,824 | 0.7 | 1.1 | (\$3,319) | \$1,303 |
| CZ10 | SDG&E | 4,905 | 0 | 1.0 | \$9,520 | \$16,302 | \$10,710 | 1.7 | 1.1 | \$6,782 | \$1,190 |
| CZ10-2 | SCE | 4,905 | 0 | 1.0 | \$9,520 | \$9,468 | \$10,710 | 0.99 | 1.1 | (\$52) | \$1,190 |
| CZ11 | PG&E | 4,701 | 0 | 0.9 | \$9,520 | \$14,193 | \$10,483 | 1.5 | 1.1 | \$4,673 | \$963 |
| CZ12 | PG&E | 4,770 | 0 | 0.9 | \$9,520 | \$15,262 | \$10,596 | 1.6 | 1.1 | \$5,742 | \$1,076 |
| CZ12-2 | SMUD | 4,770 | 0 | 0.9 | \$9,520 | \$7,848 | \$10,596 | 0.8 | 1.1 | (\$1,672) | \$1,076 |
| CZ13 | PG&E | 4,633 | 0 | 0.9 | \$9,520 | \$14,674 | \$10,105 | 1.5 | 1.1 | \$5,154 | \$584 |
| CZ14 | SDG&E | 5,377 | 0 | 1.1 | \$9,520 | \$16,615 | \$12,375 | 1.7 | 1.3 | \$7,095 | \$2,855 |
| CZ14-2 | SCE | 5,377 | 0 | 1.1 | \$9,520 | \$10,021 | \$12,375 | 1.1 | 1.3 | \$501 | \$2,855 |
| CZ15 | SCE | 4,997 | 0 | 1.0 | \$9,520 | \$9,542 | \$11,164 | 1.0 | 1.2 | \$22 | \$1,644 |
| CZ16 | PG&E | 5,240 | 0 | 1.0 | \$9,520 | \$14,961 | \$10,975 | 1.6 | 1.2 | \$5,441 | \$1,455 |
| CZ16-2 | LA | 5,240 | 0 | 1.0 | \$9,520 | \$5,670 | \$10,975 | 0.6 | 1.2 | (\$3,851) | \$1,455 |



Figure 72. Cost Effectiveness for Small Hotel - Mixed Fuel +80kW PV

| CZ | IOU territory | Elec Savings (kWh) | Gas Savings (therms) | GHG savings (tons) | Incremental Package Cost | Lifecycle Energy Cost Savings | Lifecycle TDV Savings | B/C Ratio (On-bill) | B/C Ratio (TDV) | NPV (On-bill) | NPV (TDV) |
|-----------------------------|---------------|--------------------|----------------------|--------------------|--------------------------|-------------------------------|-----------------------|---------------------|-----------------|---------------|-----------|
| Mixed Fuel + 80kW PV | | | | | | | | | | | |
| CZ01 | PG&E | 105,090 | 0 | 20.6 | \$179,470 | \$336,440 | \$221,883 | 1.9 | 1.2 | \$156,970 | \$42,413 |
| CZ02 | PG&E | 127,592 | 0 | 25.0 | \$179,470 | \$320,009 | \$275,130 | 1.8 | 1.5 | \$140,539 | \$95,660 |
| CZ03 | PG&E | 126,206 | 0 | 24.8 | \$179,470 | \$403,900 | \$266,426 | 2.3 | 1.5 | \$224,430 | \$86,956 |
| CZ04 | PG&E | 128,894 | 0 | 25.4 | \$179,470 | \$322,782 | \$278,536 | 1.8 | 1.6 | \$143,312 | \$99,066 |
| CZ04-2 | CPAU | 128,894 | 0 | 25.4 | \$179,470 | \$306,862 | \$278,536 | 1.7 | 1.6 | \$127,392 | \$99,066 |
| CZ05 | PG&E | 134,041 | 0 | 26.5 | \$179,470 | \$427,935 | \$283,834 | 2.4 | 1.6 | \$248,465 | \$104,364 |
| CZ06 | SCE | 127,168 | 0 | 25.0 | \$179,470 | \$200,425 | \$281,488 | 1.1 | 1.6 | \$20,955 | \$102,018 |
| CZ06-2 | LA | 127,168 | 0 | 25.0 | \$179,470 | \$119,357 | \$281,488 | 0.7 | 1.6 | (\$60,113) | \$102,018 |
| CZ07 | SDG&E | 132,258 | 0 | 26.1 | \$179,470 | \$247,646 | \$289,700 | 1.4 | 1.6 | \$68,176 | \$110,230 |
| CZ08 | SCE | 128,641 | 0 | 25.3 | \$179,470 | \$207,993 | \$298,594 | 1.2 | 1.7 | \$28,523 | \$119,124 |
| CZ08-2 | LA | 128,641 | 0 | 25.3 | \$179,470 | \$122,591 | \$298,594 | 0.7 | 1.7 | (\$56,879) | \$119,124 |
| CZ09 | SCE | 127,447 | 0 | 25.3 | \$179,470 | \$211,567 | \$288,830 | 1.2 | 1.6 | \$32,096 | \$109,360 |
| CZ09-2 | LA | 127,447 | 0 | 25.3 | \$179,470 | \$123,486 | \$288,830 | 0.7 | 1.6 | (\$55,984) | \$109,360 |
| CZ10 | SDG&E | 130,792 | 0 | 25.8 | \$179,470 | \$274,832 | \$285,386 | 1.5 | 1.6 | \$95,361 | \$105,916 |
| CZ10-2 | SCE | 130,792 | 0 | 25.8 | \$179,470 | \$206,865 | \$285,386 | 1.2 | 1.6 | \$27,395 | \$105,916 |
| CZ11 | PG&E | 125,366 | 0 | 24.6 | \$179,470 | \$316,781 | \$279,331 | 1.8 | 1.6 | \$137,311 | \$99,861 |
| CZ12 | PG&E | 127,203 | 0 | 25.0 | \$179,470 | \$406,977 | \$282,358 | 2.3 | 1.6 | \$227,507 | \$102,888 |
| CZ12-2 | SMUD | 127,203 | 0 | 25.0 | \$179,470 | \$198,254 | \$282,358 | 1.1 | 1.6 | \$18,784 | \$102,888 |
| CZ13 | PG&E | 123,535 | 0 | 24.4 | \$179,470 | \$317,261 | \$269,908 | 1.8 | 1.5 | \$137,791 | \$90,437 |
| CZ14 | SDG&E | 143,387 | 0 | 28.1 | \$179,470 | \$309,521 | \$330,345 | 1.7 | 1.8 | \$130,051 | \$150,875 |
| CZ14-2 | SCE | 143,387 | 0 | 28.1 | \$179,470 | \$225,083 | \$330,345 | 1.3 | 1.8 | \$45,612 | \$150,875 |
| CZ15 | SCE | 133,246 | 0 | 25.9 | \$179,470 | \$207,277 | \$297,648 | 1.2 | 1.7 | \$27,807 | \$118,177 |
| CZ16 | PG&E | 139,738 | 0 | 27.3 | \$179,470 | \$341,724 | \$292,728 | 1.9 | 1.6 | \$162,254 | \$113,258 |
| CZ16-2 | LA | 139,738 | 0 | 27.3 | \$179,470 | \$114,215 | \$292,728 | 0.6 | 1.6 | (\$65,255) | \$113,258 |



Figure 73. Cost Effectiveness for Small Hotel – Mixed Fuel + 80kW PV + 50 kWh Battery

| CZ | IOU territory | Elec Savings (kWh) | Gas Savings (therms) | GHG savings (tons) | Incremental Package Cost | Lifecycle Energy Cost Savings | Lifecycle TDV Savings | B/C Ratio (On-bill) | B/C Ratio (TDV) | NPV (On-bill) | NPV (TDV) |
|---|---------------|--------------------|----------------------|--------------------|--------------------------|-------------------------------|-----------------------|---------------------|-----------------|---------------|-----------|
| Mixed Fuel + 80kW PV + 50kWh Battery | | | | | | | | | | | |
| CZ01 | PG&E | 104,026 | 0 | 23.2 | \$207,370 | \$332,596 | \$237,740 | 1.6 | 1.1 | \$125,226 | \$30,370 |
| CZ02 | PG&E | 126,332 | 0 | 28.1 | \$207,370 | \$336,179 | \$296,058 | 1.6 | 1.4 | \$128,809 | \$88,688 |
| CZ03 | PG&E | 124,934 | 0 | 28.0 | \$207,370 | \$399,220 | \$289,360 | 1.9 | 1.4 | \$191,850 | \$81,990 |
| CZ04 | PG&E | 127,602 | 0 | 28.5 | \$207,370 | \$332,161 | \$308,887 | 1.6 | 1.5 | \$124,790 | \$101,517 |
| CZ04-2 | CPAU | 127,602 | 0 | 28.5 | \$207,370 | \$303,828 | \$308,887 | 1.5 | 1.5 | \$96,458 | \$101,517 |
| CZ05 | PG&E | 132,725 | 0 | 29.8 | \$207,370 | \$423,129 | \$303,627 | 2.0 | 1.5 | \$215,758 | \$96,257 |
| CZ06 | SCE | 125,880 | 0 | 28.4 | \$207,370 | \$193,814 | \$297,950 | 0.9 | 1.4 | (\$13,556) | \$90,580 |
| CZ06-2 | LA | 125,880 | 0 | 28.4 | \$207,370 | \$123,083 | \$297,950 | 0.6 | 1.4 | (\$84,287) | \$90,580 |
| CZ07 | SDG&E | 130,940 | 0 | 29.5 | \$207,370 | \$274,313 | \$309,682 | 1.3 | 1.5 | \$66,943 | \$102,312 |
| CZ08 | SCE | 127,332 | 0 | 28.5 | \$207,370 | \$199,786 | \$312,899 | 1.0 | 1.5 | (\$7,584) | \$105,529 |
| CZ08-2 | LA | 127,332 | 0 | 28.5 | \$207,370 | \$124,651 | \$312,899 | 0.6 | 1.5 | (\$82,719) | \$105,529 |
| CZ09 | SCE | 126,232 | 0 | 28.2 | \$207,370 | \$206,706 | \$292,804 | 1.0 | 1.4 | (\$664) | \$85,433 |
| CZ09-2 | LA | 126,232 | 0 | 28.2 | \$207,370 | \$126,710 | \$292,804 | 0.6 | 1.4 | (\$80,660) | \$85,433 |
| CZ10 | SDG&E | 129,683 | 0 | 28.4 | \$207,370 | \$292,202 | \$287,278 | 1.4 | 1.4 | \$84,832 | \$79,908 |
| CZ10-2 | SCE | 129,683 | 0 | 28.4 | \$207,370 | \$206,171 | \$287,278 | 1.0 | 1.4 | (\$1,199) | \$79,908 |
| CZ11 | PG&E | 124,337 | 0 | 26.9 | \$207,370 | \$315,330 | \$283,683 | 1.5 | 1.4 | \$107,960 | \$76,313 |
| CZ12 | PG&E | 126,013 | 0 | 27.8 | \$207,370 | \$403,127 | \$297,118 | 1.9 | 1.4 | \$195,757 | \$89,748 |
| CZ12-2 | SMUD | 126,013 | 0 | 27.8 | \$207,370 | \$198,007 | \$297,118 | 1.0 | 1.4 | (\$9,363) | \$89,748 |
| CZ13 | PG&E | 122,591 | 0 | 26.5 | \$207,370 | \$315,541 | \$280,996 | 1.5 | 1.4 | \$108,171 | \$73,626 |
| CZ14 | SDG&E | 142,257 | 0 | 30.7 | \$207,370 | \$317,565 | \$334,697 | 1.5 | 1.6 | \$110,195 | \$127,327 |
| CZ14-2 | SCE | 142,257 | 0 | 30.7 | \$207,370 | \$224,195 | \$334,697 | 1.1 | 1.6 | \$16,824 | \$127,327 |
| CZ15 | SCE | 132,418 | 0 | 27.8 | \$207,370 | \$208,044 | \$299,199 | 1.0 | 1.4 | \$674 | \$91,829 |
| CZ16 | PG&E | 138,402 | 0 | 30.7 | \$207,370 | \$358,582 | \$315,699 | 1.7 | 1.5 | \$151,212 | \$108,329 |
| CZ16-2 | LA | 138,402 | 0 | 30.7 | \$207,370 | \$118,770 | \$315,699 | 0.6 | 1.5 | (\$88,600) | \$108,329 |



Figure 74. Cost Effectiveness for Small Hotel – All-Electric + 3kW PV

| CZ | IOU territory | Elec Savings (kWh) | Gas Savings (therms) | GHG savings (tons) | Incremental Package Cost* | Lifecycle Energy Cost Savings | Lifecycle TDV Savings | B/C Ratio (On-bill) | B/C Ratio (TDV) | NPV (On-bill) | NPV (TDV) |
|------------------------------|---------------|--------------------|----------------------|--------------------|---------------------------|-------------------------------|-----------------------|---------------------|-----------------|---------------|-------------|
| All-Electric + 3kW PV | | | | | | | | | | | |
| CZ01 | PG&E | -155,861 | 16917 | 54.7 | (\$1,265,139) | (\$568,892) | (\$106,835) | 2.2 | 11.8 | \$696,246 | \$1,158,304 |
| CZ02 | PG&E | -113,954 | 12677 | 40.9 | (\$1,266,111) | (\$229,433) | (\$41,288) | 5.5 | 30.7 | \$1,036,679 | \$1,224,823 |
| CZ03 | PG&E | -105,862 | 12322 | 41.4 | (\$1,268,383) | (\$309,874) | (\$41,175) | 4.1 | 30.8 | \$958,510 | \$1,227,208 |
| CZ04 | PG&E | -108,570 | 11927 | 37.5 | (\$1,268,218) | (\$208,239) | (\$42,689) | 6.1 | 29.7 | \$1,059,980 | \$1,225,530 |
| CZ04-2 | CPAU | -108,570 | 11927 | 37.5 | (\$1,268,218) | (\$6,261) | (\$42,689) | 202.6 | 29.7 | \$1,261,958 | \$1,225,530 |
| CZ05 | PG&E | -103,579 | 11960 | 39.3 | (\$1,268,272) | (\$332,879) | (\$44,051) | 3.8 | 28.8 | \$935,393 | \$1,224,221 |
| CZ06 | SCE | -73,524 | 8912 | 30.3 | (\$1,268,413) | \$48,898 | (\$17,484) | >1 | 72.5 | \$1,317,311 | \$1,250,929 |
| CZ06-2 | LA | -64,859 | 8188 | 29.0 | (\$1,266,760) | (\$120,842) | (\$12,337) | 10.5 | 102.7 | \$1,145,918 | \$1,254,423 |
| CZ07 | SDG&E | -67,090 | 8353 | 29.2 | (\$1,264,731) | (\$43,964) | (\$11,618) | 28.8 | 108.9 | \$1,220,767 | \$1,253,113 |
| CZ08 | SCE | -67,090 | 8353 | 29.2 | (\$1,264,731) | \$48,736 | (\$11,618) | >1 | 108.9 | \$1,313,467 | \$1,253,113 |
| CZ08-2 | LA | -67,483 | 8402 | 29.3 | (\$1,266,529) | (\$35,547) | (\$11,126) | 35.6 | 113.8 | \$1,230,982 | \$1,255,403 |
| CZ09 | SCE | -67,483 | 8402 | 29.3 | (\$1,266,529) | \$52,410 | (\$11,126) | >1 | 113.8 | \$1,318,939 | \$1,255,403 |
| CZ09-2 | LA | -75,157 | 8418 | 27.2 | (\$1,263,531) | (\$156,973) | (\$25,469) | 8.0 | 49.6 | \$1,106,558 | \$1,238,061 |
| CZ10 | SDG&E | -75,157 | 8418 | 27.2 | (\$1,263,531) | (\$54,711) | (\$25,469) | 23.1 | 49.6 | \$1,208,820 | \$1,238,061 |
| CZ10-2 | SCE | -94,783 | 10252 | 31.9 | (\$1,264,340) | (\$169,847) | (\$38,904) | 7.4 | 32.5 | \$1,094,493 | \$1,225,436 |
| CZ11 | PG&E | -94,702 | 10403 | 33.0 | (\$1,265,779) | (\$324,908) | (\$34,968) | 3.9 | 36.2 | \$940,872 | \$1,230,811 |
| CZ12 | PG&E | -94,297 | 10403 | 33.1 | (\$1,265,779) | \$13,603 | (\$33,757) | >1 | 37.5 | \$1,279,382 | \$1,232,022 |
| CZ12-2 | SMUD | -92,196 | 10029 | 31.5 | (\$1,264,152) | (\$168,358) | (\$40,229) | 7.5 | 31.4 | \$1,095,794 | \$1,223,923 |
| CZ13 | PG&E | -96,021 | 10056 | 30.7 | (\$1,264,510) | (\$308,542) | (\$44,202) | 4.1 | 28.6 | \$955,969 | \$1,220,308 |
| CZ14 | SDG&E | -96,021 | 10056 | 30.7 | (\$1,264,510) | (\$110,730) | (\$44,202) | 11.4 | 28.6 | \$1,153,780 | \$1,220,308 |
| CZ14-2 | SCE | -44,856 | 5579 | 19.0 | (\$1,262,631) | \$8,996 | (\$10,256) | >1 | 123.1 | \$1,271,627 | \$1,252,375 |
| CZ15 | SCE | -211,468 | 17599 | 42.9 | (\$1,268,907) | (\$625,671) | (\$228,203) | 2.0 | 5.6 | \$643,236 | \$1,040,704 |
| CZ16 | PG&E | -211,468 | 17599 | 42.9 | (\$1,268,907) | \$37,142 | (\$228,203) | >1 | 5.6 | \$1,306,049 | \$1,040,704 |
| CZ16-2 | LA | -155,861 | 16917 | 54.7 | (\$1,265,139) | (\$568,892) | (\$106,835) | 2.2 | 11.8 | \$696,246 | \$1,158,304 |



Figure 75. Cost Effectiveness for Small Hotel – All-Electric + 3kW PV + 5 kWh Battery

| CZ | IOU territory | Elec Savings (kWh) | Gas Savings (therms) | GHG savings (tons) | Incremental Package Cost | Lifecycle Energy Cost Savings | \$-TDV Savings | B/C Ratio (On-bill) | B/C Ratio (TDV) | NPV (On-bill) | NPV (TDV) |
|---|---------------|--------------------|----------------------|--------------------|--------------------------|-------------------------------|----------------|---------------------|-----------------|---------------|-------------|
| All-Electric + 3kW PV + 5kWh Battery | | | | | | | | | | | |
| CZ01 | PG&E | -155,861 | 16917 | 54.7 | (\$1,288,428) | (\$568,892) | (\$106,835) | 2.3 | 12.1 | \$719,536 | \$1,181,593 |
| CZ02 | PG&E | -113,954 | 12677 | 40.9 | (\$1,288,428) | (\$229,433) | (\$41,288) | 5.6 | 31.2 | \$1,058,996 | \$1,247,140 |
| CZ03 | PG&E | -105,862 | 12322 | 41.4 | (\$1,288,428) | (\$309,874) | (\$41,175) | 4.2 | 31.3 | \$978,554 | \$1,247,253 |
| CZ04 | PG&E | -108,570 | 11927 | 37.5 | (\$1,288,428) | (\$208,239) | (\$42,689) | 6.2 | 30.2 | \$1,080,190 | \$1,245,740 |
| CZ04-2 | CPAU | -108,570 | 11927 | 37.5 | (\$1,288,428) | (\$6,261) | (\$42,689) | 205.8 | 30.2 | \$1,282,167 | \$1,245,740 |
| CZ05 | PG&E | -103,579 | 11960 | 39.3 | (\$1,288,428) | (\$332,879) | (\$44,051) | 3.9 | 29.2 | \$955,549 | \$1,244,377 |
| CZ06 | SCE | -73,524 | 8912 | 30.3 | (\$1,288,428) | (\$52,341) | (\$17,484) | 24.6 | 73.7 | \$1,236,087 | \$1,270,944 |
| CZ06-2 | LA | -73,524 | 8912 | 30.3 | (\$1,288,428) | \$48,898 | (\$17,484) | >1 | 73.7 | \$1,337,326 | \$1,270,944 |
| CZ07 | SDG&E | -64,859 | 8188 | 29.0 | (\$1,288,428) | (\$120,842) | (\$12,337) | 10.7 | 104.4 | \$1,167,586 | \$1,276,091 |
| CZ08 | SCE | -67,090 | 8353 | 29.2 | (\$1,288,428) | (\$43,964) | (\$11,618) | 29.3 | 110.9 | \$1,244,464 | \$1,276,810 |
| CZ08-2 | LA | -67,090 | 8353 | 29.2 | (\$1,288,428) | \$48,736 | (\$11,618) | >1 | 110.9 | \$1,337,164 | \$1,276,810 |
| CZ09 | SCE | -67,483 | 8402 | 29.3 | (\$1,288,428) | (\$35,547) | (\$11,126) | 36.2 | 115.8 | \$1,252,881 | \$1,277,302 |
| CZ09-2 | LA | -67,483 | 8402 | 29.3 | (\$1,288,428) | \$52,410 | (\$11,126) | >1 | 115.8 | \$1,340,838 | \$1,277,302 |
| CZ10 | SDG&E | -75,157 | 8418 | 27.2 | (\$1,288,428) | (\$156,973) | (\$25,469) | 8.2 | 50.6 | \$1,131,455 | \$1,262,959 |
| CZ10-2 | SCE | -75,157 | 8418 | 27.2 | (\$1,288,428) | (\$54,711) | (\$25,469) | 23.5 | 50.6 | \$1,233,718 | \$1,262,959 |
| CZ11 | PG&E | -94,783 | 10252 | 31.9 | (\$1,288,428) | (\$169,847) | (\$38,904) | 7.6 | 33.1 | \$1,118,582 | \$1,249,524 |
| CZ12 | PG&E | -94,702 | 10403 | 33.0 | (\$1,288,428) | (\$324,908) | (\$34,968) | 4.0 | 36.8 | \$963,520 | \$1,253,460 |
| CZ12-2 | SMUD | -94,297 | 10403 | 33.1 | (\$1,288,428) | \$13,603 | (\$33,757) | >1 | 38.2 | \$1,302,031 | \$1,254,671 |
| CZ13 | PG&E | -92,196 | 10029 | 31.5 | (\$1,288,428) | (\$168,358) | (\$40,229) | 7.7 | 32.0 | \$1,120,071 | \$1,248,199 |
| CZ14 | SDG&E | -96,021 | 10056 | 30.7 | (\$1,288,428) | (\$308,542) | (\$44,202) | 4.2 | 29.1 | \$979,887 | \$1,244,226 |
| CZ14-2 | SCE | -96,021 | 10056 | 30.7 | (\$1,288,428) | (\$110,730) | (\$44,202) | 11.6 | 29.1 | \$1,177,698 | \$1,244,226 |
| CZ15 | SCE | -44,856 | 5579 | 19.0 | (\$1,288,428) | \$8,996 | (\$10,256) | >1 | 125.6 | \$1,297,425 | \$1,278,172 |
| CZ16 | PG&E | -211,468 | 17599 | 42.9 | (\$1,288,428) | (\$625,671) | (\$228,203) | 2.1 | 5.6 | \$662,757 | \$1,060,225 |
| CZ16-2 | LA | -211,468 | 17599 | 42.9 | (\$1,288,428) | \$37,142 | (\$228,203) | >1 | 5.6 | \$1,325,570 | \$1,060,225 |



Figure 76. Cost Effectiveness for Small Hotel – All-Electric + 80kW PV

| CZ | IOU territory | Elec Savings (kWh) | Gas Savings (therms) | GHG savings (tons) | Incremental Package Cost | Lifecycle Energy Cost Savings | -\$TDV Savings | B/C Ratio (On-bill) | B/C Ratio (TDV) | NPV (On-bill) | NPV (TDV) |
|-------------------------------|---------------|--------------------|----------------------|--------------------|--------------------------|-------------------------------|----------------|---------------------|-----------------|---------------|-------------|
| All-Electric + 80kW PV | | | | | | | | | | | |
| CZ01 | PG&E | -54,712 | 16917 | 74.6 | (\$1,123,442) | (\$240,170) | \$106,722 | 4.7 | >1 | \$883,272 | \$1,230,164 |
| CZ02 | PG&E | 8,853 | 12677 | 65.0 | (\$1,124,415) | \$128,649 | \$223,510 | >1 | >1 | \$1,253,063 | \$1,347,925 |
| CZ03 | PG&E | 15,612 | 12322 | 65.3 | (\$1,126,687) | \$44,532 | \$215,260 | >1 | >1 | \$1,171,219 | \$1,341,947 |
| CZ04 | PG&E | 15,490 | 11927 | 62.0 | (\$1,126,522) | \$145,778 | \$225,402 | >1 | >1 | \$1,272,300 | \$1,351,924 |
| CZ04-2 | CPAU | 15,490 | 11927 | 62.0 | (\$1,126,522) | \$289,094 | \$225,402 | >1 | >1 | \$1,415,616 | \$1,351,924 |
| CZ05 | PG&E | 25,436 | 11960 | 64.8 | (\$1,126,575) | \$56,019 | \$229,149 | >1 | >1 | \$1,182,594 | \$1,355,724 |
| CZ06 | SCE | 48,875 | 8912 | 54.4 | (\$1,126,716) | \$163,343 | \$253,445 | >1 | >1 | \$1,290,060 | \$1,380,161 |
| CZ06-2 | LA | 62,439 | 8188 | 54.1 | (\$1,125,064) | \$115,822 | \$266,502 | >1 | >1 | \$1,240,886 | \$1,391,565 |
| CZ07 | SDG&E | 56,727 | 8353 | 53.5 | (\$1,123,034) | \$147,987 | \$275,773 | >1 | >1 | \$1,271,022 | \$1,398,808 |
| CZ08 | SCE | 56,727 | 8353 | 53.5 | (\$1,123,034) | \$163,971 | \$275,773 | >1 | >1 | \$1,287,005 | \$1,398,808 |
| CZ08-2 | LA | 55,185 | 8402 | 53.7 | (\$1,124,832) | \$155,101 | \$266,880 | >1 | >1 | \$1,279,933 | \$1,391,712 |
| CZ09 | SCE | 55,185 | 8402 | 53.7 | (\$1,124,832) | \$169,010 | \$266,880 | >1 | >1 | \$1,293,843 | \$1,391,712 |
| CZ09-2 | LA | 50,731 | 8418 | 52.0 | (\$1,121,834) | \$113,936 | \$249,207 | >1 | >1 | \$1,235,770 | \$1,371,041 |
| CZ10 | SDG&E | 50,731 | 8418 | 52.0 | (\$1,121,834) | \$138,265 | \$249,207 | >1 | >1 | \$1,260,099 | \$1,371,041 |
| CZ10-2 | SCE | 25,882 | 10252 | 55.6 | (\$1,122,643) | \$162,626 | \$229,944 | >1 | >1 | \$1,285,269 | \$1,352,587 |
| CZ11 | PG&E | 27,731 | 10403 | 57.1 | (\$1,124,083) | \$12,954 | \$236,794 | >1 | >1 | \$1,137,037 | \$1,360,876 |
| CZ12 | PG&E | 28,136 | 10403 | 57.2 | (\$1,124,083) | \$206,756 | \$238,005 | >1 | >1 | \$1,330,839 | \$1,362,087 |
| CZ12-2 | SMUD | 26,706 | 10029 | 55.0 | (\$1,122,455) | \$165,991 | \$219,574 | >1 | >1 | \$1,288,446 | \$1,342,030 |
| CZ13 | PG&E | 41,989 | 10056 | 57.8 | (\$1,122,814) | \$22,333 | \$273,768 | >1 | >1 | \$1,145,147 | \$1,396,582 |
| CZ14 | SDG&E | 41,989 | 10056 | 57.8 | (\$1,122,814) | \$120,943 | \$273,768 | >1 | >1 | \$1,243,757 | \$1,396,582 |
| CZ14-2 | SCE | 83,393 | 5579 | 44.0 | (\$1,120,934) | \$210,511 | \$276,228 | >1 | >1 | \$1,331,445 | \$1,397,162 |
| CZ15 | SCE | -76,971 | 17599 | 69.2 | (\$1,127,210) | (\$199,308) | \$53,550 | 5.7 | >1 | \$927,902 | \$1,180,760 |
| CZ16 | PG&E | -76,971 | 17599 | 69.2 | (\$1,127,210) | \$172,787 | \$53,550 | >1 | >1 | \$1,299,997 | \$1,180,760 |
| CZ16-2 | LA | -54,712 | 16917 | 74.6 | (\$1,123,442) | (\$240,170) | \$106,722 | 4.7 | >1 | \$883,272 | \$1,230,164 |



Figure 77. Cost Effectiveness for Small Hotel – All-Electric + 80kW PV + 50 kWh Battery

| CZ | IOU territory | Elec Savings (kWh) | Gas Savings (therms) | GHG savings (tons) | Incremental Package Cost | Lifecycle Energy Cost Savings | -\$TDV Savings | B/C Ratio (On-bill) | B/C Ratio (TDV) | NPV (On-bill) | NPV (TDV) |
|---|---------------|--------------------|----------------------|--------------------|--------------------------|-------------------------------|----------------|---------------------|-----------------|---------------|-------------|
| All-Electric + 80kW PV + 50kWh Battery | | | | | | | | | | | |
| CZ01 | PG&E | -55,323 | 16917 | 75.7 | (\$1,095,542) | (\$238,351) | \$118,605 | 4.6 | >1 | \$857,191 | \$1,214,147 |
| CZ02 | PG&E | 7,849 | 12677 | 67.4 | (\$1,096,515) | \$129,794 | \$239,632 | >1 | >1 | \$1,226,309 | \$1,336,146 |
| CZ03 | PG&E | 14,594 | 12322 | 67.7 | (\$1,098,787) | \$43,166 | \$235,280 | >1 | >1 | \$1,141,953 | \$1,334,067 |
| CZ04 | PG&E | 14,459 | 11927 | 64.4 | (\$1,098,622) | \$148,698 | \$249,244 | >1 | >1 | \$1,247,320 | \$1,347,866 |
| CZ04-2 | CPAU | 14,459 | 11927 | 64.4 | (\$1,098,622) | \$286,573 | \$249,244 | >1 | >1 | \$1,385,195 | \$1,347,866 |
| CZ05 | PG&E | 24,292 | 11960 | 67.6 | (\$1,098,675) | \$53,719 | \$244,514 | >1 | >1 | \$1,152,394 | \$1,343,189 |
| CZ06 | SCE | 47,762 | 8912 | 57.2 | (\$1,098,816) | \$165,763 | \$267,221 | >1 | >1 | \$1,264,579 | \$1,366,037 |
| CZ06-2 | LA | 61,252 | 8188 | 57.1 | (\$1,097,164) | \$138,060 | \$283,797 | >1 | >1 | \$1,235,223 | \$1,380,960 |
| CZ07 | SDG&E | 55,588 | 8353 | 56.2 | (\$1,095,134) | \$138,718 | \$286,483 | >1 | >1 | \$1,233,852 | \$1,381,618 |
| CZ08 | SCE | 55,588 | 8353 | 56.2 | (\$1,095,134) | \$165,932 | \$286,483 | >1 | >1 | \$1,261,066 | \$1,381,618 |
| CZ08-2 | LA | 54,162 | 8402 | 56.1 | (\$1,096,932) | \$149,615 | \$269,453 | >1 | >1 | \$1,246,548 | \$1,366,386 |
| CZ09 | SCE | 54,162 | 8402 | 56.1 | (\$1,096,932) | \$171,168 | \$269,453 | >1 | >1 | \$1,268,101 | \$1,366,386 |
| CZ09-2 | LA | 49,832 | 8418 | 54.1 | (\$1,093,934) | \$120,627 | \$250,720 | >1 | >1 | \$1,214,561 | \$1,344,654 |
| CZ10 | SDG&E | 49,832 | 8418 | 54.1 | (\$1,093,934) | \$136,144 | \$250,720 | >1 | >1 | \$1,230,078 | \$1,344,654 |
| CZ10-2 | SCE | 25,148 | 10252 | 57.3 | (\$1,094,743) | \$160,744 | \$233,842 | >1 | >1 | \$1,255,487 | \$1,328,585 |
| CZ11 | PG&E | 26,813 | 10403 | 59.2 | (\$1,096,183) | \$10,314 | \$247,504 | >1 | >1 | \$1,106,497 | \$1,343,686 |
| CZ12 | PG&E | 27,217 | 10403 | 59.3 | (\$1,096,183) | \$206,749 | \$248,790 | >1 | >1 | \$1,302,931 | \$1,344,973 |
| CZ12-2 | SMUD | 26,027 | 10029 | 56.5 | (\$1,094,555) | \$164,506 | \$229,300 | >1 | >1 | \$1,259,061 | \$1,323,856 |
| CZ13 | PG&E | 41,123 | 10056 | 59.7 | (\$1,094,914) | \$25,707 | \$276,947 | >1 | >1 | \$1,120,621 | \$1,371,860 |
| CZ14 | SDG&E | 41,123 | 10056 | 59.7 | (\$1,094,914) | \$119,382 | \$276,947 | >1 | >1 | \$1,214,296 | \$1,371,860 |
| CZ14-2 | SCE | 82,697 | 5579 | 45.5 | (\$1,093,034) | \$209,837 | \$277,287 | >1 | >1 | \$1,302,871 | \$1,370,321 |
| CZ15 | SCE | -77,815 | 17599 | 71.1 | (\$1,099,310) | (\$193,758) | \$65,850 | 5.7 | >1 | \$905,552 | \$1,165,160 |
| CZ16 | PG&E | -77,815 | 17599 | 71.1 | (\$1,099,310) | \$175,872 | \$65,850 | >1 | >1 | \$1,275,182 | \$1,165,160 |
| CZ16-2 | LA | -55,323 | 16917 | 75.7 | (\$1,095,542) | (\$238,351) | \$118,605 | 4.6 | >1 | \$857,191 | \$1,214,147 |



6.8 List of Relevant Efficiency Measures Explored

The Reach Code Team started with a potential list of energy efficiency measures proposed for 2022 Title 24 codes and standards enhancement measures, as well as measures from the 2018 International Green Construction Code, which is based on ASHRAE Standard 189.1-2017. The team also developed new measures based on their experience. This original list was over 100 measures long. The measures were filtered based on applicability to the prototypes in this study, ability to model in simulation software, previously demonstrated energy savings potential, and market readiness. The list of 28 measures below represent the list of efficiency measures that meet these criteria and were investigated to some degree. The column to the far right indicates whether the measure was ultimately included in analysis or not.

Figure 78. List of Relevant Efficiency Measures Explored

| Building Component | Measure Name | Measure Description | Notes | Include? |
|--------------------|---------------------------------------|---|--|----------|
| Water Heating | Drain water Heat Recovery | Add drain water heat recovery in hotel prototype | Requires calculations outside of modeling software. | Y |
| Envelope | High performance fenestration | Improved fenestration SHGC (reduce to 0.22). | | Y |
| Envelope | High SHGC for cold climates | Raise prescriptive fenestration SHGC (to 0.45) in cold climates where additional heat is beneficial. | | Y |
| Envelope | Allowable fenestration by orientation | Limit amount of fenestration as a function of orientation | | Y |
| Envelope | High Thermal Mass Buildings | Increase building thermal mass. Thermal mass slows the change in internal temperature of buildings with respect to the outdoor temperature, allowing the peak cooling load during summer to be pushed to the evening, resulting in lower overall cooling loads. | Initial energy modeling results showed marginal cooling savings, negative heating savings. | N |
| Envelope | Opaque Insulation | Increases the insulation requirement for opaque envelopes (i.e., roof and above-grade wall). | Initial energy modeling results showed marginal energy savings at significant costs which would not meet c/e criteria. | N |
| Envelope | Triple pane windows | U-factor of 0.20 for all windows | Initial energy modeling results showed only marginal energy savings and, in some cases, increased energy use. | N |



| Building Component | Measure Name | Measure Description | Notes | Include? |
|--------------------|----------------------------|--|--|----------|
| Envelope | Duct Leakage Testing | Expand duct leakage testing requirements based on ASHRAE Standard 215-2018: Method of Test to Determine Leakage of Operating HVAC Air Distribution Systems (ANSI Approved). | More research needs to be done on current duct leakage and how it can be addressed. | N |
| Envelope | Fenestration area | Reduce maximum allowable fenestration area to 30%. | Instead of this measure, analyzed measure which looked at limiting fenestration based on wall orientation. | N |
| Envelope | Skinny triple pane windows | U-factor of 0.20 for all windows, with no changes to existing framing or building structure. | Market not ready. No commercially-available products for commercial buildings. | N |
| Envelope | Permanent projections | Detailed prescriptive requirements for shading based on ASHRAE 189. PF >0.50 for first story and >0.25 for other floors. Many exceptions. Corresponding SHGC multipliers to be used. | Title 24 already allows owner to trade off SHGC with permanent projections. Also, adding requirements for permanent projections would raise concerns. | N |
| Envelope | Reduced infiltration | Reduce infiltration rates by improving building sealing. | Infiltration rates are a fixed ACM input and cannot be changed. A workaround attempt would not be precise, and the practicality of implementation by developers is low given the modeling capabilities and the fact that in-field verification is challenging. Benefits would predominantly be for air quality rather than energy. | N |



| Building Component | Measure Name | Measure Description | Notes | Include? |
|--------------------|---|---|--|----------|
| HVAC | Heat recovery ventilation | For the hotel, recover and transfer heat from exhausted air to ventilation air. | <p>For small hotels, the ventilation requirement could be met by various approaches, and the most common ones are:</p> <ul style="list-style-type: none"> a. Exhaust only system, and ventilation is met by infiltration or window operation. b. Through a Z-duct that connects the zone AC unit's intake to an outside air intake louver. c. Centralized ventilation system (DOAS) <p>The prototype developed for the small hotel is using Type 2 above. The major consideration is that currently, HRV + PTACs cannot be modeled at each guest room, only at the rooftop system. Option 1 would require the same type of HRV implementation as Option 2. Option 3 may be pursuable, but would require a significant redesign of the system, with questionable impacts. Previous studies have found heat recovery as cost effective in California only in buildings with high loads or high air exchange rates, given the relatively mild climate.</p> | N |
| HVAC | Require Economizers in Smaller Capacity Systems | Lower the capacity trigger for air economizers. Previous studies have shown cost effectiveness for systems as low as 3 tons. | | Y |
| HVAC | Reduce VAV minimum flow limit | Current T24 and 90.1 requirements limit VAV minimum flow rates to no more than 20% of maximum flow. Proposal based on ASHRAE Guideline 36 which includes sequences that remove technical barriers that previously existed. Also, most new DDC controllers are now capable of lower limits. The new limit may be as low as the required ventilation rate. A non-energy benefit of this measure is a reduction in over-cooling, thus improving comfort. | | Y |



| Building Component | Measure Name | Measure Description | Notes | Include? |
|--------------------|--|---|---|----------|
| HVAC | Building Automation System (BAS) improvements | With adoption of ASHRAE Guideline 36 (GDL-36), there is now a national consensus standard for the description of high-performance sequences of operation. This measure will update BAS control requirements to improve usability and enforcement and to increase energy efficiency. BAS control requirement language will be improved either by adoption of similar language to GDL-36, or reference to GDL-36. Specific T24 BAS control topics that will be addressed include at a minimum: DCV, demand-based reset of SAT, demand-based reset of SP, dual-maximum zone sequences, and zone groups for scheduling. | In order to realize any savings in the difference, we would need a very detailed energy model with space-by-space load/occupant diversity, etc. We would also need more modeling capability than is currently available in CBECC-Com. | N |
| HVAC | Fault Detection Devices (FDD) | Expand FDD requirements to a wider range of AHU faults beyond the economizer. Fault requirements will be based on NIST field research, which has consequently been integrated into ASHRAE Guideline 36 Best in Class Sequences of Operations. Costs are solely to develop the sequences, which is likely minimal, and much of the hardware required for economizer FDD is also used to detect other faults. | Market not ready. | N |
| HVAC | Small circulator pumps ECM, trim to flow rate | Circulator pumps for industry and commercial. | Hot water pump energy use is small already (<1% building electricity usage) so not much savings potential. More savings for CHW pumps. Modeling limitations as well. | N |
| HVAC | High Performance Ducts to Reduce Static Pressure | Revise requirements for duct sizing to reduce static pressure. | Preliminary energy modeling results showed only marginal energy savings compared to measure cost. | N |
| HVAC | Parallel fan-powered boxes | Use of parallel fan-powered boxes | Unable to model PFPB with variable speed fans in modeling software. | N |
| Lighting | Daylight Dimming Plus OFF | Automatic daylight dimming controls requirements include the OFF step. | | Y |
| Lighting | Occupant Sensing in Open Plan Offices | Take the PAF without allowing for increased design wattage | | Y |
| Lighting | Institutional tuning | Take the PAF without allowing for increased design wattage | | Y |



| Building Component | Measure Name | Measure Description | Notes | Include? |
|--------------------|---|--|--|----------|
| Lighting | Reduced Interior Lighting Power Density | Reduced interior LPD values. | | Y |
| Lighting | Shift from general to task illumination | Low levels of general illumination with task and accent lighting added to locations where higher light levels are required. The shift from general to task illumination measure is based on the assumption that proper lighting of a desk surface with high efficacy lighting can allow for the significant reduction of ambient general lighting. | This is a tough measure to require as the LPDs decrease. | N |
| Lighting | Future-proof lighting controls | Fill any holes in the current code that could lead to the situations where TLEDS or LED fixtures that are not dimmable or upgradable in the future, or any other issues with code that make it hard to transition to ALCS/IoT lighting in the future | Major lighting controls already covered in other measures being considered | N |
| Lighting | Integrated control of lighting and HVAC systems | Formalize the definition of "lighting and HVAC control integration" by defining the level of data sharing required between systems and the mechanism needed to share such data. The highest savings potential would likely be generated from VAV HVAC systems by closing the damper in unoccupied zones based on the occupancy sensor information from the lighting systems. | Not market ready enough. | N |
| Other | NR Plug Load Controls | Energy savings opportunities for plug loads, which may include: energy efficient equipment, equipment power management, occupancy sensor control, and occupant awareness programs. The proposal could be extending controlled receptacles requirements in Section 130.5(d) to more occupancy types. It would also consider circuit-level controls. | Office equipment now all have their own standby power modes that use very little power, making plug load controls very difficult to be cost-effective. | N |



6.9 Additional Rates Analysis - Healdsburg

After the final version of the report was released, the Reach Code Team provided additional cost effectiveness analysis in Climate Zone 2 using City of Healdsburg electric utility rates and PG&E gas rates. All aspects of the methodology remain the same, and the results for each package and prototype are aggregated below in Figure 79 through Figure 81. Results generally indicate:

- ◆ Mixed fuel prototypes achieve positive compliance margins for EE packages and are cost effective.
- ◆ All-electric prototypes achieve slightly lower compliance margins than mixed fuel for EE packages and are cost effective.
- ◆ All PV and PV+Battery packages are cost effective both using an on-bill and TDV approach.



Figure 79. Healdsburg Utility Rates Analysis - Medium Office, All Packages Cost Effectiveness Summary

| Prototype | Package | Elec Savings (kWh) | Gas Savings (therms) | GHG savings (tons) | Compliance Margin (%) | Incremental Package Cost | Lifecycle Energy Cost Savings | \$-TDV Savings | B/C Ratio (On-bill) | B/C Ratio (TDV) | NPV (On-bill) | NPV (TDV) |
|---------------|------------------------------|--------------------|----------------------|--------------------|-----------------------|--------------------------|-------------------------------|----------------|---------------------|-----------------|---------------|-----------|
| Medium Office | Mixed Fuel + EE | 40,985 | -505 | 8.1 | 17% | \$66,649 | \$89,645 | \$99,181 | 1.3 | 1.5 | \$22,996 | \$32,532 |
| | Mixed Fuel + EE + PVB | 255,787 | -505 | 50.6 | 17% | \$359,648 | \$510,922 | \$573,033 | 1.4 | 1.6 | \$151,274 | \$213,385 |
| | Mixed Fuel + HE | 3,795 | 550 | 4.3 | 4% | \$68,937 | \$24,204 | \$24,676 | 0.4 | 0.4 | -\$44,733 | -\$44,261 |
| | All-Electric | -49,684 | 3,868 | 5.0 | -7% | -\$73,695 | -\$7,042 | -\$41,429 | 10.5 | 1.8 | \$66,653 | \$32,266 |
| | All-Electric + EE | -11,811 | 3,868 | 15.2 | 10% | -\$7,046 | \$83,285 | \$58,563 | >1 | >1 | \$90,331 | \$65,609 |
| | All-Electric + EE + PVB | 203,026 | 3,868 | 57.8 | 10% | \$285,953 | \$511,954 | \$532,273 | 1.8 | 1.9 | \$226,001 | \$246,320 |
| | All-Electric + HE | -45,916 | 3,868 | 6.1 | -5% | -\$22,722 | \$6,983 | -\$26,394 | >1 | 0.9 | \$29,705 | -\$3,672 |
| | Mixed Fuel + 3kW | 4,785 | 0 | 0.9 | n/a | \$5,566 | \$10,430 | \$10,500 | 1.9 | 1.9 | \$4,864 | \$4,934 |
| | Mixed Fuel + 3kW + 5kWh | 4,785 | 0 | 0.9 | n/a | \$8,356 | \$10,430 | \$10,500 | 1.2 | 1.3 | \$2,074 | \$2,144 |
| | Mixed Fuel + 135kW | 215,311 | 0 | 41.5 | n/a | \$250,470 | \$424,452 | \$471,705 | 1.7 | 1.9 | \$173,982 | \$221,235 |
| | Mixed Fuel + 135kW + 50kWh | 214,861 | 0 | 42.6 | n/a | \$278,370 | \$423,721 | \$472,898 | 1.5 | 1.7 | \$145,351 | \$194,528 |
| | All-Electric + 3kW | -44,899 | 3,868 | 6.0 | n/a | -\$68,129 | \$3,299 | -\$30,928 | >1 | 2.2 | \$71,429 | \$37,201 |
| | All-Electric + 3kW + 5kWh | -44,899 | 3,868 | 6.0 | n/a | -\$65,339 | \$3,299 | -\$30,928 | >1 | 2.1 | \$68,639 | \$34,411 |
| | All-Electric + 135kW | 165,627 | 3,868 | 46.6 | n/a | \$176,775 | \$424,146 | \$430,276 | 2.4 | 2.4 | \$247,371 | \$253,501 |
| | All-Electric + 135kW + 50kWh | 165,200 | 3,868 | 47.7 | n/a | \$204,675 | \$423,466 | \$431,469 | 2.1 | 2.1 | \$218,792 | \$226,795 |
| | All-Electric + 80kW + 50kWh | 40,985 | -505 | 8.1 | 17% | \$66,649 | \$89,645 | \$99,181 | 1.3 | 1.5 | \$22,996 | \$32,532 |



Figure 80. Healdsburg Utility Rates Analysis – Medium Retail, All Packages Cost Effectiveness Summary

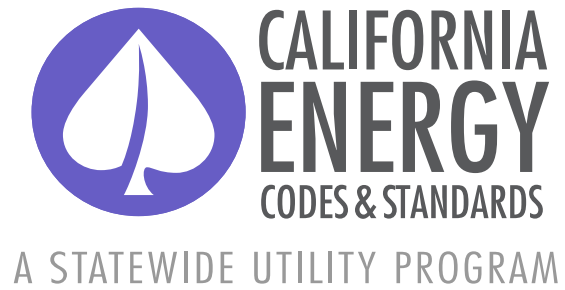
| Prototype | Package | Elec Savings (kWh) | Gas Savings (therms) | GHG savings (tons) | Compliance Margin (%) | Incremental Package Cost | Lifecycle Energy Cost Savings | \$-TDV Savings | B/C Ratio (On-bill) | B/C Ratio (TDV) | NPV (On-bill) | NPV (TDV) |
|---------------|------------------------------|--------------------|----------------------|--------------------|-----------------------|--------------------------|-------------------------------|----------------|---------------------|-----------------|---------------|-----------|
| Medium Retail | Mixed Fuel + EE | 18,885 | 613 | 8.7 | 13% | \$5,569 | \$49,546 | \$59,135 | 8.9 | 10.6 | \$43,977 | \$53,566 |
| | Mixed Fuel + EE + PVB | 189,400 | 613 | 43.8 | 13% | \$249,475 | \$376,219 | \$465,474 | 1.5 | 1.9 | \$126,744 | \$215,999 |
| | Mixed Fuel + HE | 2,288 | 229 | 2.0 | 3% | \$9,726 | \$13,143 | \$13,998 | 1.4 | 1.4 | \$3,417 | \$4,273 |
| | All-Electric | -21,786 | 2,448 | 7.5 | -1% | -\$27,464 | \$9,228 | -\$4,483 | >1 | 6.1 | \$36,692 | \$22,981 |
| | All-Electric + EE | 2,843 | 2,448 | 14.6 | 13% | -\$21,895 | \$61,918 | \$56,893 | >1 | >1 | \$83,813 | \$78,788 |
| | All-Electric + EE + PVB | 173,387 | 2,448 | 49.9 | 13% | \$222,012 | \$391,257 | \$463,431 | 1.8 | 2.1 | \$169,245 | \$241,419 |
| | All-Electric + HE | -16,989 | 2,448 | 8.9 | 3% | -\$4,211 | \$23,567 | \$11,251 | >1 | >1 | \$27,779 | \$15,463 |
| | Mixed Fuel + 3kW | 4,685 | 0 | 0.9 | n/a | \$5,566 | \$10,256 | \$10,262 | 1.8 | 1.8 | \$4,690 | \$4,696 |
| | Mixed Fuel + 3kW + 5kWh | 4,685 | 0 | 0.9 | n/a | \$8,356 | \$10,256 | \$10,262 | 1.2 | 1.2 | \$1,900 | \$1,906 |
| | Mixed Fuel + 110kW | 171,790 | 0 | 33.3 | n/a | \$204,087 | \$316,293 | \$376,300 | 1.5 | 1.8 | \$112,206 | \$172,213 |
| | Mixed Fuel + 110kW + 50kWh | 170,542 | 0 | 35.1 | n/a | \$231,987 | \$320,349 | \$398,363 | 1.4 | 1.7 | \$88,363 | \$166,376 |
| | All-Electric + 3kW | -17,101 | 2,448 | 8.4 | n/a | -\$21,898 | \$19,523 | \$5,779 | >1 | >1 | \$41,421 | \$27,677 |
| | All-Electric + 3kW + 5kWh | -17,101 | 2,448 | 8.4 | n/a | -\$19,108 | \$19,523 | \$5,779 | >1 | >1 | \$38,631 | \$24,887 |
| | All-Electric + 110kW | 150,004 | 2,448 | 40.8 | n/a | \$176,623 | \$332,213 | \$371,817 | 1.9 | 2.1 | \$155,591 | \$195,194 |
| | All-Electric + 110kW + 50kWh | 148,793 | 2,448 | 42.9 | n/a | \$204,523 | \$335,043 | \$394,099 | 1.6 | 1.9 | \$130,520 | \$189,577 |



Figure 81. Healdsburg Utility Rates Analysis - Small Hotel, All Packages Cost Effectiveness Summary

| Prototype | Package | Elec Savings (kWh) | Gas Savings (therms) | GHG savings (tons) | Compliance Margin (%) | Incremental Package Cost | Lifecycle Energy Cost Savings | -\$TDV Savings | B/C Ratio (On-bill) | B/C Ratio (TDV) | NPV (On-bill) | NPV (TDV) |
|-------------|-----------------------------|--------------------|----------------------|--------------------|-----------------------|--------------------------|-------------------------------|----------------|---------------------|-----------------|---------------|-------------|
| Small Hotel | Mixed Fuel + EE | 3,802 | 976 | 3.9 | 7% | \$20,971 | \$22,829 | \$29,353 | 1.1 | 1.4 | \$1,857 | \$8,381 |
| | Mixed Fuel + EE + PVB | 130,144 | 976 | 31.1 | 7% | \$205,967 | \$254,577 | \$336,575 | 1.2 | 1.6 | \$48,610 | \$130,608 |
| | Mixed Fuel + HE | 981 | 402 | 2.7 | 3% | \$23,092 | \$12,291 | \$11,808 | 0.5 | 0.5 | -\$10,801 | -\$11,284 |
| | All-Electric | - | 12,677 | 40.0 | -12% | -\$1,297,757 | -\$24,318 | -\$51,620 | 53.4 | 25.1 | \$1,273,439 | \$1,246,137 |
| | All-Electric + EE | -88,410 | 12,677 | 45.9 | 5% | -\$1,265,064 | \$45,918 | \$20,860 | >1 | >1 | \$1,310,982 | \$1,285,924 |
| | All-Electric + EE + PVB | 38,115 | 12,677 | 73.5 | 5% | -\$1,080,068 | \$296,233 | \$317,296 | >1 | >1 | \$1,376,301 | \$1,397,365 |
| | All-Electric + HE | - | 12,677 | 41.2 | -11% | -\$1,283,243 | -\$83,994 | -\$44,505 | 15.3 | 28.8 | \$1,199,249 | \$1,238,738 |
| | Mixed Fuel + 3kW | 4,785 | 0 | 0.9 | n/a | \$5,566 | \$8,927 | \$10,332 | 1.6 | 1.9 | \$3,361 | \$4,766 |
| | Mixed Fuel + 3kW + 5kWh | 4,785 | 0 | 0.9 | n/a | \$8,356 | \$8,927 | \$10,332 | 1.1 | 1.2 | \$571 | \$1,976 |
| | Mixed Fuel + 80kW | 127,592 | 0 | 25.0 | n/a | \$148,427 | \$229,794 | \$275,130 | 1.5 | 1.9 | \$81,367 | \$126,703 |
| | Mixed Fuel + 80kW + 50kWh | 126,332 | 0 | 28.1 | n/a | \$176,327 | \$236,570 | \$296,058 | 1.3 | 1.7 | \$60,243 | \$119,731 |
| | All-Electric + 3kW | - | 12,677 | 40.9 | n/a | -\$1,292,191 | -\$14,447 | -\$41,288 | 89.4 | 31.3 | \$1,277,744 | \$1,250,902 |
| | All-Electric + 3kW + 5kWh | - | 12,677 | 40.9 | n/a | -\$1,289,401 | -\$14,447 | -\$41,288 | 89.3 | 31.2 | \$1,274,954 | \$1,248,112 |
| | All-Electric + 80kW | 8,853 | 12,677 | 65.0 | n/a | -\$1,149,330 | \$222,070 | \$223,510 | >1 | >1 | \$1,371,400 | \$1,372,840 |
| | All-Electric + 80kW + 50kWh | 7,849 | 12,677 | 67.4 | n/a | -\$1,121,430 | \$223,812 | \$239,632 | >1 | >1 | \$1,345,241 | \$1,361,062 |





Title 24, Parts 6 and 11
Local Energy Efficiency Ordinances

2019 Mid-Rise New Construction Reach Code Cost-Effectiveness Study

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Last Modified: June 22, 2020

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Acronyms

| | |
|------------------|---|
| 2020 PV\$ | Present value costs in 2020 |
| ACM | Alternative Calculation Method |
| B/C | Lifecycle Benefit-to-Cost Ratio |
| BSC | Building Standards Commission |
| CBECC-Com | Computer program developed by the California Energy Commission for use in demonstrating compliance with the California Residential Building Energy Efficiency Standards |
| CFI | California Flexible Installation |
| CFM | Cubic Feet per Minute |
| CPC | California Plumbing Code |
| CZ | California Climate Zone |
| DHW | Domestic Hot Water |
| DOE | Department of Energy |
| DWHR | Drain Water Heat Recovery |
| EDR | Energy Design Rating |
| EER | Energy Efficiency Ratio |
| EF | Energy Factor |
| EPS | Expanded Polystyrene |
| HERS Rater | Home Energy Rating System Rater |
| HPWH | Heat Pump Water Heater |
| HVAC | Heating, Ventilation, and Air Conditioning |
| IOU | Investor Owned Utility |
| kBtu | kilo-British thermal unit |
| kWh | Kilowatt Hour |
| kW _{DC} | Kilowatt Direct Current. Nominal rated power of a photovoltaic system |
| LBNL | Lawrence Berkeley National Laboratory |
| LCC | Lifecycle Cost |
| MF | Multifamily |
| NAECA | National Appliance Energy Conservation Act |
| 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 |
| SF | Solar Fraction |
| SHGC | Solar Heat Gain Coefficient |
| SMUD | Sacramento Municipal Utility District |
| CASE | Codes and Standards Enhancement |
| TDV | Time Dependent Valuation |
| Therm | Unit for quantity of heat that equals 100,000 British thermal units |
| Title 24 | Title 24, Part 6 |
| TOU | Time-Of-Use |
| UEF | Uniform Energy Factor |
| W | Watts |

1 Introduction

The California Building Energy Efficiency Standards Title 24, Part 6 (Title 24) (California Energy Commission, 2018b) is maintained and updated every three years by two state agencies, the California Energy Commission (Energy Commission) and the Building Standards Commission (BSC). In addition to enforcing the code, local jurisdictions have the authority to adopt local energy efficiency ordinances, or reach codes, that exceed the minimum standards defined by Title 24 (as established by Public Resources Code Section 25402.1(h)2 and Section 10-106 of the Building Energy Efficiency Standards). Local jurisdictions must demonstrate that the requirements of the proposed ordinance are cost-effective and do not result in buildings consuming more energy than is permitted by Title 24. In addition, the jurisdiction must obtain approval from the Energy Commission and file the ordinance with the BSC for the ordinance to be legally enforceable.

This report documents cost-effective combinations of measures that exceed the minimum state requirements, the 2019 Building Energy Efficiency Standards, effective January 1, 2020, for new mid-rise (four- to seven-story) multifamily residential construction. The analysis includes evaluation of both mixed-fuel and all-electric residential construction, documenting that the performance requirements can be met by either type of building design. Compliance package options and cost-effectiveness analysis in all 16 California climate zones (CZs) are presented (see Appendix A – California Climate Zone Map for a graphical depiction of Climate Zone locations).

2 Methodology and Assumptions

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

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

2.1 Building Prototypes

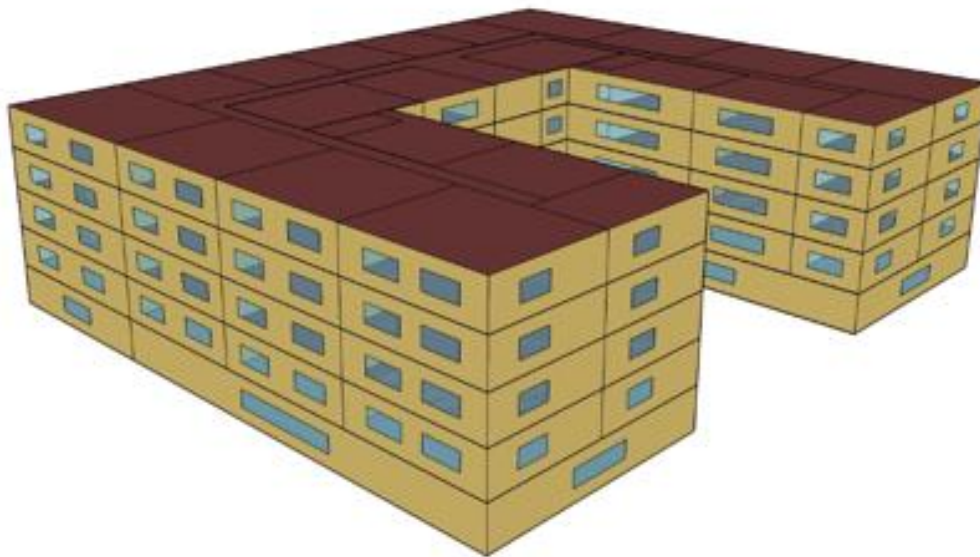
The Energy Commission defines building prototypes which it uses to evaluate the cost-effectiveness of proposed changes to Title 24 requirements. The CEC recently developed new prototype designs for multifamily buildings to more closely reflect typical designs for new multifamily buildings across the state. The new prototypes include two low-rise residential designs, a mid-rise, and a high-rise design. At the time that this report was written, there was one mid-rise multifamily prototype, which is used in this analysis in development of the above-code packages (TRC, 2019). The midrise prototype is a 6-story building with one below-grade parking level, ground floor commercial space, and four stories of residential space. Table 1 describes the basic characteristics of the mid-rise prototype and Figure 1 shows a depiction of the building.



Table 1: Prototype Characteristics

| Characteristic | Multifamily 5-Story Mid-Rise |
|-------------------------------------|---|
| Conditioned Floor Area | 113,100 ft ² Total: 33,660 ft ² Nonresidential & 79,440 ft ² Residential |
| Number of Stories | 6 Stories Total: 1 Story Parking Garage (below grade) 1 Story of Nonresidential Space 4 Stories of Residential Space |
| Number of Dwelling Units / Bedrooms | (8) studios, (40) 1-bed units, (32) 2-bed units, & (8) 3-bed units |
| Foundation | Concrete podium with underground parking |
| Wall Assembly | Wood frame over a first-floor concrete podium |
| Roof Assembly | Flat roof |
| Window-to-Wall Area Ratio | 22.5% |
| HVAC System | Ducted split heat pumps at each apartment |
| Domestic Hot Water System | Gas central boiler with solar thermal sized to meet the prescriptive requirements by climate zone |

Source: TRC 2019



Source: TRC 2019

Figure 1: 5-story mid-rise multifamily prototype depiction.

The methodology used in the analyses for the prototypical building type begins with a design that meets the minimum 2019 Title 24 prescriptive requirements (zero compliance margin). Table 140.3-B and 140.3-C in the 2019 Title 24 (California Energy Commission, 2018a) lists the prescriptive measures that determine the baseline design in each climate zone for the nonresidential and high-rise residential spaces, respectively. Other features are consistent with the Standard Design in the Nonresidential ACM Reference Manual (California Energy Commission, 2019a) with one exception. The apartments use split system heat pumps instead of a split furnace

and air conditioner that is prescribed in Table 2 of the Nonresidential ACM Reference Manual. This modeling choice was made to better reflect current market data, which shows heat pumps to be the most common system type and a very low prevalence of gas furnaces for multifamily buildings four stories and greater. This is based on a report completed by TRC (TRC, 2019) and validated by analysis of CA HERS Registry Data by SCE that showed 47% of low-rise multifamily new construction in the 2013 and 2016 code cycles had electric space heating. The analysis also assumed electric cooking in the apartment units to reflect current market data. Laundry was not addressed in this study. The building prototype assumes central laundry facilities and no laundry in the units.

2.2 Measure Analysis

EnergyPro 8.1, which uses the California Building Energy Code Compliance simulation tool, CBECC-Com 2019.1.2, as the simulation engine, was used to evaluate energy impacts using the 2019 Title 24 prescriptive standards as the benchmark, and the 2019 TDV values. CBECC-Com was used for this analysis to evaluate the mid-rise building for code compliance under the 2019 non-residential standards. TDV is the energy metric used by the Energy Commission since the 2005 Title 24 energy code to evaluate compliance with the Title 24 Standards.

Using the 2019 baseline as the starting point, prospective energy efficiency measures were identified and modeled to determine the projected site energy (Therm and kWh) and compliance impacts. Annual utility costs were calculated using hourly data output from CBECC-Com, and electricity and natural gas tariffs for each of the investor owned utilities (IOUs).

This analysis focused on the residential apartments only. A prior study and report demonstrated the cost-effectiveness of above code packages for nonresidential buildings (Statewide Reach Code Team, 2019a). The Statewide Reach Code Team selected measures for evaluation based on the residential and nonresidential 2019 reach code analysis ((Statewide Reach Code Team, 2019a), (Statewide Reach Code Team, 2019b)) as well as experience with and outreach to architects, builders, and engineers along with general knowledge of the relative acceptance of many measures. Efficiency measure packages found to be cost-effective in the nonresidential building reach code analysis were applied to the nonresidential spaces for evaluating performance relative to compliance, but the incremental costs and energy impacts of these measures on the nonresidential spaces were not included in this analysis. Refer to the nonresidential reach code study for more details (Statewide Reach Code Team, 2019a).

2.2.1 Federal Preemption

The Department of Energy (DOE) sets minimum efficiency standards for equipment and appliances that are federally regulated under the National Appliance Energy Conservation Act (NAECA), including heating, cooling, and water heating equipment. Since state and local governments are prohibited from adopting policies that mandate higher minimum efficiencies than the federal standards require, the focus of this study is to identify and evaluate cost-effective packages that do not include high efficiency equipment. While this study is limited by federal preemption, in practice builders may use any package of compliant measures to achieve the performance goals, including high efficiency appliances. Often, these measures are the simplest and most affordable measures to increase energy performance.

2.2.2 Energy Efficiency Measures

Following are descriptions of each of the efficiency measures evaluated for the residential spaces under this analysis. Because not all of the measures described below were found to be cost-effective, and cost-effectiveness varied by climate zone, not all measures are included in all packages and some of the measures listed are not included in any final package.

Improved Fenestration – Lower U-factor: Reduce window U-factor to 0.25 Btu/hr-ft²-°F. The prescriptive maximum U-factor is 0.36 in all climates. This measure is applied to all windows on floors two through five.



Improved Fenestration – Lower SHGC: Reduce window solar heat gain coefficient (SHGC) to 0.22. The prescriptive maximum SHGC is 0.25 for fixed windows in all climates. The Statewide Reach Code Team evaluated increased SHGC in heating dominated climates (Climate Zone 1, 3, 5, and 16) but results were better with a lower SHGC. This measure is applied to all windows on floors two through five.

Exterior Wall Insulation: Add one inch of R-4 exterior continuous insulation. To meet the prescriptive wall requirements, it's assumed that exterior wall insulation is used in the basecase, therefore this measure adds additional R-value to existing exterior insulation. This measure is applied to all walls on floors two through five.

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

Low Pressure Drop Ducts: Upgrade the duct distribution system to reduce external static pressure and meet a maximum fan efficacy of 0.25 watts per cfm operating at full speed. This may involve upsizing ductwork, reducing the total effective length of ducts, and/or selecting low pressure drop components, such as filters. This measure is applied to the ducted split heat pumps serving the apartments.

Solar Thermal: Prescriptively, central water heating systems require a solar thermal system with a 20% solar fraction in Climates Zones 1 through 9 and 35% solar fraction in Climate Zones 10 through 16. This measure upgrades the prescriptive solar thermal system to meet a 50% solar fraction in all climates, assuming there is available roof space for the additional collectors.

Drain Water Heat Recovery: Add drain water heat recovery with a 50% effectiveness to serve all the apartments. The assumption is for an unequal flow design where the output of the heat exchanger feeds only the cold water inlets to the apartment showers, not the water heater cold water makeup.

Efficiency measures were applied to the nonresidential spaces based on the 2019 Nonresidential Reach Code Cost-Effectiveness Study (Statewide Reach Code Team, 2019a).

2.2.3 All Electric Measures

This analysis assumes that the basecase prototype model uses individual heat pumps for space heating and all electric appliances in the apartments. Therefore, the domestic hot water system is the only equipment serving the apartment spaces to electrify in the all-electric design. The Statewide Reach Code Team evaluated two configurations for electric heat pump water heaters (HPWHs) described below.

Clustered Heat Pump Water Heater: This clustered design uses residential integrated storage HPWHs to serve more than one apartment; 4 to 5 bedrooms on average for a total of 32 HPWHs in the 88-unit building. The water heaters are located in interior closets throughout the building and designed for short plumbing runs without using a hot water recirculation loop. A minimum efficiency 2.0 UEF HPWH was used for this analysis (to avoid federal preemption). This approach has been selectively used in multifamily projects because of its reliance on lower cost small capacity HPWH products. Since it uses residential equipment with each HPWH serving fewer than 8 apartments the CBECC-Com compliance software had the capability to evaluate this design strategy, even before central HPWH recirculation options were incorporated into the software. The clustered strategy is not a prescriptive option but is allowed in the performance path if the water heater serves no more than 8 units and has no recirculation control. The standard design assumes solar thermal, so the proposed design is penalized in compliance for no solar thermal and made up with other efficiency measures.



Prescriptive Central Heat Pump Water Heater: Per Section 150.1(c)8C of the 2019 Standards, the Energy Commission made an executive determination outlining requirements of a prescriptive approach for central heat pump water heating systems in December 2019 (California Energy Commission, 2019b). Key aspects of the prescriptive approach are described below:

- The system must be configured with a design similar to what is presented in the schematic in Figure 2 of the executive determination document.
- HPWH must be single-pass split system with the compressor located outdoors and be able to operate down to -20°F. In CBECC-Com 2019.1.2, the current version at the time of writing this report, the software only has the capability of modeling Sanden HPWHs.
- The system must include either a solar thermal water heating system that meets the current prescriptive requirements or 0.1 kW_{DC} of photovoltaic system capacity per apartment/dwelling unit.

For this configuration the Statewide Reach Code Team evaluated costs for a central HPWH system using Sanden compressors that met these prescriptive requirements. Based on the system sizing requirements, 15 Sanden units and 1,200 gallons of primary storage capacity are required for the 88-unit building. At the time that cost-effectiveness was initially compared for the two HPWH configurations, the latest CBECC-Com software with the ability to model central HPWH systems was not yet available. To estimate the energy use for the central configuration, the water heating energy use for the clustered configuration was used. It is expected that the energy use of the central system will be higher than the clustered approach primarily as a result of recirculation pump energy and losses.

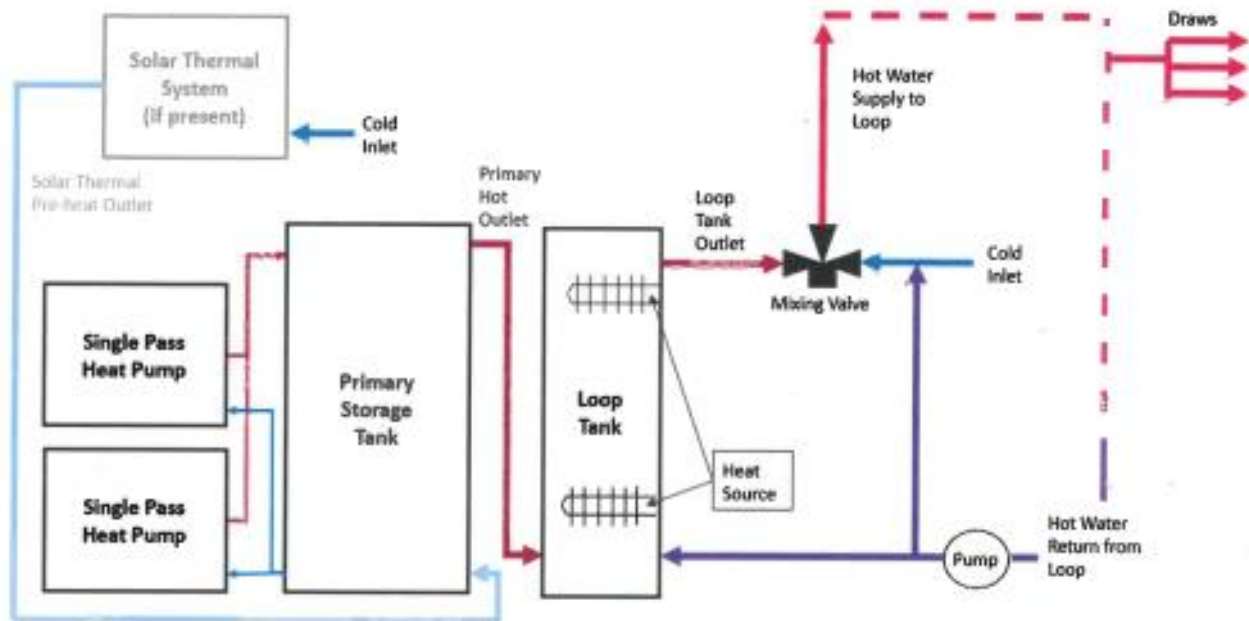


Figure 2: Prescriptive central heat pump water heater system schematic.

All-electric measures were applied to the nonresidential spaces based on the 2019 Nonresidential Reach Code Cost-Effectiveness Study (Statewide Reach Code Team, 2019a).

2.2.4 Renewable Energy

Solar Photovoltaic (PV): There is no existing requirement for PV in the 2019 Title 24 nonresidential code for high-rise residential buildings (four or more stories). The PV sizing methodology was developed to offset a portion of annual residential electricity use and avoid oversizing which would violate net energy metering (NEM)

rules. In all cases, PV is evaluated using the PV simulations within CBECC-Com using a Standard module type, 180 degree azimuth, and 22 degree .tilt. The analysis evaluated PV system capacities equal to 0.1, 0.2, 0.3, and 1 kW_{DC} per apartment. The PV system offsets approximately XX4%, XX8%, XX13%, and 42%, of the apartment electricity usage, respectively. Assuming 15 Watts per square foot for a typical commercial PV system, 1 kW_{DC} per apartment, or 88 kW_{DC} total, would take up about 25% of the total roof area.

2.3 Package Development

Four packages were evaluated for each climate zone, as described below.

- 1) **Efficiency – Mixed-fuel:** This package applies efficiency measures that don't trigger federal preemption including envelope, water heating distribution, and duct distribution efficiency measures.
- 2) **Efficiency – All Electric:** This package applies efficiency measures that don't trigger federal preemption in addition to converting any natural gas appliances to electric appliances. For the residential spaces, only water heating is converted from natural gas to electric.
- 3) **Efficiency & PV – Mixed-fuel:** Beginning with the Efficiency Package , PV was added to offset a portion of the apartment estimated electricity use.
- 4) **Efficiency & PV – All Electric:** Beginning with the Efficiency Package, PV was added to offset a portion of the apartment estimated electricity use.

2.4 Incremental Costs

2.4.1 Energy Efficiency Measure Costs

Table 22 summarizes the incremental cost assumptions for measures evaluated in this study relative to the residential parts of the building. Incremental costs represent the equipment, installation, replacement, and maintenance costs of the proposed measures relative to the base case. Replacement costs are applied to PV inverters and battery systems over the 30-year evaluation period. There is no assumed maintenance on the envelope, HVAC, or DHW measures. Costs were estimated to reflect costs to the building owner. When costs were obtained from a source that did not already include builder overhead and profit, a markup of 10% was added. All costs are provided as present value in 2020 (2020 PV\$). Costs due to variations in furnace, air conditioner, and heat pump capacity by climate zone were not accounted for in the analysis.

Table 2: Incremental Cost Assumptions

| Measure | Performance Level | Incremental Cost (2020 PV\$) | Source & Notes |
|-------------------------------|--|------------------------------|--|
| Non-Preempted Measures | | | |
| Window U-factor | 0.25 vs 0.36 | \$28,301 | \$6.95/ft ² window area based on analysis conducted for the 2019 and 2022 Title 24 code cycles (Statewide CASE Team, 2018). |
| Window SHGC | 0.22 vs 0.25 | \$0 | Data from CASE Report along with direct feedback from Statewide CASE Team that higher SHGC does not necessarily have any incremental cost impact (Statewide CASE Team, 2017b). |
| Exterior Wall Insulation | Add 1-inch | \$14,058 | \$0.86/ft ² based on adding 1" of exterior insulation on a wall with some level of existing exterior insulation. Costs are averaged from two sources ((Statewide CASE Team, 2014), (Statewide CASE Team, 2017a)) and for expanded polystyrene (EPS) and polyisocyanurate products with a 10% mark-up added to account for cost increases over time. |
| HERS Verified Pipe Insulation | HERS verified pipe insulation vs no verification | \$7,260 | \$83 per apartment for a HERS Rater to conduct verification of pipe insulation based on feedback from HERS Raters. |
| Low Pressure Drop Ducts | 0.25 W/cfm vs 0.35 W/cfm | \$12,654 | \$144 per apartment. Costs assume 1.5 hours labor per multifamily apartment. Labor rate of \$96 per hour is from 2019 RSMeans for sheet metal workers and includes an average City Cost Index for labor for California cities. |
| Solar Thermal | 50% solar fraction vs prescriptive 20%-35% | \$79,560 | Costs based on 2022 multifamily solar thermal measure CASE proposal (Statewide CASE Team, 2020) and include first cost of \$70,727 and \$8,834 present value for replacement/maintenance costs. |
| Drain Water Heat Recovery | 50% effectiveness, flows to shower | \$16,984 | Costs from 2019 DWHR CASE Report which assumes 1 heat exchanger per 4 units (Statewide CASE Team, 2017c). Costs do not include additional cost of water meters at each apartment (per SB7), which would add approx. \$175 per dwelling unit. |
| Renewable Energy (PV) | | | |
| PV System | System size varies | \$3.17/W _{DC} | First costs are from LBNL's Tracking the Sun 2018 costs (Barbose et al., 2018) and represent costs for the first half of 2018 of \$2.90/W _{DC} for nonresidential systems ≤500 kW _{DC} . These costs were reduced by 16% for the solar investment tax credit, which is the average credit over years 2020-2022. Inverter replacement cost of \$0.14/W _{DC} present value includes replacements at year 11 at \$0.15/W _{DC} (nominal) and at year 21 at \$0.12/W _{DC} (nominal) per the 2019 PV CASE Report (California Energy Commission, 2017). System maintenance costs of \$0.31/W _{DC} present value assumes additional \$0.02/W _{DC} (nominal) annually per the 2019 PV CASE Report (California Energy Commission, 2017). 10% overhead and profit added to all costs. |



2.4.2 All Electric Measure Costs

The Statewide Reach Code Team reached out to stakeholders to collect project cost information for central gas boilers and both clustered and central HPWH designs. Project data sources included Association for Energy Affordability (AEA), Redwood Energy, Mithun, Ecotope, and the All-Electric Multifamily Compliance Pathway 2022 Draft CASE Report (Statewide CASE Team, 2020). Costs are presented in Table 3.

Table 3: Costs for Gas versus Electric Water Heating Equipment over 30-Year Period of Analysis

| | Central Gas Boiler (CZs 1-9) | Central Gas Boiler (CZs 10-16) | Clustered HPWH | Central HPWH |
|---|------------------------------|--------------------------------|---------------------------------------|---|
| System Quantity/Description | 1 boiler recirc | | 32 units 80 gal. each no recirc | 15 units .1,200-gal total recirc |
| Total Equipment Cost | \$98,733 | | \$126,778 | \$213,364 |
| Solar Thermal | (20% SF) 110,096 | (35% SF) \$131,817 | - | - |
| Solar PV | - | - | - | \$23,580 (8.8 kW _{DC}) |
| Total First Cost | \$202,920 | \$224,641 | \$126,778 | \$236,944 |
| Maintenance/Replacement Cost (NPV) | \$69,283 | \$69,283 | \$81,374 | \$120,683 |
| Total Cost (NPV) | \$272,203 | \$293,924 | \$208,152 | \$357,627 |
| Incremental Cost CZ 1-9 (NPV) | | | (\$64,051) | \$85,424 |
| Incremental Cost CZ 10-16 (NPV) | | | (\$85,772) | \$63,703 |

Typical costs for the water heating systems are based on the following assumptions:

Central Gas Boiler: Based on the average of total estimated project costs from contractors for four multi-family projects ranging from 32 to 340 apartments and cost estimates for mid-rise and high-rise buildings from the All-Electric Multifamily Compliance Pathway 2022 Draft CASE Report (Statewide CASE Team, 2020). The cost per dwelling unit ranged from \$547 to \$2,089 and the average cost applied in this analysis was \$1,122 per dwelling unit. Costs include installation of gas piping from the building meter to the water heater. Water heater lifetime is assumed to be 15 years and the net present value replacement cost at year 15 is \$63,373.

Clustered HPWH: Based on costs from one project with RHEEM HPWHs used in a clustered design. Costs include water heater interior closet, electrical outlets, and increased breaker size and sub feed. Water heater based on 2.0 UEF 80-gallon appliance with 32 total HPWHs serving the building (1 per 4 to 5 bedrooms). Water heater lifetime is assumed to be 15 years and the net present value replacement cost at year 15 is \$81,374. This design assumes 8 water heater closets per floor, at approximately 15 square feet per closet. While this has an impact on leasable floor area, the design impacts have been found to be minimal when addressed early in design.

Central HPWH: Based on average total installed project costs from four multi-family projects with Sanden HPWHs ranging from 4 to 16 Sanden units per project. The cost per Sanden HPWH ranged from \$13,094 to \$15,766 and the average cost applied in this analysis was \$14,224 per HPWH. Based on the prescriptive system sizing requirements, 15 Sanden units are required for the 88-unit building, resulting in a total first cost of \$213,364. Water heater lifetime is assumed to be 15 years. Because Sanden HPWHs are an emerging technology in the United States, it is expected that over time their costs will decrease and for replacement at year 15 the costs are assumed to have decreased by 15%.



Solar Thermal: Based on system costs provided in the All-Electric Multifamily Compliance Pathway 2022 Draft CASE Report (Statewide CASE Team, 2020). First costs reflect the material, labor, and markup costs presented in the Draft CASE Report for the mid-rise prototype. Replacement and maintenance costs assume replacement of the solar thermal tank at year 15 at \$6,110 and glycol replacement of \$1,300 each time at years 9, 18, and 27. The cost of the remaining useful life of the glycol at year 30 is deducted from the final cost. The Draft CASE Report included costs for replacing the solar collectors at year 20. Collectors can have longer lifetimes up to 30 years if well maintained, therefore this analysis does not assume any replacement of the collectors over the 30 year analysis period.

Table 4: Solar Thermal Detailed Costs over 30-Year Period of Analysis

| Solar Fraction | 20% | 35% |
|------------------------------|------------------|------------------|
| Materials | \$33,975 | \$48,975 |
| Labor | \$47,740 | \$49,776 |
| Markup | 27.5% | 27.5% |
| First Cost | \$104,187 | \$125,908 |
| Replacement/Maintenance (PV) | \$5,910 | \$5,910 |
| Total PV Cost | \$110,096 | \$131,817 |

2.4.3 *Natural Gas Infrastructure Costs*

This analysis assumes that in an all-electric new construction project, natural gas would not be supplied to the building. Eliminating natural gas to the building would save costs associated with connecting a service line from the street main to the building, piping distribution within the building, and monthly meter connection charges from the utility. Incremental costs for natural gas infrastructure in the mixed-fuel building are presented in Table 5. Cost data for the plan review and service extension was estimated on a per building basis and then **apportioned to the residential and nonresidential portions of the buildings based on annual gas consumption.** For the basecase prototype building 49% to 93% of estimated building annual gas use is attributed to the residential water heating system across all climate zones. A statewide average of 80% was calculated and applied to the costs in Table 5 based on housing starts provided by the California Energy Commission for the 2019 Title 24 code development process. The meter costs were based on the service provided to the residential and nonresidential portion of the building separately. Following the table are descriptions of assumptions for each of the cost components. Costs for gas piping from the meter to the gas boilers are included in the central gas boiler costs above. Gas piping distribution costs were typically included in total project costs and could not be broken out in all cases.

Table 5: Natural Gas Infrastructure Cost Savings for All-Electric Building

| Item | Total | NonResidential Portion | Residential Portion |
|--------------------------------|-----------------|------------------------|---------------------|
| Natural Gas Plan Review | \$2,316 | \$452 | \$1,864 |
| Service Extension ¹ | \$4,600 | \$898 | \$3,702 |
| Meter | \$7,200 | \$3,600 | \$3,600 |
| Total First Cost | \$14,116 | \$4,950 | \$9,166 |

¹Service extension costs include 50% reduction assuming portion of the costs are passed on to gas customers.

Natural Gas Plan Review: Total costs are based on TRC's 2019 reach code analysis for Palo Alto (TRC, 2019) and then split between the residential and nonresidential spaces in the building proportionately according to annual gas consumption with 80% of the annual load is attributed to residential units on a statewide basis.

Service Extension: Service extension costs to the building were taken from PG&E memo dated December 5, 2019, to Energy Commission staff, include costs for trenching, and assume non-residential new construction within a developed area (see Appendix C – PG&E Gas Infrastructure Cost Memo, PG&E, 2019). The total cost of



\$9,200 from the memo is reduced by 50% to account for the portion of the costs paid for by all customers due to application of Utility Gas Main Extensions rules¹. The resultant cost is apportioned between the residential and nonresidential spaces in the building based on annual gas consumption of residential and nonresidential uses, with 80% of the annual load natural gas use attributed to residential units on a statewide basis.

Meter: Cost per meter provided by PG&E for commercial meters. Assume one meter for nonresidential boilers serving space heating and service water heating, and another for residential boilers serving domestic hot water.

2.5 Cost-effectiveness

Cost-effectiveness was evaluated for all 16 California climate zones and is presented based on both TDV energy, using the Energy Commission’s LCC methodology, and an On-Bill approach using residential customer utility rates. Both methodologies require estimating and quantifying the value of the energy impact associated with energy efficiency measures over the life of the measures (30 years) as compared to the prescriptive Title 24 requirements.

Cost-effectiveness is presented using both lifecycle net present value (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.

- **Net Present Value (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).
- **Benefit-to-Cost (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 greater than 1.0. 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.

¹ PG&E Rule 15: https://www.pge.com/tariffs/tm2/pdf/GAS_RULES_15.pdf

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

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



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

Equation 2

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

Where:

- n = analysis term
- r = real discount rate
- t = year at which cost/benefit is incurred

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

- Analysis term of 30 years
- Real discount rate of 3% (does not include inflation)

2.5.1 On-Bill Customer Lifecycle Cost

Residential utility rates were used to calculate utility costs for all cases and determine On-Bill customer cost-effectiveness for the proposed packages. Utility costs of the nonresidential spaces were not evaluated in this study, only apartment and water heating energy use. 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. Annual utility costs were calculated using hourly electricity and gas output from CBECC-Com, and applying the utility tariffs summarized in Table 6. Appendix B – Utility Tariff Details includes details on the utility rate schedules used for this study. The applicable residential time-of-use (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 a lot of uncertainty about what those changes will be and if they will become effective during the 2019 Title 24 code cycle (2020-2022).

Based on guidance from the IOUs, the residential electric TOU tariffs that apply to individually metered residential apartments were also used to calculate electricity costs for the central water heating systems. Where baseline allowances are included in the tariffs (SCE TOU-D and SDG&E TOU-DR1) the allowances were applied on a per unit basis for all-electric service.

Based on guidance from the IOUs, master metered multifamily service gas tariffs were used to calculate gas costs for the central water heating systems. The baseline quantities were applied on a per unit basis, as is defined in the schedules, and when available water heating only baseline values were used.

Utility rates were applied to each climate zone based on the predominant IOU serving the population of each zone according to Table 6. 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, Sacramento Municipal Utility District (SMUD) in Climate Zone 12 and City of Palo Alto Utilities (CPAU) in Climate Zone 4.



Table 6: IOU Utility Tariffs Applied Based on Climate Zone

| Climate Zones | Electric/Gas Utility | Electricity (Apartment Use) | Electricity (Central Water Heating) | Natural Gas (Central Water Heating) ¹ |
|----------------|----------------------|-----------------------------|-------------------------------------|--|
| 1-5, 11-13, 16 | PG&E | E-TOU-C | E-TOU-C | PG&E GM |
| 5 | PG&E/SoCalGas | | | SoCalGas GM-E |
| 6, 8-10, 14,15 | SCE/SoCalGas | TOU-D (Option 4-9) | TOU-D (Option 4-9) | SoCalGas GM-E |
| 7, 10, 14 | SDG&E | TOU-DR1 | TOU-DR1 | SDG&E GM |
| 12 | SMUD/PG&E | R-TOD (RT02) | GSN-T | PG&E GM |
| 4 | CPAU | E-1 | E-2 | G-2 |

¹ These rates are allowed assuming no gas is used in the apartments.

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

2.5.2 TDV Lifecycle Cost

Cost-effectiveness was also assessed using the Energy Commission’s TDV LCC methodology. TDV is a normalized monetary format developed and used by the Energy Commission for comparing electricity and natural gas savings, and it considers the cost of electricity and natural gas consumed during different times of the day and year. The 2019 TDV values are based on long term discounted costs of 30 years for all residential measures. The CBECC-Com simulation software results are expressed in terms of TDV kBtus. The present value of the energy cost savings in dollars is calculated by multiplying the TDV kBtu savings by a net present value (NPV) factor, also developed by the Energy Commission. The 30-year NPV factor is \$0.154/TDV kBtu for nonresidential projects under 2019 Title 24.

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.

Equation 3

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

2.6 Greenhouse Gas Emissions

Equivalent CO2 emission savings were calculated based on estimates from Zero Code reports available in CBECC-Com simulation software.² Electricity emissions vary by region and by hour of the year, accounting for time dependent energy use and carbon emissions based on source emissions, including renewable portfolio standard

² More information at: : <https://zero-code.org/wp-content/uploads/2018/11/ZERO-Code-TSD-California.pdf>



projections. Two distinct hourly profiles, one for Climate Zones 1 through 5 and 11 through 13 and another for Climate Zones 6 through 10 and 14 through 16. For natural gas a fixed factor of 0.005307 metric tons/therm is used. To compare the mixed fuel and all-electric cases side-by-side, greenhouse gas (GHG) emissions are presented as CO₂-equivalent emissions per dwelling unit.

3 Results

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

This analysis evaluated a package of efficiency measures applied to a mixed-fuel design and a similar package for an all-electric design. Each design was evaluated using the predominant utility rates in all 16 California climate zones. Solar PV was also added to the efficiency packages and a sensitivity analysis was conducted at various PV system capacities to optimize cost-effectiveness.

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

- Improved fenestration
- Wall insulation
- Low pressure-drop distribution system
- HERS verified pipe insulation

The following measures were evaluated but were found to not be cost-effective and were not included in any of the packages.

- Solar thermal system with higher solar fraction than prescriptive requirements
- Drain water heat recovery

Cost-effectiveness results for the all-electric case are based upon the clustered HPWH approach only. Lower first costs with the clustered approach resulted in better cost-effectiveness than the central HPWH design.

3.1 Mid-Rise Multifamily Results

Table 7 and Table 9 present results for the mixed-fuel and all-electric packages, respectively. Each table shows cost-effectiveness results for **Efficiency Only** packages and **Efficiency + PV** packages (with a 17.6 kW_{DC} PV system sized based on 0.2 kW_{DC} per apartment). Both mixed-fuel and all-electric results are relative to the mixed-fuel 2019 Title 24 prescriptive baseline. B/C ratios for all packages are presented according to both the On-Bill and TDV methodologies for the mixed-fuel and the all-electric cases, respectively. Detailed results are presented in *Appendix D – Detailed Results Mixed-Fuel* and *Appendix E – Detailed Results All-Electric*.

Efficiency Only:

Compliance margins for the **Mixed-Fuel Efficiency Only** cases range from 5% to 8%, which meets the CALGreen Tier 1 energy performance requirement for high-rise residential buildings. **Mixed-Fuel Efficiency Only** cases are cost-effective based on TDV in all climate zones except for 1 and 16. The cases are cost-effective from an On-Bill perspective in all climate zones except 1.

The **All-Electric Efficiency Only** package does not meet minimum code requirements in Climate Zones 1 and 16. Compliance margins for all other climate zones range from 1% to 5%. **All-Electric Efficiency Only** cases are cost-

effective in all climate zones based on TDV. Cost-effectiveness from an On-Bill perspective is favorable in all climate zones except 1, 16, and 5 in SCG territory.

Efficiency + PV:

Several PV system size options were evaluated for the **Efficiency + PV** packages. Of the PV system sizes evaluated, 0.2 kW_{DC} per apartment represents the smallest system that resulted in B/C ratios greater than one based on both metrics in all climate zones for the mixed-fuel scenario. Adding a 0.1 kW_{DC} per apartment in the all-electric cases, resulted in B/C ratios greater than one in all climate zones.

Table 11 and Table 12 describe the efficiency measures included in the mixed-fuel and all-electric packages, respectively.



Table 7: Mixed-Fuel Package Results: Efficiency Only (SAVINGS/COST PER APARTMENT)

| Climate Zone | Elec Utility | Gas Utility | Comp. Margin | Total Gas Savings (therms) | Total Electric Savings (kWh) | GHG Reductions (lb. CO2) | Savings (2020 PV\$) | | Incremental Cost (2020 PV\$) | B/C Ratio ¹ | | NPV | |
|--------------|--------------|-------------|--------------|----------------------------|------------------------------|--------------------------|----------------------|-------------|------------------------------|------------------------|------|---------|---------|
| | | | | | | | Utility Cost Savings | TDV Savings | | On-Bill | TDV | On-Bill | TDV |
| CZ01 | PGE | PGE | 5.8% | 0 | 26 | 18 | \$133 | \$105 | \$304 | 0.44 | 0.35 | (\$171) | (\$199) |
| CZ02 | PGE | PGE | 5.9% | 0 | 47 | 29 | \$391 | \$285 | \$144 | 2.72 | 1.98 | \$248 | \$141 |
| CZ03 | PGE | PGE | 6.7% | 0 | 44 | 27 | \$345 | \$226 | \$144 | 2.40 | 1.57 | \$202 | \$82 |
| CZ04 | PGE | PGE | 6.6% | 0 | 61 | 37 | \$465 | \$331 | \$144 | 3.24 | 2.31 | \$321 | \$188 |
| CZ04-2 | CPAU | CPAU | 6.6% | 0 | 61 | 37 | \$248 | \$331 | \$144 | 1.73 | 2.31 | \$104 | \$188 |
| CZ05 | PGE | PGE | 6.7% | 0 | 42 | 24 | \$320 | \$206 | \$144 | 2.22 | 1.43 | \$176 | \$62 |
| CZ05-2 | PGE | SCG | 6.7% | 0 | 42 | 24 | \$320 | \$206 | \$144 | 2.22 | 1.43 | \$176 | \$62 |
| CZ06 | SCE | SCG | 7.1% | 0 | 74 | 42 | \$424 | \$351 | \$144 | 2.95 | 2.44 | \$280 | \$207 |
| CZ07 | SDGE | SDGE | 7.6% | 0 | 81 | 48 | \$593 | \$374 | \$144 | 4.13 | 2.60 | \$449 | \$230 |
| CZ08 | SCE | SCG | 7.0% | 0 | 84 | 50 | \$484 | \$420 | \$144 | 3.37 | 2.92 | \$341 | \$276 |
| CZ09 | SCE | SCG | 6.5% | 0 | 83 | 51 | \$468 | \$441 | \$144 | 3.26 | 3.06 | \$324 | \$297 |
| CZ10 | SCE | SCG | 6.5% | 0 | 82 | 50 | \$410 | \$427 | \$144 | 2.85 | 2.97 | \$266 | \$283 |
| CZ10-2 | SDGE | SDGE | 6.5% | 0 | 82 | 50 | \$599 | \$427 | \$144 | 4.16 | 2.97 | \$455 | \$283 |
| CZ11 | PGE | PGE | 6.8% | 0 | 104 | 70 | \$637 | \$635 | \$625 | 1.02 | 1.02 | \$11 | \$10 |
| CZ12 | PGE | PGE | 6.8% | 0 | 93 | 60 | \$572 | \$568 | \$304 | 1.88 | 1.87 | \$268 | \$265 |
| CZ12-2 | SMUD | PGE | 6.8% | 0 | 93 | 71 | \$319 | \$568 | \$304 | 1.05 | 1.87 | \$15 | \$265 |
| CZ13 | PGE | PGE | 7.3% | 0 | 132 | 89 | \$798 | \$779 | \$625 | 1.28 | 1.25 | \$173 | \$154 |
| CZ14 | SCE | SCG | 6.0% | 0 | 80 | 49 | \$407 | \$449 | \$304 | 1.34 | 1.48 | \$103 | \$145 |
| CZ14-2 | SDGE | SDGE | 6.0% | 0 | 80 | 49 | \$576 | \$449 | \$304 | 1.90 | 1.48 | \$273 | \$145 |
| CZ15 | SCE | SCG | 6.8% | 0 | 145 | 93 | \$719 | \$802 | \$625 | 1.15 | 1.28 | \$94 | \$177 |
| CZ16 | PGE | PGE | 7.4% | 0 | 117 | 76 | \$646 | \$563 | \$625 | 1.03 | 0.90 | \$21 | (\$62) |

¹ Values in red indicate B/C ratios less than 1.



Table 8: Mixed-Fuel Package Results: PV + Efficiency 0.2 kW_{DC} per Apartment (SAVINGS/COST PER APARTMENT)

| Climate Zone | Elec Utility | Gas Utility | Comp. Margin | Total Gas Savings (therms) | Total Electric Savings (kWh) | GHG Reductions (lb. CO ₂) | Savings (2020 PV\$) | | Incremental Cost (2020 PV\$) | B/C Ratio ¹ | | NPV | |
|--------------|--------------|-------------|--------------|----------------------------|------------------------------|---------------------------------------|----------------------|-------------|------------------------------|------------------------|------|---------|-------|
| | | | | | | | Utility Cost Savings | TDV Savings | | On-Bill | TDV | On-Bill | TDV |
| CZ01 | PGE | PGE | 5.8% | 0 | 291 | 131 | \$1,637 | \$1,090 | \$937 | 1.75 | 1.16 | \$701 | \$153 |
| CZ02 | PGE | PGE | 5.9% | 0 | 360 | 163 | \$2,431 | \$1,469 | \$777 | 3.13 | 1.89 | \$1,655 | \$692 |
| CZ03 | PGE | PGE | 6.7% | 0 | 359 | 161 | \$2,400 | \$1,397 | \$777 | 3.09 | 1.80 | \$1,624 | \$620 |
| CZ04 | PGE | PGE | 6.6% | 0 | 385 | 176 | \$2,579 | \$1,562 | \$777 | 3.32 | 2.01 | \$1,802 | \$785 |
| CZ04-2 | CPAU | CPAU | 6.6% | 0 | 61 | 176 | \$1,335 | \$1,562 | \$777 | 1.72 | 2.01 | \$558 | \$785 |
| CZ05 | PGE | PGE | 6.7% | 0 | 379 | 168 | \$2,480 | \$1,461 | \$777 | 3.19 | 1.88 | \$1,704 | \$685 |
| CZ05-2 | PGE | SCG | 6.7% | 0 | 379 | 168 | \$2,480 | \$1,461 | \$777 | 3.19 | 1.88 | \$1,704 | \$685 |
| CZ06 | SCE | SCG | 7.1% | 0 | 392 | 178 | \$1,987 | \$1,587 | \$777 | 2.56 | 2.04 | \$1,210 | \$810 |
| CZ07 | SDGE | SDGE | 7.6% | 0 | 411 | 189 | \$2,770 | \$1,647 | \$777 | 3.57 | 2.12 | \$1,993 | \$870 |
| CZ08 | SCE | SCG | 7.0% | 0 | 402 | 186 | \$2,059 | \$1,708 | \$777 | 2.65 | 2.20 | \$1,282 | \$931 |
| CZ09 | SCE | SCG | 6.5% | 0 | 410 | 192 | \$1,876 | \$1,742 | \$777 | 2.41 | 2.24 | \$1,099 | \$965 |
| CZ10 | SCE | SCG | 6.5% | 0 | 409 | 190 | \$1,797 | \$1,681 | \$777 | 2.31 | 2.16 | \$1,020 | \$904 |
| CZ10-2 | SDGE | SDGE | 6.5% | 0 | 409 | 190 | \$2,646 | \$1,681 | \$777 | 3.41 | 2.16 | \$1,869 | \$904 |
| CZ11 | PGE | PGE | 6.8% | 0 | 422 | 206 | \$2,438 | \$1,877 | \$1,258 | 1.94 | 1.49 | \$1,180 | \$619 |
| CZ12 | PGE | PGE | 6.8% | 0 | 406 | 193 | \$2,352 | \$1,794 | \$937 | 2.51 | 1.91 | \$1,415 | \$857 |
| CZ12-2 | SMUD | PGE | 6.8% | 0 | 406 | 193 | \$1,226 | \$1,794 | \$937 | 1.31 | 1.91 | \$289 | \$857 |
| CZ13 | PGE | PGE | 7.3% | 0 | 441 | 221 | \$2,548 | \$1,965 | \$1,258 | 2.03 | 1.56 | \$1,290 | \$707 |
| CZ14 | SCE | SCG | 6.0% | 0 | 439 | 201 | \$1,923 | \$1,901 | \$937 | 2.05 | 2.03 | \$987 | \$964 |
| CZ14-2 | SDGE | SDGE | 6.0% | 0 | 439 | 201 | \$2,819 | \$1,901 | \$937 | 3.01 | 2.03 | \$1,882 | \$964 |
| CZ15 | SCE | SCG | 6.8% | 0 | 478 | 234 | \$2,128 | \$2,110 | \$1,258 | 1.69 | 1.68 | \$870 | \$852 |
| CZ16 | PGE | PGE | 7.4% | 0 | 457 | 222 | \$2,567 | \$1,818 | \$1,258 | 2.04 | 1.44 | \$1,309 | \$560 |

¹ Values in red indicate B/C ratios less than 1.



Table 9: All-Electric Package Results: Efficiency Only (SAVINGS/COSTS PER APARTMENT)

| Climate Zone | Elec Utility | Gas Utility | Comp. Margin | Total Gas Savings (therms) | Total Electric Savings (kWh) | GHG Reductions (lb. CO2) | Savings (2020 PV\$) | | Incremental Cost (2020 PV\$) | B/C Ratio ^{1,2} | | NPV | |
|--------------|--------------|-------------|--------------|----------------------------|------------------------------|--------------------------|----------------------|-------------|------------------------------|--------------------------|-----|---------|---------|
| | | | | | | | Utility Cost Savings | TDV Savings | | On-Bill | TDV | On-Bill | TDV |
| CZ01 | PGE | PGE | -0.4% | 125 | -873 | 1040 | -\$674 | \$199 | -\$446 | 0.7 | >1 | (\$228) | \$645 |
| CZ02 | PGE | PGE | 1.6% | 114 | -762 | 971 | -\$238 | \$528 | -\$606 | 2.5 | >1 | \$368 | \$1,134 |
| CZ03 | PGE | PGE | 1.1% | 115 | -767 | 975 | -\$287 | \$390 | -\$606 | 2.1 | >1 | \$319 | \$996 |
| CZ04 | PGE | PGE | 3.4% | 111 | -714 | 952 | -\$102 | \$625 | -\$606 | 6.0 | >1 | \$504 | \$1,231 |
| CZ04-2 | CPAU | CPAU | 3.4% | 111 | -714 | 952 | \$345 | \$625 | -\$606 | >1 | >1 | \$951 | \$1,231 |
| CZ05 | PGE | PGE | 1.3% | 117 | -788 | 991 | -\$350 | \$391 | -\$606 | 1.7 | >1 | \$255 | \$996 |
| CZ05-2 | PGE | SCG | 1.3% | 117 | -788 | 991 | -\$827 | \$391 | -\$606 | 0.7 | >1 | (\$221) | \$996 |
| CZ06 | SCE | SCG | 3.7% | 107 | -670 | 933 | \$153 | \$612 | -\$606 | >1 | >1 | \$759 | \$1,218 |
| CZ07 | SDGE | SDGE | 4.8% | 106 | -653 | 930 | -\$58 | \$665 | -\$606 | 10.4 | >1 | \$547 | \$1,271 |
| CZ08 | SCE | SCG | 3.9% | 104 | -633 | 912 | \$227 | \$693 | -\$606 | >1 | >1 | \$833 | \$1,298 |
| CZ09 | SCE | SCG | 3.8% | 104 | -633 | 912 | \$212 | \$739 | -\$606 | >1 | >1 | \$817 | \$1,345 |
| CZ10 | SCE | SCG | 1.8% | 90 | -626 | 743 | -\$214 | \$396 | -\$853 | 4.0 | >1 | \$639 | \$1,249 |
| CZ10-2 | SDGE | SDGE | 1.8% | 90 | -626 | 743 | -\$478 | \$396 | -\$853 | 1.8 | >1 | \$375 | \$1,249 |
| CZ11 | PGE | PGE | 2.0% | 91 | -619 | 769 | -\$241 | \$430 | -\$371 | 1.5 | >1 | \$130 | \$802 |
| CZ12 | PGE | PGE | 1.4% | 94 | -662 | 773 | -\$414 | \$288 | -\$693 | 1.7 | >1 | \$279 | \$980 |
| CZ12-2 | SMUD | PGE | 1.4% | 94 | -662 | 773 | \$1,060 | \$288 | -\$693 | >1 | >1 | \$1,753 | \$980 |
| CZ13 | PGE | PGE | 2.6% | 90 | -579 | 777 | -\$62 | \$505 | -\$371 | 6.0 | >1 | \$309 | \$876 |
| CZ14 | SCE | SCG | 1.1% | 92 | -653 | 759 | -\$258 | \$305 | -\$693 | 2.7 | >1 | \$435 | \$998 |
| CZ14-2 | SDGE | SDGE | 1.1% | 92 | -653 | 759 | -\$532 | \$305 | -\$693 | 1.3 | >1 | \$161 | \$998 |
| CZ15 | SCE | SCG | 4.4% | 74 | -409 | 679 | \$332 | \$832 | -\$371 | >1 | >1 | \$704 | \$1,203 |
| CZ16 | PGE | PGE | -5.8% | 108 | -777 | 895 | -\$621 | \$127 | -\$371 | 0.6 | >1 | (\$250) | \$498 |

¹ Values in red indicate B/C ratios less than 1.

² ">1" indicates cases where there are both incremental measure cost savings and energy cost savings.



Table 10: All-Electric Package Results: PV + Efficiency 0.1 kW_{DC} per Apartment (SAVINGS/COSTS PER APARTMENT)

| Climate Zone | Elec Utility | Gas Utility | Comp. Margin | Total Gas Savings (therms) | Total Electric Savings (kWh) | GHG Reductions (lb. CO ₂) | Savings (2020 PV\$) | | Incremental Cost (2020 PV\$) | B/C Ratio ^{1,2} | | NPV | |
|--------------|--------------|-------------|--------------|----------------------------|------------------------------|---------------------------------------|----------------------|-------------|------------------------------|--------------------------|-----|---------|---------|
| | | | | | | | Utility Cost Savings | TDV Savings | | On-Bill | TDV | On-Bill | TDV |
| CZ01 | PGE | PGE | -0.4% | 125 | -741 | 1,097 | \$78 | \$692 | -\$129 | >1 | >1 | \$208 | \$821 |
| CZ02 | PGE | PGE | 1.6% | 114 | -606 | 1,038 | \$782 | \$1,120 | -\$289 | >1 | >1 | \$1,071 | \$1,409 |
| CZ03 | PGE | PGE | 1.1% | 115 | -609 | 1,042 | \$741 | \$975 | -\$289 | >1 | >1 | \$1,030 | \$1,264 |
| CZ04 | PGE | PGE | 3.4% | 111 | -552 | 1,021 | \$955 | \$1,240 | -\$289 | >1 | >1 | \$1,244 | \$1,529 |
| CZ04-2 | CPAU | CPAU | 3.4% | 111 | -714 | 1,021 | \$904 | \$1,240 | -\$289 | >1 | >1 | \$1,194 | \$1,529 |
| CZ05 | PGE | PGE | 1.3% | 117 | -619 | 1,063 | \$730 | \$1,018 | -\$289 | >1 | >1 | \$1,019 | \$1,307 |
| CZ05-2 | PGE | SCG | 1.3% | 117 | -619 | 1,063 | \$254 | \$1,018 | -\$289 | >1 | >1 | \$543 | \$1,307 |
| CZ06 | SCE | SCG | 3.7% | 107 | -512 | 1,001 | \$935 | \$1,231 | -\$289 | >1 | >1 | \$1,224 | \$1,520 |
| CZ07 | SDGE | SDGE | 4.8% | 106 | -488 | 1,000 | \$1,049 | \$1,302 | -\$289 | >1 | >1 | \$1,339 | \$1,591 |
| CZ08 | SCE | SCG | 3.9% | 104 | -474 | 981 | \$1,014 | \$1,337 | -\$289 | >1 | >1 | \$1,304 | \$1,626 |
| CZ09 | SCE | SCG | 3.8% | 104 | -469 | 983 | \$924 | \$1,390 | -\$289 | >1 | >1 | \$1,213 | \$1,679 |
| CZ10 | SCE | SCG | 1.8% | 90 | -463 | 813 | \$480 | \$1,023 | -\$536 | >1 | >1 | \$1,016 | \$1,559 |
| CZ10-2 | SDGE | SDGE | 1.8% | 90 | -463 | 813 | \$546 | \$1,023 | -\$536 | >1 | >1 | \$1,082 | \$1,559 |
| CZ11 | PGE | PGE | 2.0% | 91 | -460 | 837 | \$660 | \$1,052 | -\$55 | >1 | >1 | \$714 | \$1,106 |
| CZ12 | PGE | PGE | 1.4% | 94 | -505 | 839 | \$476 | \$900 | -\$376 | >1 | >1 | \$852 | \$1,276 |
| CZ12-2 | SMUD | PGE | 1.4% | 94 | -505 | 839 | \$1,513 | \$900 | -\$376 | >1 | >1 | \$1,890 | \$1,276 |
| CZ13 | PGE | PGE | 2.6% | 90 | -424 | 843 | \$813 | \$1,098 | -\$55 | >1 | >1 | \$867 | \$1,153 |
| CZ14 | SCE | SCG | 1.1% | 92 | -473 | 835 | \$500 | \$1,031 | -\$376 | >1 | >1 | \$877 | \$1,407 |
| CZ14-2 | SDGE | SDGE | 1.1% | 92 | -473 | 835 | \$589 | \$1,031 | -\$376 | >1 | >1 | \$965 | \$1,407 |
| CZ15 | SCE | SCG | 4.4% | 74 | -242 | 750 | \$1,037 | \$1,485 | -\$55 | >1 | >1 | \$1,091 | \$1,540 |
| CZ16 | PGE | PGE | -5.8% | 108 | -608 | 969 | \$339 | \$754 | -\$55 | >1 | >1 | \$394 | \$809 |

¹ Values in red indicate B/C ratios less than 1.

² ">1" indicates cases where there are both incremental measure cost savings and energy cost savings.



Table 11: Mixed-Fuel Measure Package Summary

| Climate Zone | Compliance Margin | MEASURE SPECIFICATION | | | | |
|--------------|-------------------|-----------------------|-------------|---------------|---------------|----------------|
| | | Window U-value | Window SHGC | Add Wall Ins. | Fan Watt Draw | HERS Pipe Ins. |
| CZ01 | 5.8% | | | + 1" | 0.25 W/cfm | No |
| CZ02 | 5.9% | | 0.22 | | 0.25 W/cfm | No |
| CZ03 | 6.7% | | 0.22 | | 0.25 W/cfm | No |
| CZ04 | 6.6% | | 0.22 | | 0.25 W/cfm | No |
| CZ05 | 6.7% | | 0.22 | | 0.25 W/cfm | No |
| CZ06 | 7.1% | | 0.22 | | 0.25 W/cfm | No |
| CZ07 | 7.6% | | 0.22 | | 0.25 W/cfm | No |
| CZ08 | 7.0% | | 0.22 | | 0.25 W/cfm | No |
| CZ09 | 6.5% | | 0.22 | | 0.25 W/cfm | No |
| CZ10 | 6.5% | | 0.22 | | 0.25 W/cfm | No |
| CZ11 | 6.8% | 0.25 | 0.22 | + 1" | 0.25 W/cfm | No |
| CZ12 | 7.3% | | 0.22 | + 1" | 0.25 W/cfm | No |
| CZ13 | 7.3% | 0.25 | 0.22 | + 1" | 0.25 W/cfm | No |
| CZ14 | 6.8% | | 0.22 | + 1" | 0.25 W/cfm | No |
| CZ15 | 6.8% | 0.25 | 0.22 | + 1" | 0.25 W/cfm | No |
| CZ16 | 7.4% | 0.25 | 0.22 | + 1" | 0.25 W/cfm | No |

Table 12: All-Electric Measure Package Summary

| Climate Zone | Compliance Margin | MEASURE SPECIFICATION | | | | |
|--------------|-------------------|-----------------------|-------------|---------------|---------------|----------------|
| | | Window U-value | Window SHGC | Add Wall Ins. | Fan Watt Draw | HERS Pipe Ins. |
| CZ01 | -0.4% | | | + 1" | 0.25 W/cfm | Yes |
| CZ02 | 1.6% | | 0.22 | | 0.25 W/cfm | Yes |
| CZ03 | 1.1% | | 0.22 | | 0.25 W/cfm | Yes |
| CZ04 | 3.4% | | 0.22 | | 0.25 W/cfm | Yes |
| CZ05 | 1.3% | | 0.22 | | 0.25 W/cfm | Yes |
| CZ06 | 3.7% | | 0.22 | | 0.25 W/cfm | Yes |
| CZ07 | 4.8% | | 0.22 | | 0.25 W/cfm | Yes |
| CZ08 | 3.9% | | 0.22 | | 0.25 W/cfm | Yes |
| CZ09 | 3.8% | | 0.22 | | 0.25 W/cfm | Yes |
| CZ10 | 1.8% | | 0.22 | | 0.25 W/cfm | Yes |
| CZ11 | 2.0% | 0.25 | 0.22 | + 1" | 0.25 W/cfm | Yes |
| CZ12 | 2.0% | | 0.22 | + 1" | 0.25 W/cfm | Yes |
| CZ13 | 2.6% | 0.25 | 0.22 | + 1" | 0.25 W/cfm | Yes |
| CZ14 | 2.0% | | 0.22 | + 1" | 0.25 W/cfm | Yes |
| CZ15 | 4.4% | 0.25 | 0.22 | + 1" | 0.25 W/cfm | Yes |
| CZ16 | -5.8% | 0.25 | 0.22 | + 1" | 0.25 W/cfm | Yes |



4 Conclusions & Summary

This report evaluated the feasibility and cost-effectiveness of “above code” performance specifications for newly constructed mid-rise multifamily buildings. The analysis included application of efficiency measures, electric appliances, and PV in all 16 California climate zones, and found cost-effective packages across the state. For the building designs and climate zones where cost-effective packages were identified, the results of this analysis can be used by local jurisdictions to support the adoption of reach codes. Cost-effectiveness was evaluated according to two metrics: On-Bill customer lifecycle benefit-to-cost ratio and TDV lifecycle benefit-to-cost ratio.

For mixed-fuel buildings, this analysis demonstrates that there are cost-effective **Efficiency Only** packages that achieve a minimum 5% compliance margin in most climate zones. The exception is Climate Zone 1 where the package was not cost-effective based on either the TDV or the On-Bill methodology. In all other cases the package is cost-effective for at least one of the metrics.

When 0.1 kW_{DC} per apartment is included, all climate zones are cost-effective based on at least one of the metrics. The addition of 0.1 kW_{DC} per apartment, or 8.8 kW_{DC} total for the building, results in an incremental cost for the PV system of \$27,855. When 0.2 kW_{DC} per apartment is included, all climate zones are cost-effective based on both metrics. The addition of 0.2 kW_{DC} per apartment, or 17.6 kW_{DC} for the building, results in an incremental cost for the PV system of \$55,711.

This study evaluated electrification of residential loads in new mid-rise multifamily buildings. Based on typical construction across California, the basecase condition incorporated all electric appliances within the apartment spaces. As a result, only central water heating was converted from natural gas to electric as part of this analysis. For all-electric buildings, this analysis demonstrates that there are cost-effective **All-Electric Efficiency Only** packages that meet minimum Title 24 code compliance in all climate zones except 1 and 16. The package is cost-effective based on the TDV methodology in all climate zones. It is cost-effective based on the On-Bill methodology in Climate Zones 2 through 15, except for Climate Zones 5 in SCG territory.

When 0.1 kW_{DC} per apartment is included, all climate zones are cost-effective based on both metrics. The addition of 0.1 kW_{DC} per apartment, or 8.8 kW_{DC} for the building, results in an incremental cost for the PV system of \$27,855.

Additional considerations

- This study found that electrification of central domestic hot water loads, in combination with efficiency measures, can result in a benefit to the consumer through lower utility bills under certain electricity and gas tariff scenarios (Climate Zones 6, 8, 9, 15, 4 in CPAU territory, and 12 in SMUD territory territory). The all-electric results demonstrate a trend with On-Bill cost-effectiveness across the different electric utilities. Net Present Value in SCE and SDG&E territories, as well as SMUD and CPAU territories, are typically higher than the cases in PG&E territory. This indicates that rate design can play an important role in encouraging or discouraging electrification.
- This study did not evaluate federally preempted high efficiency appliances. Specifying high efficiency equipment is a viable approach to meeting Title 24 code compliance and local ordinance requirements and is commonly used by project teams. Other studies have found that efficiency packages and electrification packages that employ high efficiency equipment can be quite cost-effective ((Statewide Reach Code Team, 2019b), (Energy & Environmental Economics. 2019)).
- If PV capacity is added to both the mixed-fuel and all-electric efficiency packages, all cases are cost-effective based on at least one of the two evaluated metrics. In some cases, cost-effectiveness improves, and in other cases it decreases relative to the case with efficiency and/or electrification measures only. The cost-effectiveness of adding PV up to 1 kW per apartment, as an independent measure, results in On-Bill benefit-to-cost ratios between 2.3 and 3.1 for PGE territory, 2.1 to 2.3 for SCE territory, and 3.2 to 3.5 for SDG&E territory. The TDV B/C ratio for PV alone is approximately 2.0 for most climate zones



for all service territories. Adding PV in addition to the efficiency packages improves cost-effectiveness where the B/C ratios for the efficiency measures alone are lower than the B/C ratios for PV alone, and vice versa where they are higher. Annual basecase electricity costs and annual utility savings from PV are lower in SCE territory than in PG&E and SDG&E territories. This is due to lower off-peak cost and a bigger difference in peak versus off-peak rate for the TOU-D SCE electricity rate tariff. Most PV production occurs during off-peak times (4 pm to 9 pm peak period).

Table 13 summarizes compliance margin and cost-effectiveness results for the mixed-fuel and all-electric cases. Compliance margin is reported in the cells and cost-effectiveness is indicated by the color of the cell according to the following:

- Cells highlighted in green depict a positive compliance margin and cost-effective results using both On-Bill and TDV approaches.
- Cells highlighted in yellow depict a positive compliance margin and cost-effective results using either the On-Bill or TDV approach but not both.
- Cells not highlighted either depict a negative compliance margin (red text) or a package that was not cost-effective using either the On-Bill or TDV approach.

For more detail on the results, please refer to *Section 3.1 Mid-Rise Multifamily Results, Appendix D – Detailed Results Mixed-Fuel* and *Appendix E – Detailed Results All-Electric*.

Table 13: Mid-Rise Multifamily Summary of Compliance Margin and Cost-Effectiveness

| Climate Zone | Elec Utility | Gas Utility | Mixed-Fuel | | | All-Electric | | | | |
|--------------|--------------|-------------|------------|---------------------------|---------------------------|---------------------------|-------|---------------------------|---------------------------|---------------------------|
| | | | No PV | 0.1 kW _{DC} /Apt | 0.2 kW _{DC} /Apt | 0.3 kW _{DC} /Apt | No PV | 0.1 kW _{DC} /Apt | 0.2 kW _{DC} /Apt | 0.3 kW _{DC} /Apt |
| CZ01 | PGE | PGE | 5.8% | 5.8% | 5.8% | 5.8% | -0.4% | -0.4% | -0.4% | -0.4% |
| CZ02 | PGE | PGE | 5.9% | 5.9% | 5.9% | 5.9% | 1.6% | 1.6% | 1.6% | 1.6% |
| CZ03 | PGE | PGE | 6.7% | 6.7% | 6.7% | 6.7% | 1.1% | 1.1% | 1.1% | 1.1% |
| CZ04 | PGE | PGE | 6.6% | 6.6% | 6.6% | 6.6% | 3.4% | 3.4% | 3.4% | 3.4% |
| CZ04-2 | CPAU | CPAU | 6.6% | 6.6% | 6.6% | 6.6% | 3.4% | 3.4% | 3.4% | 3.4% |
| CZ05 | PGE | PGE | 6.7% | 6.7% | 6.7% | 6.7% | 1.3% | 1.3% | 1.3% | 1.3% |
| CZ05-2 | PGE | SCG | 6.7% | 6.7% | 6.7% | 6.7% | 1.3% | 1.3% | 1.3% | 1.3% |
| CZ06 | SCE | SCG | 7.1% | 7.1% | 7.1% | 7.1% | 3.7% | 3.7% | 3.7% | 3.7% |
| CZ07 | SDGE | SDGE | 7.6% | 7.6% | 7.6% | 7.6% | 4.8% | 4.8% | 4.8% | 4.8% |
| CZ08 | SCE | SCG | 7.0% | 7.0% | 7.0% | 7.0% | 3.9% | 3.9% | 3.9% | 3.9% |
| CZ09 | SCE | SCG | 6.5% | 6.5% | 6.5% | 6.5% | 3.8% | 3.8% | 3.8% | 3.8% |
| CZ10 | SCE | SCG | 6.5% | 6.5% | 6.5% | 6.5% | 1.8% | 1.8% | 1.8% | 1.8% |
| CZ10-2 | SDGE | SDGE | 6.5% | 6.5% | 6.5% | 6.5% | 1.8% | 1.8% | 1.8% | 1.8% |
| CZ11 | PGE | PGE | 6.8% | 6.8% | 6.8% | 6.8% | 2.0% | 2.0% | 2.0% | 2.0% |
| CZ12 | PGE | PGE | 6.8% | 6.8% | 6.8% | 6.8% | 1.4% | 1.4% | 1.4% | 1.4% |
| CZ12-2 | SMUD | PGE | 6.8% | 6.8% | 6.8% | 6.8% | 1.4% | 1.4% | 1.4% | 1.4% |
| CZ13 | PGE | PGE | 7.3% | 7.3% | 7.3% | 7.3% | 2.6% | 2.6% | 2.6% | 2.6% |
| CZ14 | SCE | SCG | 6.0% | 6.0% | 6.0% | 6.0% | 1.1% | 1.1% | 1.1% | 1.1% |
| CZ14-2 | SDGE | SDGE | 6.0% | 6.0% | 6.0% | 6.0% | 1.1% | 1.1% | 1.1% | 1.1% |
| CZ15 | SCE | SCG | 6.8% | 6.8% | 6.8% | 6.8% | 4.4% | 4.4% | 4.4% | 4.4% |
| CZ16 | PGE | PGE | 7.4% | 7.4% | 7.4% | 7.4% | -5.8% | -5.8% | -5.8% | -5.8% |



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Appendix A - California Climate Zone Map

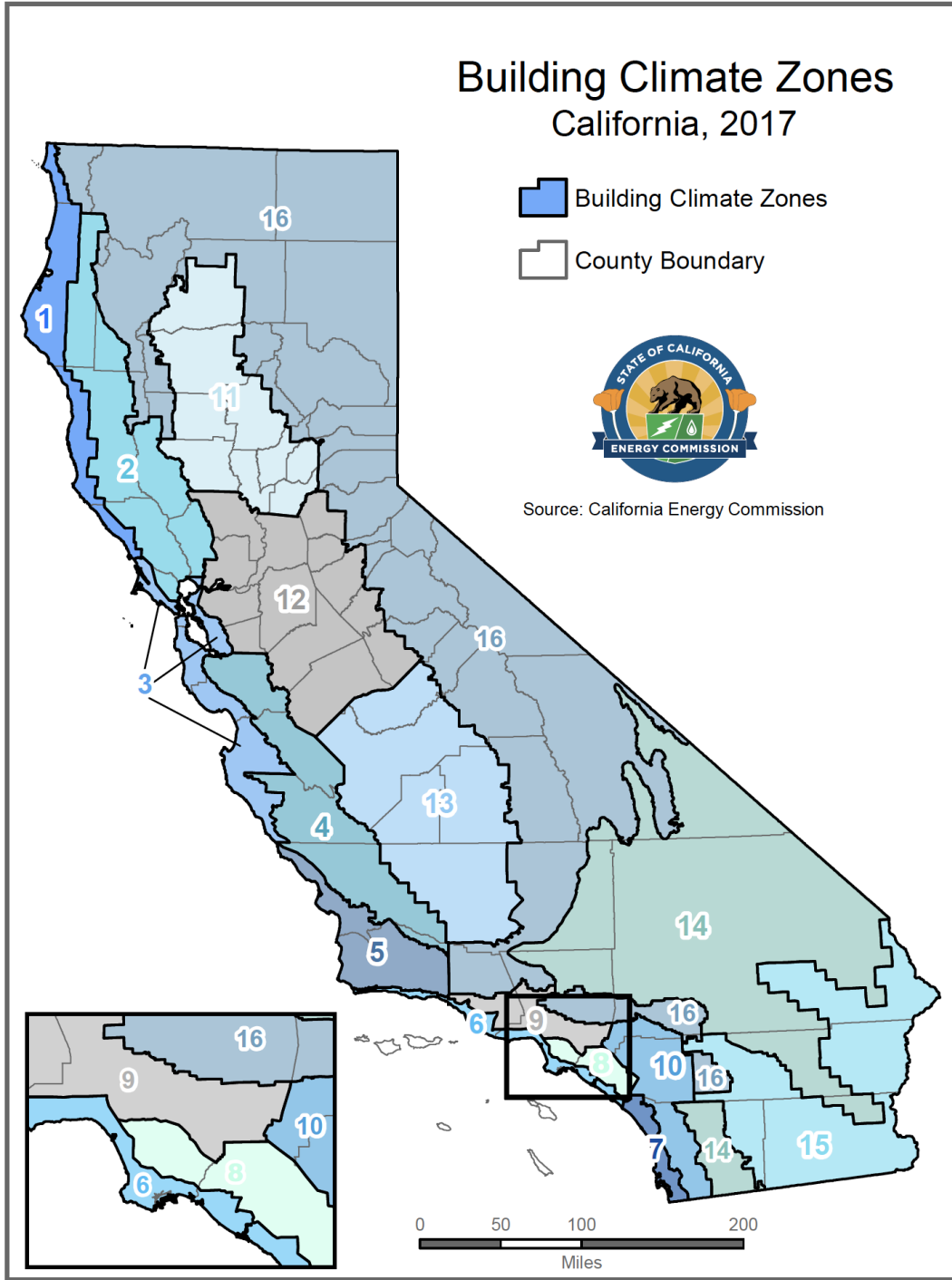


Figure 3: Map of California climate zones. (Source, California Energy Commission³)

³ https://ww2.energy.ca.gov/maps/renewable/building_climate_zones.html



Appendix B – Utility Tariff Details

| | |
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| SoCalGas | 35 |
| SDG&E..... | 38 |
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| Escalation Assumptions | 44 |



PG&E

The following pages provide details on the PG&E electricity and natural gas tariffs applied in this study. Table 14 describes the baseline territories that were assumed for each climate zone.

Table 14: PG&E Baseline Territory by Climate Zone

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

The PG&E monthly gas rate in \$/therm was applied on a monthly basis for the 12-month period ending April 2020 according to the rates shown in Table 15. Rates are based on historical data provided by PG&E.⁴

Table 15: PG&E Monthly Gas Rate (\$/Therm)

| Month | Procurement Charge | Transportation Charge | | Total Charge | |
|-----------|-------------------------|-----------------------|-----------|--------------|-----------|
| | | Baseline | Excess | Baseline | Excess |
| Jan 2020 | \$0.45813 | \$0.99712 | \$1.59540 | \$1.45525 | \$2.05353 |
| Feb 2020 | \$0.44791 | \$0.99712 | \$1.59540 | \$1.44503 | \$2.04331 |
| Mar 2020 | \$0.35346 | \$1.13126 | \$1.64861 | \$1.48472 | \$2.00207 |
| Apr 2020 | \$0.23856 | \$1.13126 | \$1.64861 | \$1.36982 | \$1.88717 |
| May 2019 | \$0.21791 | \$0.99933 | \$1.59892 | \$1.21724 | \$1.81683 |
| June 2019 | \$0.20648 | \$0.99933 | \$1.59892 | \$1.20581 | \$1.80540 |
| July 2019 | \$0.28462 | \$0.99933 | \$1.59892 | \$1.28395 | \$1.88354 |
| Aug 2019 | \$0.30094 | \$0.96652 | \$1.54643 | \$1.26746 | \$1.84737 |
| Sept 2019 | \$0.25651 | \$0.96652 | \$1.54643 | \$1.22303 | \$1.80294 |
| Oct 2019 | \$0.27403 | \$0.98932 | \$1.58292 | \$1.26335 | \$1.85695 |
| Nov 2019 | \$0.33311 | \$0.96729 | \$1.54767 | \$1.30040 | \$1.88078 |
| Dec 2019 | \$0.40178 ^{7/} | \$0.96729 | \$1.54767 | \$1.36907 | \$1.94945 |

⁴The PG&E procurement and transportation charges were obtained from the following site:

<https://www.pge.com/tariffs/GRF.SHTML#RESGAS>





Cancelling Revised Cal. P.U.C. Sheet No. 46539-E
 Revised Cal. P.U.C. Sheet No. 46325-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 RATES

| Total Energy Rates (\$ per kWh) | PEAK | OFF-PEAK |
|--|-----------------|-----------------|
| <i>Summer</i> | | |
| Total Usage | \$0.41333 (I) | \$0.34989 (I) |
| Baseline Credit (Applied to Baseline Usage Only) | (\$0.08633) (R) | (\$0.08633) (R) |
| <i>Winter</i> | | |
| Total Usage | \$0.31624 (I) | \$0.29891 (I) |
| Baseline Credit (Applied to Baseline Usage Only) | (\$0.08633) (R) | (\$0.08633) (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) [†] | (\$35.73) | |

(T)

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

[†] Pursuant to D.20-04-027, distribution of the October 2020 California Climate Credit will be advanced and split to the May 2020 and June 2020 bill cycles, \$17.87 and \$17.86 respectively.. (N)
 (N)

(Continued)

| | | | | |
|----------|----------|------------------------------------|------------|----------------|
| Advice | 5661-E-B | Issued by | Submitted | April 28, 2020 |
| Decision | | Robert S. Kenney | Effective | May 1, 2020 |
| | | Vice President, Regulatory Affairs | Resolution | |





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

Revised
Revised
Cal. P.U.C. Sheet No. 46540-E
Cal. P.U.C. Sheet No. 46252-E

ELECTRIC SCHEDULE E-TOU-C Sheet 3
RESIDENTIAL TIME-OF-USE (PEAK PRICING 4 - 9 p.m. EVERY DAY)

RATES: **UNBUNDLING OF E-TOU-C TOTAL RATES**
(Cont'd.)

| Energy Rates by Component (\$ per kWh) | PEAK | | OFF-PEAK | |
|---|-----------|-----|-------------|-----|
| Generation: | | | | |
| Summer (all usage) | \$0.16735 | (R) | \$0.11391 | (R) |
| Winter (all usage) | \$0.11859 | (R) | \$0.10356 | (R) |
| Distribution**: | | | | |
| Summer (all usage) | \$0.12767 | (I) | \$0.11767 | (I) |
| Winter (all usage) | \$0.07935 | (I) | \$0.07705 | (I) |
| | | | | |
| Conservation Incentive Adjustment (Baseline Usage) | | | (\$0.03294) | (I) |
| Conservation Incentive Adjustment (Over Baseline Usage) | | | \$0.05339 | (I) |
| | | | | |
| Transmission* (all usage) | | | \$0.03595 | |
| Transmission Rate Adjustments* (all usage) | | | \$0.00314 | |
| Reliability Services* (all usage) | | | (\$0.00066) | |
| Public Purpose Programs (all usage) | | | \$0.01298 | (I) |
| Nuclear Decommissioning (all usage) | | | \$0.00101 | (I) |
| Competition Transition Charges (all usage) | | | \$0.00096 | (R) |
| Energy Cost Recovery Amount (all usage) | | | \$0.00005 | (I) |
| DWR Bond (all usage) | | | \$0.00580 | |
| New System Generation Charge (all usage)** | | | \$0.00571 | (I) |

* 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.

(Continued)

Advice 5861-E-B
Decision

Issued by
Robert S. Kenney
Vice President, Regulatory Affairs

Submitted April 28, 2020
Effective May 1, 2020
Resolution





Pacific Gas and Electric Company
San Francisco, California

Revised Revised Cal. P.U.C. Sheet No. 46190-E
Cancelling Revised Cal. P.U.C. Sheet No. 43414-E

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

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

BASELINE QUANTITIES (kWh PER DAY)

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

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

Summer (service from June 1 through September 30):

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

Off-Peak: All other times

Winter (service from October 1 through May 31):

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

Off-Peak: All other times

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

(Continued)

| | | | |
|-----------------|-------------|---|-------------------|
| <i>Advice</i> | 5759-E | <i>Issued by</i> | <i>Submitted</i> |
| <i>Decision</i> | D.19-07-004 | Robert S. Kenney | February 14, 2020 |
| | | <i>Vice President, Regulatory Affairs</i> | <i>Effective</i> |
| | | | March 1, 2020 |
| | | | <i>Resolution</i> |





Pacific Gas and Electric Company
San Francisco, California

Cancelling Revised Cal. P.U.C. Sheet No. 35762-G
Revised Cal. P.U.C. Sheet No. 35696-G

GAS SCHEDULE GM
MASTER-METERED MULTIFAMILY SERVICE

Sheet 2

RATES: Customers on this schedule pay a Procurement Charge and a Transportation Charge, per meter, as follows:

| | <u>Baseline</u> | | <u>Per Therm</u> | | <u>Excess</u> |
|-------------------------------|------------------|-----|------------------|-----|---------------|
| <u>Procurement Charge:</u> | \$0.23856 | (R) | \$0.23856 | (R) | |
| <u>Transportation Charge:</u> | <u>\$1.13126</u> | | <u>\$1.64861</u> | | |
| Total: | \$1.36982 | (R) | \$1.88717 | (R) | |

California Natural Gas Climate Credit (\$27.18)
(per Household, annual payment occurring in the April bill cycle)

Public Purpose Program Surcharge:

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

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

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





Pacific Gas and Electric Company
 San Francisco, California

Cancelling Revised Cal. P.U.C. Sheet No. 35447-G
 Revised Cal. P.U.C. Sheet No. 34307-G

GAS SCHEDULE GM
 MASTER-METERED MULTIFAMILY SERVICE

Sheet 3

BASELINE QUANTITIES:

The above rates are applicable only to residential use. PG&E may require the Customer to submit a completed "Declaration of Eligibility for Baseline Quantities for Residential Rates." The delivered quantities of gas shown below are billed at the rates for baseline use. As an exception, service under this schedule not used to supply space heating but used to supply water heating from a central source to residential dwelling units that are individually metered by PG&E for either gas or electricity will be billed using a baseline quantity of 0.5 therms per dwelling unit per day (Code W) in all baseline territories and in both seasons.

| Baseline Territories | BASELINE QUANTITIES (Therms Per Day Per Dwelling Unit) | | | | | | (T) (T) |
|----------------------|--|-----|---------------------------------|-----|---------------------------|-----|-----------------|
| | Summer (April-October) | | Winter Off-Peak (Nov, Feb, Mar) | | Winter On-Peak (Dec, Jan) | | |
| | Effective Apr. 1, 2020 | | Effective Nov. 1, 2019 | | Effective Dec. 1, 2019 | | |
| ** | | | | | | | |
| P | 0.29 | (R) | 0.87 | (R) | 1.00 | (I) | |
| Q | 0.49 | (R) | 0.64 | (R) | 0.77 | (I) | |
| R | 0.33 | (R) | 0.84 | (R) | 1.19 | (I) | |
| S | 0.29 | (R) | 0.54 | (R) | 0.68 | (I) | |
| T | 0.49 | (R) | 0.94 | (R) | 1.06 | (R) | |
| V | 0.56 | | 1.18 | (R) | 1.29 | (I) | |
| W | 0.23 | (R) | 0.61 | (R) | 0.87 | (R) | |
| X | 0.33 | (R) | 0.64 | (R) | 0.77 | (I) | |
| Y | 0.36 | | 0.87 | (R) | 1.00 | (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.

STANDARD MEDICAL QUANTITIES:

Additional medical quantities (Code M) are available as provided in Rule 19.

RESIDENTIAL DWELLING UNITS:

It is the responsibility of the Customer to advise PG&E within 15 days following any change in the number of residential dwelling units, mobile home spaces, and permanent-residence RV units receiving gas service.

CENTRAL BOILERS:

Service to central boilers for water and/or space heating will be billed with monthly baseline quantities related to the number of dwelling units furnished such water and/or space heating.



SCE

The following pages provide details on are the SCE electricity tariffs applied in this study. Table 16 describes the baseline territories that were assumed for each climate zone.

Table 16: SCE Baseline Territory by Climate Zone

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

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

Sheet 2

RATES

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

| | Delivery Service | | |
|---|---------------------|-----------------|--------------------|
| | Total ¹ | UG ² | DWREC ³ |
| Option 4-9 PM / Option 4-9 PM-CPP | | | |
| Energy Charge - \$/kWh | | | |
| Summer Season - On-Peak | 0.21574 (I) | 0.17870 (I) | (0.00007) |
| Mid-Peak | 0.21574 (I) | 0.10434 (R) | (0.00007) |
| Off-Peak | 0.17099 (I) | 0.07584 (R) | (0.00007) |
| Winter Season - Mid-Peak | 0.21574 (I) | 0.12676 (R) | (0.00007) |
| Off-Peak | 0.17099 (I) | 0.08874 (R) | (0.00007) |
| Super-Off-Peak | 0.16567 (I) | 0.07025 (R) | (0.00007) |
| Baseline Credit ⁴ - \$/kWh | (0.07456) (R) | 0.00000 | |
| Basic Charge - \$/day | | | |
| Single-Family Residence | 0.031 | | |
| Multi-Family Residence | 0.024 | | |
| Minimum Charge ² - \$/day | | | |
| Single Family Residence | 0.346 | | |
| Multi-Family Residence | 0.346 | | |
| Minimum Charge (Medical Baseline) ³ - \$/day | | | |
| Single Family Residence | 0.173 | | |
| Multi-Family Residence | 0.173 | | |
| California Climate Credit ⁴ | (37.00) (I) | | |
| California Alternate Rates for Energy Discount - % | 100.00 [*] | | |
| Family Electric Rate Assistance Discount - % | 100.00 | | |
| Option 4-9 PM-CPP | | | |
| CPP Event Energy Charge - \$/kWh | | 0.80000 | |
| Summer CPP Non-Event Credit | | | (0.15170) |
| On-Peak Energy Credit - \$/kWh | | | (0.15170) |
| Maximum Available Credit - \$/kWh ⁴ | | | (0.58504) (R) |
| Summer Season | | | (0.58504) (R) |

* 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 \$0.00089 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.
⁴ 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.
 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.



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

SPECIAL CONDITIONS

1. Applicable rate time periods are defined as follows:

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

(T)

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

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 |



SoCalGas

Following are the SoCalGas natural gas tariffs applied in this study. Table 17 describes the baseline territories that were assumed for each climate zone.

Table 17: 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 April 2020 according to the rates shown in Table 18. Historical natural gas rate data was only available for SoCalGas' procurement charges⁵. 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 April 2020 costs.

Table 18: SoCalGas Monthly Gas Rate (\$/Therm)

| Month | Procurement Charge | Transmission Charge | | Total Charge | |
|-----------|--------------------|---------------------|-----------|--------------|-----------|
| | | Baseline | Excess | Baseline | Excess |
| Jan 2020 | \$0.34730 | \$0.81742 | \$1.17186 | \$1.16472 | \$1.51916 |
| Feb 2020 | \$0.28008 | \$0.81742 | \$1.17186 | \$1.09750 | \$1.45194 |
| Mar 2020 | \$0.22108 | \$0.81742 | \$1.17186 | \$1.03850 | \$1.39294 |
| Apr 2020 | \$0.20307 | \$0.81742 | \$1.17186 | \$1.02049 | \$1.37493 |
| May 2019 | \$0.23790 | \$0.81742 | \$1.17186 | \$1.05532 | \$1.40976 |
| June 2019 | \$0.24822 | \$0.81742 | \$1.17186 | \$1.06564 | \$1.42008 |
| July 2019 | \$0.28475 | \$0.81742 | \$1.17186 | \$1.10217 | \$1.45661 |
| Aug 2019 | \$0.27223 | \$0.81742 | \$1.17186 | \$1.08965 | \$1.44409 |
| Sept 2019 | \$0.26162 | \$0.81742 | \$1.17186 | \$1.07904 | \$1.43348 |
| Oct 2019 | \$0.30091 | \$0.81742 | \$1.17186 | \$1.11833 | \$1.47277 |
| Nov 2019 | \$0.27563 | \$0.81742 | \$1.17186 | \$1.09305 | \$1.44749 |
| Dec 2019 | \$0.38067 | \$0.81742 | \$1.17186 | \$1.19809 | \$1.55253 |

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. 57458-G
LOS ANGELES, CALIFORNIA CANCELING Revised CAL. P.U.C. SHEET NO. 57432-G

| | | | |
|--|---------------------------|------------------------------|--------------|
| Schedule No. GM | | | Sheet 2 |
| MULTI-FAMILY SERVICE | | | |
| (Includes GM-E, GM-C, GM-EC, GM-CC, GT-ME, GT-MC and all GMB Rates) | | | |
| (Continued) | | | |
| APPLICABILITY (Continued) | | | |
| Multi-family Accommodations built prior to December 15, 1981 and currently served under this schedule may also be eligible for service under Schedule No. GS. If an eligible Multi-family Accommodation served under this schedule converts to an applicable submetered tariff, the tenant rental charges shall be revised for the duration of the lease to reflect removal of the energy related charges. | | | |
| Eligibility for service hereunder is subject to verification by the Utility. | | | |
| TERRITORY | | | |
| Applicable throughout the service territory. | | | |
| RATES | | | |
| <u>Customer Charge</u> , per meter, per day: | <u>GM/GT-M</u> 16.438¢ | <u>GMB/GT-MB</u> \$16.357 | |
| For "Space Heating Only" customers, a daily Customer Charge applies during the winter period from November 1 through April 30 ^{1/} : | | | |
| | 33.149¢ | | |
| GM | | | |
| <u>Baseline Rate</u> , per therm (baseline usage defined per Special Conditions 3 and 4): | <u>GM-E</u> | <u>GM-EC</u> ^{1/} | <u>GT-ME</u> |
| Procurement Charge: ^{2/} | 20.307¢ | 20.307¢ | N/A |
| Transmission Charge: | 81.742¢ | 81.742¢ | 81.742¢ |
| Total Baseline Charge (all usage): | 102.049¢ | 102.049¢ | 81.742¢ |
| <u>Non-Baseline Rate</u> , per therm (usage in excess of baseline usage): | | | |
| Procurement Charge: ^{2/} | 20.307¢ | 20.307¢ | N/A |
| Transmission Charge: | 117.186¢ | 117.186¢ | 117.186¢ |
| Total Non Baseline Charge (all usage): | 137.493¢ | 137.493¢ | 117.186¢ |
| <u>Non-Baseline Rate</u> , per therm (usage in excess of baseline usage): | | | |
| Procurement Charge: ^{2/} | 20.307¢ | 20.307¢ | N/A |
| Transmission Charge: | 117.186¢ | 117.186¢ | 117.186¢ |
| Total Non Baseline Charge (all usage): | 137.493¢ | 137.493¢ | 117.186¢ |
| ^{1/} For the summer period beginning May 1 through October 31, with some exceptions, usage will be accumulated to at least 20 Ccf (100 cubic feet) before billing, or it will be included with the first bill of the heating season which may cover the entire duration since a last bill was generated for the current calendar year. (Footnotes continue next page.) | | | |

(Continued)

(TO BE INSERTED BY UTILITY)
ADVICE LETTER NO. 5614
DECISION NO.

ISSUED BY
Dan Skopec
Vice President
Regulatory Affairs

(TO BE INSERTED BY CAL. PUC)
SUBMITTED Apr 6, 2020
EFFECTIVE Apr 10, 2020
RESOLUTION NO. G-3351

207



SOUTHERN CALIFORNIA GAS COMPANY Revised CAL. P.U.C. SHEET NO. 57168-G
 LOS ANGELES, CALIFORNIA CANCELING Revised CAL. P.U.C. SHEET NO. 41015-G

Schedule No. GM

Sheet 5

MULTI-FAMILY SERVICE

(Includes GM-E, GM-C, GM-EC, GM-CC, GT-ME, GT-MC and all GMB Rates)

(Continued)

SPECIAL CONDITIONS (Continued)

3. (Continued)

| Codes | Per Residence | Daily Therm Allowance for Climate Zones* | | |
|-------|---|---|-------|-------|
| | | 1 | 2 | 3 |
| 1 | Space heating only | | | |
| | Summer | 0.000 | 0.000 | 0.000 |
| | Winter | 1.210 | 1.343 | 2.470 |
| 2 | Water heating and cooking | 0.477 | 0.477 | 0.477 |
| 3 | Cooking, water heating and space heating | | | |
| | Summer | 0.473 | 0.473 | 0.473 |
| | Winter | 1.691 | 1.823 | 2.950 |
| 4 | Cooking and space heating | | | |
| | Summer | 0.088 | 0.088 | 0.088 |
| | Winter | 1.299 | 1.432 | 2.559 |
| 5 | Cooking only | 0.089 | 0.089 | 0.089 |
| 6 | Water heating only | 0.388 | 0.388 | 0.388 |
| 7 | Water heating and space heating | | | |
| | Summer | 0.385 | 0.385 | 0.385 |
| | Winter | 1.601 | 1.734 | 2.861 |

* Climate Zones are described in the Preliminary Statement.

4. Medical Baseline: Upon completion of an application and verification by a state-licensed physician, nurse practitioner, physician's assistant, or osteopath (Form No. 4859-E), an additional Baseline allowance of 0.822 therms per day will be provided for paraplegic, quadriplegic, or hemiplegic persons, those afflicted with multiple sclerosis or scleroderma, or persons being treated for a life threatening illness or who have a compromised immune system.

Where it is established that the energy required for a Life-Support Device, as defined in Rule No. 1, exceeds 0.822 therms per day, an additional uniform daily Baseline allowance will be provided. The amount of the additional allowance will be determined by the Utility from load and operating time data of the Life-Support Device.

5. Space Heating Only: Applies to customers who are using gas primarily for space heating, as determined by survey or under the presumption that customers who use less than 11 Ccf per month during each of the regular billing periods ending in August and September qualify for Heat Only billing.

(Continued)

(TO BE INSERTED BY UTILITY)
 ADVICE LETTER NO. 5576-A
 DECISION NO. 02-04-026

ISSUED BY
Dan Skopec
 Vice President

(TO BE INSERTED BY CAL. PUC)
 SUBMITTED Jan 31, 2020
 EFFECTIVE Feb 27, 2020



SDG&E

Following are the SDG&E electricity and natural gas tariffs applied in this study. Table 19 describes the baseline territories that were assumed for each climate zone. All-Electric baseline allowances were applied.

Table 19: SDG&E Baseline Territory by Climate Zone

| | Baseline Territory |
|------|--------------------|
| CZ07 | Coastal |
| CZ10 | Inland |
| CZ14 | Mountain |



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) | | | | | | | | |

2C8

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

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) | 6.8 | 9.2 | 15.6 | 17.5 |
| Winter (November 1 to May 31) | 10.4 | 13.4 | 23.4 | 18.1 |

* 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. 24487-G

Canceling Revised Cal. P.U.C. Sheet No. 24422-G

| SCHEDULE GM | | | | Sheet 2 |
|---|------------------|---|------------------|-----------------------|
| MULTI-FAMILY NATURAL GAS SERVICE | | | | |
| <i>(Includes Rates for GM, GM-C and GTC/GTCA)</i> | | | | |
| <u>RATES</u> | | | | |
| | GM | | GM-C | GTC/GTCA ¹ |
| <u>Baseline Rate, per therm (baseline usage defined in Special Condition 4)</u> | | | | |
| Procurement Charge ² | \$0.20327 | R | \$0.22130 | N/A |
| Transmission Charge..... | <u>\$1.35948</u> | | <u>\$1.35948</u> | <u>\$1.37374</u> |
| Total Baseline Charge..... | \$1.56273 | R | \$1.58078 | \$1.37374 |
| <u>Non-Baseline Rate (usage in excess of baseline usage)</u> | | | | |
| Procurement Charge ² | \$0.20327 | R | \$0.22130 | N/A |
| Transmission Charge..... | <u>\$1.59125</u> | | <u>\$1.59125</u> | <u>\$1.80553</u> |
| Total Non-Baseline Charge..... | \$1.79452 | R | \$1.81255 | \$1.80553 |
| <u>Minimum Bill, per day³</u> | | | | |
| Non-CARE customers..... | \$0.09863 | | \$0.09863 | \$0.09863 |
| CARE customers..... | \$0.07890 | | \$0.07890 | \$0.07890 |

(Continued)

2C6

Advice Ltr. No. 2858-G

Decision No. _____

Issued by

Dan Skopec

Vice President
Regulatory Affairs

Submitted

Mar 31, 2020

Effective

Apr 1, 2020

Resolution No. _____

Baseline Usage. The following quantities of gas are to be billed at the baseline rate for multi-family units. Usage in excess of applicable baseline usage will be billed at non-baseline rates.

| | <u>Daily Therm Allowance Per Residential Unit</u> |
|--|---|
| Summer (May 1 to October 31, inclusive) | 0.345 |
| Winter (November 1 to April 30, inclusive) | 1.082 |



The SDG&E monthly gas rate in \$/therm was applied on a monthly basis for the 12-month period ending April 2020 according to the rates shown in Table 20. Historical natural gas rate data was only available for SoCalGas' procurement charges⁶. 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 April 2020 costs.

Table 20: SDG&E Monthly Gas Rate (\$/Therm)

| Month | Procurement Charge | Transmission Charge | | Total Charge | |
|-----------|--------------------|---------------------|-----------|--------------|-----------|
| | | Baseline | Excess | Baseline | Excess |
| Jan 2020 | \$0.34761 | \$1.36166 | \$1.59166 | \$1.70927 | \$1.93927 |
| Feb 2020 | \$0.28035 | \$1.36166 | \$1.59166 | \$1.64201 | \$1.87201 |
| Mar 2020 | \$0.22130 | \$1.36166 | \$1.59166 | \$1.58296 | \$1.81296 |
| Apr 2020 | \$0.20327 | \$1.35946 | \$1.59125 | \$1.56273 | \$1.79452 |
| May 2019 | \$0.23804 | \$1.06349 | \$1.25253 | \$1.30153 | \$1.49057 |
| June 2019 | \$0.24838 | \$1.06349 | \$1.25253 | \$1.31187 | \$1.50091 |
| July 2019 | \$0.28491 | \$1.06349 | \$1.25253 | \$1.34840 | \$1.53744 |
| Aug 2019 | \$0.27239 | \$1.06349 | \$1.25253 | \$1.33588 | \$1.52492 |
| Sept 2019 | \$0.26178 | \$1.06349 | \$1.25253 | \$1.32527 | \$1.51431 |
| Oct 2019 | \$0.30109 | \$1.06349 | \$1.25253 | \$1.36458 | \$1.55362 |
| Nov 2019 | \$0.27580 | \$1.06349 | \$1.25253 | \$1.33929 | \$1.52833 |
| Dec 2019 | \$0.38090 | \$1.06349 | \$1.25253 | \$1.44439 | \$1.63343 |

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



SMUD

Following are the SMUD electricity tariffs applied in this study.

RTOD Rate Schedule

II. Firm Service Rates

| A. Time-of-Day (5-8 p.m.) Rate | Rate Category RT02 |
|---|---------------------------|
| Non-Summer Prices* – January 1 through May 31 | |
| System Infrastructure Fixed Charge per month | \$21.05 |
| Electricity Usage Charge | |
| Peak \$/kWh | \$0.1388 |
| Off-Peak \$/kWh | \$0.1006 |
| Summer Prices - June 1 through September 30 | |
| System Infrastructure Fixed Charge per month | \$21.05 |
| Electricity Usage Charge | |
| Peak \$/kWh | \$0.2941 |
| Mid-Peak \$/kWh | \$0.1671 |
| Off-Peak \$/kWh | \$0.1209 |
| Non-Summer Prices* – October 1 through December 31 | |
| System Infrastructure Fixed Charge per month | \$21.70 |
| Electricity Usage Charge | |
| Peak \$/kWh | \$0.1430 |
| Off-Peak \$/kWh | \$0.1035 |

* 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 . |



GSN_T Rate Schedule:

II. Firm Service Rates

| Rate Category | Nondemand GSN_T | Flat GFN | Demand GSS_T |
|--|--------------------|-------------|-----------------|
| Winter Season – January 1 through May 31 | | | |
| System Infrastructure Fixed Charge - per month per meter | \$21.15 | \$9.45 | \$25.75 |
| Site Infrastructure Charge (per 12 months max kW or contract capacity) | n/a | n/a | \$7.94 |
| Electricity Usage Charge | | | |
| All day \$/kWh | \$0.1365 | \$0.1381 | \$0.1071 |
| Summer Season - June 1 through September 30 | | | |
| System Infrastructure Fixed Charge - per month per meter | \$21.15 | \$9.45 | \$25.75 |
| Site Infrastructure Charge (per 12 months max kW or contract capacity) | n/a | n/a | \$7.94 |
| Electricity Usage Charge | | | |
| On-peak \$/kWh | \$0.3151 | \$0.1381 | \$0.2733 |
| Off-peak \$/kWh | \$0.1152 | \$0.1381 | \$0.0948 |

| Rate Category | Nondemand GSN_T | Flat GFN | Demand GSS_T |
|--|--------------------|-------------|-----------------|
| Winter Season - October 1 through December 31 | | | |
| System Infrastructure Fixed Charge - per month per meter | \$21.80 | \$9.70 | \$26.50 |
| Site Infrastructure Charge (per 12 months max kW or contract capacity) | n/a | n/a | \$8.18 |
| Electricity Usage Charge | | | |
| All day \$/kWh | \$0.1406 | \$0.1423 | \$0.1103 |

D. Billing Periods

1. Winter (October 1 – May 31) All hours are off-peak.

2. Summer Time-of-Use Billing Periods (June 1 – September 30)

| | |
|-----------------|---|
| On-Peak | Summer weekdays between 3:00 p.m. and 6:00 p.m. |
| Off-Peak | All other hours, including holidays shown below |



CPAU

Following are the CPAU electricity and natural gas tariffs applied in this study.

E1 Rate Schedule:

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 |

E2 Rate Schedule:

RESIDENTIAL MASTER-METERED AND SMALL NON-RESIDENTIAL ELECTRIC SERVICE

UTILITY RATE SCHEDULE E-2

A. APPLICABILITY:

This Rate Schedule applies to the following Customers receiving Electric Service from the City of Palo Alto Utilities:

1. Small non-residential Customers receiving Non-Demand Metered Electric Service; and
2. Customers with Accounts at Master-Metered multi-family facilities.

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> |
|--------------------------------|------------------|---------------------|------------------------|--------------|
| Summer Period | \$0.11855 | \$0.08551 | \$0.00447 | \$0.20853 |
| Winter Period | 0.08502 | 0.05675 | 0.00447 | 0.14624 |
| <u>Minimum Bill (\$/day)</u> | | | | 0.8359 |



G-2 Rate Schedule:

RESIDENTIAL MASTER-METERED AND COMMERCIAL GAS SERVICE

UTILITY RATE SCHEDULE G-2

A. APPLICABILITY:

This schedule applies to the following Customers receiving Gas Service from the City of Palo Alto Utilities:

1. Commercial Customers who use less than 250,000 therms per year at one site.
2. Master-metered residential Customers in multi-family residential facilities.

B. TERRITORY:

This schedule applies anywhere the City of Palo Alto provides Gas Service.

C. UNBUNDLED RATES:

Per Service

Monthly Service Charge:\$104.95

Per Therm

Supply Charges:

1. Commodity (Monthly Market Based) \$0.10-\$2.00
2. Cap and Trade Compliance Charges \$0.00-0.25
3. Transportation Charge.....\$0.00-\$0.15
4. Carbon Offset Charge\$0.00-\$0.10

Distribution Charge: \$0.6102

G2 Monthly Per Therm Rates:

| Effective Date | Commodity Rate | Cap and Trade Compliance Charge | Transportation Charge | Carbon Offset Charge | G2 Total Volumetric Rate |
|----------------|----------------|---------------------------------|-----------------------|----------------------|--------------------------|
| 1/1/20 | \$0.3289 | 0.033 | 0.09941 | 0.040 | 1.11151 |
| 2/1/20 | 0.2466 | 0.033 | 0.09941 | 0.040 | 1.02921 |
| 3/1/20 | 0.2416 | 0.033 | 0.09891 | 0.040 | 1.02371 |
| 4/1/20 | 0.2066 | 0.033 | 0.09891 | 0.040 | 0.98871 |
| 5/1/20 | 0.2258 | 0.033 | 0.09891 | 0.040 | 1.00791 |
| 6/1/20 | 0.2279 | 0.033 | 0.09891 | 0.040 | 1.01001 |
| 7/1/19 | 0.2471 | 0.033 | 0.11757 | 0.040 | 1.04787 |
| 8/1/19 | 0.2507 | 0.033 | 0.10066 | 0.040 | 1.03456 |
| 9/1/19 | 0.2461 | 0.033 | 0.10066 | 0.040 | 1.02996 |
| 10/1/19 | 0.2811 | 0.033 | 0.10288 | 0.040 | 1.06718 |
| 11/1/19 | 0.2923 | 0.033 | 0.10288 | 0.040 | 1.07838 |
| 12/1/19 | 0.3781 | 0.033 | 0.10288 | 0.040 | 1.16418 |



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. The statewide electricity escalation rates were also applied to the analysis for SMUD and CPAU. PG&E gas escalation rates were applied to CPAU as the best available estimate since CPAU uses PG&E gas infrastructure.

Table 21: Real Utility Rate Escalation Rate Assumptions
Statewide Electric Residential Average Rate (%/year, real)
Natural Gas Residential Core Rate (%/yr escalation, real)

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



Appendix C – PG&E Gas Infrastructure Cost Memo



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December 5, 2019

Energy Commission Staff:

On March 2, 2018, PG&E provided gas extension cost estimates for residential existing and new subdivisions (see attached memo). We have recently updated our estimates and are therefore providing an updated memo.

In addition to mainline and service extension costs, we are also providing estimates of the cost of gas meters for different building types including both residential and commercial customers. These estimates are based on PG&E historical jobs.

Developing gas extension cost estimates is complex and the actual costs are project dependent. Costs vary widely with location, terrain, distance to the nearest main, joint trenching, materials, number of dwellings per development, and several other site and job-specific conditions. For these reasons, it is not practical to come up with estimates that represent every case. Instead we are including estimates based on historical averages taken from projects within PG&E's territory. It is not recommended to compare specific project costs to these estimates as any number of factors could lead to higher or lower costs than these averages are representing.

We are also including estimates for in-house gas infrastructure costs and specific plan review costs. These estimates are from external sources, and are not based on PG&E data, but have been provided for the sake of completeness and for use in energy efficiency analysis.

To further anchor the estimates, several assumptions have been made:

1. It is assumed that during new construction, gas infrastructure will likely be joint trenched with electric infrastructure. As a result, the incremental cost of trenching associated with the gas infrastructure alone is minimal. Therefore, all mainline cost estimates exclude trench costs. Service extension cost estimates include both estimates with and without trench costs. In the case where new construction would require overhead electric and underground gas infrastructure, the estimates with trench costs included for service extensions should be utilized.
2. It is assumed that new construction in an existing subdivision would not generally require a mainline extension. In cases where a mainline extension would be required to an existing subdivision, the costs are highly dependent on the location, terrain, and distance to the nearest main.





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3. These estimates are for total costs. The cost estimates have not been reduced to account for the portion of the costs paid by all customers due to application of Rule 15¹ and Rule 16² allowances. Hence, costs to the specific customer may be lower than the estimates below, as the specific customer benefits from the Rule 15 and Rule 16 allowances.

Table 1: PG&E Gas Infrastructure Cost Estimates

| | Existing Subdivision/Development | New Greenfield Subdivision/Development |
|---|---|--|
| Mainline Extension | N/A ³ | <u>Single-Family</u> \$17/ft ⁴ <u>Multi-Family</u> \$11/ft ⁴ |
| Service Extension (Typically 1" pipe from mainline to the meter) | \$6750 per service/building ⁴ (excludes trench costs) \$9200 per service/building ⁴ (includes trench costs) | \$1300 per service/building ⁴ (includes mainline extension costs within the subdivision; excludes trench costs) \$1850 per service/building ⁴ (includes mainline extension costs within the subdivision; includes trench costs) |
| Meter | <u>Residential Single Family</u> \$300 per meter ⁵ <u>Residential Multi-Family</u> \$300 per meter + \$300 per meter manifold outlet ⁵ <u>Small/Medium Commercial</u> \$3600 per meter ⁶ | <u>Residential Single Family</u> \$300 per meter ⁵ <u>Residential Multi-Family</u> \$300 per meter + \$300 per meter manifold outlet ⁵ <u>Small/Medium Commercial</u> \$3600 per meter ⁶ |

¹ https://www.pge.com/tariffs/tm2/pdf/ELEC_RULES_15.pdf

² https://www.pge.com/tariffs/tm2/pdf/ELEC_RULES_16.pdf

³ It is assumed that new construction in an existing subdivision would not require a main extension.

⁴ Estimates based on PG&E jobs from Jan 2016 - Dec 2017 from PG&E's Service Planning team.

⁵ Estimates from PG&E's Dedicated Estimating Team. For Multi-Family units, the costs of \$300 per meter and \$300 per meter manifold outlet should be combined for a total of \$600 per meter.

⁶ PG&E Marginal Customer Access Cost Estimates presented in the 2018 Gas Cost Allocation Proceedings (GCAP), A.17-09-006, Exhibit PG&E-2, Appendix A, Section A, Table A-1. The Average Connection Cost per Customer values were included in the MCAC workpaper that accompanied the GCAP testimony





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| | | |
|--|--|--|
| | <u>Large Commercial</u> \$32,000 per meter ⁶ | <u>Large Commercial</u> \$32,000 per meter ⁶ |
|--|--|--|

Note: Service extension cost estimates for New Greenfield Subdivisions include mainline extension costs as well. Therefore, mainline cost estimates can be ignored for the purpose of estimating total project costs.

Table 2: Gas Infrastructure Cost Estimates from Other Sources

| | Existing Subdivision/Development | New Greenfield Subdivision/Development |
|--|--|--|
| In-House Infrastructure | <u>Single-Family</u> \$800 ⁷ | <u>Single-Family</u> \$800 ⁷ |
| | <u>Multi-Family</u> \$600 per unit ⁷ | <u>Multi-Family</u> \$600 per unit ⁷ |
| | <u>Medium Office</u> \$600-4500 ^{7,8} | <u>Medium Office</u> \$600-4500 ^{7,8} |
| | <u>Medium Retail</u> \$10,000 ⁸ | <u>Medium Retail</u> \$10,000 ⁸ |
| Plan Review (Will vary by city and often not a fixed fee) | <u>Residential</u> Palo Alto - \$850 ⁹ | <u>Residential</u> Palo Alto - \$850 ⁹ |
| | <u>Nonresidential</u> Palo Alto - \$2316 ⁹ | <u>Nonresidential</u> Palo Alto - \$2316 ⁹ |

Please let us know if there are any follow-up questions or clarifications.

Best regards,

⁷ Frontier Energy, Inc., Misti Bruceri & Associates, LLC. 2019. "2019 Cost-effectiveness Study: Low Rise Residential New Construction." Available at: <https://localenergycodes.com/content/performance-ordinances>

⁸ TRC, EnergySoft. 2019. "2019 Nonresidential New Construction Reach Code Cost Effectiveness Study." Available at: <https://localenergycodes.com/content/performance-ordinances>

⁹ TRC. 2018. "City of Palo Alto 2019 Title 24 Energy Reach Code Cost Effectiveness Analysis Draft." Available at: <http://cityofpaloalto.org/civicax/filebank/documents/66742>



Appendix D – Detailed Results Mixed-Fuel

Table 22: Mixed-Fuel Efficiency Only Package Results (SAVINGS/COST PER APARTMENT)¹

| Climate Zone | Elec Utility | Gas Utility | Apartments | | | Central Water Heating | | | Total | Savings (2020 PV\$) | | | B/C Ratio ¹ | |
|--------------|--------------|-------------|----------------------|--------------------|-----------------------------|-----------------------|--------------------|-----------------------------|-----------------------------|------------------------------|------------------|----------------------|------------------------|------|
| | | | Gas Savings (therms) | Elec Savings (kWh) | Year 1 Utility Cost Savings | Gas Savings (therms) | Elec Savings (kWh) | Year 1 Utility Cost Savings | Year 1 Utility Cost Savings | On-Bill Utility Cost Savings | TDV Cost Savings | Total Inc. Cost (\$) | On-Bill | TDV |
| CZ01 | PGE | PGE | 0.0 | 26 | \$6 | 0.0 | 0 | \$0 | \$6 | \$133 | \$105 | \$304 | 0.44 | 0.35 |
| CZ02 | PGE | PGE | 0.0 | 47 | \$17 | 0.0 | 0 | \$0 | \$17 | \$391 | \$285 | \$144 | 2.72 | 1.98 |
| CZ03 | PGE | PGE | 0.0 | 44 | \$15 | 0.0 | 0 | \$0 | \$15 | \$345 | \$226 | \$144 | 2.40 | 1.57 |
| CZ04 | PGE | PGE | 0.0 | 61 | \$20 | 0.0 | 0 | \$0 | \$20 | \$465 | \$331 | \$144 | 3.24 | 2.31 |
| CZ04-2 | CPAU | CPAU | 0.0 | 61 | \$10 | 0.0 | 0 | \$0 | \$10 | \$248 | \$331 | \$144 | 1.73 | 2.31 |
| CZ05 | PGE | PGE | 0.0 | 42 | \$14 | 0.0 | 0 | \$0 | \$14 | \$320 | \$206 | \$144 | 2.22 | 1.43 |
| CZ05-2 | PGE | SCG | 0.0 | 42 | \$14 | 0.0 | 0 | \$0 | \$14 | \$320 | \$206 | \$144 | 2.22 | 1.43 |
| CZ06 | SCE | SCG | 0.0 | 74 | \$18 | 0.0 | 0 | \$0 | \$18 | \$424 | \$351 | \$144 | 2.95 | 2.44 |
| CZ07 | SDGE | SDGE | 0.0 | 81 | \$25 | 0.0 | 0 | \$0 | \$25 | \$593 | \$374 | \$144 | 4.13 | 2.60 |
| CZ08 | SCE | SCG | 0.0 | 84 | \$20 | 0.0 | 0 | \$0 | \$20 | \$484 | \$420 | \$144 | 3.37 | 2.92 |
| CZ09 | SCE | SCG | 0.0 | 83 | \$20 | 0.0 | 0 | \$0 | \$20 | \$468 | \$441 | \$144 | 3.26 | 3.06 |
| CZ10 | SCE | SCG | 0.0 | 82 | \$17 | 0.0 | 0 | \$0 | \$17 | \$410 | \$427 | \$144 | 2.85 | 2.97 |
| CZ10-2 | SDGE | SDGE | 0.0 | 82 | \$25 | 0.0 | 0 | \$0 | \$25 | \$599 | \$427 | \$144 | 4.16 | 2.97 |
| CZ11 | PGE | PGE | 0.0 | 104 | \$27 | 0.0 | 0 | \$0 | \$27 | \$637 | \$635 | \$625 | 1.02 | 1.02 |
| CZ12 | PGE | PGE | 0.0 | 93 | \$24 | 0.0 | 0 | \$0 | \$24 | \$572 | \$568 | \$304 | 1.88 | 1.87 |
| CZ12-2 | SMUD | PGE | 0.0 | 93 | \$13 | 0.0 | 0 | \$0 | \$13 | \$319 | \$568 | \$304 | 1.05 | 1.87 |
| CZ13 | PGE | PGE | 0.0 | 132 | \$34 | 0.0 | 0 | \$0 | \$34 | \$798 | \$779 | \$625 | 1.28 | 1.25 |
| CZ14 | SCE | SCG | 0.0 | 80 | \$17 | 0.0 | 0 | \$0 | \$17 | \$407 | \$449 | \$304 | 1.34 | 1.48 |
| CZ14-2 | SDGE | SDGE | 0.0 | 80 | \$24 | 0.0 | 0 | \$0 | \$24 | \$576 | \$449 | \$304 | 1.90 | 1.48 |
| CZ15 | SCE | SCG | 0.0 | 145 | \$30 | 0.0 | 0 | \$0 | \$30 | \$719 | \$802 | \$625 | 1.15 | 1.28 |
| CZ16 | PGE | PGE | 0.0 | 117 | \$27 | 0.0 | 0 | \$0 | \$27 | \$646 | \$563 | \$625 | 1.03 | 0.90 |

¹ Values in red indicate B/C ratios less than 1.



Table 23: Mixed-Fuel Efficiency + PV Package Results (SAVINGS/COST PER APARTMENT)¹

| Climate Zone | Elec Utility | Gas Utility | 0.1 kW _{DC} per Apartment | | | | | 0.2 kW _{DC} per Apartment | | | | |
|---------------|--------------|-------------|--|------------------------------|-----------------|-------------------|---------------|--|------------------------------|-----------------|-------------------|---------------|
| | | | On-Bill Utility Cost Savings (2020 PV\$) | TDV Cost Savings (2020 PV\$) | Total Inc. Cost | On-Bill B/C Ratio | TDV B/C Ratio | On-Bill Utility Cost Savings (2020 PV\$) | TDV Cost Savings (2020 PV\$) | Total Inc. Cost | On-Bill B/C Ratio | TDV B/C Ratio |
| CZ01 | PGE | PGE | \$885 | \$597 | \$620 | 1.43 | 0.96 | \$1,637 | \$1,090 | \$937 | 1.75 | 1.16 |
| CZ02 | PGE | PGE | \$1,411 | \$877 | \$460 | 3.07 | 1.91 | \$2,431 | \$1,469 | \$777 | 3.13 | 1.89 |
| CZ03 | PGE | PGE | \$1,373 | \$812 | \$460 | 2.98 | 1.76 | \$2,400 | \$1,397 | \$777 | 3.09 | 1.80 |
| CZ04 | PGE | PGE | \$1,522 | \$947 | \$460 | 3.31 | 2.06 | \$2,579 | \$1,562 | \$777 | 3.32 | 2.01 |
| CZ04-2 | CPAU | CPAU | \$807 | \$947 | \$460 | 1.75 | 2.06 | \$1,335 | \$1,562 | \$777 | 1.72 | 2.01 |
| CZ05 | PGE | PGE | \$1,400 | \$834 | \$460 | 3.04 | 1.81 | \$2,480 | \$1,461 | \$777 | 3.19 | 1.88 |
| CZ05-2 | PGE | SCG | \$1,400 | \$834 | \$460 | 3.04 | 1.81 | \$2,480 | \$1,461 | \$777 | 3.19 | 1.88 |
| CZ06 | SCE | SCG | \$1,206 | \$969 | \$460 | 2.62 | 2.11 | \$1,987 | \$1,587 | \$777 | 2.56 | 2.04 |
| CZ07 | SDGE | SDGE | \$1,701 | \$1,010 | \$460 | 3.69 | 2.19 | \$2,770 | \$1,647 | \$777 | 3.57 | 2.12 |
| CZ08 | SCE | SCG | \$1,272 | \$1,064 | \$460 | 2.76 | 2.31 | \$2,059 | \$1,708 | \$777 | 2.65 | 2.20 |
| CZ09 | SCE | SCG | \$1,181 | \$1,091 | \$460 | 2.57 | 2.37 | \$1,876 | \$1,742 | \$777 | 2.41 | 2.24 |
| CZ10 | SCE | SCG | \$1,104 | \$1,054 | \$460 | 2.40 | 2.29 | \$1,797 | \$1,681 | \$777 | 2.31 | 2.16 |
| CZ10-2 | SDGE | SDGE | \$1,622 | \$1,054 | \$460 | 3.52 | 2.29 | \$2,646 | \$1,681 | \$777 | 3.41 | 2.16 |
| CZ11 | PGE | PGE | \$1,537 | \$1,256 | \$942 | 1.63 | 1.33 | \$2,438 | \$1,877 | \$1,258 | 1.94 | 1.49 |
| CZ12 | PGE | PGE | \$1,462 | \$1,181 | \$620 | 2.36 | 1.90 | \$2,352 | \$1,794 | \$937 | 2.51 | 1.91 |
| CZ12-2 | SMUD | PGE | \$772 | \$1,181 | \$620 | 1.25 | 1.90 | \$1,226 | \$1,794 | \$937 | 1.31 | 1.91 |
| CZ13 | PGE | PGE | \$1,673 | \$1,372 | \$942 | 1.78 | 1.46 | \$2,548 | \$1,965 | \$1,258 | 2.03 | 1.56 |
| CZ14 | SCE | SCG | \$1,165 | \$1,175 | \$620 | 1.88 | 1.89 | \$1,923 | \$1,901 | \$937 | 2.05 | 2.03 |
| CZ14-2 | SDGE | SDGE | \$1,697 | \$1,175 | \$620 | 2.74 | 1.89 | \$2,819 | \$1,901 | \$937 | 3.01 | 2.03 |
| CZ15 | SCE | SCG | \$1,423 | \$1,456 | \$942 | 1.51 | 1.55 | \$2,128 | \$2,110 | \$1,258 | 1.69 | 1.68 |
| CZ16 | PGE | PGE | \$1,606 | \$1,191 | \$942 | 1.71 | 1.26 | \$2,567 | \$1,818 | \$1,258 | 2.04 | 1.44 |

¹ Values in red indicate B/C ratios less than 1.



Table 24: Mixed-Fuel Efficiency + PV Package Results, cont. (SAVINGS/COST PER APARTMENT)¹

| Climate Zone | Elec Utility | Gas Utility | 0.3 kW _{DC} per Apartment | | | | | 1 kW _{DC} per Apartment | | | | |
|---------------|--------------|-------------|--|------------------------------|-----------------|-------------------|---------------|--|------------------------------|-----------------|-------------------|---------------|
| | | | On-Bill Utility Cost Savings (2020 PV\$) | TDV Cost Savings (2020 PV\$) | Total Inc. Cost | On-Bill B/C Ratio | TDV B/C Ratio | On-Bill Utility Cost Savings (2020 PV\$) | TDV Cost Savings (2020 PV\$) | Total Inc. Cost | On-Bill B/C Ratio | TDV B/C Ratio |
| CZ01 | PGE | PGE | \$2,389 | \$1,582 | \$1,253 | 1.91 | 1.26 | \$7,466 | \$5,029 | \$3,469 | 2.15 | 1.45 |
| CZ02 | PGE | PGE | \$3,452 | \$2,061 | \$1,093 | 3.16 | 1.88 | \$9,590 | \$6,203 | \$3,309 | 2.90 | 1.87 |
| CZ03 | PGE | PGE | \$3,428 | \$1,982 | \$1,093 | 3.14 | 1.81 | \$9,687 | \$6,079 | \$3,309 | 2.93 | 1.84 |
| CZ04 | PGE | PGE | \$3,635 | \$2,177 | \$1,093 | 3.32 | 1.99 | \$9,992 | \$6,483 | \$3,309 | 3.02 | 1.96 |
| CZ04-2 | CPAU | CPAU | \$1,863 | \$2,177 | \$1,093 | 1.70 | 1.99 | \$5,184 | \$6,483 | \$3,309 | 1.57 | 1.96 |
| CZ05 | PGE | PGE | \$3,561 | \$2,089 | \$1,093 | 3.26 | 1.91 | \$10,109 | \$6,482 | \$3,309 | 3.05 | 1.96 |
| CZ05-2 | PGE | SCG | \$3,561 | \$2,089 | \$1,093 | 3.26 | 1.91 | \$10,109 | \$6,482 | \$3,309 | 3.05 | 1.96 |
| CZ06 | SCE | SCG | \$2,769 | \$2,206 | \$1,093 | 2.53 | 2.02 | \$7,593 | \$6,534 | \$3,309 | 2.29 | 1.97 |
| CZ07 | SDGE | SDGE | \$3,805 | \$2,283 | \$1,093 | 3.48 | 2.09 | \$10,818 | \$6,739 | \$3,309 | 3.27 | 2.04 |
| CZ08 | SCE | SCG | \$2,838 | \$2,352 | \$1,093 | 2.60 | 2.15 | \$7,543 | \$6,861 | \$3,309 | 2.28 | 2.07 |
| CZ09 | SCE | SCG | \$2,570 | \$2,393 | \$1,093 | 2.35 | 2.19 | \$7,285 | \$6,948 | \$3,309 | 2.20 | 2.10 |
| CZ10 | SCE | SCG | \$2,490 | \$2,308 | \$1,093 | 2.28 | 2.11 | \$7,197 | \$6,697 | \$3,309 | 2.17 | 2.02 |
| CZ10-2 | SDGE | SDGE | \$3,670 | \$2,308 | \$1,093 | 3.36 | 2.11 | \$10,636 | \$6,697 | \$3,309 | 3.21 | 2.02 |
| CZ11 | PGE | PGE | \$3,338 | \$2,498 | \$1,575 | 2.12 | 1.59 | \$9,480 | \$6,846 | \$3,791 | 2.50 | 1.81 |
| CZ12 | PGE | PGE | \$3,242 | \$2,406 | \$1,253 | 2.59 | 1.92 | \$9,299 | \$6,694 | \$3,469 | 2.68 | 1.93 |
| CZ12-2 | SMUD | PGE | \$1,680 | \$2,406 | \$1,253 | 1.34 | 1.92 | \$4,855 | \$6,694 | \$3,469 | 1.40 | 1.93 |
| CZ13 | PGE | PGE | \$3,423 | \$2,558 | \$1,575 | 2.17 | 1.62 | \$9,402 | \$6,709 | \$3,791 | 2.48 | 1.77 |
| CZ14 | SCE | SCG | \$2,682 | \$2,626 | \$1,253 | 2.14 | 2.10 | \$7,820 | \$7,707 | \$3,469 | 2.25 | 2.22 |
| CZ14-2 | SDGE | SDGE | \$3,940 | \$2,626 | \$1,253 | 3.14 | 2.10 | \$11,557 | \$7,707 | \$3,469 | 3.33 | 2.22 |
| CZ15 | SCE | SCG | \$2,832 | \$2,764 | \$1,575 | 1.80 | 1.76 | \$7,676 | \$7,342 | \$3,791 | 2.03 | 1.94 |
| CZ16 | PGE | PGE | \$3,527 | \$2,445 | \$1,575 | 2.24 | 1.55 | \$10,032 | \$6,836 | \$3,791 | 2.65 | 1.80 |

¹ Values in red indicate B/C ratios less than 1.

Appendix E – Detailed Results All-Electric

Table 25: All-Electric Efficiency Only Package Results (SAVINGS/COST PER APARTMENT)^{1,2}

| Climate Zone | Elec Utility | Gas Utility | Apartments | | | Central Water Heating | | | Total | Savings (2020 PV\$) | | Total Inc. Cost (\$) | B/C Ratio | |
|--------------|--------------|-------------|----------------------|--------------------|-----------------------------|-----------------------|--------------------|-----------------------------|-----------------------------|------------------------------|------------------|----------------------|-----------|-----|
| | | | Gas Savings (therms) | Elec Savings (kWh) | Year 1 Utility Cost Savings | Gas Savings (therms) | Elec Savings (kWh) | Year 1 Utility Cost Savings | Year 1 Utility Cost Savings | On-Bill Utility Cost Savings | TDV Cost Savings | | On-Bill | TDV |
| CZ01 | PGE | PGE | 0.0 | 26 | \$6 | 124.6 | -899 | -\$46 | -\$40 | -\$674 | \$199 | -\$446 | 0.7 | >1 |
| CZ02 | PGE | PGE | 0.0 | 48 | \$17 | 114.3 | -810 | -\$38 | -\$21 | -\$238 | \$528 | -\$606 | 2.5 | >1 |
| CZ03 | PGE | PGE | 0.0 | 44 | \$15 | 114.9 | -811 | -\$38 | -\$23 | -\$287 | \$390 | -\$606 | 2.1 | >1 |
| CZ04 | PGE | PGE | 0.0 | 62 | \$20 | 110.7 | -775 | -\$35 | -\$15 | -\$102 | \$625 | -\$606 | 6.0 | >1 |
| CZ04-2 | CPAU | CPAU | 0.0 | 62 | \$11 | 110.7 | -775 | -\$5 | \$5 | \$345 | \$625 | -\$606 | >1 | >1 |
| CZ05 | PGE | PGE | 0.0 | 42 | \$14 | 117.3 | -830 | -\$40 | -\$26 | -\$350 | \$391 | -\$606 | 1.7 | >1 |
| CZ05-2 | PGE | SCG | 0.0 | 42 | \$14 | 117.3 | -830 | -\$66 | -\$53 | -\$827 | \$391 | -\$606 | 0.7 | >1 |
| CZ06 | SCE | SCG | 0.0 | 74 | \$18 | 107.0 | -744 | -\$28 | -\$10 | \$153 | \$612 | -\$606 | >1 | >1 |
| CZ07 | SDGE | SDGE | 0.0 | 81 | \$25 | 105.9 | -734 | -\$43 | -\$18 | -\$58 | \$665 | -\$606 | 10.4 | >1 |
| CZ08 | SCE | SCG | 0.0 | 84 | \$20 | 103.6 | -717 | -\$27 | -\$6 | \$227 | \$693 | -\$606 | >1 | >1 |
| CZ09 | SCE | SCG | 0.0 | 83 | \$20 | 103.5 | -716 | -\$27 | -\$7 | \$212 | \$739 | -\$606 | >1 | >1 |
| CZ10 | SCE | SCG | 0.0 | 83 | \$17 | 90.0 | -709 | -\$40 | -\$23 | -\$214 | \$396 | -\$853 | 4.0 | >1 |
| CZ10-2 | SDGE | SDGE | 0.0 | 83 | \$25 | 90.0 | -709 | -\$59 | -\$34 | -\$478 | \$396 | -\$853 | 1.8 | >1 |
| CZ11 | PGE | PGE | 0.0 | 104 | \$27 | 91.1 | -723 | -\$46 | -\$19 | -\$241 | \$430 | -\$371 | 1.5 | >1 |
| CZ12 | PGE | PGE | 0.0 | 93 | \$24 | 93.9 | -755 | -\$51 | -\$27 | -\$414 | \$288 | -\$693 | 1.7 | >1 |
| CZ12-2 | SMUD | PGE | 0.0 | 93 | \$13 | 93.9 | -755 | \$22 | \$36 | \$1,060 | \$288 | -\$693 | >1 | >1 |
| CZ13 | PGE | PGE | 0.0 | 132 | \$34 | 89.6 | -711 | -\$45 | -\$11 | -\$62 | \$505 | -\$371 | 6.0 | >1 |
| CZ14 | SCE | SCG | 0.0 | 80 | \$17 | 92.2 | -733 | -\$42 | -\$25 | -\$258 | \$305 | -\$693 | 2.7 | >1 |
| CZ14-2 | SDGE | SDGE | 0.0 | 80 | \$24 | 92.2 | -733 | -\$61 | -\$36 | -\$532 | \$305 | -\$693 | 1.3 | >1 |
| CZ15 | SCE | SCG | 0.0 | 145 | \$30 | 73.8 | -554 | -\$28 | \$3 | \$332 | \$832 | -\$371 | >1 | >1 |
| CZ16 | PGE | PGE | 0.0 | 119 | \$28 | 107.8 | -896 | -\$64 | -\$37 | -\$621 | \$127 | -\$371 | 0.6 | >1 |

¹ Values in red indicate B/C ratios less than 1.

² ">1" indicates cases where there are both incremental measure cost savings and energy cost savings.



Table 26: Table 19: All-Electric Efficiency + PV Package Results (SAVINGS/COST PER APARTMENT)^{1,2}

| Climate Zone | Elec Utility | Gas Utility | 0.1 kW _{DC} per Apartment | | | | | 0.2 kW _{DC} per Apartment | | | | |
|--------------|--------------|-------------|--|------------------------------|-----------------|-------------------|---------------|--|------------------------------|-----------------|-------------------|---------------|
| | | | On-Bill Utility Cost Savings (2020 PV\$) | TDV Cost Savings (2020 PV\$) | Total Inc. Cost | On-Bill B/C Ratio | TDV B/C Ratio | On-Bill Utility Cost Savings (2020 PV\$) | TDV Cost Savings (2020 PV\$) | Total Inc. Cost | On-Bill B/C Ratio | TDV B/C Ratio |
| CZ01 | PGE | PGE | \$78 | \$692 | -\$129 | >1 | >1 | \$830 | \$1,184 | \$187 | 4.44 | 6.33 |
| CZ02 | PGE | PGE | \$782 | \$1,120 | -\$289 | >1 | >1 | \$1,802 | \$1,712 | \$27 | 65.85 | 62.55 |
| CZ03 | PGE | PGE | \$741 | \$975 | -\$289 | >1 | >1 | \$1,768 | \$1,560 | \$27 | 64.62 | 57.02 |
| CZ04 | PGE | PGE | \$955 | \$1,240 | -\$289 | >1 | >1 | \$2,012 | \$1,855 | \$27 | 73.51 | 67.79 |
| CZ04-2 | CPAU | CPAU | \$904 | \$1,240 | -\$289 | >1 | >1 | \$1,432 | \$1,855 | \$27 | 52.33 | 67.79 |
| CZ05 | PGE | PGE | \$730 | \$1,018 | -\$289 | >1 | >1 | \$1,810 | \$1,646 | \$27 | 66.14 | 60.14 |
| CZ05-2 | PGE | SCG | \$254 | \$1,018 | -\$289 | >1 | >1 | \$1,334 | \$1,646 | \$27 | 48.74 | 60.14 |
| CZ06 | SCE | SCG | \$935 | \$1,231 | -\$289 | >1 | >1 | \$1,716 | \$1,849 | \$27 | 62.71 | 67.56 |
| CZ07 | SDGE | SDGE | \$1,049 | \$1,302 | -\$289 | >1 | >1 | \$2,118 | \$1,938 | \$27 | 77.41 | 70.82 |
| CZ08 | SCE | SCG | \$1,014 | \$1,337 | -\$289 | >1 | >1 | \$1,802 | \$1,981 | \$27 | 65.83 | 72.37 |
| CZ09 | SCE | SCG | \$924 | \$1,390 | -\$289 | >1 | >1 | \$1,619 | \$2,040 | \$27 | 59.16 | 74.56 |
| CZ10 | SCE | SCG | \$480 | \$1,023 | -\$536 | >1 | >1 | \$1,173 | \$1,650 | -\$219 | >1 | >1 |
| CZ10-2 | SDGE | SDGE | \$546 | \$1,023 | -\$536 | >1 | >1 | \$1,570 | \$1,650 | -\$219 | >1 | >1 |
| CZ11 | PGE | PGE | \$660 | \$1,052 | -\$55 | >1 | >1 | \$1,560 | \$1,673 | \$262 | 5.96 | 6.39 |
| CZ12 | PGE | PGE | \$476 | \$900 | -\$376 | >1 | >1 | \$1,366 | \$1,513 | -\$60 | >1 | >1 |
| CZ12-2 | SMUD | PGE | \$1,513 | \$900 | -\$376 | >1 | >1 | \$1,967 | \$1,513 | -\$60 | >1 | >1 |
| CZ13 | PGE | PGE | \$813 | \$1,098 | -\$55 | >1 | >1 | \$1,687 | \$1,691 | \$262 | 6.44 | 6.46 |
| CZ14 | SCE | SCG | \$500 | \$1,031 | -\$376 | >1 | >1 | \$1,259 | \$1,757 | -\$60 | >1 | >1 |
| CZ14-2 | SDGE | SDGE | \$589 | \$1,031 | -\$376 | >1 | >1 | \$1,710 | \$1,757 | -\$60 | >1 | >1 |
| CZ15 | SCE | SCG | \$1,037 | \$1,485 | -\$55 | >1 | >1 | \$1,741 | \$2,139 | \$262 | 6.65 | 8.17 |
| CZ16 | PGE | PGE | \$339 | \$754 | -\$55 | >1 | >1 | \$1,299 | \$1,381 | \$262 | 4.96 | 5.27 |

¹ Values in red indicate B/C ratios less than 1.² ">1" indicates cases where there are both incremental measure cost savings and energy cost savings. Values in red indicate B/C ratios less than 1.0

Table 27: All-Electric Package Results with PV, cont. (SAVINGS/COST PER APARTMENT)^{1,2}

| Climate Zone | Elec Utility | Gas Utility | 0.3 kW _{DC} per Apartment | | | | | 1.0 kW _{DC} per Apartment | | | | |
|--------------|--------------|-------------|--|------------------------------|-----------------|-------------------|---------------|--|------------------------------|-----------------|-------------------|---------------|
| | | | On-Bill Utility Cost Savings (2020 PV\$) | TDV Cost Savings (2020 PV\$) | Total Inc. Cost | On-Bill B/C Ratio | TDV B/C Ratio | On-Bill Utility Cost Savings (2020 PV\$) | TDV Cost Savings (2020 PV\$) | Total Inc. Cost | On-Bill B/C Ratio | TDV B/C Ratio |
| CZ01 | PGE | PGE | \$1,582 | \$1,676 | \$504 | 3.14 | 3.33 | \$6,660 | \$5,123 | \$2,719 | 2.45 | 1.88 |
| CZ02 | PGE | PGE | \$2,822 | \$2,304 | \$344 | 8.21 | 6.70 | \$8,960 | \$6,446 | \$2,560 | 3.50 | 2.52 |
| CZ03 | PGE | PGE | \$2,796 | \$2,146 | \$344 | 8.13 | 6.24 | \$9,055 | \$6,242 | \$2,560 | 3.54 | 2.44 |
| CZ04 | PGE | PGE | \$3,069 | \$2,470 | \$344 | 8.92 | 7.18 | \$9,425 | \$6,777 | \$2,560 | 3.68 | 2.65 |
| CZ04-2 | CPAU | CPAU | \$1,960 | \$2,470 | \$344 | 5.70 | 7.18 | \$5,281 | \$6,777 | \$2,560 | 2.06 | 2.65 |
| CZ05 | PGE | PGE | \$2,890 | \$2,274 | \$344 | 8.40 | 6.61 | \$9,439 | \$6,667 | \$2,560 | 3.69 | 2.60 |
| CZ05-2 | PGE | SCG | \$2,414 | \$2,274 | \$344 | 7.02 | 6.61 | \$8,962 | \$6,667 | \$2,560 | 3.50 | 2.60 |
| CZ06 | SCE | SCG | \$2,498 | \$2,467 | \$344 | 7.26 | 7.17 | \$7,322 | \$6,796 | \$2,560 | 2.86 | 2.65 |
| CZ07 | SDGE | SDGE | \$3,154 | \$2,575 | \$344 | 9.17 | 7.49 | \$10,166 | \$7,030 | \$2,560 | 3.97 | 2.75 |
| CZ08 | SCE | SCG | \$2,581 | \$2,625 | \$344 | 7.51 | 7.63 | \$7,286 | \$7,133 | \$2,560 | 2.85 | 2.79 |
| CZ09 | SCE | SCG | \$2,314 | \$2,691 | \$344 | 6.73 | 7.83 | \$7,028 | \$7,247 | \$2,560 | 2.75 | 2.83 |
| CZ10 | SCE | SCG | \$1,866 | \$2,277 | \$97 | 19.22 | 23.46 | \$6,573 | \$6,666 | \$2,313 | 2.84 | 2.88 |
| CZ10-2 | SDGE | SDGE | \$2,594 | \$2,277 | \$97 | 26.72 | 23.46 | \$9,560 | \$6,666 | \$2,313 | 4.13 | 2.88 |
| CZ11 | PGE | PGE | \$2,461 | \$2,294 | \$578 | 4.25 | 3.97 | \$8,602 | \$6,641 | \$2,794 | 3.08 | 2.38 |
| CZ12 | PGE | PGE | \$2,256 | \$2,125 | \$257 | 8.78 | 8.28 | \$8,313 | \$6,413 | \$2,473 | 3.36 | 2.59 |
| CZ12-2 | SMUD | PGE | \$2,421 | \$2,125 | \$257 | 9.43 | 8.28 | \$5,596 | \$6,413 | \$2,473 | 2.26 | 2.59 |
| CZ13 | PGE | PGE | \$2,562 | \$2,284 | \$578 | 4.43 | 3.95 | \$8,541 | \$6,435 | \$2,794 | 3.06 | 2.30 |
| CZ14 | SCE | SCG | \$2,017 | \$2,482 | \$257 | 7.85 | 9.67 | \$7,155 | \$7,563 | \$2,473 | 2.89 | 3.06 |
| CZ14-2 | SDGE | SDGE | \$2,831 | \$2,482 | \$257 | 11.02 | 9.67 | \$10,448 | \$7,563 | \$2,473 | 4.23 | 3.06 |
| CZ15 | SCE | SCG | \$2,445 | \$2,793 | \$578 | 4.23 | 4.83 | \$7,289 | \$7,371 | \$2,794 | 2.61 | 2.64 |
| CZ16 | PGE | PGE | \$2,260 | \$2,009 | \$578 | 3.91 | 3.47 | \$8,764 | \$6,399 | \$2,794 | 3.14 | 2.29 |

¹ Values in red indicate B/C ratios less than 1.² ">1" indicates cases where there are both incremental measure cost savings and energy cost savings. Values in red indicate B/C ratios less than 1.0



Electric Vehicle Infrastructure Cost Analysis Report for Peninsula Clean Energy (PCE) & Silicon Valley Clean Energy (SVCE)

To: Peninsula Clean Energy & Silicon Valley Clean Energy

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Energy Solutions

Date: November 20, 2019

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1. Executive Summary

California and the Bay Area are on the verge of a massive transformation. Current estimates² put electric vehicles (EVs) and plug-in hybrid vehicles (PHEVs) at a 5% market share but by 2030, that is expected to grow to 18-20%. Access to electric vehicles (EV) infrastructure is currently a major barrier for consumers' willingness to purchase electric vehicles. Meanwhile, several studies show that installation of EV infrastructure has significant costs, most notably in a retrofit scenario which has multiple cost factors. This report investigates infrastructure costs associated with EV infrastructure reach codes by building an EV cost effectiveness model, which examined three common building types and applied different EV infrastructure penetration rates. The model also studied utility-side infrastructure, such as distribution transformers, that potentially yield additional costs and affect a building owner's ability to comply with expanded EV infrastructure adoption, to understand the scale and frequency of those costs.

EV Infrastructure: New Construction vs. Retrofit: Customer costs

The cost effectiveness model compared three building scenarios: (1) a medium 60-unit multi-unit dwelling (MUD) with 60 parking spaces, (2) a high-density 150-unit MUD with 150 parking spaces, and (3) a medium commercial office building with 60 parking spots. The model compares customer-side electrical infrastructure costs, such as wiring, switch gear, conduit, trenching, and secondary transformer. Primary transformer costs which are usually the responsibility of utilities, were considered separately in a later section³. The building models were then analyzed to compare the new construction requirements with the retrofit requirements. Results from Table 1 below show that costs for new construction were significantly lower, at almost four times as much per spot compared to the retrofit scenario. This indicates that increasing code requirements for charging infrastructure could potentially save significant amounts of money to building owners in the new construction context rather than waiting for tenants to become interested in electric vehicles, at which point significant costs related to invasive demolition and electrical infrastructure replacement would be necessary.

Table 1. Estimated Cost of Installing EV Infrastructure (price per spot)

| Code Scenario: | Market Rate 25% Level 2 75% Level 1 | | Affordable Housing 10% Level 2 90% Level 1 | |
|--------------------------|---|-----------------------|--|----------|
| | New Construction | Retrofit ⁴ | New Construction | Retrofit |
| 60-Unit MUD | \$1,410 | \$4,443 | \$1,049 | +\$3,982 |
| 150-Unit MUD | \$1,197 | \$4,101 | \$1,002 | +\$3,854 |
| 60-Space Office Building | \$1,166 | \$3,232 | N/A | N/A |

² <http://businessportal.ca.gov/wp-content/uploads/2019/07/GoBIZ-EVCharging-Guidebook.pdf>

³ Primary transformers are owned and operated by the utility and covered in a subsequent section but have cost components that can spill over to customer fees in multiple ways (PG&E Electric [Rule 16](#)).

⁴ "New Construction" and "Retrofit" costs are relative to a CALGreen 2019 mandatory baseline building

In a retrofit context, there are significant known costs, such as those documented in this infrastructure costing model, but there are a high level of unknown opaque costs that either are born by the utility or by the customer, which while infrequent, can cause significant burden on a small number of building owners and tenants that are not present in New Construction projects. In addition, retrofitting parking structures for Americans with Disabilities Act (ADA) compliance can be a significant source of costs. Recent large-scale pilot studies conducted by the California utilities confirmed these cost burdens. For example, Pacific Gas & Electric’s (PG&E) EV Charge Ready program reported an “Average Cost per Port” costs for retrofit projects in their program to be almost \$18,000⁵ with a range between \$10,000 and \$31,000⁶. The utility reports specifically call out ADA requirements and inconsistent requirements across jurisdictions, which required significant redesign costs for ADA compliance.

EV Infrastructure: Building size / Transformers

Distribution transformers are a key piece of EV infrastructure and their costs and magnitude are heavily influenced by building size. For most situations, small buildings utilize shared distribution transformers split between multiple electrical accounts; medium buildings feature a dedicated utility-owned transformer and large buildings may feature several transformers, some are utility-owned and some are customer-owned depending on the uses and electrical design of the building. The particular trigger points between building sizes are influenced by the utility rules on electrical infrastructure equipment specifications and are not comparative between utilities. The graph below illustrates when certain costs become important to assist policy makers:

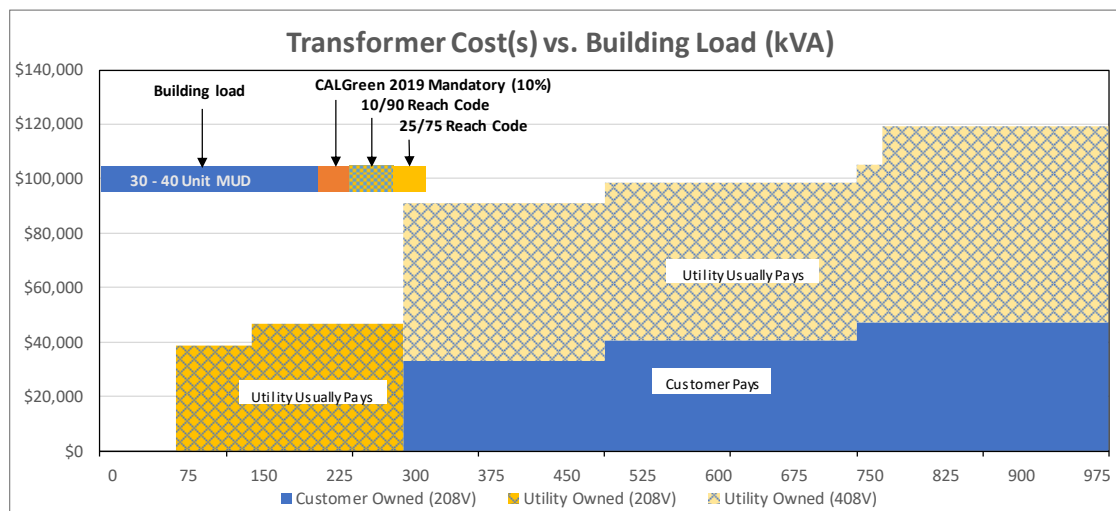


Figure 1: Costs of Transformers vs. Transformer system size (PG&E service territory)⁷

⁵ Note that these costs include extensive design and re-design as well as utility side costs:

[Pacific Gas and Electric Company EV Charge Network Quarterly Report \(Q1-2019\)](#)

⁶ [Q2 2019 Clean Transportation Program Advisory Council Meeting](#)

⁷ This graph shows PG&E’s specific equipment sizing and is not comparable to other utilities. Calculations are based on estimates from the infrastructure cost model.

Costs of distribution and/or service-line upgrades are partially split between customer and utility. Customers are responsible for excavation, conduits, and protective structures. Utilities are typically responsible for wiring, metering, and transformer(s) (where necessary), however, utility costs can spill over into customer costs anytime that the costs exceed the preset “allowance” for a customer, based on historical energy usage.⁸ In addition, if new load, does not materialize, the utility is able to assess additional charges for the difference in expected revenue. Currently, costs are described by California Public Utilities Commission’s (CPUC) Electric Rules 2, 15, and 16 which lay out which party is responsible for these costs, however, these costs are complicated, opaque, and hard to predict. Luckily, the CPUC is tracking costs related to EV infrastructure and has found that utility-side infrastructure upgrades triggered by EV-only projects are rare. To date, for PG&E’s service territory found only 3% of projects required distribution or service-line upgrades to accommodate EV infrastructure. However those costs spanned a wide cost range from \$14 to \$338,274 (additional details on this study can be found in the Transformers section below).

Reach Code Context

This study investigated EV-infrastructure reach codes for communities in the jurisdiction of Silicon Valley Clean Energy (SVCE) and Peninsula Clean Energy (PCE), shown in Table 4 below. The study found that increasing the electric vehicle infrastructure requirements for new construction will save significant costs for all buildings when compared to a retrofitting. The study also found that transformer capacity limitations are not expected to occur very frequently and that even in the retrofit context most buildings should be able to meet the added load. For those that do not have significant capacity, utilizing lower power “Level 1” ports or load management may be a promising options.

Buildings near the boundary conditions highlighted above in Figure 1, in particular those that approach the 300 kVA capacity size⁹, face added risk of electrical infrastructure upgrade costs. For owners of those new buildings, the electrical systems would have to accommodate a second transformer and associated electrical infrastructure and the owner/developer would need to bear those costs estimated to be approximately \$50,000 (or significantly more in a retrofit context).

⁸ Customers have an “allowance” based on their billing history to fund utility upgrades, but if allowance costs are exceeded, they are charged directly to the customer (PG&E Electric [Rule 15](#) & [Rule 16](#)). This allowance is based on the net revenue of the customer account. In addition, if the expected load does not materialize to use the system upgrade, the utility is permitted to recover their costs from the customer.

⁹ For example, for a 30-40 unit MUD, this may be a consideration as shown in Figure 1.

2. Background and Purpose

Purpose

The purpose of this report is to provide cost analysis data on electric vehicle infrastructure and to support and inform potential adoption of reach codes for cities and municipalities in Santa Clara and San Mateo counties. This report investigates potential reach codes that would 1) require “EV-ready” parking spaces, parking spaces which are already equipped with wiring and simply need an electric vehicle supply equipment (EVSE) to provide charging, and 2) increase the EV charging space requirements for market-rate housing, affordable housing, and commercial-office buildings. The CALGreen nonresidential code currently requires only that “EV capable” parking spaces be provided, which requires conduit and electrical panel capacity for a 40 ampere, 208/240-volt circuit serving the space, but does not require wiring nor EVSE installation and associated expenses. The following table describes these EV equipment tiers:

| | |
|-----------------------------------|--|
| EV Capable | Includes conduit / raceways |
| EV Ready (“Plug and play”) | Includes full circuit with a receptacle / outlet |
| EV Installed | Includes full charging capability with EVSE |

This cost report estimates the incremental costs associated with expanding EV infrastructure requirements beyond existing CALGreen 2019 mandatory requirements and compares the incremental construction costs from a new construction project with those of a retrofit project, utilizing an EV infrastructure cost model for three prototype buildings: (1) a 60-unit medium MUD, (2) a 150-unit large MUD, and (3) a medium-sized commercial office with 60 parking spaces. In all residential cases, we assumed one parking space per unit was assumed.

In addition, the report also investigates distribution current transformers, which will be increasingly important as electrical loads increase due to building and transportation electrification. Specifically, the utility rules and electrical load requirements were analyzed to determine boundary conditions where transformers would be required, the relative cost to incorporate them, and points at which multiple current transformers may be required, and the relative magnitude of those costs. The report also delineates specific situations for when transformers are utility owned and when they become a customer costs

California’s EV Infrastructure Policy Goals

The increased proliferation of EV charging infrastructure supports many of California’s zero-emission vehicle adoption goals, including the objective to deploy 1.5 million zero-emission vehicles and 250,000 publicly

available EV charging stations including 10,000 direct current (DC) fast chargers by 2025.¹⁰ California also has a goal of deploying 5 million ZEVs by 2030, which will require an even larger scale-up of public stations in addition to millions of non-public EV charging stations.¹¹ As of October 2019, California had approximately 18,500 public Level 2 charging ports at over 5,000 locations and approximately 3,200 public DC fast charging stations at over 700 locations.¹² California must make significant progress quickly, including updating CALGreen requirements and for local communities, investigating reach codes and the potential costs.

Parking spaces at workplaces and other non-residential buildings will be needed to accommodate a California vehicle fleet that is expected to have 18%-24% ZEVs in 2030. The future percentage of ZEVs will require a much higher percentage of parking spaces than the current CALGreen code requirements.¹³

EV charging infrastructure is a critical policy to help California reach its climate and EV adoption goals by providing opportunities at homes and workplaces as well as overcoming the critical challenge of “range anxiety” associated with EV adoption.¹⁴ Surveys of communities in the Bay Area have shown that access to vehicle charging remains a main hurdle to wider adoption and in spite of that electric vehicle adoption is expected to grow significantly.

Building codes are an important way to facilitate access to EV charging so that residents, commuters, fleets, and car-sharing services can benefit from the significant operating cost advantages in a way that is cost-effective and accessible for all. Furthermore, because EV capable parking spaces can avoid or greatly reduce several types of costs associated with installing EV charging stations, public and private funding can achieve greater number of EV charging stations faster and more efficiently. Thus, increasing the levels of EV capable parking spaces beyond those set by CALGreen will lead to significant increases in EV charging infrastructure.

CALGreen and Beyond

CALGreen is the first mandatory green building standards code in the nation and often serves as a model for other state and local governments across the country. It was originally developed in 2007 by the California Building Standards Commission (CBSC) to help meet the goals of AB 32 in reducing greenhouse gases to 1990 levels by 2020.¹⁵ Every three years, the CALGreen code is reviewed, revised, and adopted statewide

¹⁰ Former Governor Edmund G. Brown Jr. Executive Order B-16-2012 set the goal of placing 1.5 million zero-emission vehicles on California’s roads by 2025. Former Governor Edmund G. Brown’s Executive Order B-48-18 set the goal of 250,000 electric vehicle charging stations, including 10,000 DCFC charging stations, by 2025. In addition, the Charge Ahead California Initiative, [SB 1275 (De León), Chapter 530, Statutes of 2014] set a goal of placing 1 million zero- and near-zero-emission vehicles into service on California’s roads by 2023.

¹¹ Former Governor Edmund G. Brown Jr. Executive Order B-48-18 set the goal of 5 million zero-emission vehicles on California’s roads by 2030.

¹² Statistics are from the Alternative Fueling Station Locator (August 2019): https://afdc.energy.gov/stations/#/analyze?region=US-CA&fuel=ELEC&ev_levels=dc_fast&country=US

¹³ The California Air Resources Board’s EMFAC2017 database estimates that 21.0 million “LDA” (automobiles) and “LDT1” (light duty trucks) will be on the road in 2030. The database also estimates that 6.3 million additional “LDT2” (a second category of light duty trucks) will be on the road, some of which could be used for workplace commuting or other trips to non-residential buildings.

¹⁴ “Range anxiety” refers to concerns about insufficient range and inability to find EV charging stations.

¹⁵ “CALGreen”, Department of General Service, <https://www.dgs.ca.gov/BSC/Resources/Page-Content/Building-Standards-Commission-Resources-List-Folder/CALGreen>

along with other sections of Title 24 for residential and nonresidential buildings. The latest version of the CALGreen code takes effect on January 1, 2020 and is referred to by CBSC as “CALGreen 2019.”

The nonresidential CALGreen EV capable infrastructure requirements (California Code of Regulations, Title 24, Part 11 Sections 5.106 and A5.106) and the multifamily requirements (California Code of Regulations, Title 24, Part 11, Sections 4.106 and A4.106) which will take effect January 1, 2020 are shown in Table 2 and Table 3.

Table 2. Summary of Mandatory and Voluntary CALGreen 2019 EV Capable Parking Space Standards for New Construction (Non-Residential)

| Current Mandatory | Voluntary Tier 1 | Voluntary Tier 2 |
|-------------------|------------------|------------------|
| 6% | 8% | 10% |

Table 3. Summary of Mandatory and Voluntary CALGreen 2019 EV Capable Parking Space Standards for New Construction (Residential)

| Current Mandatory | Voluntary Tier 1 | Voluntary Tier 2 |
|-------------------|------------------|------------------|
| 10% | 15% | 20% |

The California Building Standards allow for more restrictive local amendments that are necessary because of local climatic, geological, or topographical conditions. Currently, two dozen municipalities in California have adopted local building codes that require more EV parking spaces than CALGreen and in many cases already require “EV ready” spaces with complete wiring.¹⁶ Given the findings of this report, local jurisdictions that expand upon CALGreen requirements, could yield improved cost-savings potential for local businesses and developers.

As mentioned above, this report investigated the cost effectiveness of “EV reach codes” for market-rate housing, affordable housing, and commercial-office buildings. Table 4 below shows the following code levels that were investigated. Note that the baseline CALGreen 2019 levels are shown in “()” for comparative purposes.

¹⁶ Pike, E. et. al. 2018. Driving Plug-in Electric Vehicle Adoption with Green Building Codes, August 17. ACEEE Summer Conference. Examples of agencies that are proposing local codes include Berkeley, Brisbane, San Jose, San Mateo, and many others.

Table 4. Summary of EV Reach Code Scenarios Analyzed

| | MUD Market Rate (25/75) | MUD Affordable Housing (10/90) | Commercial Office |
|--------------|----------------------------------|---|----------------------|
| “EV Capable” | (10%) | (10%) | 30% (6%) |
| Level 2 | 25% | 10% | 10%, EVSE |
| Level 1 | 75% | 90% | 10% |

3. Cost Modeling

Scenarios

The model investigates three prototype building models at the CALGreen 2019 mandatory requirement level. Those models were then analyzed for EV infrastructure installation costs as described in the scenarios described in Table 4 above for a new construction scenario and a retrofit scenario for a total of thirteen runs in the cost model. Table 5 below provides a high-level view of the building prototype models in terms of number of parking spaces, approximate building area, parking lot area, and number of stories. These buildings represent hypothetical building scenarios that are based on several assumptions and may not be reflective of any one building. Please refer to the appendix and methodology for additional details.

Buildings Types Descriptions

60-unit MUD: A 60-unit apartment building with enclosed parking with 60 parking spaces to represent a medium-sized MUD building.

150-unit MUD: A 150-unit apartment building with enclosed parking with 150 parking spaces to representing a large MUD building.

60-space Commercial Office: An open parking lot with 60 spaces, to representing a medium-sized office building.

TRANSFORMER-RELATED DEFINITIONS:

Primary Transformer: A utility-owned transformer used to convert medium voltage utility distribution lines (normally 12kV) to customer level power at either 480V/277V for large buildings or 208V/120V or 240V/120V for medium buildings. Primary transformers are owned and operated by the utility but any upgrade installation costs are partially split with the building owner.

Secondary Transformer: A customer-owned transformer that converts 480V/277V power down to 208V/120V service (or 240V/120V). Usually only necessary for medium-sized or large-sized buildings.

Headroom: Additional space left for transformer sizing to account for future unspecified load, typically 20%.

Table 5. Building Prototypes & Baseline Conditions

| Building Type | 60-unit MUD | 150-unit MUD | 60-Space Office |
|--|-------------------|-------------------|-----------------|
| Number of Units | 60 | 150 | n/a |
| Total number of parking spaces required | 60 | 150 | 60 |
| Building Area [ft ²] | 65,000 | 163,000 | 20,000 |
| Number of Floors | 4 to 5 | 8 to 9 | 1 to 3 |
| Parking Lot Size [ft ²] | 14,000 | 38,800 | 14,000 |
| Parking Lot Type | 1-level structure | 2-level structure | stand-alone lot |
| CALGreen Level 2 Charging Requirement | 6 | 15 | 4 |
| Building Load [kVA] | 292 | 700 | 98 |
| CALGreen EV Load [kVA] | 43 | 86 | 29 |
| Total Load [kVA] | 335 | 786 | 126 |
| Load with Headroom [kVA] | 402 | 944 | 152 |
| Percent of load from CalGreen EV Load | 11% | 11% | 18% |
| Secondary Transformer [kVA] (480V -> 208V / 120V) | 500 | 1000 | 225 |
| Primary Transformer [kVA] (12kV -> 480V / 277V) | 750 | 1000 | 300 |

Table 6. Load Comparisons across Scenarios

| Building Type | 60-Unit MUD ¹⁷ | | 150-Unit MUD | | 60-Space Office Building |
|--|---------------------------|--------------------|------------------------|--------------------|--------------------------|
| Baseline Building Load [kVA] | 292 | | 700 | | 98 |
| Baseline Level 2 [# of Ports] (CALGreen 2019) | 6 | | 15 | | 4 |
| Baseline EV Load [kVA] (CALGreen 2019) | 43 | | 86 | | 29 |
| Capacity Requirement (with headroom) | 402 kVA | | 944 kVA | | 152 kVA |
| Secondary Transformer Size | 500 kVA | | 1000 kVA | | 300 kVA |
| Reach Code Scenario | Market Rate | Affordable Housing | Market Rate | Affordable Housing | 10% L2 40% L1 |
| Additional Level 2 Ports | +12 ports | 0 ports | +22 ports | 0 ports | +2 ports |
| Additional Level 1 Ports | +45 ports | +54 ports | +113 ports | +135 L1 | +24 ports |
| Additional EV Load [kVA] | +95 kVA | +54 kVA | +257 kVA | +156 kVA | +33 kVA |
| TOTAL EV Load [kVA] | 430 kVA | 389 kVA | 1043 kVA | 942 kVA | 160 kVA |
| Secondary Transformer Size | 500 kVA | 500 kVA | 1500 kVA ¹⁸ | 1000 kVA | 300 kVA |
| Percent of load from EVs | 32% | 25% | 33% | 26% | 39% |

¹⁷ Some of the capacity loading calculations do not appear additive. For any parking scenario with more than 10 chargers, we utilized a diversity factor of 80% to account for non-coincident charging.

¹⁸ Our cost model assumes that for a retrofit scenario, a second 500 kVA transformer would be installed rather than demolition

Results

The results of the cost analysis model show that installing EV capable spaces as a stand-alone retrofit are close to four times as expensive compared to during new construction. Costs for these project types are shown in Table 7 and Table 9 with detailed breakdowns in Appendix A.

Several factors related to *building types* affect these results:

- Costs per space are generally higher for small buildings with a small number of retrofits for EV capable infrastructure. Smaller projects must divide fixed costs among fewer spaces than larger projects.
- Buildings that are at the cusp of needing an upgraded switch gear or transformers represent **significant cost** increases to add electric vehicles, particularly in a retrofit context where there are large costs from demolition and site disruption. The prototypes we studied were unable to illustrate this point so additional narrative about these costs have been added in the ‘Distribution Transformers’ section. For this study, the prototype buildings we used only surpassed the baseline transformer capacity on one scenario – and the loading was such that we did not expect significant demolition was not expected. Switch gear and secondary transformer costs were included but did not include added costs for demolition, removal, or expansion of electrical rooms¹⁹ -or- any costs associated with utility-owned primary transformer upgrades²⁰.
- Our cost model found that enclosed parking was less expensive than an open parking lot. This is because surface-mounted conduit is often less expensive to retrofit than trenching, and repairing surface parking areas. However, enclosed parking is usually much more expensive when considering ADA compliance due to grading, restriping, and accounting for path of travel.

Several factors related to *project type* affect these results:

- Installing conduit in new construction is much less expensive than retrofitting it later for several reasons.
 - Demolition, disposal of materials, and repair of surface parking areas is not required.
 - Conduit can be installed directly underneath parking rather than routing around existing barriers. In addition, less expensive PVC (plastic) conduit can be installed in the parking floor (tied to rebar before concrete is poured) rather than surface mounted later. While wiring of branch circuits is not included in this report, these shorter lengths will also reduce wiring costs.
 - Running conduit through existing buildings will likely require demolition of walls, and potentially through floors as well²¹
 - Requiring that new electrical service panels contain capacity for EV capable infrastructure can achieve economies of scale and avoid the situations where an electrical room must be

¹⁹ Demolition, Removal, and expansion of electrical rooms were not considered because they are highly dependent on site-specific factors that are difficult to estimate from the generic building prototypes we developed.

²⁰ Utility-side transformer costs are analyzed in a separate section

²¹ X-ray cameras are usually used to prevent damage to concrete structures.

expanded to add additional charging. This latter cost is not included in the model, and thus, some retrofits for EV capable spaces would be significantly more expensive.

- Compared to stand-alone retrofits, incremental “soft” costs will be lower for new construction. This is because fixed costs not related to EV capable spaces will already be required for construction and the incremental cost will be much lower.²²
- Equipment needed for trenching of surface parking will likely already be on-site during new construction, limiting costs.

Table 7. Incremental Costs Required to Install EV Infrastructure

| Code Scenario | Market Rate 25% Level 2 75% Level 1 | | Affordable Housing 10% Level 2 90% Level 1 | |
|--------------------------|---|-----------|--|-----------|
| | New Construction | Retrofit | New Construction | Retrofit |
| 60-Unit MUD | \$76,142 | \$239,909 | \$56,629 | \$215,051 |
| 150-Unit MUD | \$161,550 | \$553,682 | \$135,301 | \$520,227 |
| 60-Space Office Building | \$34,971 | \$96,970 | N/A | N/A |

²² Pike, Ed and Steuben, Jeff. “Plug-In Electric Vehicle Infrastructure, Cost-Effectiveness Report.” 2016

Table 8. Number of EV Charging Ports per Scenario

| Code Scenario: | CALGreen 2019 | Market Rate 25% Level 2 75% Level 1 | Affordable Housing 10% Level 2 90% Level 1 |
|--------------------------|---------------|---|--|
| 60-Unit MUD | 6 L2 | 15 L2 45 L1 | 6 L2 54 L1 |
| 150-Unit MUD | 15 L2 | 38 L2 112 L1 | 15 L2 135 L1 |
| 60-Space Office Building | 4 L2 | 6 L2 24 L1 | N/A |

Table 9. Estimated Cost of Installing EV Infrastructure (price per spot)²³

| Code Scenario: | Market Rate 25% Level 2 75% Level 1 | | Affordable Housing 10% Level 2 90% Level 1 | |
|--------------------------|---|----------|--|----------|
| Building Type | New Construction | Retrofit | New Construction | Retrofit |
| 60-Unit MUD | \$1,410 | \$4,443 | \$1,049 | \$3,982 |
| 150-Unit MUD | \$1,197 | \$4,101 | \$1,002 | \$3,854 |
| 60-Space Office Building | \$1,166 | \$3,232 | N/A | N/A |

Figure 2, 3, and 4 summarize the major categories of costs such as: demolishing and repairing parking lots and sidewalks, upgrading electrical service panels, obtaining permits and inspections, and installing conduit and associated equipment. CALGreen is the baseline cost - all other scenarios are costs *in addition* to the CALGreen baseline. Tables showing the specific dollar amounts and percent of total project cost by category are shown in the Appendix A.

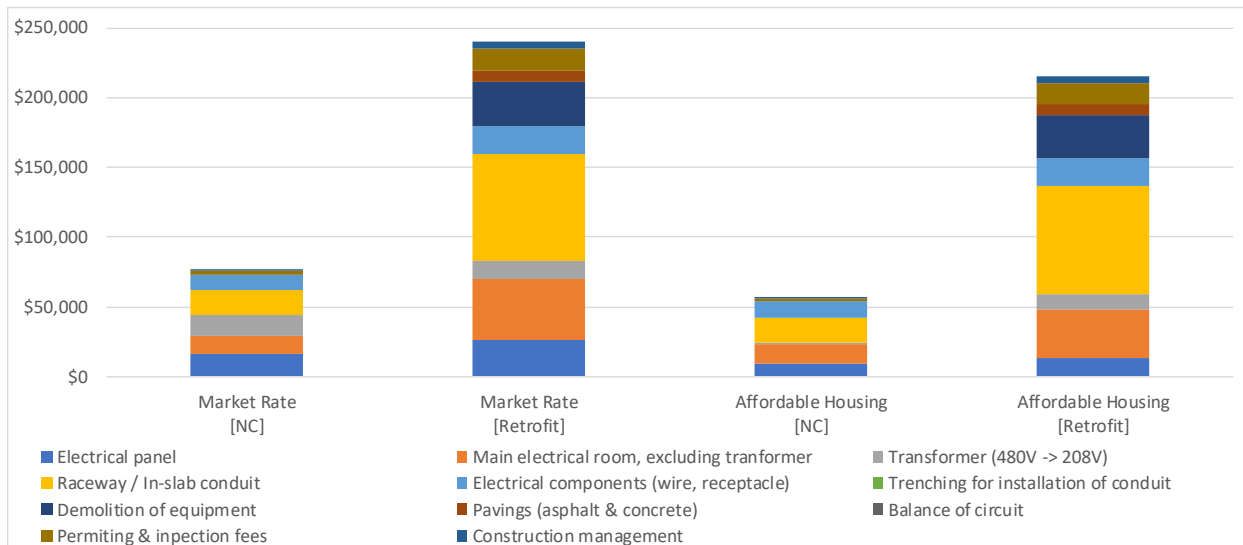


Figure 2. Cost Break-Down for 60-unit MUD

²³ Price per spot is calculated against the baseline CALGreen level. For illustrative purposes: 60-unit scenarios are divided by 54 spaces, which represents the incremental number of spaces added for the incremental cost.

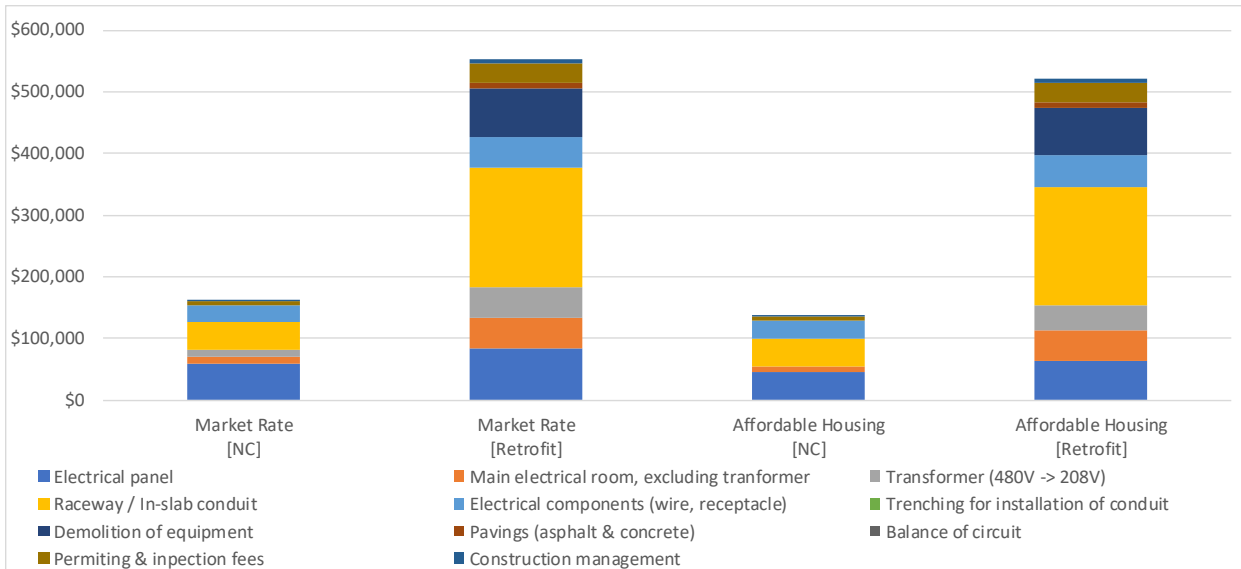


Figure 3. Cost Break-Down for 150-unit MUD

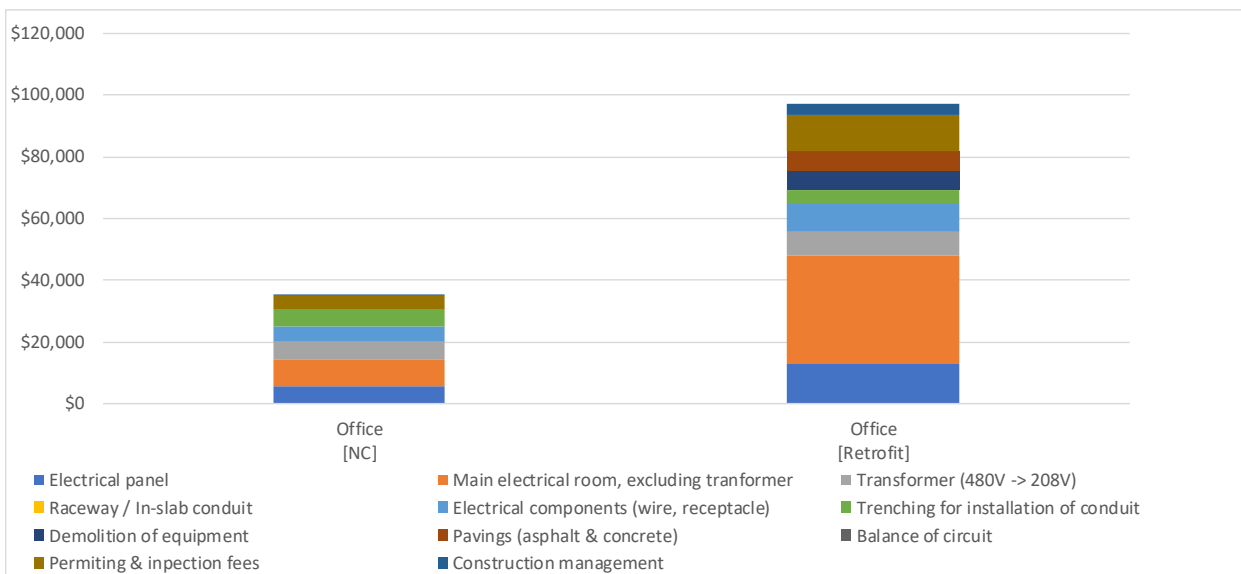


Figure 4. Cost Break-Down for 60-space Commercial Office (assumes surface-level parking)

Building code requirements for EV capable parking spaces can also reduce or avoid non-cost barriers such as coordinating between building owners/operators and tenants, potential loss of productive time for tenants during construction, lack of awareness of EV charging as an option, and the additional time and expense of undertaking a stand-alone EV charging infrastructure construction project. This study does not include specific accessibility requirements such as slope, vertical clearance, and path of travel and any of the associated costs with restriping, curb-cutting, or re-grading to meet ADA requirements, however a rough contingency to account for these ADA requirements has been included. For additional information on ADA compliance, the Governor’s Office of Business and Economic Development recently released an Electric

Vehicle Charging Station Permitting Guidebook which highlights several ADA-specific issues around accessibility.²⁴

Cost Savings Due to EVSE Installation in New Construction

This section discusses the benefits of requiring EVSE installation in a subset of spaces. This section also discusses the potential benefits of good design practices to greatly reduce the potential for expensive redesign and engineering to meet accessibility requirements for buildings subject to Title 24, Part 2, Chapter 11B.

EVSE Installation

We note that several local jurisdictions already require the complete installation of an EVSE on a complete electrical circuit for some parking spaces in nonresidential new construction including Carlsbad, Contra Costa County, Palo Alto and Santa Cruz. Installing a complete electrical circuit, including wiring and circuit breakers, will achieve better economies of scale and avoid the overhead and time needed to hire an electrician. This includes the need for tenants to get approvals from building owner for an electrical wiring retrofit (for the residential sector, condo owners would typically need approval from the homeowners association).

In addition, many EVSE installation tasks can be completed during new construction at much lower cost than retrofitting later, such as:

- Retrofitting concrete pads for pedestals if needed to mount EVSE (and any associated payment kiosks) and/or bollards if needed, including concrete cutting, excavation, and repair;
- Mounting brackets for EVSE installed on walls or pillars;
- Any conduit or infrastructure needed to provide data for EVSE that are networked;
- Accessibility, as discussed further below in the Good Design Practices section;
- Soft costs such as customer (or customer representative) and contractor project management; project planning including design, engineering, and permitting; contractor mobilization; and any additional retrofit tasks needed for EVSE installations;
- Lighting, if required and not already installed on-site;
- Additional site-specific, real-world contingencies.

Installing a complete circuit with an EVSE installed will reduce burdens on local building officials and thus will tend to increase code compliance. Inspectors can more easily verify that a complete circuit is installed and operating correctly with an EVSE installed, rather than determining the specific electrical components that would be required for EV capable spaces.

Good Design Practices

Several local jurisdictions have adopted building codes that require good design practices to facilitate compliance with accessibility requirements for buildings subject to the CalGreen requirements, California

²⁴ <http://businessportal.ca.gov/wp-content/uploads/2019/07/GoBIZ-EVCharging-Guidebook.pdf>

Code of Regulations Title 24, Part 2, Chapter 11B Section 11B-812. Section 11B-812 requires that a facility providing Electric Vehicle Charging Stations (EVCS), i.e. a parking spaces with an EVSE installed, for public and common use also provide one or more accessible EVCS, as specified in Table 11B-228.3.2.1. Chapter 11B applies to certain facilities including, but not limited to, public accommodations and publicly-funded housing (see Part 2, Section 1.9 of the California Building Code). It does not require review prior to construction of whether a building is designed to allow compliance with these requirements, and local codes require good design practices to fill this gap.

These local codes typically require that projects subject to the California Code of Regulations Title 24, Part 2, Chapter 11B, document how many accessible EVCS would be required as per Title 24, Chapter 11B to convert all required EV capable or EV ready parking spaces to EVCS. They also typically require that the builder demonstrate that the facility is designed such that compliance with accessibility standards, including Chapter 11B accessible routes, will be feasible for the required accessible EVCS at the time of EVCS installation.²⁵

We note that retrofitting spaces that were not designed to facilitate compliance with accessibility requirements can be very expensive. For instance, this study finds that removing and repairing about 100 to 300 linear feet of surface parking that add conduit to non-accessible parking spaces for a small or medium facility can cost \$11,500 to \$32,000 in demolition and repair costs. While the scope of work for accessibility retrofits may be different from the conduit installation task, this information indicates that the types of costs required for accessibility retrofits (absent good design practices) may be similarly significant and in retrofit contexts may be cost prohibitive, space prohibitive, or both.

Methodology

The methodology for this report is similar to prior 2016 reports for the City of Oakland (with funding from the City of Oakland and grant funding from the California Energy Commission), and for the City and County of San Francisco (with funding from Pacific Gas & Electric and in-kind support from the City and County of San Francisco).^{26 27}

The cost analysis model that breaks each scenario and number of EV capable parking spaces into individual tasks and quantities, as shown in Appendix C. The model also contains estimates for the costs of each job task. Estimates of retrofit and new construction costs per job task are largely based on RS Means, a construction cost reference handbook for residential and nonresidential hardware and related installation

²⁵ For instance, section 11B-812 requires that "Parking spaces, access aisles and vehicular routes serving them shall provide a vertical clearance of 98 inches (2489 mm) minimum." It also requires that parking spaces and access aisles meet maximum slope requirements of 1 unit vertical in 48 units horizontal (2.083 percent slope) in any direction at the time of new building construction or renovation. Section 11B-812.5 contains accessible route requirements. In addition, Title 24 Part 11 Section 4.106.4.2 requires that developers meet certain aspects of accessibility requirements at the time of new construction for a limited number of parking spaces.

²⁶ Pike, Ed and Steuben, Jeff. "Plug-In Electric Vehicle Infrastructure, Cost-Effectiveness Report." 2016; and Pike, Ed, Jeffrey Steuben, and Evan Kamei. 2016. "Plug-In Electric Vehicle Infrastructure Cost-Effectiveness Report for San Francisco."

²⁷ Pike, Ed, Jeffrey Steuben, and Evan Kamei. 2016. "Plug-In Electric Vehicle Infrastructure Cost-Effectiveness Report for San Francisco."

costs.²⁸ Additional costs for contractor labor, permits, architectural drawings, plans, site and/or load studies (for retrofit projects), inspections, and local permit and inspection fees are based on the resources listed in Appendix B and C. Additional information used to model these costs includes feedback from industry and utility experts, engineering estimates, and direct experience. For additional details on the methodology and information specific to the EV capable parking space details, please see Appendix C and Appendix D.

The cost analysis model includes hypothetical installation scenarios to compare costs between different numbers of EV capable parking space for new construction and retrofit projects. Actual project costs and configurations will vary; these cases are intended to provide representative examples for comparison purposes rather than to estimate site-specific costs. The model excludes project-specific costs outside the scope of EV capable parking space building code compliance such as acquisition and installation of the EVSE, signage, lighting, pedestal mounts, bollards, wheel stops, any required accessibility retrofit, and any other factors outside of CALGreen EV capable parking spaces requirements.²⁹ (Codes that address accessibility during alterations and additions such as the City of Fremont, City of Oakland, and City and County of San Francisco local codes can result in significant cost savings compared to changing these design parameters later as part of a stand-alone retrofit project.³⁰)

Recent editions to this model have added secondary transformers costs and electrical room costs (switchgear). The model still excludes utility-side infrastructure, such as concrete transformer pads, utility service connections, and associated demolition, to accommodate potential swap-out for a larger capacity primary transformer. Additional information on those costs can be found in the Table 7 of the Transformers section below.

Furthermore, the scenarios do not include sub-metering or separate metering equipment, which are optional, but could be selected by a building owner to access a special electricity rate.³¹ Primary model costs are based on the City of Sacramento with a correction for PCE and SVCE's service area based on an average of San Jose and San Mateo's labor and material costs for the first quarter of 2019.

²⁸ For additional information, see www.rsmeans.com.

²⁹ RS Means specifies a range of potential design costs, while noting that design costs will likely be 50 percent higher for alterations. We note that wheel stops may cost \$150-\$200 each and bollards may cost \$500-\$750 each based on input from an installer and RS Means costs for equipment types similar to bollards.

³⁰ San Francisco Green Building Code 2016:

[http://library.amlegal.com/nxt/gateway.dll/California/sfbuilding/greenbuildingcode2016edition?f=templates\\$fn=default.htm\\$3.0\\$vid=amlegal:sanfrancisco_ca\\$sanc=JD_GreenBuilding](http://library.amlegal.com/nxt/gateway.dll/California/sfbuilding/greenbuildingcode2016edition?f=templates$fn=default.htm$3.0$vid=amlegal:sanfrancisco_ca$sanc=JD_GreenBuilding)

³¹ A sub-meter may be a desirable add-on for some building owners or PEV drivers to allocate electricity costs and/or provide access to utility PEV charging electricity tariffs, though some special electricity rates for PEV owners are available through whole-house rates and utilities are also conducting pilots of metering via electric vehicle service equipment. The authors believe that builders wishing to install a socket for a sub-meter at the time of new construction may achieve cost savings compared to retrofits but have not quantified this potential.

4. Distribution Transformer Study

One important distinction in transformer classifications is between primary transformers (which are owned and operated by the utility) and secondary “step-down” transformers (which are owned and operated by a building owner). The main distinguishing factor between these is the overall building load and the particular utility rules which specify trigger points for the electrical design. For most situations, small buildings utilize shared distribution primary transformers split between multiple electrical accounts; medium-sized buildings feature a dedicated utility-owned primary transformer; and large buildings may feature a dedicated utility-owned primary transformer along with secondary transformer(s) depending on the electrical design of the building.

Primary Transformers (utility-owned, often with customer costs)

Primary transformers are needed to convert medium voltage utility distribution lines (normally 12kV) to customer level power at either 480V/277V for large buildings or 208V/120V or 240V/120V for medium buildings (for the purposes of this report, small buildings are on a shared transformer). Primary transformers are owned and operated by the utility but costs are partially split with the building owner. The costs borne by the utility operate with a ceiling, insulating utilities from the ballooning costs of the upgrades, allowing any excess above to be charged to the customer. This mechanism is known as an “allowance,” effectively a budget for infrastructure upgrades funded through the electric rates. For PG&E, it is governed by Electric Rule 2³², Electric Rule 15³³ & Electric Rule 16³⁴ which together lay out the rules for expanding service, extending distribution lines, and upgrading transformers. The allowance is dictated by these rules and based on historical electrical usage. The following excerpt is from Electric Rule 15:

$$\text{Allowance} = \frac{\text{Net Revenue}}{\text{Cost-of Service Factor}}$$

where the Cost of Service Factor is the annualized utility-financed Cost of Ownership as (N)
stated in Electric Rule 2. (N)

As written, these formulas and rule exceptions are complex because they apply for all electrical infrastructure situations, including agricultural, industrial, or rural contexts. However, generally-speaking, utility infrastructure upgrades have costs that are broken down between the building owner and the utility. For utility-owned transformers, the building owner will pay for the following nine elements:

- 1- a load study from the utility’s service planning department,
- 2- trenching,
- 3- excavation
- 4- backfill,
- 5- compaction,
- 6- conduit,

³² https://www.pge.com/tariffs/tm2/pdf/ELEC_RULES_2.pdf

³³ https://www.pge.com/tariffs/tm2/pdf/ELEC_RULES_15.pdf

³⁴ https://www.pge.com/tariffs/tm2/pdf/ELEC_RULES_16.pdf

- 7- substructures (boxes and pads),
- 8- pavings (cut, patch, and final repair), and
- 9- taxes and cost of ownership.

Meanwhile, the utility will pay (up to the allowance) for metering, wiring, and transformers. For any excess work required above the allowance, an advance is required by the customer, but can be converted to a monthly payment. If the revenue for the utility does not end up materializing in the first ten years, utilities have a mechanism to claw back funds called “deficiency billing.”

The CPUC has been tracking service and distribution system upgrades for EV-projects from the three major California Investor-Owned Utilities, publishing their 7th annual report in April 2019³⁵. The study indicates the relative frequency and magnitude of utility-side infrastructure costs that include both service upgrades and **primary** transformer upgrades. While this equipment is owned and operated by the utility, the customer will pay for upgrade costs until their allowance is exceeded.

In many cases this allowance is insufficient and costs can spread over to the customer in lump sum costs ahead of construction and/or higher monthly costs. The following table is pulled from the CPUC report and provides a high-level summary of these costs:

Table 10: Summary of Service Line and Distribution System Upgrades

| | PG&E | SCE | SDG&E | Total |
|--|-------------------|-----------------|------------------|-------------|
| Residential Customers | | | | |
| Estimated PEV customers through December 31, 2018 | 216,845 | 163,594 | 34,833 | 415,272 |
| Residential Upgrades | | | | |
| Number of PEV-related Infrastructure Checks Completed | 10,138 | Not tracked | Not tracked | N/A |
| Number of PEV-related Service Line and/or Distribution System Upgrades | 323 | 243 | 52 | 618 |
| Total Costs Incurred by Utility for Upgrades | \$6,627,544 | \$351,675 | \$53,365 | \$7,032,584 |
| Range of Costs for Upgrades | \$14 to \$338,274 | \$1 to \$30,067 | \$47 to \$10,958 | N/A |
| Average Cost for Distribution System Upgrade | \$19,262 | \$4,514 | \$4,089 | N/A |
| Average Cost for Service Line Upgrade | \$1,168 | \$1,382 | \$730 | N/A |
| Number of Service Line Upgrades Exceeding Residential Allowance | 39 | 33 | 0 | 72 |
| Current Residential Allowance | \$2,431 | \$3,084 | \$3,241 | N/A |
| Amount of Foregone Billings to Customers for Service Line Upgrades Pursuant to "Common Facility Treatment" Policy Exemption for PEVs | \$190,207 | \$37,887 | \$0 | \$228,094 |

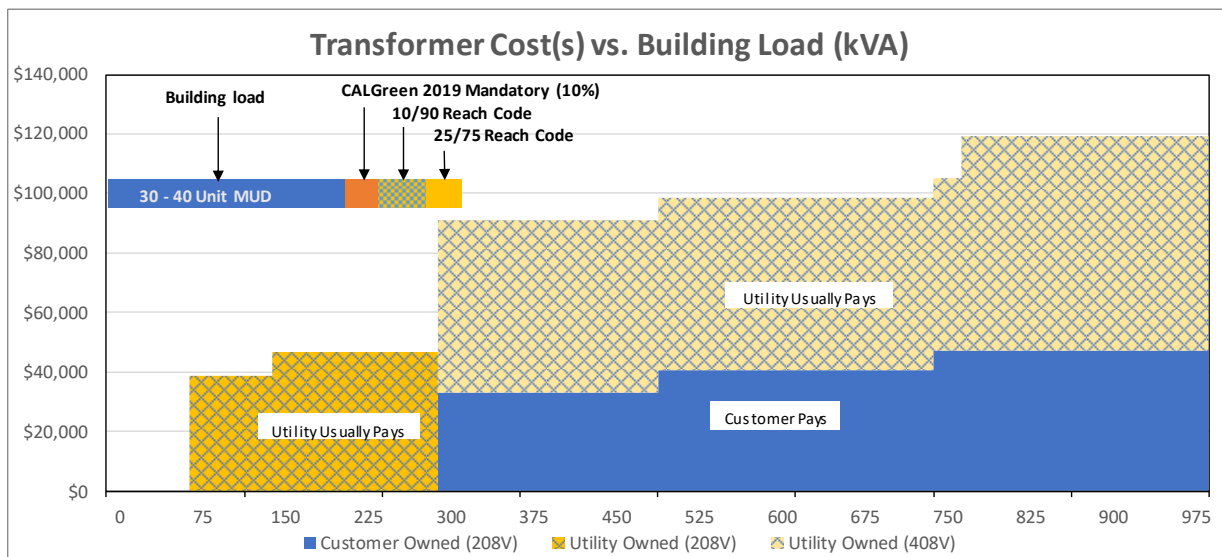
As shown above, PG&E’s service territory indicates just over 3% (323 service line upgrades of 10,138 PEV-related Infrastructure Checks) of sites required distribution or service-line upgrades to accommodate EV infrastructure, demonstrating projects that exceed existing transformer capacity is not common yet. And of these less than 0.4% (39) exceeded the residential allowance resulting in additional costs to the building owner beyond the baseline upgrade costs. Two large caveats should be highlighted here. The first is that most of

³⁵ [7th Joint IOU Electric Vehicle Load Research Report: April 2019 \(CPUC\)](#)

these early EV installations are residential customers and the second is that overall demand for charging infrastructure is increasing and it can be expected that more ports will be installed per parking lot than in the past. In addition, local jurisdictions may have local restrictions regarding placing transformers in public right of ways necessitating alternative siting such as placing transformers within the property line and under owner cost. The most important considerations are the “Range of Costs for Upgrades” (\$14 - \$338,274) and the “Average Cost for Distribution System Upgrade” (\$19,262) which indicate both a very wide range between projects and the average magnitude for transformers upgrades in PG&E territory. It should be noted that the distribution upgrade costs across utilities are significant with PG&E (\$19,262) incurring much higher costs than those of SCE (\$4,514) and SDG&E (\$4,089).

Secondary Transformers (customer-owned)

Secondary transformers are required from larger buildings based on the electrical service being provided by the utility. These rules are pre-determined by the utility’s electric rules. In the context of this report, secondary transformers are those that convert 480V/277V power down to 208V/120V service. PG&E’s Unit Cost Guide³⁶, PG&E’s Greenbook³⁷, and RS Means were investigated to develop a characterization of electrical infrastructure costs (transformers) vs. building load (kVA). In the graph below, primary transformers costs are indicated in gold/yellow with blue-accented patterns³⁸ and secondary transformers costs are indicated in solid blue (costs associated with site preparation are not included). In addition to this, load estimates that were utilized for the cost effectiveness model are overlaid to provide a rough back-of-the-envelope load calculation for MUDs, to illustrate when certain costs become important in order to assist policy makers of the relative situations in which these triggers would occur:



³⁶ PG&E Unit Cost Guide - April 2019

³⁷ 2017-2018 PG&E Greenbook: Electric & Gas Service Requirements:(<http://www.pge.com/greenbook>)

³⁸ The blue accent is to highlight that these costs often end up part of customer costs.

Figure 5: Costs of Transformers vs. Transformer system size (PG&E service territory)³⁹

The figure above shows the magnitude of these transformer costs along with boundary points for small/medium and medium/large buildings utilizing rough estimates for number of units in a MUD with electric vehicle charging equivalent CALGreen 2019 mandatory levels. The sample number of MUDs shown in the figure above are meant to point out sizeable non-linear costs associated with transformer upgrades for this climate and this utility. In particular, attention should be paid to the 300kV load point which may cause considerable cost escalation as the electrical service would switch from 208V/120V to 480V/277V. As mentioned previously, this graphic is high-level, intended for policy makers and does not provide appropriate level of detail for a specific microclimate or a specific site.⁴⁰

Transformer-sizing and other considerations

Electrical designers typically oversize transformers for future unspecified loads as “transformer headroom.” A typical approach to transformer sizing is to obtain the calculated design load from the electrical schedule (building plan documents) and add 20% spare capacity for future load growth to be shown in the equipment schedule, unless otherwise directed by the facility based on design parameters⁴¹. Due to the large step-wise nature of transformers, it is possible that after accounting for headroom significantly more capacity is afforded. The table below illustrates this for the building models produced for this report:

Table 11. Transformer Sizing & Capacity

| Building Type | 60-Unit MUD | | 150-Unit MUD | | 60-Space Office Building |
|--|---------------|--------------------|---------------|--------------------|--------------------------|
| Baseline Building Load [kVA] | 292 | | 700 | | 95 |
| Baseline EV Load [kVA] (CALGreen 2019) | 43 | | 99 | | 29 |
| Capacity Requirement [kVA] | 335 kVA | | 786 kVA | | 126 kVA |
| Capacity Requirement (with 20% headroom) [kVA] | 402 kVA | | 944 kVA | | 152 kVA |
| Secondary Transformer Size [kVA] | 500 kVA | | 1000 kVA | | 300 kVA |
| Overall Unused Capacity [kVA (% unused)] | 165 kVA (33%) | | 214 kVA (21%) | | 174 kVA (58%) |
| Code Scenario | Market Rate | Affordable Housing | Market Rate | Affordable Housing | 10% L2 40% L1 |
| Additional Level 2 Ports | +12 L2 | 0 | +22 L2 | 0 | +2 L2 |
| Additional Level 1 Ports | +45 L1 | +54 L1 | +113 L1 | +135 L1 | +24 L1 |
| Additional EV Load [kVA] | +95 kVA | +54 kVA | +257 kVA | +156 kVA | +33 kVA |
| TOTAL EV Load [kVA] | 430 | 389 | 1043 | 942 | 160 |

³⁹ This graph shows PG&E’s specific equipment sizing and is not comparable to other utilities. Calculations are based on estimates from the infrastructure cost model.

⁴⁰ For example: Electrical system loading was developed by averaging climatic design data from Climate Zone 3 (Oakland) and 4 (San Jose) to develop a prototype HVAC system:

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

⁴¹ <https://www.csemag.com/articles/selecting-sizing-transformers-for-commercial-buildings/>

In the table above, the scenarios that are able to meet the EV reach codes with the existing headroom have been highlighted in green and the one scenario that would be unable to do so is highlighted in red. In most of these cases, the 20% headroom for the secondary transformer afforded significant flexibility to meet the reach codes. Transformers are sized for a worse-case scenario based on the requirements in the electrical code and very seldom operate near capacity. While it may be tempting to oversize a transformer above the typical industry headroom, significant oversizing should be cautioned because it can result in transformer operation significantly out of the normal efficient operation. As shown in Figure 6 below, load factor (percentage of total rated capacity) can have a significant influence on the transformer efficiency. In most times of the day, the transformer is operating at part load and oversizing a transformer can move performance out of the normal operating range and result in inefficient operation. The following figure shows a generalized transformer efficiency curve for a residential distribution transformer sized and highlights where a 20% load point might fall were the transformer pushed to the next size up, typically 40-55% increase in capacity.

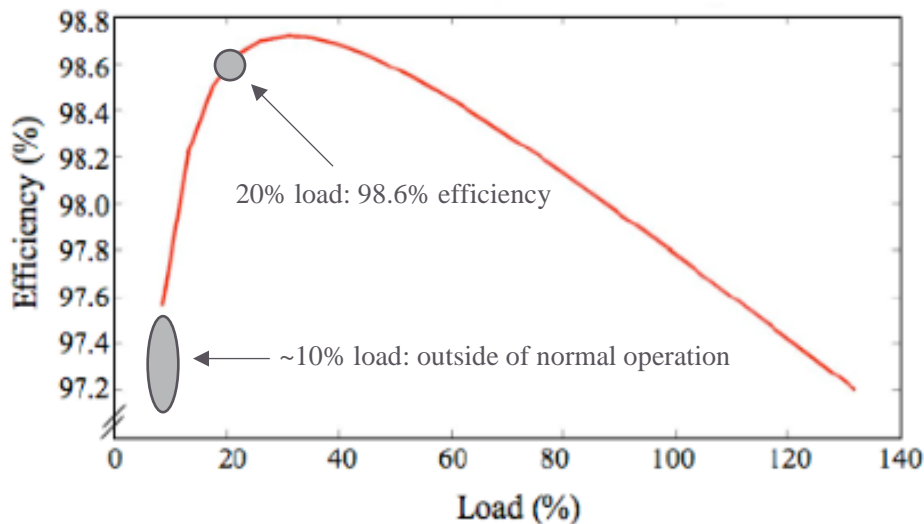


Figure 6: Transformer Efficiency vs. Load Factor⁴²

The primary concern around transformers and associated costs pertain to the boundary cases where buildings close to the boundary of (1) needing to host a utility's dedicated primary transformer or (2) will require different utility service (480V instead of 208V) and need to modify their site to provide a secondary transformer. Approximate ranges of which MUDs would need to contend with this are noted in Figure 1 and Figure 5 above. If more capacity is required, it is likely that a combination of solar, energy efficiency measures, or adding battery storage would be able to prevent a transformer upgrades. On the other hand, the interest in electrification of existing gas appliances may compete for the existing capacity.

In the face of all this, load management is a promising option to allow more electric vehicle charging ports without needing to pay for larger infrastructure upgrades. This technology works by managing the amount of

⁴²https://www.researchgate.net/publication/224598589_Challenges_of_PHEV_Penetration_to_the_Residential_Distribution_Network

throughput to individual charging ports based on what the control system defines for limitations. To date, this feature has primarily been marketed to limit electrical demand charges but could be utilized to prevent overloading panels and/or transformers. Load management for electric vehicles is still nascent technology and would benefit with more developed industry standards. However, the National Electric Code has permitted power management since 2014 but industry may need training to create packaged solutions that can reassure plan checkers and building inspectors.⁴³

⁴³ California Electrical Code (Title 24, Part 3): Article 750.30 – Load Management

Appendix A: Cost Estimates by Type of Expense

The following tables (Table 12 through Table 14) summarize model results for each type of expense per building. All costs below represent **incremental** costs compared to a baseline CALGreen 2019 mandatory building. See Appendix B and Appendix C for more details on the individual tasks included in each of the categories below. The per parking space costs are calculated by dividing the total incremental cost of by the number of added EV capable parking spaces. So for example, for the 60-unit MUD scenario shown below, a CALGreen 2019 mandatory baseline model was created to size the electrical use of a 60-unit MUD apartment building including electrical infrastructure associated with switchgear, panels, and secondary transformer. Under the new construction scenario, the additional 54 EV ports were added to the load and the system resized along with conduits added. For the retrofit scenario, the costs to upsize infrastructure, demolish structures, and provide raceways were added. NOTE: This study does not include costs for EVSE, and does not include and has a overall 20% contingency to account for ADA compliance. ADA can be a significant source of cost and in this study is only intended to capture a limited scope of ADA compliance.

Labor costs generally range from half to two-thirds of total project costs. Labor costs for small buildings with two EV capable parking spaces, based on current CALGreen six percent requirements, were estimated at about four fifths of the total project costs in new construction; however, this may not be representative of other projects for this building type with different site-specific circumstances.

Table 12. Estimated Incremental Cost of Installing EV Infrastructure: 60-Unit MUD

| Retrofit | 60-Unit MUD | | | |
|---|------------------|------------------------|-------------------------|-------------------------------|
| | Market Rate [NC] | Market Rate [Retrofit] | Affordable Housing [NC] | Affordable Housing [Retrofit] |
| Level 2 Ports Added | 9 | 9 | 0 | 0 |
| Level 1 Ports Added | 45 | 45 | 54 | 54 |
| Electrical panel | \$15,960 | \$26,008 | \$9,289 | \$13,004 |
| Main electrical room, excluding transformer | \$13,609 | \$43,911 | \$14,055 | \$35,193 |
| Transformer (480V -> 208V) | \$14,164 | \$12,743 | \$1,081 | \$10,897 |
| Raceway / In-slab conduit | \$18,059 | \$77,247 | \$18,059 | \$77,247 |
| Electrical components (wire, receptacle) | \$11,366 | \$20,131 | \$11,307 | \$20,049 |
| Trenching for installation of conduit | \$0 | \$0 | \$0 | \$0 |
| Demolition of equipment | \$0 | \$31,940 | \$0 | \$30,918 |
| Pavings (asphalt & concrete) | \$0 | \$7,889 | \$0 | \$7,889 |
| Permitting & inspection fees | \$2,435 | \$15,592 | \$2,435 | \$15,592 |
| Construction management | \$549 | \$4,449 | \$403 | \$4,264 |
| TOTAL | \$76,142 | \$239,909 | \$56,629 | \$215,051 |
| TOTAL (Price per Port) | \$1,410 | \$4,443 | \$1,049 | \$3,982 |

Table 13. Estimated Incremental Cost of Installing EV Infrastructure: 150-Unit MUD

| Retrofit | 150-Unit MUD | | | |
|---|------------------|------------------------|-------------------------|-------------------------------|
| | Market Rate [NC] | Market Rate [Retrofit] | Affordable Housing [NC] | Affordable Housing [Retrofit] |
| Level 2 Ports Added | 23 | 23 | 0 | 0 |
| Level 1 Ports Added | 112 | 112 | 135 | 135 |
| Electrical panel | \$59,785 | \$83,699 | \$44,926 | \$62,896 |
| Main electrical room, excluding transformer | \$10,059 | \$49,276 | \$10,059 | \$49,276 |
| Transformer (480V -> 208V) | \$11,539 | \$49,742 | \$0 | \$40,621 |
| Raceway / In-slab conduit | \$45,147 | \$193,116 | \$45,147 | \$193,116 |
| Electrical components (wire, receptacle) | \$28,062 | \$49,833 | \$28,407 | \$50,317 |
| Trenching for installation of conduit | \$0 | \$0 | \$0 | \$0 |
| Demolition of equipment | \$0 | \$79,850 | \$0 | \$77,294 |
| Pavings (asphalt & concrete) | \$0 | \$8,442 | \$0 | \$8,442 |
| Permitting & inspection fees | \$5,798 | \$33,069 | \$5,798 | \$33,069 |
| Construction management | \$1,159 | \$6,655 | \$964 | \$5,196 |
| TOTAL | \$161,550 | \$553,682 | \$135,301 | \$520,227 |
| TOTAL (Price per Port) | \$1,197 | \$4,101 | \$1,002 | \$3,854 |

Table 14. Estimated Incremental Cost of Installing EV Infrastructure: 60-Space Office

| Retrofit | 60-Space Office | |
|---|-----------------|-------------------|
| | Office [NC] | Office [Retrofit] |
| Level 2 Ports Added | 2 | 2 |
| Level 1 Ports Added | 24 | 24 |
| Electrical panel | \$5,571 | \$13,004 |
| Main electrical room, excluding transformer | \$8,558 | \$35,005 |
| Transformer (480V -> 208V) | \$5,748 | \$7,786 |
| Raceway / In-slab conduit | \$0 | \$0 |
| Electrical components (wire, receptacle) | \$5,285 | \$9,031 |
| Trenching for installation of conduit | \$5,133 | \$4,562 |
| Demolition of equipment | \$0 | \$6,211 |
| Pavings (asphalt & concrete) | \$0 | \$6,305 |
| Permitting & inspection fees | \$4,448 | \$11,652 |
| Construction management | \$227 | \$3,414 |
| TOTAL | \$34,971 | \$96,970 |
| TOTAL (Price per Port) | \$1,166 | \$3,232 |

Appendix B: Permitting and Inspection Costs

Table 15 shows examples of permitting and inspection fees. These fees are not calculated in the model per project but as inputs based on the closest representative level for a project. Table 16 shows the details for these calculations based on the City and County of San Francisco and costs may vary by region.

Table 15. Examples of Total Permit and Inspection Cost Summary

| # of Circuits | Stand-alone Retrofit | | | New Construction (Incremental Costs) | | |
|---------------|----------------------|--------------------|---------|---|--------------------|-------|
| | Fee | Builder Staff Time | Total | Fee | Builder Staff Time | Total |
| 2 | \$461 | \$650 | \$1,111 | \$27 | \$75 | \$102 |
| 4 | \$1,365 | \$850 | \$2,215 | \$164 | \$125 | \$289 |

Table 16. Electrical and Building Permit and Inspection Cost Data

| Electrical and Building Permit and Inspection Cost Data | | | | | |
|---|---|---|------------|--|--|
| <i>Electrical</i> | | | | | |
| Fees | | | | | |
| \$335 | Minimum inspection fee, which covers from 1 to 3 inspections | | | | |
| \$11 | Estimated average application fee per additional circuit beyond minimum | | | | |
| Builder Time Costs | | | | | |
| New Construction, alterations & | Stand-alone Retrofit | | | | |
| \$25 | \$100 | Builder staff time to obtain new permit (inclusive of travel) | | | |
| \$25 | \$100 | Builder staff time per inspection (inclusive of travel) | | | |
| \$0 | \$150 | Electrical engineer staff time for load calculations | | | |
| <i>Building</i> | | | | | |
| Fees | | | | | |
| <i>New Construction, alterations, additions</i> | | <i>Stand-alone retrofit</i> | | | |
| Plan | Permitting | Plan | Permitting | | |
| - | - | \$ 144.85 | \$ 62.08 | up to \$500 | |
| - | - | \$ 2.93 | \$ 1.26 | per hundred from \$500 up to \$2000 | |
| - | - | \$ 1.78 | \$ 0.76 | per hundred from \$2000 up to \$50,000 | |
| \$ | 0.19 | \$ | 0.10 | per hundred from \$5,000,000 to \$50m | |
| source: San Francisco Fee Table 1A-A note: only costs used in model are listed | | | | | |
| Builder Time Costs | | | | | |
| Incremental Cost, New | Retrofit | | | | |
| \$25 | \$100 | Builder staff time to obtain new permit | | | |
| \$0 | \$100 | Builder staff time per inspection (inclusive of travel) | | | |

Notes:

- Fees are calculated based on San Francisco Fee Table 1A-A (building) and Table 1A-E (electrical). New construction fees are based on the incremental cost of adding EV charging infrastructure to a project.
- Two building inspections are assumed for small retrofits, and no additional building inspections are assumed for new construction. One electrical inspection is assumed for adding two circuits and three are assumed for adding 12 circuits.

Appendix C: Methodology Details

This appendix provides additional details on the general assumptions used in the models, data sources for per unit equipment and other costs, and the methods used to determine the quantities needed for each expense type. This appendix does not contain data specific to the scenarios that were modeled, but rather a more general overview of the cost model.

General Assumptions

- Cost estimates include a fixed general overhead and profit factor.⁴⁴
- Labor costs and equipment costs are based on cost estimates from RSMeans 2019 Q1 and utilize standard union rates.
- RSMeans cost data specified Sacramento, CA with a geographic correction which averaged the RS Means City Cost Index of San Mateo and San Jose.
- In some cases, RS Means contains minimum retrofit task costs.⁴⁵ Where related tasks had separate minimum task costs but the labor crew could likely perform more than one related task, the model applied one minimum labor charge.
- Building electrical infrastructure was sized utilizing W/ft² engineering calculations for lighting, air conditioning, and other major appliances.
- Building area was estimated using US Census Data
- Common area is assumed for Laundry usage
- Air Conditioner sizing was calculated based on California Climate Zone data for Zone 3 and Zone 4
- California CEUS⁴⁶ data is utilized to determine demand for offices

Data Sources

Estimates of per unit equipment and installation costs were based on retrofit and new construction costs from RS Means, a construction cost reference handbook and online tool for hardware and related installation costs. The City and County of San Francisco rates were used for permit and inspection fee sheets; and the authors estimated costs for contractor labor for permitting, inspections, site inspection, and architectural plans. Cost data from RS Means was for 2018 and was scaled to 2019 using U.S. Bureau of Labor Statistics Producer Price Index statistics. Additional data sources include: feedback from industry experts, engineering estimates, and direct experience to capture different tasks required for the scenarios that were analyzed. This appendix contains a list of all tasks included in the analysis.

⁴⁴ Individual RS Means line items related to overhead (under General Requirements) are assumed to be addressed by overhead and profit.

⁴⁵ Minimum task costs are typically not relevant for new construction due to the overall project scale.

⁴⁶ <http://capabilities.itron.com/CeusWeb/ChartsSF/Default2.aspx>

Soft Costs

Permit and Inspection Fees

Permitting costs for breaking concrete and electrical permit fees are based on available information from the City and County of San Francisco fees.⁴⁷ The total estimated costs include rough and final building and electrical permit fees where applicable. The cost for adding EV capable spaces during construction of a new building is assumed to be relatively low. Builder time spent towards permit filing and inspections is included at \$100 per hour spent on site. Permit and inspection costs can vary between regions.

The model includes a small amount of labor to accommodate permitting and inspection of elements specific to EV capable parking spaces in new construction and alterations and additions, since these activities are already required and minimal additional effort should be needed to add EV capable infrastructure.

Since economies of scale occur with larger quantities, these fees generally scale up with increasing quantities of EV capable infrastructure, though they are not completely scalable. Costs are higher for outdoor circuits than for indoor circuits due to trenching and are higher for retrofits than for new construction or alterations and additions due to demolition, repaving, and repairs.⁴⁸

ARCHITECTURAL PLAN FEES

Costs to add EV capable parking spaces to architectural plans and drawings will vary between projects based on their overall complexity. They are based on the estimated number of hours for each project and a fee of \$150/hour before geographic adjustments. Costs will also vary if the project is new construction or a retrofit. In the former case, costs will be relatively minor because the architectural firm will likely be familiar with the plan of the building and can easily influence relevant design decisions like adding EV capable infrastructure. For retrofit projects, costs will likely be significantly higher due to the need to investigate and accommodate more complex on-site conditions such as: longer conduit runs, demolition and reconstruction, meeting accessibility requirements based on existing conditions, and/or more limited options for electrical room and panel placement.

A minimal incremental cost is required for adding several EV capable parking spaces to a new building or alteration and addition. In contrast, preparing construction plans for large numbers of EV capable parking spaces to an existing building may take a significant amount of time considering the layout and construction details for each parking space and existing site conditions. Costs will partially scale by the number of EV capable parking spaces.

LOAD STUDY/SITE CONDITIONS STUDY

Additional expenses are required for stand-alone retrofits at medium or large buildings to assess existing load and other conditions. The load study is necessary to determine the current electrical supply capacity, such as

⁴⁷ See [Table 1A-A](#) and [Table 1A-E](#)

⁴⁸ We note that efforts are underway to streamline permitting and inspections of EV charging infrastructure including EV capable parking spaces.

the transformer and other systems related to the main electrical supply and the current actual load.⁴⁹ The study will then determine which on-site upgrades may be needed to install EV capable parking spaces. In addition, site-specific conditions may need to be determined such as current concrete conditions, soils conditions, and/or other conditions. A load study at a facility where other site condition studies aren't needed is assumed to cost \$1,000. Factors such as demolition and/or a greater number of EV parking spaces will drive costs up and a more complex study is assumed to cost \$5,000 in this report (prior to prime contractor expenses). X-ray costs are roughly \$1,000 for a half dozen images, which may be enough for retrofit installations at a medium sized facility, however, more may be required for a 150-space garage.⁵⁰ A specific site may require more or less resources depending on actual conditions.

Assuming alterations and additions originally intended for non-EV charging purposes will require an assessment of load and existing conditions, the assessment would also suffice for EV charging as well.

ELECTRICAL PANEL LOCATIONS AND SIZING

Some electrical panels are located in the main electrical room while others are distributed closer to EV parking spaces to reduce branch circuit lengths and costs. Distributed panels are more practical in locations with convenient wall mounting locations protected from weather and vandalism. All panel and sub-panel conduits are assumed to be installed in 1 ½ inch steel surface-mounted conduits for 225 ampere panels (to carry 250 MCM wire) or 2-inch conduits for 400 ampere panels (to carry 600 MCM wire) to provide a high level of protection and allow for easy visual inspection.

In some cases, a panel installed in new construction can be upsized to serve both base loads (such as garage lighting, elevators, and miscellaneous outlets) and EV charging loads. In other cases, panels for EV charging are sized to their maximum practical size (typically 400 amperes) just to meet EV charging needs. (Panels are generally limited by electrical panel capacity rather than physical size for EV electrical infrastructure. A single-phase 400-ampere panel has electrical capacity for 10 circuits and typically has physical space for 15 40-ampere circuits even if they utilize double slot 20-ampere breakers.)

The type of electrical panels will depend on whether a building is served by three-phase (4-wire) electrical service or one-phase (3-wire) electrical service. Medium and large commercial buildings and multifamily buildings usually receive three-phase service. When a panel receives three phases of electricity instead of one, it can accommodate additional EV capable parking spaces. However, the phases must be “balanced”, which restricts how many additional circuits for EV capable parking spaces can be accommodated. We assumed that three-phase 225 ampere panels can accommodate 9 40-amp circuits and three-phase 400 ampere panels can accommodate 15 40 ampere circuits based on interviews with contractors and an electrical design firm.

⁴⁹ Transformers are usually sized based on the typical maximum actual load of a building. Unlike electrical panels and electrical circuits, transformers can be under loaded to extend their lifetime of fully loading, or even occasionally overloaded without causing an immediate reliability issue but with potential reduced long-term lifetime.

⁵⁰ Concrete X- Ray Imaging, Penhall, <https://www.penhall.com/concrete-x-ray-imaging/> accessed 7-4-2019.

Construction Management

The model also includes a cost factor to represent additional fixed costs incurred by contractors for retrofit installations prior to project initiation. These costs include contractor time spent traveling to a site for surveying, evaluating existing conditions, estimating project costs, and preparing bids. Costs will vary based on the complexity of the project.⁵¹ For new construction, these costs likely do not apply or require minimal additional effort to address EV capable electrical infrastructure. The construction management category also includes general permit application fees.

Raceways, Wire, and Termination Point

PVC materials (i.e. plastic) are included for branch circuit conduits installed in new construction of enclosed parking areas and alterations and additions to enclosed parking that remove the parking surface, while wall and ceiling-mounted metal conduit is assumed for stand-alone retrofits. The authors assumed that intermediate metal conduit was installed for any outdoor raceway in trenches to provide corrosion resistance and for any indoor retrofit cases where walls and floors will not be replaced. Additional raceways may be needed between floors and inaccessible areas.

1¼-inch raceways are generally assumed to carry up to twelve #8 wires rated at 40 amperes (three per circuit) to support 30-ampere EVSE, with the potential to add wiring for a fifth circuit where convenient.^{52,53} Some additional raceways are also needed to serve individual termination locations (i.e. a main conduit run carrying four wires may end at one receptacle pair and a local distribution conduit would carry the other pair to its termination point). These short distribution raceways were also sized at one and a quarter inches for simplicity; though they could be sized at one inch or below, we do not expect that this difference would be significant. In some cases, raceways installed in-slab during new construction will accommodate more and/or higher capacity wires than retrofits that are wall mounted and encounter additional bends at corners and obstacles, limiting their capacity. These potential cost savings are site-specific and not included in the model. Wire is not included for branch circuits for EV capable parking spaces. Wires for any distributed panels that are noted in the scenario summary table are included in the costs.

The length of raceways within a given floor for enclosed parking at new construction and repaving are calculated based on direct routes from the electrical panel to the termination point since no obstacles are present during new construction. Retrofitting surface-mounted conduit is generally assumed to be twice as long in new construction because they must follow walls and ceilings with less direct routing. Compared to new construction, raceway distances are increased by 125 percent for gut rehabilitation because significant

⁵¹ This estimate assumes that contractors win some of their bids for retrofit projects. The success rate will vary based on specific circumstances. For instance, a sole source contracting mechanism would result in a higher success rate while a contracting mechanism requiring three or more bids would result in a lower success rate. Actual costs will vary from project to project.

⁵² Because EV charging is considered a continuous load, the circuit capacity must be at least 25 percent higher than the end load.

⁵³ We note that higher capacity #6 wire could also be installed at a rate of four sets per 1 ¼ inch conduit without larger sized conduit, unless conduit capacity is limited due to bends that restrict fill rates. For an example of allowable fill rates, see Elliot Electric Supply "Conduit Fill Table" at https://www.elliotelectric.com/StaticPages/ElectricalReferences/ElectricalTables/Conduit_Fill_Table.aspx.

portions of the building are removed while some obstructions may remain. Raceway distances are also increased by 150 percent for stand-alone retrofits in outdoor trenches to account for indirect routing (i.e. avoiding existing infrastructure). Surface mounted retrofit distances are increased by 200 percent, compared to new construction, due to the long distances to follow existing walls and to account for routing around existing obstacles.

Actual configurations can vary based on site-specific circumstances. For instance, if several EV parking spaces are located a significant distance from the main electrical panel, a single (larger) raceway run to an additional electrical panel closer to EV parking spaces can be installed with raceways branching from the panel to the planned EVSE location. This configuration would most likely save costs in buildings where the reduced length of raceways would exceed additional electric panel costs. Raceways for electrical panels outside of the main electrical room are sized (at ½ inch intervals, i.e. 1 ½ inch or 2 inches) based on the wire needed to serve that panel.

Conduits will generally terminate at a receptacle with an outlet box with a face plate and no EVSE (i.e. the unit that connects to the vehicle) installed at the time of construction. Local municipal building codes can also require a specific type of receptacle, which does not have a large impact on the cost-effectiveness of code. Receptacles are assumed to be installed in pairs to serve parking spaces on either side of the pair.

No additional curbs or bollards are assumed at the termination point. Local jurisdictions may wish to include a requirement for anchor points for EVSE near the termination point if the EVSE can be wall-mounted, which should not significantly affect the cost of EV capable building codes.

Demolition, Reconstruction, and Repaving

The model contains several job types related to demolition, construction, and repaving for stand-alone projects and projects where parking areas and/or electrical rooms are undergoing renovations that would allow installation of this equipment without any further demolition and reconstruction.

For both enclosed and surface parking, demolition for electrical rooms includes cutting and/or drilling, breaking large pieces into smaller pieces, minimum equipment/labor costs, loading and disposal. Reconstruction costs include concrete work (cost for pouring slabs is used as a proxy), reinforcing rods, forms, and minimum labor charges.

Demolition for parking areas include cutting a three-foot-wide section of pavement to allow two-foot-wide trenches; backhoe rental to trench, mobilization and operation, and disposal of materials. Some trenching would also be required for adding EV capable parking spaces in new construction, when repaving existing parking or adding parking. In these cases, costs would likely be much lower due to the presence of trenching equipment on-site to meet other project needs unrelated to EV capable parking spaces.

Contingencies

A 20 percent contingency was applied for stand-alone retrofit projects based on RS Means. Contingencies are necessary because specific challenges may not be visible at the start of a stand-alone retrofit project or because existing conditions may be difficult to alter without expanding the scope and cost of a retrofit project - for instance if an electrical room lacks space for additional panel(s) or was originally constructed far from parking spaces. A general contingency was not added for EV capable parking spaces installed as part of a

larger retrofit project such as resurfacing or building new parking spaces at an existing site because the conditions will more closely resemble new construction, given their broader scope. In addition, specific cost increases were already included to address higher costs for alterations and additions compared to new construction, such as conservatively assuming that additional parking spaces would be located further from electrical power than existing spaces.

On top of this, another 20 percent contingency was applied to estimate potential costs for accessibility (ADA) compliance associated with restriping, adjusting path of travel, vertical clearances, and slope modifications. ADA compliance costs can be significant but are not the focus of this report.

Transformers

Transformer costs related to secondary or “step down” transformers have been incorporated into this cost model. Only the wiring costs are considered, not the additional costs for a concrete pad, or disposal of the previous transformer. As mentioned previously, these transformers are used to “step down” 480 V service to 208/240 V for buildings connected to 480 V power, which in PG&E’s service area consist of buildings in the 300kVA and up range. CARB has found that EV charging generally represents a relatively small fraction of overall building power demand in multifamily housing with 10% EV Capable parking spaces. These transformer upgrades are often not necessary to support EV charging infrastructure for buildings but may be more likely with the higher EV infrastructure requirements such as those considered in this report.

An electrical engineering firm and several contractors were consulted with and confirmed that they have found that levels of EV capable parking spaces proposed for CALGreen typically would not require a transformer upgrade, noting the typical headroom of 20% is usually sufficient to cover this growth. It was noted that in some cases, a potential off-site utility infrastructure upgrade could be required, as noted in the Primary Transformers section above.

In the case that EV infrastructure would trigger an expensive switchgear or transformer upgrade it should be investigated whether retrofits that include more energy-efficient lighting and other equipment meeting current mandatory California, ENERGY STAR®, and/or federal standards.

We expect that in cases where a transformer upgrade would be required to install EV capable infrastructure, building codes requiring EV capable parking spaces and associated electrical capacity could achieve significant cost savings related to these costs. Stand-alone transformer retrofits could require replacing conduits serving the transformer, replacing the transformer pad or adding a new pad, and adding an additional transformer or upgrading an existing transformer. By comparison, designing the electrical room for adequate capacity would allow the installation of larger sized conduits and/or transformer pads during initial construction at minimal cost. While we have not quantified all of these costs, the incremental cost of installing a 3” conduit instead of a 2” conduit would be very small compared to breaking existing concrete to install a larger sized conduit later.

Task Descriptions

Task descriptions for each scenario are listed below in Table 17. The table lists tasks with a note to designate where the task applies to retrofits, new construction, or both. A negative number indicates the avoidance of smaller electrical panel(s) due to installation of a larger panel. (Tasks that are listed with a “0” quantity were included as an option in detailed calculations used to determine project task descriptions, but the detailed design calculations resulted in a zero quantity for the specific task).

Table 17. Task Descriptions and Quantities

| Task Description | Construction Type | Work Type | Unit | 60-unit MUD | | | 150-unit MUD | | | Medium Office | |
|---|-------------------|-----------|---------|----------------------------|-------------|--------------------|--------------|-------------|--------------------|---------------|------------------|
| | | | | CALGreen | Market Rate | Affordable Housing | CalGreen | Market Rate | Affordable Housing | CalGreen | 10% L2 40% L1 |
| | | | | Quantity for Each Scenario | | | | | | | |
| Rent core drill, electric, 2.5 H.P. 1" to 8" bit diameter, includes hourly operating cost | retro | demo | ea. | | 8 | 10 | | 20 | 25 | | 4 |
| Rent mixer power mortar & concrete gas 6 CF, 18 HP, one day including 4 hours operating cost | retro | demo | Ea. | | 2 | 2 | | 5 | 5 | | |
| Rent backhoe-loader 40 to 45 HP 5/8 CY capacity, one day including 4 hours operating cost | retro | demo | per day | | | | | | | | 3 |
| Selective demolition, rubbish handling, dumpster, 6 C.Y., 2 ton capacity, weekly rental, includes one dump per week, cost to be added to demolition cost. | retro | demo | Week | | 2 | 2 | | 5 | 5 | | 0 |
| Deconstruction of concrete, floors, concrete slab on grade, plain, 4" thick, up to 2 stories, excludes handling, packaging or disposal costs | retro | demo | S.F. | | 24 | 30 | | 60 | 75 | | |
| Selective concrete demolition, reinforce less than 1% of cross-sectional area, break up into small pieces, excludes shoring, bracing, saw or torch cutting, loading, hauling, dumping | retro | demo | C.Y. | | 8 | 10 | | 20 | 25 | | 5 |
| Selective concrete demolition, minimum labor/equipment charge | retro | demo | Job | | 2 | 2 | | 5 | 5 | | |
| Concrete sawing, concrete slabs, rod reinforced, up to 3" deep | retro | demo | L.F. | | 24 | 30 | | 60 | 75 | | 16 |
| Concrete sawing, concrete, existing slab, rod reinforced, for each additional inch of depth over 3" | retro | demo | L.F. | | 24 | 30 | | 60 | 75 | | 16 |
| Selective demolition, concrete slab cutting/sawing, minimum labor/equipment charge | retro | demo | Job | | 2 | 2 | | 5 | 5 | | 1 |
| Concrete core drilling, core, reinforced concrete slab, 2" diameter, up to 6" thick slab, includes bit, layout and set up | retro | demo | Ea. | | 60 | 60 | | 150 | 150 | | |
| Receptacle devices, residential, duplex outlet, ivory, EMT & wire, 20', 15 amp, incl box & cover plate | new | electric | Ea. | | 27 | 23 | | 68 | 56 | | 12 |

ATTACHMENT 8

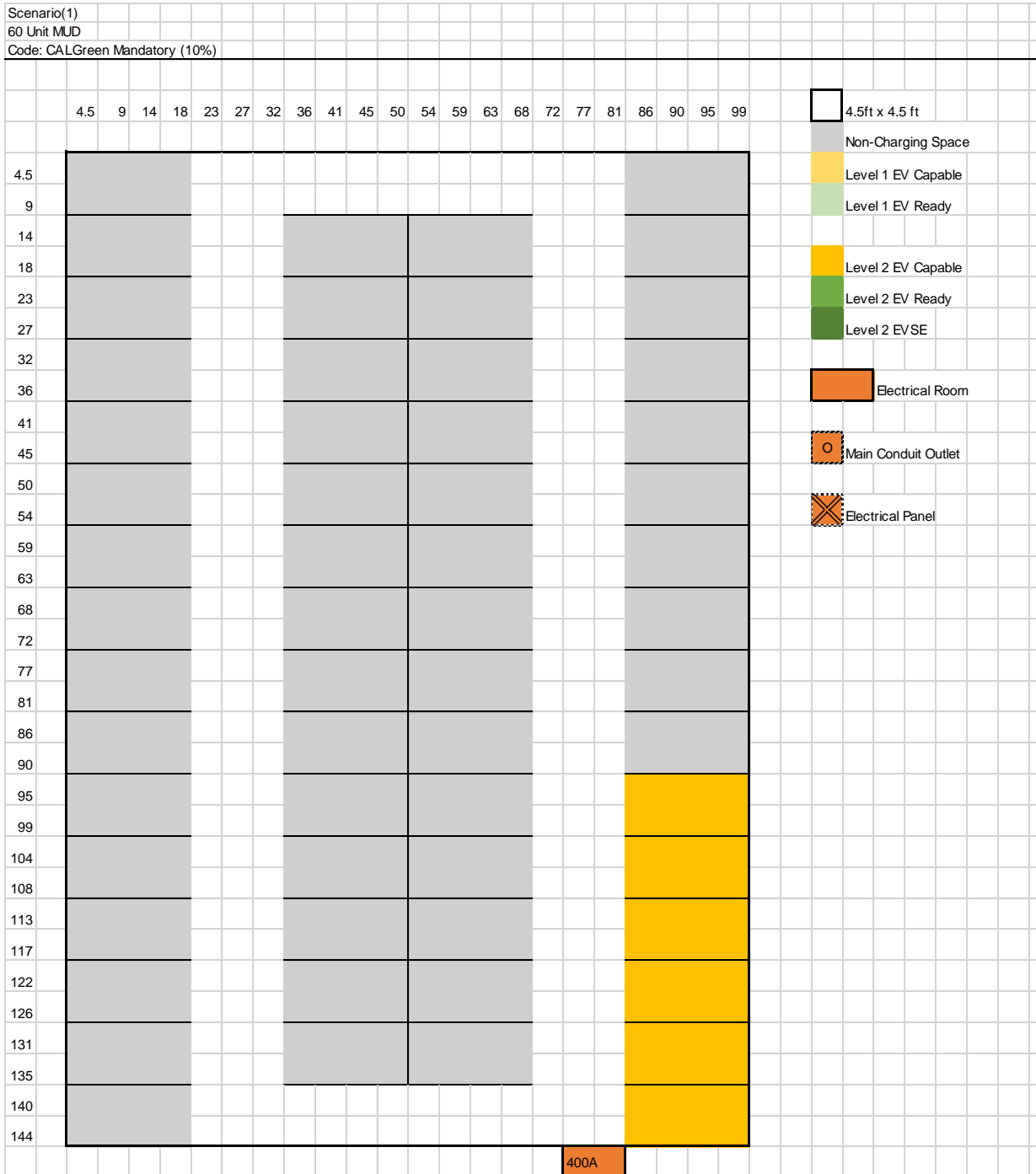
| Task Description | Construction Type | Work Type | Unit | 60-unit MUD | | | 150-unit MUD | | | Medium Office | |
|--|-------------------|-----------|-------------|----------------------------|-------------|--------------------|--------------|-------------|--------------------|---------------|------------------|
| | | | | CALGreen | Market Rate | Affordable Housing | CalGreen | Market Rate | Affordable Housing | CalGreen | 10% L2 40% L1 |
| | | | | Quantity for Each Scenario | | | | | | | |
| Receptacle, range, 50 Amp | retro | electric | Ea. | | 6 | 15 | | 15 | 38 | | 6 |
| Receptacle devices, residential, duplex outlet, ivory, EMT & wire, 20', 15 amp, incl box & cover plate | retro | electric | Ea. | | 27 | 23 | | 68 | 56 | | 12 |
| permitting & inspection, 2 internal circuits, excludes general building permit fees | new | fee | per job | | | | | | | | |
| permitting & inspection, 4 internal and 2 external circuits, excludes general building permit fees | new | fee | per job | | | | | | | 1 | 5 |
| permitting & inspection, 4 internal circuits, excludes general building permit fees | new | fee | per job | 1 | | | | | | | |
| permitting & inspection, 14 internal circuits, excludes general building permit fees | new | fee | per job | | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| permitting, per internal circuit over 4, excluding general building permit fees | new | fee | per circuit | 2 | 20 | 20 | 1 | 60 | 60 | 2 | |
| permitting & inspection, 14 internal and 7 external circuits, excludes general building permit fees | retro | fee | per job | | | | 1 | 1 | 1 | | |
| permitting & inspection, 14 internal circuits, excludes general building permit fees | retro | fee | per job | | 1 | 1 | | | | | 1 |
| permitting, per internal circuit over 4, excluding general building permit fees | retro | fee | per circuit | | 20 | 20 | | 60 | 60 | | 20 |
| architectural plans/drawings | retro | fee | per hour | 8 | 14 | 14 | 14 | 38 | 38 | 6 | 9 |
| architectural plans/drawings | new | fee | per hour | 2 | 4 | 4 | 4 | 12 | 12 | 2 | 3 |
| site and load study | retro | fee | per \$1000 | 1 | 3 | 3 | 3 | 5 | 5 | 1 | 2 |
| Circuit Breakers - 480V 3-pole, 70 to 225Amp | new | main | Ea. | 1 | -1 | -1 | | | | | |
| Circuit Breakers - 480V 3-pole, 70 to 225Amp | retro | main | Ea. | 1 | | | | | | | |
| Switchboard - 3-pole, 4-wire, 400 Amp | retro | main | Ea. | 1 | | | | | | 1 | |
| Circuit Breakers - 480V 3-pole, 450 to 600 Amp | retro | main | Ea. | | 1 | | 1 | | | | |
| Circuit Breakers - 480V 3-pole, 700 to 800 Amp | new | main | Ea. | | | 1 | | | | | |
| Circuit Breakers - 480V 3-pole, 700 to 800 Amp | retro | main | Ea. | | | 1 | | | | | |
| Circuit Breakers - 480V 3-pole, 125 to 400Amp | new | main | Ea. | | | | | | | | 1 |
| Circuit Breakers - 480V 3-pole, 125 to 400Amp | retro | main | Ea. | | | | | | | | 1 |
| Circuit Breakers - 480V 3-pole, 15 - 60 Amp | retro | main | Ea. | | | | | | | 1 | |
| Distribution Switchboard Enclosure - 4 wire, 1000 Amp | new | main | Ea. | | | | | 1 | 1 | | |
| Distribution Switchboard Enclosure - 4 wire, 1000 Amp | retro | main | Ea. | | | | | 1 | 1 | | |
| Incoming Switchboards - 277/480V, 4 wire, 800 Amp | retro | main | Ea. | | | 1 | | | | | 1 |
| Incoming Switchboards - 277/480V, 4 wire, 800 Amp (w/ Fused Switch & CT Compartment) | new | main | Ea. | | | | | 1 | 1 | | |

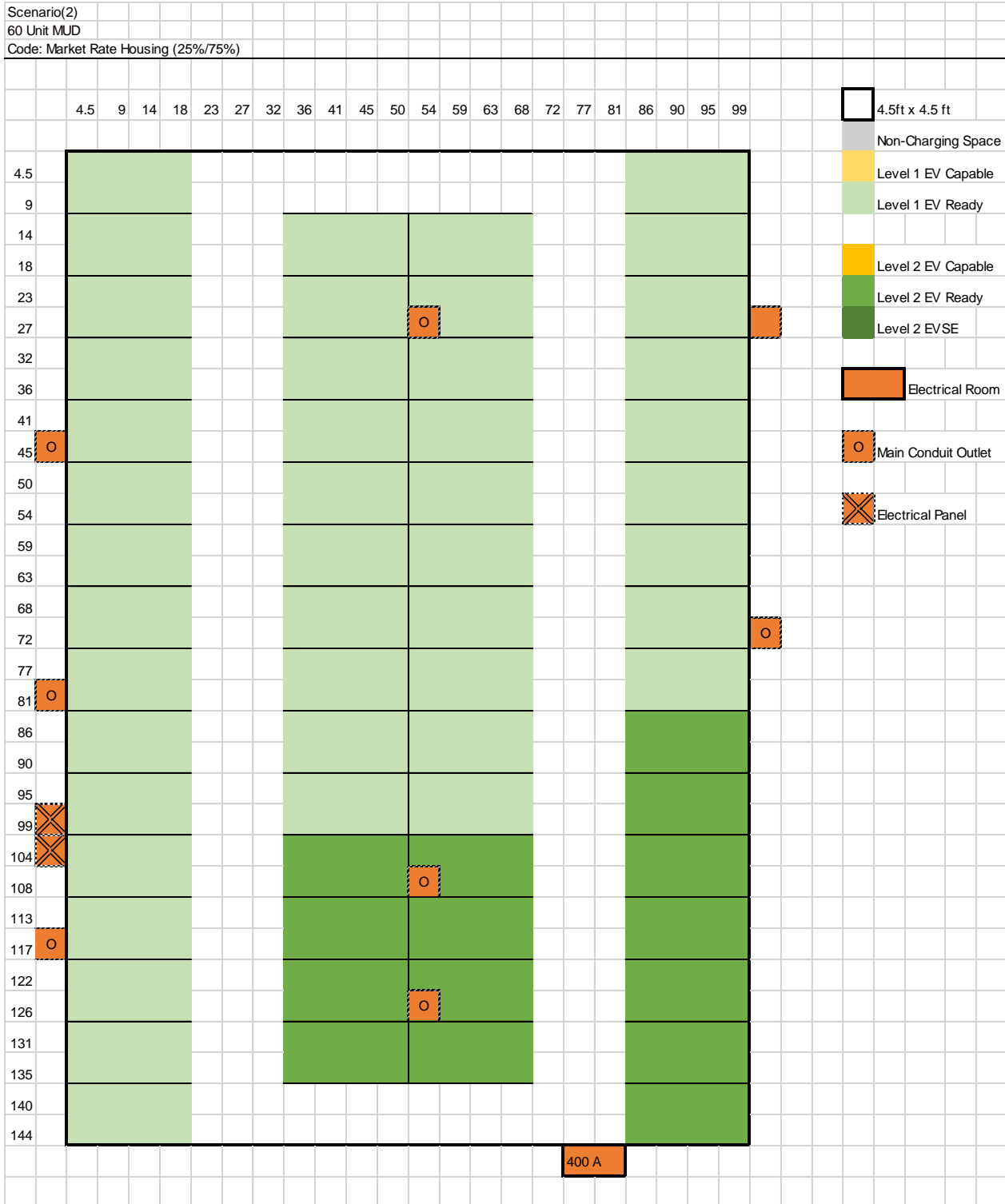
| Task Description | Construction Type | Work Type | Unit | 60-unit MUD | | | 150-unit MUD | | | Medium Office | |
|--|-------------------|-----------|------|----------------------------|-------------|--------------------|--------------|-------------|--------------------|---------------|------------------|
| | | | | CALGreen | Market Rate | Affordable Housing | CalGreen | Market Rate | Affordable Housing | CalGreen | 10% L2 40% L1 |
| | | | | Quantity for Each Scenario | | | | | | | |
| Incoming Switchboards - 277/480V, 4 wire, 800 Amp (w/ Fused Switch & CT Compartment) | retro | main | Ea. | | | | | 1 | 1 | | |
| Switchboard - 3-pole, 4-wire, 2000 Amp | new | main | Ea. | | | | | 1 | 1 | | |
| Switchboard - 3-pole, 4-wire, 2000 Amp | retro | main | Ea. | | | | | 1 | 1 | | |
| Switchboard - 3-pole, 4-wire, 600 Amp | retro | main | Ea. | | 1 | | 1 | | | | |
| Switchboard - 3-pole, 4-wire, 800 Amp | new | main | Ea. | | | 1 | | | | | 1 |
| Switchboard - 3-pole, 4-wire, 800 Amp | retro | main | Ea. | | | 1 | | | | | 1 |
| Panelboards, 1 phase 3 wire, main circuit breaker, 120/240 V, 225 amp, 30 circuits, NQOD, incl 20 A 1 pole bolt-on breakers | new | panel | | | | | | 1 | | 1 | -1 |
| Panelboards, 1 phase 3 wire, main circuit breaker, 120/240 V, 225 amp, 30 circuits, NQOD, incl 20 A 1 pole bolt-on breakers | retro | panel | | | | | | 1 | | | |
| Panelboards, 1 phase 3 wire, main circuit breaker, 120/240 V, 400 amp, 30 circuits, NQOD, incl 20 A 1 pole bolt-on breakers | new | panel | | 1 | 1 | -1 | | | 1 | | |
| Panelboards, 1 phase 3 wire, main circuit breaker, 120/240 V, 400 amp, 30 circuits, NQOD, incl 20 A 1 pole bolt-on breakers | retro | panel | | | 1 | 2 | | | 1 | | 1 |
| Reinforcing steel, in place, dowels, smooth, 12" long, 1/4" or 3/8" diameter, A615, grade 60 | retro | pave | Ea. | | 90 | 90 | | 72 | 72 | | 48 |
| Structural concrete, in place, slab on grade (3000 psi), 4" thick, includes concrete (Portland cement Type I), placing and textured finish, excludes forms and reinforcing | retro | pave | S.F. | | 30 | 30 | | 24 | 24 | | 16 |
| Structural concrete, in place, minimum labor/equipment charge | retro | pave | Job | | 1 | 1 | | 1 | 1 | | 1 |
| PVC conduit, schedule 40, 1-1/4" diameter, in concrete slab, includes terminations, fittings and supports | new | race | L.F. | 324 | 2147 | 2147 | 1080 | 5366 | 5366 | | |
| LV Transformer, Dry Type - 480V primary, 120/208V secondary (112.5 kVA) | retro | trans | Ea. | | 1 | | | | | | |
| LV Transformer, Dry Type - 480V primary, 120/208V secondary (75 kVA) | Retro | trans | Ea. | | | | | | | | 1 |
| LV Transformer, Dry Type - 480V primary, 120/208V secondary (150 kVA) | Retro | trans | Ea. | | | 1 | | | | 1 | |
| LV Transformer, Dry Type - 480V primary, 120/208V secondary (225kVA) | Retro | trans | Ea. | 1 | | | | | | | |
| LV Transformer, Dry Type - 480V primary, 120/208V secondary (300 kVA) | New | trans | Ea. | | 1 | | | | | | |
| LV Transformer, Dry Type - 480V primary, 120/208V secondary (500 kVA) | New | trans | Ea. | | | 1 | | | | | |

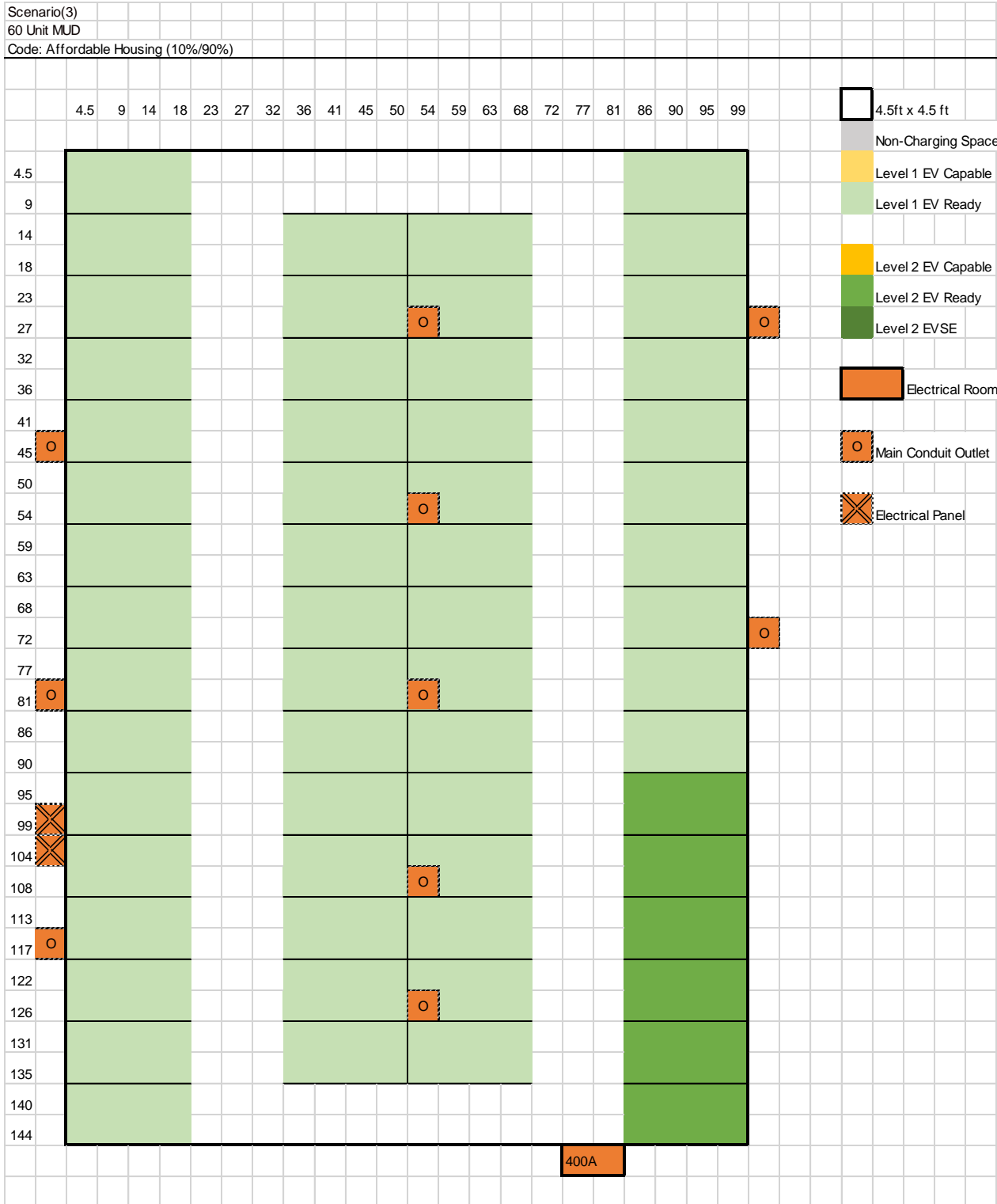
| Task Description | Construction Type | Work Type | Unit | 60-unit MUD | | | 150-unit MUD | | | Medium Office | |
|---|-------------------|-----------|------|----------------------------|-------------|--------------------|--------------|-------------|--------------------|---------------|------------------|
| | | | | CALGreen | Market Rate | Affordable Housing | CalGreen | Market Rate | Affordable Housing | CalGreen | 10% L2 40% L1 |
| | | | | Quantity for Each Scenario | | | | | | | |
| LV Transformer, Dry Type - 480V primary, 120/208V secondary (500 kVA) | Retro | trans | Ea. | | | | | 1 | | | |
| LV Transformer, Dry Type - 480V primary, 120/208V secondary (750 kVA) | Retro | trans | Ea. | | | | 2 | | 1 | | |

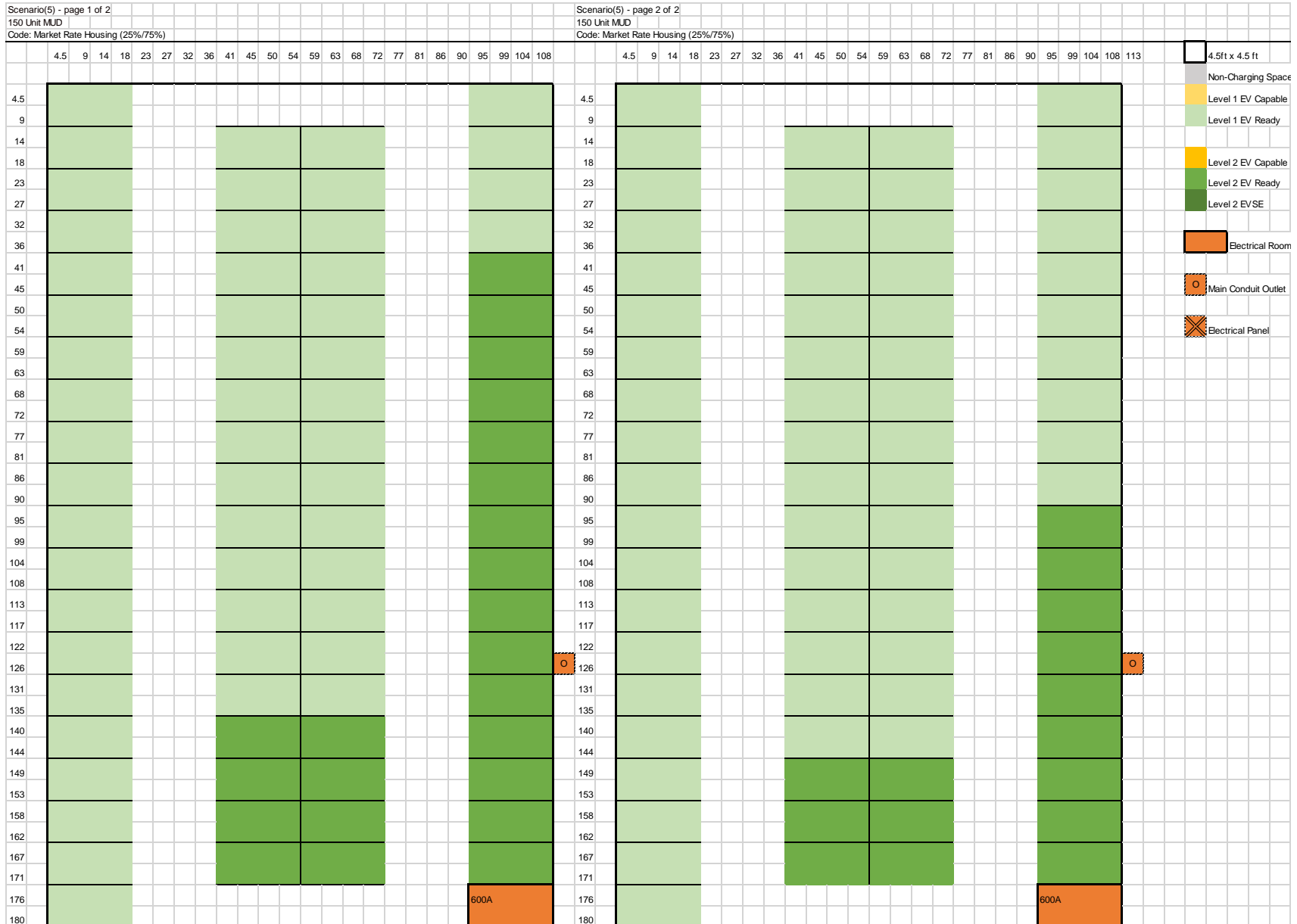
Appendix D: EV Capable Installation Configurations

This section includes figures to generally depict the configuration of each scenario that was analyzed. They are not intended to include all details of a particular installation nor are they intended to represent any particular specific installation.

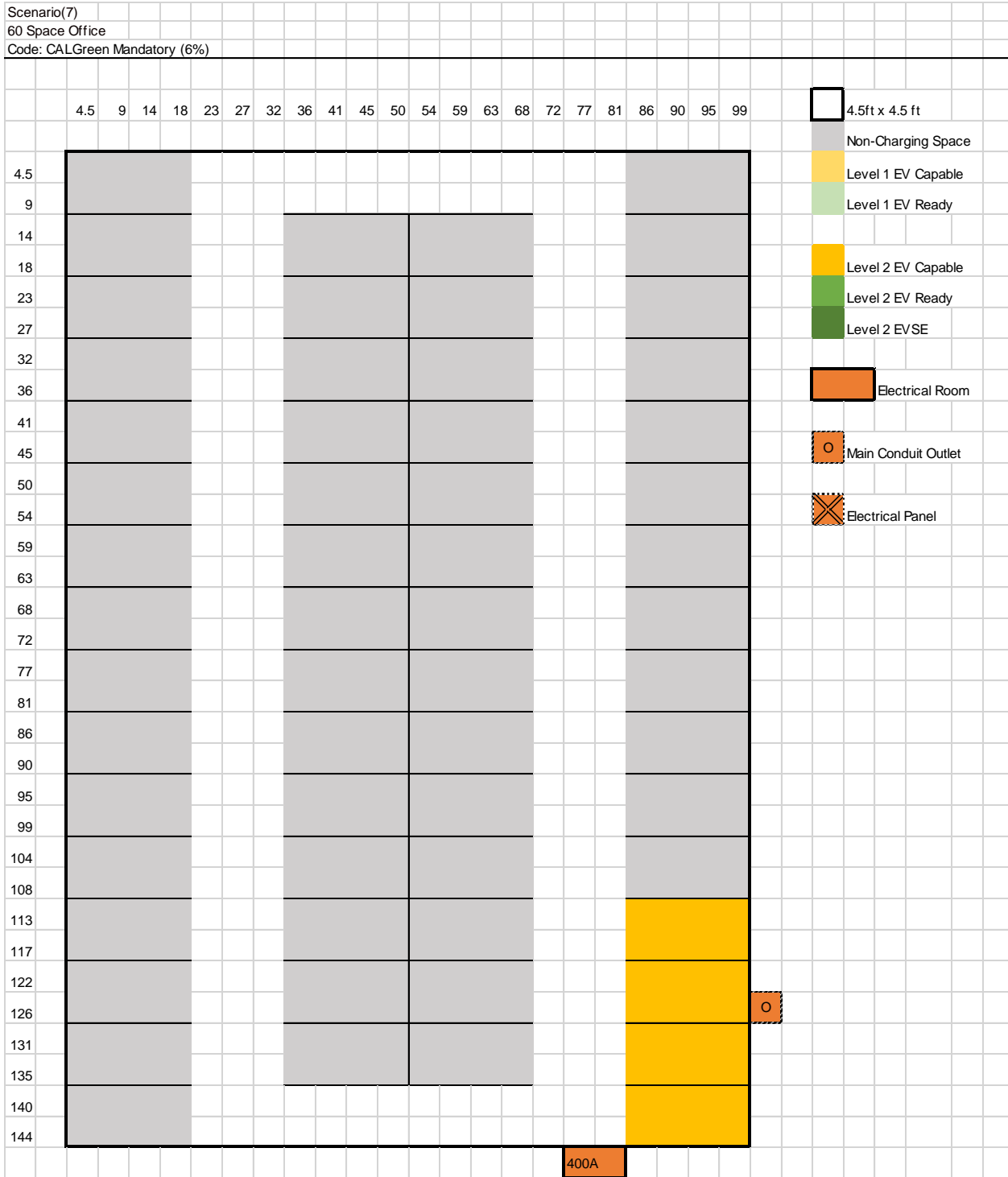


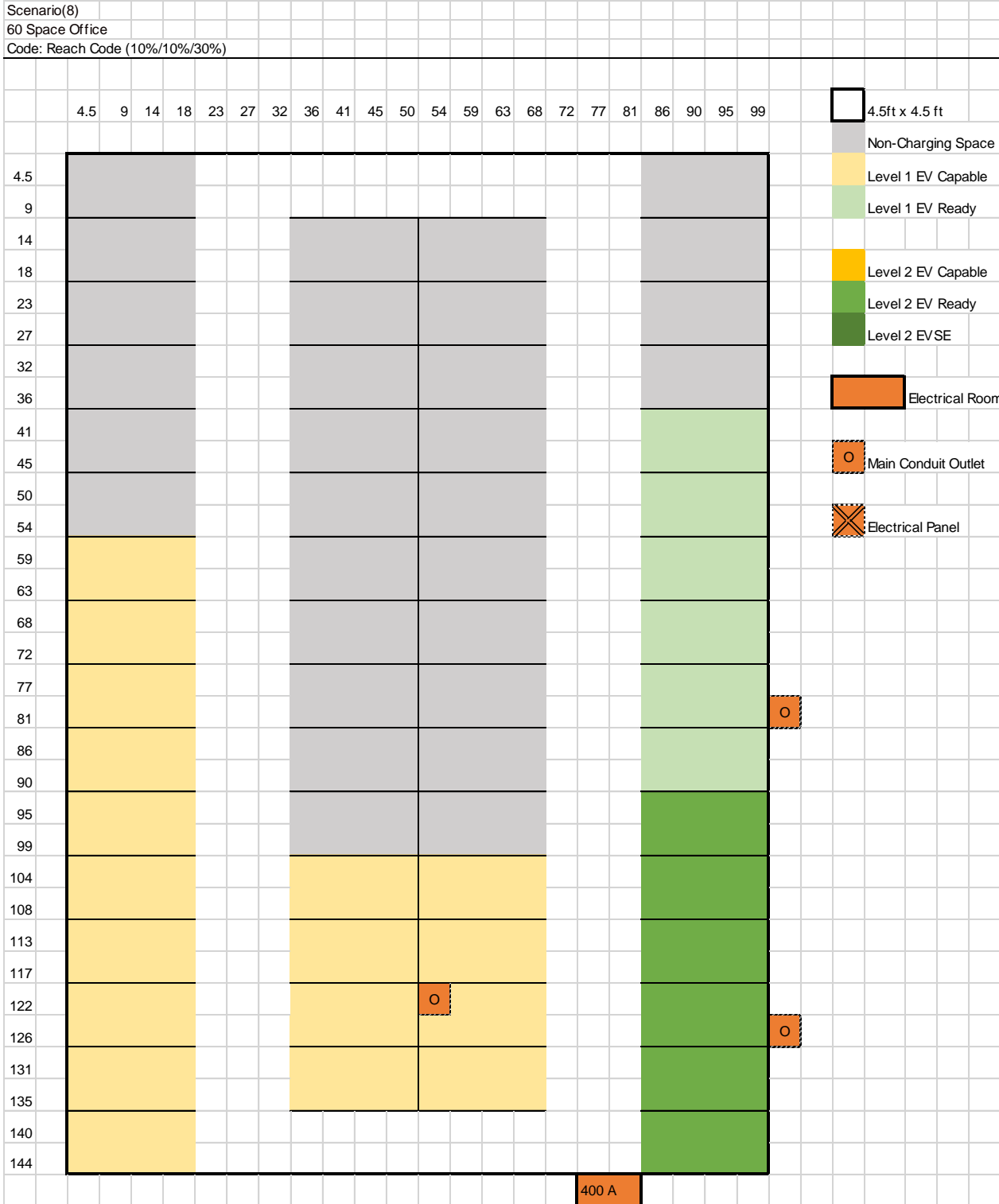














SIERRA CLUB

LOMA PRIETA CHAPTER

SAN MATEO, SANTA CLARA & SAN BENITO COUNTIES

October 27, 2020

Los Altos City Council
1 North San Antonio Road
Los Altos, CA 94022
Via email to: council@losaltosca.gov

RE: 10.27.2020 City Council Agenda Item 7: Reach Codes

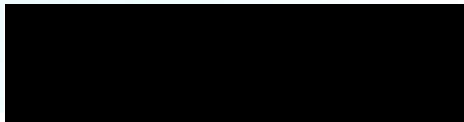
Dear Los Altos City Councilmembers,

We are living in a climate crisis that poses an existential threat to the survival of organized human life and global biodiversity. The scientific consensus on climate change tells us that our society must rapidly transition away from fossil fuels. The Sierra Club Loma Prieta Chapter is pleased that the Los Altos City Council will consider the adoption of Reach Codes tonight. It is imperative that we no longer continue to build more unnecessary fossil fuel pipelines that are a cost, health, and climate hazard to our community and to future generations.

The Loma Prieta Chapter would like to thank all of the City Councilmembers and City Staff who have worked hard to bring the code before us in its current form. **While we hope that Los Altos will adopt a fully all-electric code in the near future, we also believe it is imperative that the City move forward tonight with the Reach Code as presented in the staff report.**

We hope you take this important step to help the community transition away from fossil fuels and towards a future that is healthy for our residents and ecosystems.

Sincerely,



Dashiell Leeds, Conservation Assistant, Sierra Club Loma Prieta Chapter

Cc: James Eggers, Executive Director, Sierra Club Loma Prieta Chapter