CALIFORNIA ENERGY CODES & STANDARDS

A STATEWIDE UTILITY PROGRAM

Last modified: 2023/06/29
Revision: 1.0

2022 Cost-Effectiveness Study: All Electric and Solar Thermal Pool Heating

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Acronym List

B/C – Benefit-to-Cost Ratio

BSC – California Building Standards Commission

CBECC – California Building Energy Code Compliance

CEC – California Energy Commission

CZ – Climate Zone

GHG – Greenhouse Gas

IOU – Investor-Owned Utility

LCC – lifecycle cost

POU – Publicly Owned Utility

PG&E – Pacific Gas & Electric (utility)

SCE – Southern California Edison (utility)

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

CPAU – City of Palo Alto Utilities

SMUD – Sacramento Municipal Utility District

kWh – Kilowatt Hour

NPV – Net Present Value

PV – Solar Photovoltaic

TDV – Time Dependent Valuation

Title 24 – California Code of Regulations Title 24, Part 6

Summary of Revisions		
Date	**Description**	**Reference (page or section)**
6/29/2023	Original Release	NA

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Executive Summary

The California Codes and Standards (C&S) Reach Codes Program provides technical support to local governments considering adopting a local ordinance (reach code) intended to support meeting local and/or statewide energy efficiency and greenhouse gas (GHG) reduction goals. The program facilitates adoption and implementation of the code when requested by local jurisdictions by providing resources such as cost-effectiveness studies, model language, sample findings, and other supporting documentation.

This report documents the cost-effective use of all-electric pool and spa heating options as compared to a base case of a gas-fired pool heater. The study includes analyses of all-electric options for both single family homes and multifamily buildings. The all-electric options include a combination of electric heat pump pool heaters (HPPH) with and without a secondary electric resistance heater and a solar pool heating system to heat pools and spas. The results of the analysis indicate that there are cost-effective all-electric pool and spa heating options in most climate zones when using the time dependent valuation (TDV) metric.

Local jurisdictions may consider adopting policies that include the all-electric pool heating packages presented in this report to achieve energy savings and emissions reductions beyond what will be accomplished by enforcing minimum state requirements, the 2022 Building Energy Efficiency Standards (Title 24, Part 6), effective January 1, 2023. California law allows local jurisdictions to adopt ordinances to achieve energy savings and emissions reductions beyond what will be accomplished by enforcing minimum state requirements, Title 24, Part 6. Jurisdictions that wish to adopt local ordinances that impact building energy use must demonstrate the proposed changes are cost effective and reduce energy use. Jurisdictions must submit the ordinance language and analysis results to the California Energy Commission (CEC) for approval and file the ordinance documentation with the California Building Standards Commission (BSC) before the ordinance can take effect.

Local jurisdictions may also adopt ordinances that amend different parts of the California Building Standards Code or may elect to amend other state or municipal codes. The decision regarding which code to amend will determine the specific requirements that must be followed for an ordinance to be legally enforceable.

This study documents the estimated costs, benefits, energy impacts, and GHG emission reductions that may result from installing all-electric pool and spa heating systems. The analysis can serve as the required energy and cost effectiveness documentation that jurisdictions must provide CEC along with their proposed ordinances. The results presented in this report can also help residents, local leadership, and other stakeholders make informed policy decisions.

Table 1 and Table 2 present the results of the cost effectiveness analysis of all-electric pool heating options in each California climate zone relative to gas-fired pool heating. Table 1 presents the benefit-to-cost ratios using the TDV metric, and Table 2 presents results using an On-Bill metric. When the benefit-to-cost ratio is equal to or greater than one, the measure is cost effective. The options that are cost effective are highlighted in green.

Looking at the TDV metric results, the all-electric option of a HPPH alone without resistance heating or solar thermal is cost effective in all climate zones if used to heat a pool only. If using a heat pump to heat a single family pool and spa, the all-electric option of a HPPH with electric resistance and solar thermal is cost effective in all climate zones except 15 and 16. If heating a multifamily pool and spa, the option of HPPH with resistance backup and solar thermal is cost effective in all climate zones except 1, 15 and 16. All-electric pool heating is not as cost effective when using the On-Bill metric, as shown in Table 2.

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

Table 1. TDV Benefit-to-Cost Ratio (Cost Effectiveness) of All Electric Pool and Spa Heating

Climate Zone	Electric Utility	Single Family Pool	Single Family Pool and Spa		Multifamily Pool and Spa	
		All Electric (HPPH)	All Electric (HPPH + Electric Resistance)	All Electric + Solar (Solar + HPPH + Electric Resistance)	All Electric (HPPH + Electric Resistance)	All Electric + Solar (Solar + HPPH + Electric Resistance)
CZ01	PG&E	5.8	0.0	1.4	0.0	0.0
CZ02	PG&E	8.5	0.7	3.6	0.0	2.8
CZ03	PG&E	8.0	0.6	2.2	0.0	2.6
CZ04	PG&E	5.1	0.0	2.6	0.1	2.9
CZ04-2	CPAU	5.1	0.0	2.6	0.1	2.9
CZ05	PG&E	5.9	0.0	2.5	0.0	1.5
CZ05-2	PG&E SoCalGas	5.9	0.0	2.5	0.0	1.5
CZ06	SCE	5.1	0.0	2.3	0.0	2.1
CZ07	SDG&E	3.3	0.0	1.5	0.0	1.7
CZ08	SCE	4.2	0.0	2.0	0.0	1.3
CZ09	SCE	4.1	0.0	1.7	0.0	1.8
CZ10	SCE	7.1	0.4	2.5	0.0	1.2
CZ10-2	SDG&E	7.1	0.4	2.5	0.0	1.2
CZ11	PG&E	5.8	0.0	1.7	0.0	1.2
CZ12	PG&E	5.9	0.1	2.4	0.0	2.0
CZ12-2	SMUD	5.9	0.1	2.4	0.0	2.0
CZ13	PG&E	6.4	0.2	2.1	0.0	1.0
CZ14	SCE	10.3	1.0	2.9	0.6	3.0
CZ14-2	SDG&E	10.3	1.0	2.9	0.6	3.0
CZ15	SCE	3.7	0.0	0.9	0.0	0.2
CZ16	PG&E	3.6	0.0	0.3	0.0	0.0

Table 2. On-Bill Benefit-to-Cost Ratio (Cost Effectiveness) of All Electric Pool and Spa Heating

Climate Zone	Electric Utility	Single Family Pool	Single Family Pool and Spa		Multifamily Pool and Spa	
		All Electric (HPPH)	**All Electric** (HPPH + Electric Resistance)	**All Electric + Solar** (Solar + HPPH + Electric Resistance)	**All Electric** (HPPH + Electric Resistance)	**All Electric + Solar** (Solar + HPPH + Electric Resistance)
CZ01	PG&E	0.0	0.0	0.0	0.0	0.0
CZ02	PG&E	1.5	0.0	2.2	0.0	0.0
CZ03	PG&E	3.0	0.0	0.6	0.0	0.0
CZ04	PG&E	2.0	0.0	1.4	0.0	0.0
CZ04-2	CPAU	7.7	0.7	3.1	5.2	5.5
CZ05	PG&E	0.4	0.0	1.2	0.0	0.0
CZ05-2	PG&E SoCalGas	0.0	0.0	0.0	0.0	0.0
CZ06	SCE	1.1	0.0	0.4	0.0	0.0
CZ07	SDG&E	0.4	0.0	0.0	0.0	0.0
CZ08	SCE	0.7	0.0	0.3	0.0	0.0
CZ09	SCE	1.5	0.0	0.0	0.0	0.0
CZ10	SCE	0.2	0.0	0.0	0.0	0.0
CZ10	SDG&E	1.2	0.0	0.3	0.0	0.0
CZ11	PG&E	3.5	0.0	0.4	0.0	0.0
CZ12	PG&E	2.6	0.0	1.3	0.0	0.0
CZ12-2	SMUD	10.7	2.9	4.3	17.3	11.8
CZ13	PG&E	2.6	0.0	0.8	0.0	0.0
CZ14	SCE	0.9	0.0	0.0	0.0	0.0
CZ14-2	SDG&E	2.2	0.0	0.1	0.0	0.0
CZ15	SCE	0.7	0.0	0.0	0.0	0.0
CZ16	PG&E	0.0	0.0	0.0	0.0	0.0

1 Introduction

This report documents cost-effective all-electric pool and spa heating systems that use an equal amount or less energy than pool heating systems that are minimally compliant with the requirements in the 2022 California Building Energy Efficiency Standards (Title 24, Part 6), which took effect January 1, 2023. The analysis evaluates pool heating for single family and multifamily swimming pools and inground spas. 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 Codes Team. In 2019, the Reach Codes Team analyzed the cost effectiveness of an all-electric heat pump pool heater (HPPH) compared to a gas-fired pool heater in the City of Santa Monica (Statewide Reach Codes Team, 2019). This report builds upon the existing research, expanding the analysis to all climate zones and exploring additional all-electric configurations.

Title 24, Part 6 is maintained and updated every three years by two state agencies: the California Energy Commission (CEC) and the California Building Standards Commission (BSC) (California Energy Commission, 2022b). In addition to enforcing the code, local jurisdictions have the authority to adopt local energy efficiency ordinances—or reach codes—that exceed the minimum standards defined by Title 24, Part 6 (as established by Public Resources Code Section 25402.1(h)2 and Section 10-106 of the Building Energy Efficiency Standards). Local jurisdictions must demonstrate that the requirements of the proposed ordinance are cost effective and do not result in buildings consuming more energy than is permitted by Title 24, Part 6. In addition, the jurisdiction must obtain approval from the CEC and file the ordinance with the BSC for the ordinance to be legally enforceable.

This report documents the assumptions and cost-effectiveness analysis comparing all-electric pool heating systems with a gas-fired pool heater. The all-electric systems evaluated include a HPPH alone, and a HPPH in combination with a secondary electric resistance heater. The report also evaluates the impact of a HPPH in combination with electric resistance and a solar power heating system. The analysis looks at energy savings and cost effectiveness in all 16 California climate zones.

Note that the 2022 version of Title 24, Part 6 prohibits electric resistance pool heating unless 60 percent of annual demand is met by site-solar or recovered energy (Section 110.4(a)4). Additionally, if a pool is heated by a heat pump or gas pool heater, a pool cover is required (Section 110.4(b)2).

The 2019 Residential Appliance Saturation Study (RASS) study shows that 53 percent of pools in California have some form of pool heating (natural gas, solar thermal, electricity or propane) and the majority of those (60 percent) use natural gas (DNV GL Energy Insights USA, 2021). While natural gas pool heaters have historically dominated the residential pool heating market in California, based on conversations with manufacturers, HPPHs are much more common in other major pool markets such as Florida. In Florida, a combination of mild temperatures, low electricity prices, and limited natural gas use in general have made HPPHs a cost-effective choice for many pool owners.

Pools are not required to have heating systems. In fact, 47 percent of pools in California are not heated. In many regions of California, heating from the sun directly striking the pool combined with the heat retained by use of a pool cover provides the desired pool water temperature. In many other areas, supplemental heating systems are unnecessary. Pool heating systems are often added to extend the summer swim season into the spring and fall months or to provide elevated water temperature for an inground spa. Solar thermal heating systems are also relatively common; however, it is not always practical to have a solar thermal system due to roof space limitations, shading, or the inability to provide heating on-demand, and therefore solar thermal systems are not a suitable substitute for all pool heating systems in all applications.

The proposed code change analyzed in this report supports the inclusion of heated pools and inground spas in a local energy ordinance in climate zones where cost effective (Codes and Standards Reach Codes Team, 2022). Therefore, the analysis in this report focuses on the cost-effectiveness of the all-electric and all-electric plus solar packages compared to the base case of a gas-fired pool heater package.

The United States Department of Energy (DOE) sets minimum efficiency standards for equipment and appliances that are federally regulated under the National Appliance Energy Conservation Act, including gas pool heating equipment (E-CFR, 2020). Since state and local governments are prohibited from adopting building codes that require higher minimum efficiencies than the federal standards require, this study assumed that gas pool heaters were minimally compliant with federal efficiency standards. We did not evaluate the impact of higher efficiency gas pool heaters relative to all-electric alternatives. Using equipment that is more efficient than the minimum federal standards is often the easiest and most cost-effective approach to increase energy performance. While federal preemption limits jurisdictions from adopting reach codes that require higher efficiency equipment, in practice, builders may install any package of compliant measures, including higher efficiency equipment to achieve the performance requirements.

At the time the analysis was completed there were no federal energy efficiency requirements for HPPH. The analysis assumed the HPPH would be moderately efficient and represents approximately the average efficiency of equipment available on the market. On April 14, 2022, DOE issued a Notice of Proposed Rulemaking to establish an efficiency standard for HPPHs (DOE, Pool Heating NOPR, 2022), with a potential effective date in 2028.

2 Methodology and Assumptions

2.1 Cost Effectiveness

This section describes the approach to calculate cost effectiveness starting with the methodology to calculate energy savings, followed by estimating benefits (i.e., energy cost savings), costs, and metrics.

2.1.1 Energy Savings

To estimate energy savings, the Reach Code Team performed energy simulations using Enerpool 3.0, a pool heating simulation software developed by Natural Resources Canada (NRCan, 2009).[1] The Reach Codes Team provided inputs to the software to describe the configuration of the pool, spa, heater, and solar pool heating systems. The software performed hour-by-hour calculations to determine energy use. The Reach Codes Team used the 2022 Title 24, Part 6 weather files for the simulations. The 2022 weather files are accessible through California's public domain code compliance software programs for the 2022 code cycle, California Building Energy Code Compliance software (CBECC).[2] The analysis in Enerpool 3.0 yielded hourly energy savings estimates for the proposed measure in each California climate zone.

2.1.2 Benefits

This analysis used both On-Bill and time dependent valuation (TDV) of energy-based approaches to evaluate cost-effectiveness. Both On-Bill and TDV require estimating and quantifying the energy savings and costs associated with energy measures. The primary difference between On-Bill and TDV is how energy is valued:

- Utility Bill Impacts (On-Bill): Customer-based lifecycle cost 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 evaluation period accounting for a 3.0 percent discount rate and energy cost inflation. See Appendix 8.2 for more information on utility rate schedules and fuel escalation assumptions.
- TDV: TDV was developed by the CEC 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 and grid transmission 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.

2.1.2.1 Utility Rates

Residential utility rates were used to calculate utility costs for all cases and determine On-Bill customer cost effectiveness for the proposed packages. In coordination with the IOU rate team, and the publicly available information for several Publicly-Owned-Utilities (POUs), the Reach Codes Team determined appropriate utility rates for each climate zone and all-electric pool heating package. The utility tariffs, summarized in Table 2, were determined based on the annual load profile of the prototype and the corresponding package, and the most prevalent rate in each territory. Residential rates were used for multifamily pools based on the assumption that common areas in multifamily buildings are on residential rates in most cases.

Utility rates were applied to each climate zone based on the predominant IOU serving the population of each zone according to Table 3. Climate zones 10 and 14 are evaluated with both SCE and SDG&E tariffs since each utility has customers within these climate zones. Climate zone 5 is evaluated with both the PG&E and Southern California Gas Company since each utility has customers within this climate zone. Two POU rates were also evaluated, Sacramento

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[1] Enerpool 3.0 is a free software tool available through the Natural Resources Canada: https://www.nrcan.gc.ca/energy/enerpool-30/7437.

[2] The public domain compliance software programs are available for free on CEC's website: https://www.energy.ca.gov/programs-and-topics/programs/building-energy-efficiency-standards/2022-building-energy-efficiency-1.

Municipal Utility District (SMUD) in climate zone 12 and City of Palo Alto Utilities (CPAU) in climate zone 4. A time-of-use (TOU) rate was applied to all cases. For a more detailed breakdown of the rates selected refer to Appendix 9.2 - Utility Rate Schedules.

Table 3. Utility Tariffs Used Based on Climate Zone

IOUs			
Climate Zones	**Electric / Gas Utility**	**Electricity**	**Natural Gas**
1-5,11-13,16	PG&E	E-TOU Option C	G-1
5	PG&E / Southern California Gas Company	E-TOU Option C	GR
6, 8-10, 14, 15	SCE / Southern California Gas Company	TOU-D Option 4-9	GR
7, 10, 14	San Diego Gas and Electric Company (SDG&E)	TOU-DR-1	GM
POUs			
Climate Zones	**Electric / Gas Utility**	**Electricity**	**Natural Gas**
4	City of Palo Alto (CPAU)	E-1	G-1
12	Sacramento Municipal Utility District (SMUD) / PG&E	R TOD Option 5-8	G-1

Utility rates are assumed to escalate over time according to the assumptions from the CPUC 2021 En Banc hearings on utility costs through 2030 (California Public Utilities Commission, 2021a). Escalation rates through the remainder of the 30-year evaluation period are based on the escalation rate assumptions within the 2022 TDV factors. See Appendix 9.2.7 Fuel Escalation Assumptions for details.

2.1.2.2 Time Dependent Valuation Factors

This analysis uses TDV factors that the CEC developed and approved for the 2022 code cycle. The CEC uses TDV to evaluate the cost effectiveness of proposed revisions to Title 24, Part 6. TDV is also used to demonstrate compliance with Title 24, Part 6. While the methodology to develop TDV factors is complex, the end result is hourly factors that vary by climate zone and reflect the value of energy used (or saved) based on the mix of generation resources and demand on the grid at any given time, as well as impacts on retail energy costs. TDV energy factors account for the energy used at the building site and consumed in producing and in delivering energy to a site, including, but not limited to, power generation, transmission and distribution losses. The factors also reflect changes in the generation mix over time (in this case over 30 years) as well as the shift in the peak demand time from mid-afternoon toward early evening.

TDV energy factors are reflected in units of TDV kBtu. To convert annual TDV energy savings to “lifecycle” energy cost savings, TDV energy savings are multiplied by a TDV net present value (NPV) factor, which CEC develops and releases with TDV factors. The TDV NPV factors account for energy savings over a period of 30 years for all residential measures. That is, the TDV NPV factor has units of 30-year dollar savings per TDV kBtu. The 30-year NPV factor is $0.173/TDV kBtu for residential projects. This is calculated according to Equation 1 (Energy+Environmental Economics, 2020).

Equation 1: Present Value of Lifetime TDV Energy Cost Savings

$$2022\ PV\ \$\ of\ lifetime\ benefit = TDV\ energy\ savings * NPV\ factor$$

2.1.3 Costs

The Reach Codes Team assessed the incremental costs and savings of the energy packages over the 30-year evaluation period. Incremental costs represent the equipment, installation, replacements, and maintenance costs of the proposed measure relative to equipment that is minimally compliant with the Federal Appliance Standard for gas-fired pool heaters. The Reach Codes Team obtained measure costs from literature review, U.S. DOE Consumer Pool Heater Rulemaking documents and online sources such as pool equipment retailers. Taxes and contractor markups were added as appropriate. Maintenance and replacement costs are included. Replacement for gas-fired pool heater or HPPH occurred twice: after 11.2 and 22.4 years at the device end of life (DOE, Technical Support Document, 2022). The solar thermal heating system was replaced once at end of life after year 15 (Florida Solar Design Group, 2022). The residual value at the end of the 30-year period of the gas-fired pool heater and HPPH was subtracted from the replacement costs. The solar thermal heating system's end of life coincided with the end of the study. No residual value for the solar thermal collectors was subtracted from the replacement costs. The Reach Code Team calculated the net present value of the equipment replacement costs for comparison between the baseline and measure cases.

In calculating On-Bill and TDV cost effectiveness, incremental first costs are assumed to be paid upfront in the first year of analysis. Incremental replacement costs and any residual value of equipment at the end of the 30-year period of study were adjusted to present value.

2.1.4 Cost-Effectiveness Metrics

Cost effectiveness was evaluated for all climate zones and is presented based on both TDV energy, using the CEC's lifecycle cost (LCC) methodology (Energy+Environmental Economics, 2020), and an On-Bill approach using residential customer utility rates. Both methodologies require estimating and quantifying the value of the energy impact associated with measures over the life of the measures as compared to the minimum Title 24, Part 6 requirements. Cost effectiveness is presented using net present value (NPV) and benefit-to-cost (B/C) ratio metrics which represent the cost effectiveness of a measure over a lifetime, taking into account discounting of future savings and costs.

- **NPV Savings:** The Reach Codes 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 net savings represent net costs to the consumer. A measure that has negative energy cost benefits (energy cost increase) can still be cost effective if the costs to implement the measure are even more negative (i.e., construction and maintenance cost savings). NPV is calculated according to Equation 2.
- **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 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 B/C ratio is calculated according to Equation 3.

Equation 2: Net Present Value

$$Net\ Present\ Value = 2023\ PV\ \$\ lifetime\ benefit - 2023\ PV\ \$\ lifetime\ cost$$

Equation 3: Benefit-to-Cost Ratio

$$Benefit\ to\ Cost\ Ratio\ = \frac{2023\ PV\ \$\ lifetime\ benefit}{2023\ PV\ \$\ lifetime\ cost}$$

Improving the energy performance of a pool heating system often requires an initial investment. In most cases the benefit is represented by annual On-Bill utility or TDV cost savings, and the cost by incremental first cost and replacement costs. The present value of replacement cost is included for measures with equipment lifetimes less than the evaluation period. The present value of future incremental maintenance costs is also included where applicable. The lifetime costs or benefits are calculated according to Equation 4.

Equation 4: Lifetime Costs of Benefits

$$2023\ Lifetime\ Cost\ or\ benefit = \sum_{t=0}^{n} \frac{(Annual\ cost\ or\ benefit)_t}{(1+r)^t}$$

Where:

- *n* = analysis term
- r = discount rate
- *t* = year at which cost/benefit is incurred

The following summarizes the assumptions applied in this analysis.

- Analysis term (n) of 30-years for both the On-Bill and TDV approaches.
- Real discount rate (r) of 3.0 percent (does not include inflation).

2.2 Greenhouse Gas Emissions

The analysis uses the greenhouse gas (GHG) emissions estimates provided by the CEC for use with the 2022 CBECC-Res simulation software. There are 8760 hourly multipliers accounting for time dependent energy use and carbon emissions based on source emissions, including renewable portfolio standard projections. There are two strings of multipliers—one for Northern California climate zones, and another for Southern California climate zones.[3] GHG emissions are reported as average annual metric tons of CO_2 equivalent over the 30-year building lifetime.

2.3 Energy Design Rating

Typically, cost-effectiveness analyses for single family and multifamily buildings require projects to exceed the 2022 Title 24, Part 6 requirements based on one of the code compliance metrics: Energy Design Rating (EDR), Hourly Source Energy (HSE), or Time Dependent Valuation (TDV). The proposed ordinance must result in a decrease in energy use compared to the baseline package to meet requirements for adoption. The building compliance analyses do not consider pool energy usage for a single family or multifamily building; therefore, the Reach Codes Team has not included a discussion of state code compliance metrics in this report.

[3] CBECC-Res multipliers are the same for climate zones 1-5 and 11-13 (presumed to be Northern California), while there is another set of multipliers for climate zones 6-10 and 14-16 (assumed to be Southern California).

3 Available Equipment Survey

3.1 Performance and Efficiency of Current HPPH

A HPPH uses electricity to transfer heat from the surrounding air to the pool water through a heat exchanger. Unlike gas heaters, HPPHs are rated on **output capacity** and are typically advertised at their high air temperature (80°F), high humidity (80% relative humidity), and 80°F water temperature test point (commonly denoted as 80/80/80). This is one of the test points required by the California Appliance Efficiency Standards (Title 20). Conversely, gas heaters are typically rated based on **input capacity**. HPPHs also are rated at other conditions such as 50/63/80 as required by the CEC (California Energy Commission, 2022). The Air-Conditioning and Refrigeration Institute (AHRI) equipment database requires the CEC test conditions and 80/63/80 test condition (AHRI, 2022). At each output capacity for these ratings, a Coefficient of Performance (COP) value is produced. COP is a function of useful heat compared to work required, or a measurement of how efficient the heat pump is at the given conditions.

COP data published at standard conditions by CEC is useful, however, because outside conditions are always changing, determining the exact COP at any given temperature is challenging. As shown in Figure 1, a 2009 study at Brookhaven National Labs (BNL) testing pool heating equipment found the COP for at least one model was relatively stable from roughly 57°F outdoor air temperature and above, but COP declined below 57°F as would be expected (Brookhaven National Laboratory, 2009). COP declines with decreasing temperature as less heat is available to be harvested from the surrounding air.

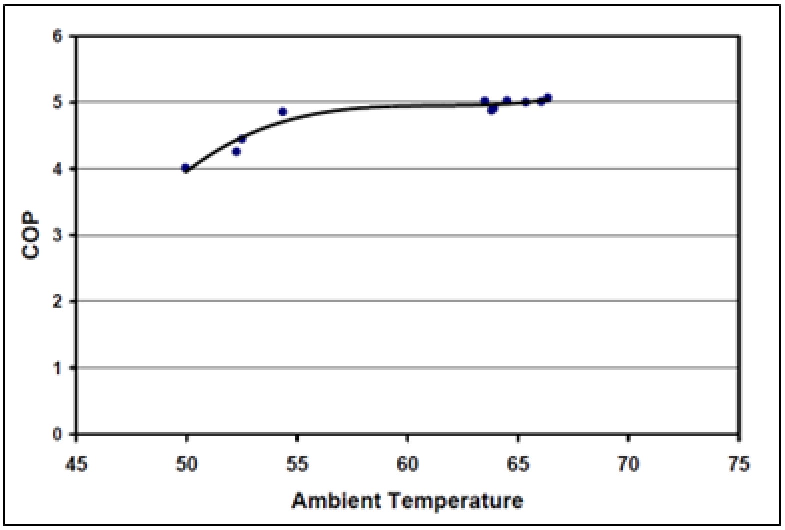

Figure 1: Brookhaven National Labs COP Test Results, Rheem Model 8320ti HPPH

Source: (Brookhaven National Laboratory, 2009)

Figure 2 shows the assumed COP curve for this study. The Reach Codes Team used the BNL data as a starting point and extrapolated the curve to 40°F. The COP drops to 0.99 at 40°F to account for the transition from HPPH heating to electric resistance heating. For this analysis, the Reach Codes Team assumed that single family pools would not operate during winter months, so for single family pools there are very few hours when the air temperature is below 40°F. The Reach Codes Team assumed that multifamily pools operate year-round, so the all-electric pool heating system included an electric resistance heater for both multifamily scenarios. The electric resistance heaters were modeled at 99 percent efficient.

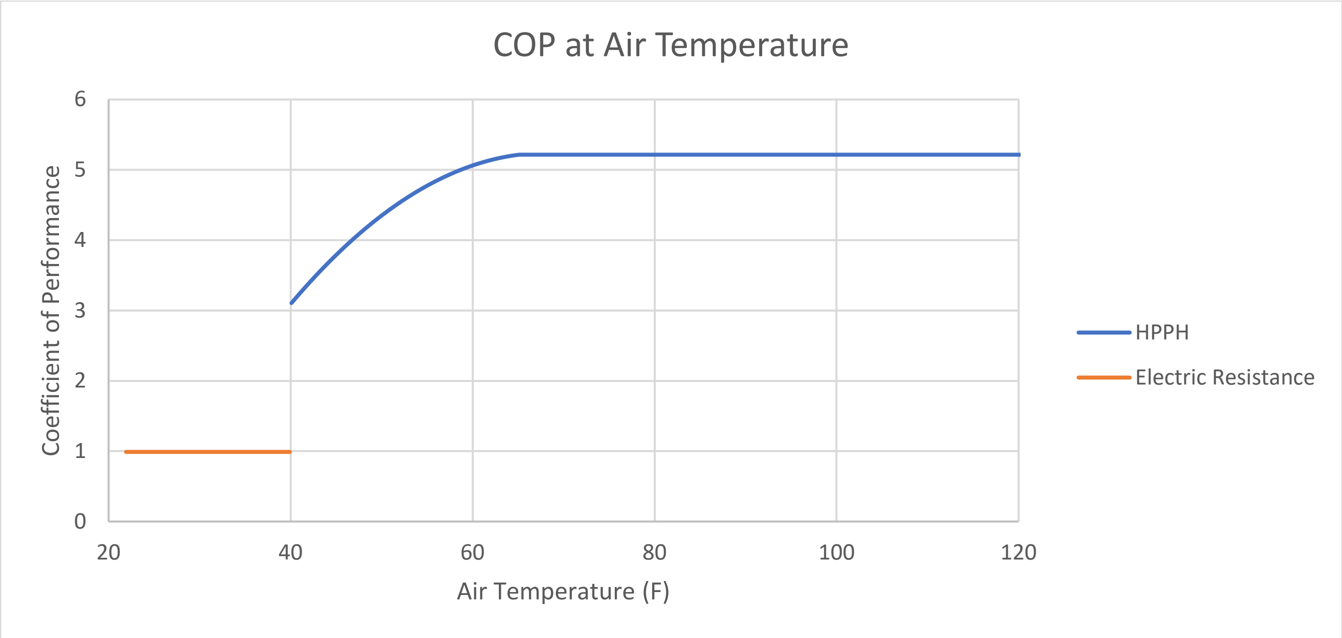

Figure 2: Modeled COP of HPPH

Source: Reach Codes Team

Figure 3 below plots the 231 models of HPPHs in the CEC database as of October 2022. California has had an appliance standard for HPPHs since 2003 requiring the average of the standard (warm) and low temperature condition COP values to be greater than 3.5.[4] Currently the database shows the lowest average COP at the warm and low temperature conditions to be 4.0, significantly higher than minimal compliance with the Title 20 standard (California Energy Commission, 2022). As Figure 3 shows, in warm conditions, COPs mostly range between 5 and 7.1. This analysis assumes a HPPH with a maximum COP of 5.2 during warm weather. During cooler weather the COP is assumed to diminish as shown in Figure 3. Below 40°F the analysis assumed electric resistance heating as some HPPHs may not be operated at low temperature due to diminished performance and danger of damage due to freezing. Based on manufacturer information, some HPPHs limit operation below 55°F, some limit at 40°F, and some operate down to 25°F. The Reach Codes Team selected 40°F as the minimum temperature for the HPPH as a mid-range assumption.

Some HPPHs may be operated below freezing if the freezing temperatures do not last longer than eight hours. Many locations in California have temperate climates that would allow year-round operation without the need for electric resistance heating. HPPHs with the capability to operate in winter conditions typically have reversible cycles to de-ice the HPPH. Data is limited on cold temperature performance of HPPH and these cold temperature HPPH were not considered in the assumptions for the HPPH analysis. Again, this analysis assumes that HPPHs do not operate below 40°F and an electric resistance heater provides heating at low temperatures. The Reach Codes Team evaluated the impact of including an electric resistance heater in the pool heating system so the all-electric alternative could maintain the heated pool amenity during the winter months when air temperatures dropped below 40 °F. A pool owner could choose not to include the electric resistance heater, but they may have several unheated months of pool use as compared to year-round heating with gas use. The inclusion of the electric resistance heating resulted in the all-electric pool heating system being less cost-effective than a HPPH-only system due to increased incremental costs and lower efficiency during times of high heating loads in the winter.

[4] The test points are defined through the CEC's Title 20 regulation. See Section 1604 (g)(1) and Section 1606(a)(3)(D) Table X part G.

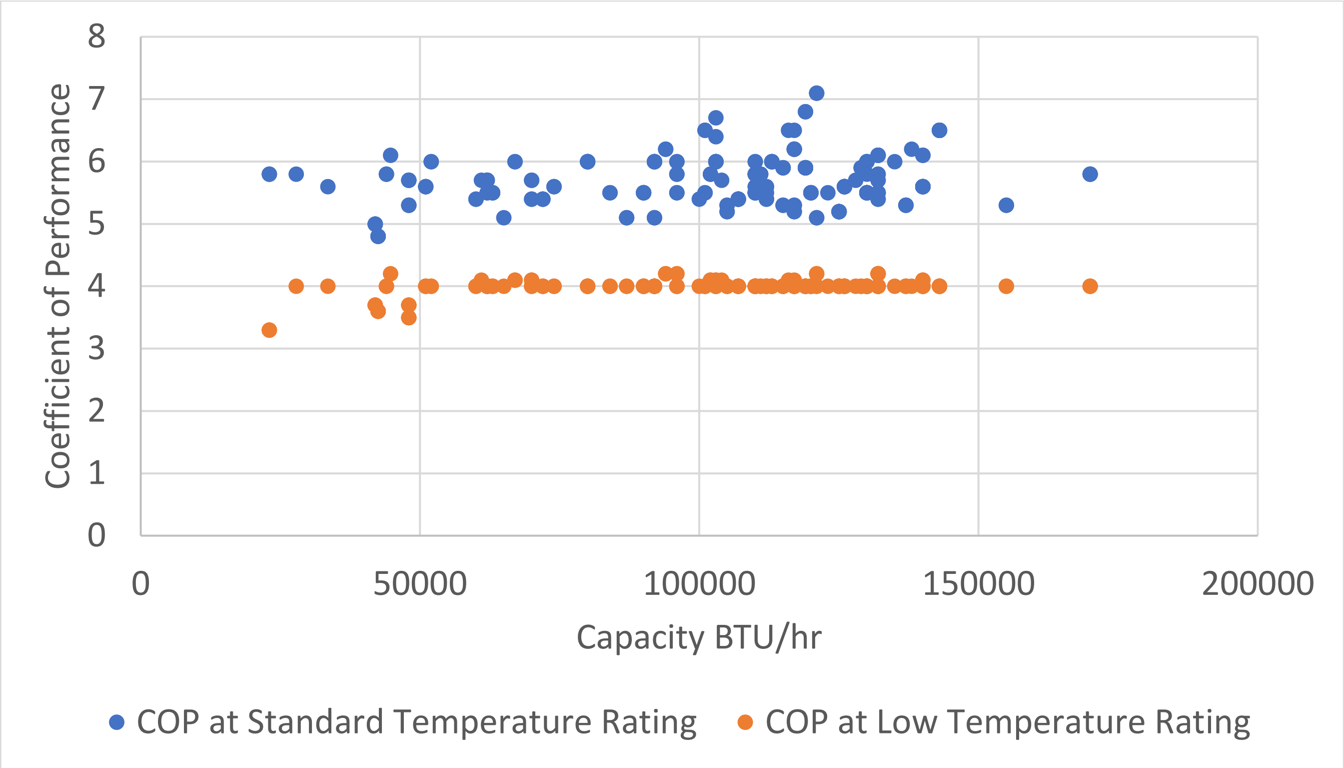

Figure 3: Heat Pump Pool Heater Performance

Source: (MAEDbS, 2022)

3.2 Key Differences Between Gas-fired Pool Heaters and HPPH

Gas-fired pool heaters and HPPH have differing operating characteristics. Pool owners who upgrade from a gas-fired pool heater to a HPPH will need to adjust their pool heating habits and settings to attain comparable heating at all temperatures (i.e., amenity) to gas-fired pool heaters. The difference in operating characteristics is driven by the smaller heating capacity of the HPPH compared to the gas-fired pool heater. The lower capacity results in the HPPH taking longer than a gas-fired pool heater to raise the pool temperature. While both types of heaters can maintain the pool or spa at the desired temperature, pool owners will need to adopt modifications recommended by HPPH manufacturers.

Some pool owners set the pool heater temperature down (setback) when the pool or spa is not in use. For a gas-fired pool heater the setback may be ten degrees Fahrenheit or more, and the pool owner may be able to heat the pool to the desired setpoint temperature by starting the pool heater several hours before swim time. A HPPH will require the pool owner to keep the setback temperature closer to the desired swim temperature to minimize the required time to raise the temperature. The change in heating behavior is required by the lower heating capacity of the HPPH compared to the gas-fired pool heater. The analysis in this report assumes this modification in behavior.

Pool owners must also adopt a habit of using the pool cover to reduce heat loss from the pool during times of inactivity. The cover will help maintain the pool water at higher temperature and reduce the reheat time for the pool. The use of a pool cover will also reduce energy use and the cost to heat the pool. Title 24, Part 6 already requires that all heated pools have pool covers (2022 Title 24, Part 6, Section 110.4(b)2.).

HPPHs, as well as other heat pumps, generate noise while in operation. A survey by a HPPH manufacturer found HPPHs create between 55 to 65 decibels, which is equivalent to the sound of moderate rain fall to a friendly conversation. Most HPPH manufacturers provide information on the sound level of their equipment (AquaCal, 2015). Gas-fired pool heaters run nearly silently, like a domestic hot water heater.

The analysis in this report considered pools sized at 30,000 gallons (22 ft x 30 ft x 6 ft) and found a single HPPH coupled with an electric resistance heater that would be used below 40°F could provide adequate heat through the winter months assuming consistent use of the pool cover. The load for electric resistance may be up to 200 amps at 240 volts or 48 kW. Larger pools will have larger loads and may require multiple HPPHs and electric resistance heaters.

3.3 HPPH Equipment Cost

Figure 4 provides details of a recent cost survey of gas pool heater and HPPH from the online pool equipment retailer Inyo Pools for three common pool heater brands that make both inground pool gas pool heaters and HPPHs: Raypack, Pentair, and Hayward (Inyo Pools, 2022). The data was used to confirm the installation costs provided by the U.S. DOE installation costs for the equipment. The equipment is priced by capacity for both types of heaters.

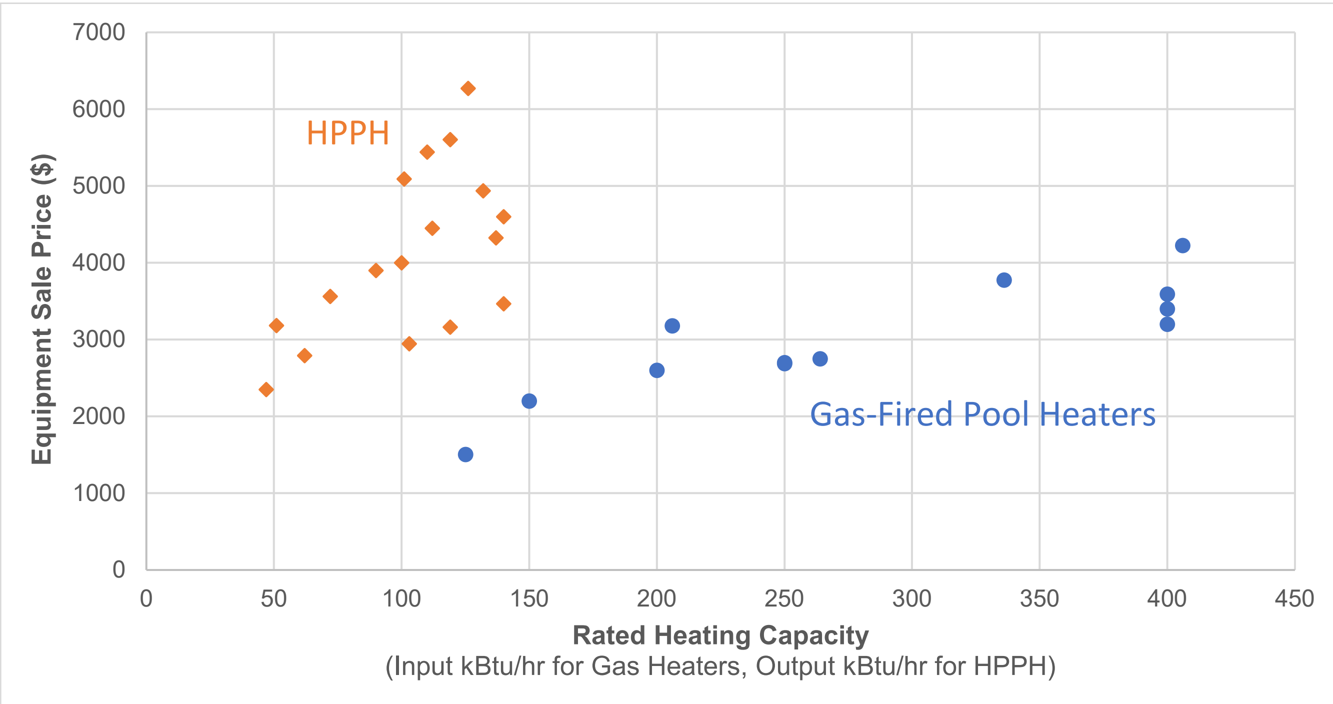

Figure 4: Equipment Cost Data

Source: (InyoPools.com, 2022)

3.4 HPPH Market Trends

3.4.1 Gas-fired pool heater and HPPH Sizing Recommendations

There is a range of pool heater sizing recommendations in the market, especially for gas pool heaters. In many cases gas pool heater sizing has long been influenced by "bigger is better." Pool heaters are often sized for a worst-case winter-heating scenario and the ability to raise the temperature of the pool in a certain period on a cold day. There are advantages to large capacity gas-fired pool heaters as they can heat a pool or spa more quickly than a smaller capacity pool heater, for a relatively low incremental cost. However, this often leads to significantly oversized equipment for residential applications, especially in mild climates like those in Southern California.

In the CEC database, the average residential gas pool heater capacity (where residential is defined as <400 $kBtu_{input}$) is 270 $kBtu_{input}$ (or ~226 $kBtu_{output}$ assuming a DOE minimum efficiency of 82%), whereas the average residential HPPH is rated at 107 $kBtu_{output}$. HPPHs have a much narrower band of capacities in the market and generally have a maximum capacity of 140 $kBtu_{output}$ in the residential sector (California Energy Commission, 2022).

Pool heaters with a 140 $kBtu_{output}$ capacity (gas-fired or HPPH) could meet make-up heat and start-up heating demands for the pool under study. However, a HPPH would heat the same size pool at a slower rate as compared to using a 400 $kBtu_{input}$ gas heater.

In general, while not intuitive, most pool heater sizing recommendations yield higher capacity gas heaters compared to heat pumps. For example, according to the previous Reach Codes Report on this topic 300 $kBtu_{input}$ sized pool heater would be recommended for a 20,000 gallon pool (Statewide Reach Codes Team, 2019). However, for HPPHs, the same source stated, “For pool heat pump sizing, as a general rule, plan on 50,000 BTU of pool heat pump heater capacity for every 10,000 gallons of pool water”. Therefore, it is recommended to have HPPH with roughly 100 $kBtu_{output}$ of capacity for a 20,000 gallon pool. This is less than half of the output capacity recommended for a gas pool heater of 246 $kBtu_{output}$.

As another example of differences in capacity recommendations between gas and HPPH, the largest HPPH manufactured by Raypak designed for in-ground pools is 140 $kBtu_{output}$ while the smallest gas-fired pool heater is 200 $kBtu_{input}$, or 164 $kBtu_{output}$ (RayPak Inc., 2019). There is no overlap in capacities for products marketed to the same sized pools.

If a consumer wished to maintain the same quick-to-heat utility of a gas-fired pool heater with a HPPH, they may consider a system of two or more HPPH units to operate in parallel. The additional units would require more space on the pool pad and a larger electrical service to enable simultaneous operation. The pool plumbing may also impose limitations on multiple units if the pump and pipes cannot provide a minimum of 45-50 gallon per minute of water to each of the HPPHs. Otherwise, consumers will need to adapt habits to allow for longer heat up times and consistent use of a pool cover to conserve the heat of the pool water.

3.4.2 Variable-Speed HPPH Capability

Manufacturers are introducing HPPH models that feature variable speed capabilities to match the heating capacity to the pool’s heating load. The capability allows for the HPPH to run continuously but at a lower power consumption to provide savings to the consumer by reducing overall energy consumption. The COP at the lower loads can often exceed ten compared to the best full speed COP that tops out at around seven. Some systems can take the allotted run time into account to calculate the speed required to obtain the desired pool temperature. The analysis presented in this report did not assume variable speed operation.

3.4.3 HPPH Automation Capability

The pool industry has introduced pool controls to automate and coordinate the operation of the pool pump, filter, chlorinator, lights, and pool heating system. The control system provides the user with more options to schedule energy use during times of off-peak electrical rates and synchronize operation with the sun for solar thermal heating systems. Pool owners may also program the pool control to run the HPPH or solar thermal pool heater during the day when warmer temperatures and sunlight increase the efficiency of the heating system.

3.5 Solar Thermal Heating Systems

Solar thermal heating systems are devices that collect solar energy to heat the water in a swimming pool. The systems will have collectors that are usually installed on the roof of the single family or multifamily building. The collectors transfer heat from solar energy to heat pool water that is pumped through the collectors. Pool and spa heating provides a low temperature solar thermal water heating opportunity.

Figure 5 shows how the solar thermal collectors absorb and transfer heat to the pool water. Pool water is pumped from the pool through the filter and into the solar thermal collector where the heat from the sunlight warms the water. The ideal flow rate keeps the temperature rise of the pool water within the collector low to encourage maximum heat transfer. The water then passes through the HPPH. The HPPH provides supplemental heat only if the solar collector does not meet the pool water setpoint. The solar collector can provide sufficient heat for most of the swim season so that the HPPH only heats the water during the early and late swim season and during cooler months.

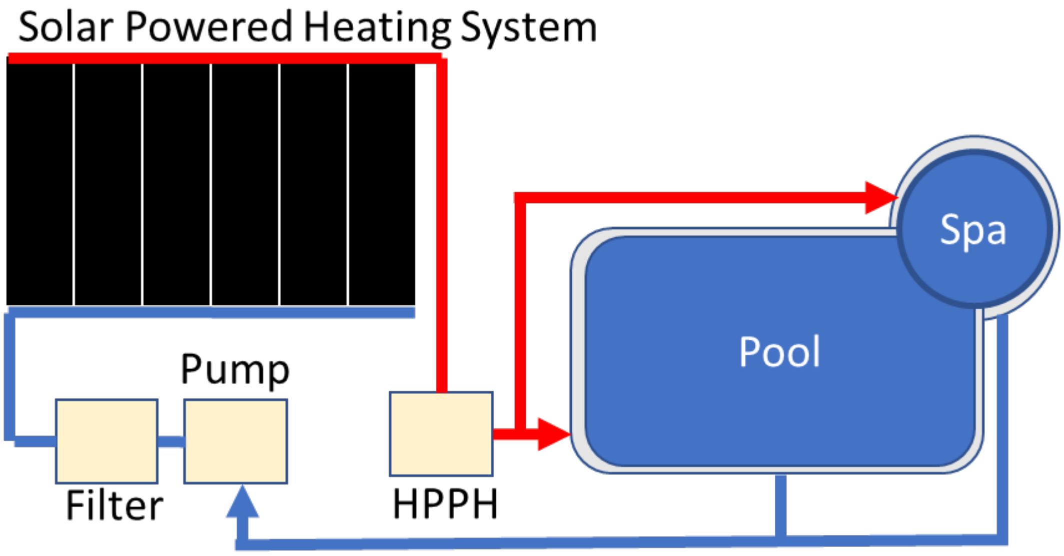

Figure 5. HPPH and Solar Thermal Heating System Schematic

3.5.1 Types of Solar Thermal Collectors

There are primarily three types of solar thermal collector equipment: unglazed, glazed and glycol systems. Each type of system is described below. Unglazed collectors are the most popular type of system for pool heating in California, and the Reach Codes Team assumed unglazed collectors for the energy and cost-effectiveness analysis.

3.5.1.1 Unglazed Collectors

Unglazed systems are the least expensive and most efficient at converting solar energy to low temperature (less than 100˚F) heated water. Unglazed solar collectors are an efficient, low-cost system for heating swimming pools. They are made of a black plastic material that absorbs the sun's energy, converting it into heat. This heat is then transferred to the water in the pool. Unglazed solar collectors are popular for swimming pools because they are easy to install, require little to no maintenance, and are much less expensive than other pool heating systems. Unglazed solar collectors are more efficient than glazed solar collectors because they can absorb more of the sun's energy, but they also lose more heat to the environment. Due to the high flow rate, the collector can generate a significant amount of heat for the pool water despite the relatively low temperature rise between the inlet and outlet of the system.

3.5.1.2 Glazed Collectors

Compared to unglazed systems, glazed systems are not as efficient for the low temperature application, cost more per unit of heating capacity, and have shorter lifetimes due to corrosion of their pipes with chemicals in the pool water. Glazed collectors are made up of two main components: a glazed panel and an absorber plate. The glazed panel is made of tempered glass that protects the absorber plate from the elements. The absorber plate is coated with a dark, heat absorbent material (such as black chrome) that absorbs the sun's energy. The heat is transferred to the pool by circulating the pool water through the absorber plate.

3.5.1.3 Glycol Systems

Compared to unglazed systems, glycol systems are also not as efficient for the low temperature application, cost more per unit of heating capacity, and have shorter lifetimes due to corrosion of their pipes with chemicals in the pool water. Glycol solar collectors differ from the glazed and unglazed solar collectors in that a glycol solution is circulated through the collectors to gather the heat from the solar energy. The heat is transferred from the glycol solution to the pool water by a heat exchanger.

3.5.2 Solar Collector Sizing Recommendations

Design guidelines typically recommend sizing unglazed solar thermal systems at 50% of the surface of the pool for seasonal pools and 100%-125% of the surface of the pool for year-round applications.[5] The collector performance describes the ability to gather solar energy to heat the water. The collector performance can be adversely affected by losses due to wind or cold ambient air conditions. The solar heating capacity of collectors depends on the weather and season, with the highest capacity attained during the summer months. Capacity may diminish drastically during periods of cool weather. The Solar Rating & Certification Corporation (SRCC) offers ratings of solar collector efficiency through OG-100 and solar heating system ratings through OG-400 (ICC-SRCC Certification and Listing Directories, 2022). There are no minimum performance requirements for solar collectors or solar thermal heating systems.

Both unglazed and glazed systems must be winterized to prevent the freezing of pool water within them when air temperatures drop below freezing. Pools that require heating during the winter months must size an auxiliary heating system to maintain pool temperatures. In the case of all-electric designs, electric resistance heaters provide heating when air temperatures are low in winter months.

3.5.3 Solar Thermal Heating System Costs

The assumptions used in the cost analysis for this report are presented in Section 5.3. At the time of publication, the California Statewide Utility Codes and Standards Enhancement (CASE) Team is developing a code change proposal that will be submitted to CEC for consideration that would establish a mandatory solar thermal heating requirement in Title 24 Part 6 for certain pools for the 2025 code cycle. More information on solar system costs will be presented in the CASE report developed through that effort.[6] The CEC is expected to adopt the 2025 Title 24, Part 6 requirements in spring 2024 and the requirements would take effect January 1, 2026.

[5] 2022 Title 24, Part 6 Section 110.4(a)4 prohibits electric resistance pool heating unless at least 60 percent of the annual heating energy is derived from site solar energy or recovered energy. Jurisdictions may want to consider modifying this requirement to an all-electric system that includes a HPPH, solar thermal, and electric resistance would be allowed even if the solar thermal system provides less than 60 percent of annual heating energy.

[6] Visit https://title24stakeholders.com/measures/cycle-2025/swimming-pool-and-spa-heating/ for more information about the CASE proposal.

4 Prototypes, Measure Packages, and Costs

This section describes the prototype and the scope of analysis drawing from previous Reach Codes research where necessary.

4.1 Building Prototypes

The CEC defines building prototypes, which it uses to evaluate the cost effectiveness of proposed changes to Title 24, Part 6 requirements. Pool heater performance is not dependent on building size or the building efficiency measures, but the Reach Codes Team used the building prototypes to establish appropriate whole-site load profiles for the analysis. For single family buildings, since the building and the pool are on the same billing account, the building load profile and the pool heater load profile were added together to arrive at the site load estimate that is needed for proper calculation of the electric and gas costs using tiered utility rates for the On-Bill analysis.

There are two single family new construction prototypes that were used in this analysis. Additional details on these prototypes can be found in the Alternative Calculation Method (ACM) Approval Manual (California Energy Commission, 2022c). An existing home prototype was also evaluated and is based on the prototype applied in the 2019 Cost-Effectiveness Study of Existing Single Family Residential Building Upgrades (Statewide Reach Codes Team, 2021). Table 4 describes the basic characteristics of each prototype.

Table 4. Single Family Prototype Characteristics

Characteristic	New Construction One-Story	New Construction Two-Story	Existing Building
Conditioned Floor Area	2,100 ft^2	2,700 ft^2	1,665 ft^2
Number of Stories	1	2	1
Number of Bedrooms	3	4	3
Window-to-Floor Area Ratio	20%	20%	13%

The pool and spa evaluated for this report is typical for one that may be found in a low-rise multifamily building. The characteristics of the prototypical low-rise multifamily building are described in Table 5. The pool and spa are part of the "common area" of the building, thus the pool heating load would be metered to the building owner rather than to the tenants. No additional building load is added to the pool heater load since the common area electrical load of the multifamily prototypical building is assumed to be small compared to the pool heating load for the purpose of this report, and the loads other than pool heating are not expected to impact the utility billing use tier that vary based on monthly usage. Residential rates are assumed for multifamily buildings because common areas in multifamily buildings are typically billed on residential rates.[7]

Table 5. Multifamily Prototype Characteristics

Characteristic	Multifamily (common area)
Conditioned Floor Area	6,960 ft^2
Number of Stories	2
Number of Bedrooms	(4) 1-bed & (4) 2-bed units
Window-to-Floor Area Ratio	15%

[7] See for example, PG&E E-TOU-C Applicability Section that describes this residential rate applies to single-phase and polyphase service in common areas in a multifamily complex.

4.2 Swimming Pool and Spa Prototypes

The Reach Codes Team designed three prototypes to represent pools and pool and spa combinations found in single family and multifamily buildings:

- Prototype 1 has a pool at a single family house.
- Prototype 2 has pool and spa at a single family house.
- Prototype 3 has a pool and spa at a location with multifamily housing.

The size, water temperature and pool usage were selected to reflect typical pools and spas in California with some assumptions varying with climate. The baseline prototypes use a minimally compliant natural gas-fired pool water heater.

To determine a typical set of pool and spa characteristics, the Reach Codes Team contacted pool heater manufacturers and trade organizations and reviewed data from the CEC 2019 Residential Appliance Saturation Survey (DNV GL Energy Insights USA, 2021).

Pool sizes can range from roughly 10,000 gallons for a small pool to over 30,000 gallons for large pools. In-ground spas can range from 500 to 1,000 gallons. The Reach Codes Team selected 30,000 gallons for the pool and 1,000 gallons for the spa. The Reach Codes Team chose the larger pool and spa volumes to understand the impacts of large capacity heaters. Larger pools and spas require more heating. A 30,000 gallon pool is a relatively large pool and is more typical of an older pool than is the current trend for new construction based on industry interviews. The surface area of the pool and spa was also carefully selected since most heat is lost through the top surface.

Other assumptions for this analysis that applied to pools with gas-fired pool heating and all-electric heating include:

- **Pool and spa temperature for pool and spa use:** The desired water temperature (setpoint temperature) for the heated pool is 80 °F. The desired water temperature for a spa is 102 °F. For single family pools and spas, the water temperature settings are setback during weekdays as specified in Table 6.
- **Cover use:** The pool cover will remain on the pool when it is not in use. For the single family pool, it remains covered during weekdays when the pool is assumed to not be in use. The multifamily pool is uncovered daily from 10 A.M. to 8 P.M. to reflect open pool hours. Use of the pool cover minimizes heat lost to the environment and helps reduce the capacity requirements for the pool heater. The Enerpool software further controlled the cover use through the swimmable days feature, which assumes the cover will remain on during periods of cold weather through its swimmable days feature.
- **Swim season:** Swim season varies by climate zone as shown in Table 7. For single family pools the swim season is limited to the warmer months when the average high temperature is 70 °F or greater. The single family pool is not heated during the winter months as indicated in Table 6 below due to lower passive heat gain from the sun leading to a greater need for pool heater use. The multifamily pool is assumed to be open year-round with more significant heating costs in the winter when air temperatures are lower and there is less natural heating from the sun. The residential and multifamily spa is assumed to be heated and used year-round.
- **Pool use:** The single family pool and spa are assumed to be used only on the weekends while the multifamily pool and spa have daily use.
- **Pool pump annual load:** The pool pump moves the pool water from the pool, through the pool filter and pool heater, and then back into the pool. The Reach Codes Team estimated the annual electric pool pump load as 940 kWh based upon analysis by the U.S. Department of Energy Appliance Standards (DOE, Technical Support Document, 2022).

Table 6 and Table 7 detail the characteristics of the pool and spa prototypes used for this analysis.

Table 6. Characteristics of Pool and Spa Prototypes and Measure Packages

	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5
Prototype Name	Single Family Pool	Single Family Pool and Spa	Single Family Pool and Spa	Multifamily Pool and Spa	Multifamily Pool and Spa
Measure Package Description	All-Electric Pool Heating Package – Without Electric Resistance	All-Electric Pool Heating Package – With Electric Resistance	All-Electric and Solar Thermal Pool Heating Package	All-Electric Pool Heating Package	All-Electric and Solar Thermal Pool Heating Package
Pool Volume	30,000 gal	30,000 gal	30,000 gal	30,000 gal	30,000 gal
Pool Surface Area	660 ft^2	660 ft^2	660 ft^2	660 ft^2	660 ft^2
Spa Volume	N/A	1,000 gal	1,000 gal	1,000 gal	1,000 gal
Spa Surface Area	N/A	64 ft^2	64 ft^2	64 ft^2	64 ft^2
Pool Water Temp Weekday (setback for single family scenarios)	70 °F (gas) / 75 °F (HPPH)	70 °F (gas) / 75 °F (HPPH)	70 °F (gas) / 75 °F (HPPH)	80 °F	80 °F
Pool Water Temp Weekend	80 °F	80 °F	80 °F	80 °F	80 °F
Spa Water Temp Weekday	N/A	70 °F (gas) / 85 °F (HPPH)	70 °F (gas) / 85 °F (HPPH)	102 °F	102 °F
Spa Water Temp Weekend	N/A	102 °F	102 °F	102 °F	102 °F
Pool Swim Season	Part-year	Part-year	Part-year	Year-round	Year-round
Spa Swim Season	N/A	Year-round	Year-round	Year-round	Year-round
Pool and Spa Use	Weekends	Weekends	Weekends	Daily	Daily
Cover Use	Covered when not in use	Covered when not in use	Covered when not in use	Covered when not in use	Covered when not in use
Baseline Auxiliary Heater	Gas-Fired Pool Heater	Gas-Fired Pool Heater	Gas-Fired Pool Heater	Gas-Fired Pool Heater	Gas-Fired Pool Heater
Measure Auxiliary Heater	HPPH	Electric Resistance and HPPH	Electric Resistance and HPPH	Electric Resistance and HPPH	Electric Resistance and HPPH
Solar Collector Type and Size	None	None	Unglazed 450 ft^2	None	Unglazed 825 ft^2

Table 7. Single family pool Swim Season by Climate Zone for Prototypes 1, 2, and 3

Climate Zone	Start of Swim Season	End of Swim Season
CZ 1 Arcata	June 15	September 15
CZ 2 Santa Rosa	May 1	October 31
CZ 3 Oakland	June 1	September 30
CZ 4 San Jose	May 15	October 31
CZ 5 Santa Maria	June 1	October 15
CZ 6 Torrance	May 15	October 31
CZ 7 San Diego	June 1	October 15
CZ 8 Fullerton	April 1	October 31
CZ 9 Burbank	May 15	October 31
CZ 10 Riverside	April 1	October 31
CZ 11 Red Bluff	May 1	October 31
CZ 12 Sacramento	May 1	October 31
CZ 13 Fresno	April 1	October 31
CZ 14 Palmdale	April 15	October 31
CZ 15 Palm Springs	April 1	October 31
CZ 16 Blue Canyon	June 15	September 15

4.3 Measure Definitions and Costs

Pool measures fall into two categories: those associated with switching from gas to electric pool heating and switching from gas to electric pool heating with solar thermal heating.

4.3.1 All-Electric Heating

The Reach Codes Team assumed a HPPH would provide auxiliary heating to supplement natural heating from the sun. The HPPH would provide the most heating early and late in the swim season when shorter days and lower solar insolation reduce the natural pool heating gains. HPPHs may also provide supplemental heating during the middle of the swim season during periods of cool weather. The capacity of the HPPH was the same for all scenarios, but the run times varied by scenario and climate zone.

As discussed above in Section 4, the COPs of HPPHs decrease at low air temperatures (see Figure 1 and Figure 2). Some HPPHs operate at temperatures as low as 25°F, but at temperatures lower than 40 °F the HPPH evaporator may be at risk of damage from freezing unless designed to operate at lower temperatures. For this analysis, the Reach Codes Team assumed the HPPH would not operate below 40 °F. To heat the single family spa[8] and the multifamily pool and spa during winter months, a second electric resistance heater would be used to provide heat when air temperatures fall below 40 °F. While some pool owners may choose not to heat their pools when temperatures are low, the Reach Codes Team evaluated an all-electric system with an electric-resistance heater to evaluate a system that provides the same amenity as a gas heater at all temperatures.

Although not considered as part of this study, the use of electric resistance heaters may require upgrades to the electrical system with some climate zones requiring up to 200 amps of service. Newly constructed single family buildings are typically designed with 200 amp service.

[8] The single family spa does not operate during winter months. See Table 6 for operation schedules by climate zone.

The Reach Codes Team found through interviews with manufacturers that nearly all residential pool heater applications are limited to one pool heater due to limitations on space and electrical service capacity. In situations where capacity is a challenge the consumer would need to set a higher pool water temperature setpoint during times of non-use.

Table 8 presents the total equipment costs of the baseline gas-fired pool heating system and the all-electric systems with just a HPPH and a HPPH with a secondary electric resistance heater. As discussed in section 2.1.3, it was assumed that both gas and electric pool heating equipment is replaced twice during the 30-year period of analysis. The first replacement occurs in year 11 and the second in year 22. The residual value of equipment at the end of year 30 is subtracted from the equipment replacement costs. Costs of all-electric heating systems with solar thermal are provided in the next section.

Table 8. New Construction and Alterations Pool Heating Equipment Costs, All Climate Zones

Baseline Measure	Baseline Equipment Cost	All-Electric Measure	All-Electric Cost	All-Electric Incremental Cost
Gas-Fired Pool Heater with 82% Thermal Efficiency	$2,881	Electric HPPH	$4,063	$1,182
Gas-Fired Pool Heater with 82% Thermal Efficiency	$2,881	Electric HPPH and Electric Resistance Pool Heater Backup	$7,277	$4,396

Source: U.S. DOE (DOE, Technical Support Document, 2022)

Annual repair and maintenance costs for the baseline gas system and all-electric systems are provided in Table 9.

Table 9. New Construction and Alterations Pool Heating Annual Maintenance Costs, All Climate Zones

Baseline Measure	Baseline Equipment Cost	All-Electric Measure	All-Electric Cost	All-Electric Incremental Cost
Gas-Fired Pool Heater with 82% Thermal Efficiency	$108.24	Electric HPPH	$107.58	$(0.66)
Gas-Fired Pool Heater with 82% Thermal Efficiency	$108.24	Electric HPPH and Electric Resistance Pool Heater Backup	$208.21	$99.97

4.3.2 All-Electric and Solar Thermal Heating

The Reach Codes Team added solar thermal heating systems to aid in the higher heating load in the scenarios with an additional inground spa. The Reach Codes Team sized the surface area of the solar thermal collectors according to industry estimates of 50-125% of the surface area of the pool. The range in surface area accounts for variation in climate, use of the pool cover, and length of the swim season. The solar collector for the multifamily pool and spa is sized larger than the single family prototypes due to the longer swim season and longer time the pool cover is off the pool.

The Reach Codes Team used unglazed collectors as a suitable and less costly alternative for use in moderate climates in California. The Reach Codes Team interviewed two solar thermal heater system installers. The installers said unglazed collectors are the most common type installed in California due to their low cost and ability to meet most pool heating installation needs. Glazed collectors typically made of copper or aluminum and covered in glass should be considered in colder climates where freezing conditions are common. The installers also said that glazed and glycol heat exchanging systems introduce additional maintenance costs while not providing additional utility to the pool owner and are typically not used for pool heating. The solar thermal system provides between 57 and 89 percent of the annual pool heating energy needs, depending on the scenario and climate zone.

The Enerpool software requires assumptions of three factors that determine the collector efficiency per the Hottel-Whillier-Bliss equation. These factors are the heat removal factor (FR), the effective transmittance-absorptance product (α) and the overall heat loss coefficient (UL). The Reach Codes Team assumed a value for all three factors that are typical for an unglazed solar collector. The following equations and performance coefficients were used for the simulation of the energy performance of the solar collectors:

$FR\alpha = 0.85-0.04V$

$FRUL = 11.56+4.37V$

Where V is equal to the incident wind speed per the Title 24 weather files.

Unglazed systems must be drained and winterized at the end of the swim season or when temperatures are forecasted to be below freezing, which is not included in the cost as this can be done by the homeowner with instructions from the installer. The analysis assumes the solar thermal heating systems operate only in months where the lowest monthly air temperature is above 36 °F.

The Reach Codes Team assumed the same flow rate through the collectors as is used to test the system efficiency. Depending on operation schedules, these flow rates may be higher than is seen in practice. Lower flow rates will reduce the system efficiency and therefore the overall cost effectiveness of all-electric systems that have solar thermal systems.

Table 10 presents the total equipment costs of the baseline gas-fired pool heating system and the all-electric systems with a HPPH, a secondary electric resistance heater, and a solar thermal system. The single family and multifamily solar thermal systems are 450 and 825 square feet, respectively. As discussed in section 2.1.3, it was assumed that the solar thermal equipment is replaced once during the 30-year period of analysis in year 15.

Table 10. New Construction and Alterations Pool Heating Equipment Costs for Single Family and Multifamily, All Climate Zones

Baseline Measure	Baseline Cost	All-Electric Pool Heating with Solar Thermal	All-Electric Cost	All-Electric Incremental Cost	Source
		Single Family			
Gas-Fired Pool Heater with 82% Thermal Efficiency	$2,881	Electric HPPH and 450 ft^2 solar thermal system and Electric Resistance Pool Heater	$9,944	$7,063	U.S. DOE
		Multifamily			
Gas-Fired Pool Heater with 82% Thermal Efficiency	$2,881	Electric HPPH and 825 ft^2 solar thermal system and Electric Resistance Pool Heater	$11,944	$9,063	U.S. DOE

4.4 Measure Packages

The Reach Codes Team examined the two electrification packages against a baseline measure package:

- Gas-Fired Pool Heater Baseline Package: Gas-fired pool heater provides the only source of pool water heating.
- All-Electric Pool Heating Package: All-electric pool heating where a HPPH provides the primary source of heat with electric resistance as a backup heating source during cold weather.
- All-Electric and Solar Thermal Pool Heating Package: Solar thermal pool heater provides the primary source of heating with HPPH and electric resistance heating only when the solar resource or cold weather make solar heating impractical.

As described in Table 5 above, the Reach Codes Team evaluated the following scenarios where a gas-fired pool water heater is the baseline for each scenario:

Scenario 1: Single family pool (no spa) with a HPPH (no electric resistance backup)

Scenario 2: Single family pool and spa with a HPPH with electric resistance backup

Scenario 3: Single family pool and spa with solar thermal heating and a HPPH with electric resistance backup

Scenario 4: Multifamily pool and spa with a HPPH with electric resistance backup

Scenario 5: Multifamily pool and spa with both a HPPH with electric resistance backup and solar thermal heating

5 Results

Results are presented as per the prototype-specific Measure Packages described in Section 5.4.

There are several overarching factors to keep in mind when reviewing the results including:

- 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 the 'cost.'
- All-electric packages will have lower **GHG emissions** than the gas-fired baseline package due to the clean power sources currently available from California's power providers.
- To receive the CEC's approval, local reach codes that amend the energy code must **be cost effective** compared to the gas-fired pool heater baseline package. The tables in this section highlight in green the modeling results that are cost effective. It also highlights the opportunities or challenges that the scenario presents. The highlights in red indicate the measure package did not achieve cost effectiveness.
- As mentioned in Section 3.1.4, the Reach Codes Team coordinated with utilities to select tariffs given the annual energy demand profile and the most prevalent rates in each utility territory. The Reach Codes Team **did not compare a variety of tariffs** to determine their impact on cost effectiveness although utility rate changes or updates can affect On-Bill cost-effectiveness results.

5.1 All-Electric Pool Heating Results

Table 11 through Table 15 present the results of the cost-effectiveness analysis for all five scenarios for both the TDV and On-Bill metrics. Values in parenthesis are negative and indicate a cost to pool owner.

Table 11 shows results of Scenario 1: a single family pool (no spa) that is heated seasonally with a HPPH with no electric resistance backup heating. The measure is cost effective in all climate zones using the TDV approach. It is also cost effective using the On-Bill approach for at least one prototypical building and utility tariff in all climate zones except 1, 5, 7, 15, and 16.

Table 11. Cost-Effectiveness: All-Electric Pool Heating (HPPH Without Electric Resistance) Scenario 1 Single Family Pool

Climate Zone	Utility	Prototype (square feet)	Annual Elec Savings (kWh)	Annual Gas Savings (therms)	Annual GHG Reductions (mtons)	Upfront Incremental Package Cost	Lifecycle Utility Cost Savings	Lifecycle $TDV Savings	B/C Ratio (On-Bill)	B/C Ratio (TDV)	NPV (On-Bill)	NPV (TDV)
CZ01	PG&E	1,665	(3,777)	568	2.6	$1,182	$(2,316)	$14,629	0.0	5.8	$(4,826)	$12,126
CZ01	PG&E	2,100 and 2,700 Avg.	(3,777)	568	2.6	$1,182	$(1,077)	$14,629	0.0	5.8	$(3,587)	$12,126
CZ02	PG&E	1,665	(5,641)	823	3.8	$1,182	$1,532	$21,394	0.6	8.5	$(978)	$18,892
CZ02	PG&E	2,100 and 2,700 Avg.	(5,641)	823	3.8	$1,182	$4,966	$21,394	2.0	8.5	$2,456	$18,892
CZ03	PG&E	1,665	(3,472)	629	3.0	$1,182	$6,496	$20,140	2.6	8.0	$3,986	$17,638
CZ03	PG&E	2,100 and 2,700 Avg.	(3,472)	629	3.0	$1,182	$8,098	$20,140	3.2	8.0	$5,589	$17,638
CZ04	CPAU	1,665	(3,633)	559	2.6	$1,182	$19,236	$12,936	7.7	5.1	$16,727	$10,434
CZ04	CPAU	2,100 and 2,700 Avg	(3,633)	559	2.6	$1,182	$19,346	$12,936	7.7	5.1	$16,837	$10,434
CZ04	PG&E	1,665	(3,633)	559	2.6	$1,182	$3,015	$12,936	1.2	5.1	$505	$10,434
CZ04	PG&E	2,100 and 2,700 Avg.	(3,633)	559	2.6	$1,182	$6,186	$12,936	2.5	5.1	$3,676	$10,434
CZ05	PG&E	1,665	(3,905)	579	2.6	$1,182	$(356)	$14,716	0.0	5.9	$(2,866)	$12,213
CZ05	PG&E	2,100 and 2,700 Avg.	(3,905)	579	2.6	$1,182	$1,495	$14,716	0.6	5.9	$(1,015)	$12,213
CZ05	PG&E SoCalGas	1,665	(3,905)	579	2.6	$1,182	$(6,355)	$14,716	0.0	5.9	$(8,865)	$12,213
CZ05	PG&E SoCalGas	2,100 and 2,700 Avg.	(3,905)	579	2.6	$1,182	$(4,324)	$14,716	0.0	5.9	$(6,833)	$12,213
CZ06	SCE	1,665	(2,967)	461	2.2	$1,182	$336	$12,940	0.1	5.1	$(2,173)	$10,437
CZ06	SCE	2,100 and 2,700 Avg.	(2,967)	461	2.2	$1,182	$3,926	$12,940	1.6	5.1	$1,417	$10,437
CZ07	SDG&E	1,665	(1,946)	301	1.4	$1,182	$(1,572)	$8,207	0.0	3.3	$(4,081)	$5,704
CZ07	SDG&E	2,100 and 2,700 Avg.	(1,946)	301	1.4	$1,182	$1,473	$8,207	0.6	3.3	$(1,037)	$5,704
CZ08	SCE	1,665	(2,626)	402	1.9	$1,182	$(326)	$10,482	0.0	4.2	$(2,836)	$7,980

Climat e Zone	Utility	Prototype (square feet)	Annual Elec Savings (kWh)	Annual Gas Savings (therms)	Annual GHG Reductions (mtons)	Upfront Incremental Package Cost	Lifecycle Utility Cost Savings	Lifecycle $TDV Savings	B/C Ratio (On-Bill)	B/C Rati o (TD V)	NPV (On-Bill)	NPV (TDV)
CZ08	SCE	2,100 and 2,700 Avg.	(2,626)	402	1.9	$1,182	$2,784	$10,482	1.1	4.2	$274	$7,980
CZ09	SCE	1,665	(2,468)	401	1.9	$1,182	$1,381	$10,397	0.6	4.1	$(1,128)	$7,895
CZ09	SCE	2,100 and 2,700 Avg.	(2,468)	401	1.9	$1,182	$4,957	$10,397	2.0	4.1	$2,448	$7,895
CZ10	SCE	1,665	(3,638)	577	2.8	$1,182	$443	$17,936	0.2	7.1	$(2,067)	$15,433
CZ10	SCE	2,100 and 2,700 Avg.	(3,638)	577	2.8	$1,182	$4,341	$17,936	1.7	7.1	$1,831	$15,433
CZ10	SDG&E	1,665	(3,638)	577	2.8	$1,182	$(3,479)	$17,936	0.0	7.1	$(5,988)	$15,433
CZ10	SDG&E	2,100 and 2,700 Avg.	(3,638)	577	2.8	$1,182	$755	$17,936	0.3	7.1	$(1,754)	$15,433
CZ11	PG&E	1,665	(3,071)	510	2.5	$1,182	$6,575	$14,570	2.6	5.8	$4,065	$12,067
CZ11	PG&E	2,100 and 2,700 Avg	(3,071)	510	2.5	$1,182	$10,058	$14,570	4.0	5.8	$7,548	$12,067
CZ12	PG&E	1,665	(3,587)	551	2.6	$1,182	$3,732	$14,938	1.5	5.9	$1,222	$12,435
CZ12	PG&E	2,100 and 2,700 Avg.	(3,587)	551	2.6	$1,182	$7,997	$14,938	3.2	5.9	$5,487	$12,435
CZ12	SMUD	1,665	(3,587)	551	2.6	$1,182	$26,805	$14,938	10.7	5.9	$24,295	$12,435
CZ12	SMUD	2,100 and 2,700 Avg.	(3,587)	551	2.6	$1,182	$26,796	$14,938	10.7	5.9	$24,287	$12,435
CZ13	PG&E	1,665	(3,534)	539	2.6	$1,182	$4,346	$16,067	1.7	6.4	$1,836	$13,565
CZ13	PG&E	2,100 and 2,700 Avg.	(3,534)	539	2.6	$1,182	$7,647	$16,067	3.0	6.4	$5,137	$13,565
CZ14	SCE	1,665	(4,995)	825	4.0	$1,182	$2,618	$25,901	1.0	10.3	$108	$23,398
CZ14	SCE	2,100 and 2,700 Avg.	(4,995)	825	4.0	$1,182	$6,796	$25,901	2.7	10.3	$4,286	$23,398
CZ14	SDG&E	1,665	(4,995)	825	4.0	$1,182	$(2,027)	$25,901	0.0	10.3	$(4,536)	$23,398
CZ14	SDG&E	2,100 and 2,700 Avg.	(4,995)	825	4.0	$1,182	$3,435	$25,901	1.4	10.3	$925	$23,398
CZ15	SCE	1,665	(1,664)	281	1.4	$1,182	$962	$9,311	0.4	3.7	$(1,547)	$6,808
CZ15	SCE	2,100 and 2,700 Avg.	(1,664)	281	1.4	$1,182	$2,125	$9,311	0.8	3.7	$(385)	$6,808
CZ16	PG&E	1,665	(2,501)	369	1.7	$1,182	$(2,463)	$9,091	0.0	3.6	$(4,973)	$6,588
CZ16	PG&E	2,100 and 2,700 Avg.	(2,501)	369	1.7	$1,182	$(150)	$9,091	0.0	3.6	$(2,660)	$6,588

Table 12 shows results for Scenario 2: a single family pool that is heated seasonally and spa that is heated year-round with a HPPH and electric resistance heater. The all-electric pool heating pathway is only cost effective in climate zone 12 under the On-Bill approach and the climate zone 14 under the TDV approach.

Table 12. Cost-Effectiveness: All-Electric Pool Heating (HPPH With Electric Resistance) Scenario 2 Single Family Pool and Spa

Climate Zone	Utility	Prototype (square feet)	Annual Elec Savings (kWh)	Annual Gas Savings (therms)	Annual GHG Reductions (mtons)	Upfront Incremental Package Cost	Lifecycle Utility Cost Savings	Lifecycle $TDV Savings	B/C Ratio (On-Bill)	B/C Ratio (TDV)	NPV (On-Bill)	NPV (TDV)
CZ01	PG&E	1,665	(12,721)	1,081	3.7	$4,396	$(45,756)	$(3,123)	0.0	0.0	$(56,066)	$(14,499)
CZ01	PG&E	2,100 and 2,700 Avg.	(12,721)	1,081	3.7	$4,396	$(45,688)	$(3,123)	0.0	0.0	$(55,998)	$(14,499)
CZ02	PG&E	1,665	(13,744)	1,250	4.5	$4,396	$(39,966)	$8,437	0.0	0.7	$(50,276)	$(2,939)
CZ02	PG&E	2,100 and 2,700 Avg.	(13,744)	1,250	4.5	$4,396	$(38,423)	$8,437	0.0	0.7	$(48,733)	$(2,939)
CZ03	PG&E	1,665	(11,635)	1,078	3.8	$4,396	$(34,157)	$7,222	0.0	0.6	$(44,467)	$(4,153)
CZ03	PG&E	2,100 and 2,700 Avg.	(11,635)	1,078	3.8	$4,396	$(34,067)	$7,222	0.0	0.6	$(44,377)	$(4,153)
CZ04	CPAU	1,665	(11,254)	954	3.2	$4,396	$9,711	$(626)	0.9	0.0	$(599)	$(12,001)
CZ04	CPAU	2,100 and 2,700 Avg.	(11,254)	954	3.2	$4,396	$6,730	$(626)	0.6	0.0	$(3,580)	$(12,001)
CZ04	PG&E	1,665	(11,254)	954	3.2	$4,396	$(36,403)	$(626)	0.0	0.0	$(46,713)	$(12,001)
CZ04	PG&E	2,100 and 2,700 Avg.	(11,254)	954	3.2	$4,396	$(34,700)	$(626)	0.0	0.0	$(45,010)	$(12,001)
CZ05	PG&E	1,665	(11,884)	1,008	3.3	$4,396	$(40,811)	$(810)	0.0	0.0	$(51,121)	$(12,185)
CZ05	PG&E	2,100 and 2,700 Avg.	(11,884)	1,008	3.3	$4,396	$(40,736)	$(810)	0.0	0.0	$(51,046)	$(12,185)
CZ05	PG&E SoCalGas	1,665	(11,884)	1,008	3.3	$4,396	$(52,132)	$(810)	0.0	0.0	$(62,442)	$(12,185)
CZ05	PG&E SoCalGas	2,100 and 2,700 Avg.	(11,884)	1,008	3.3	$4,396	$(51,969)	$(810)	0.0	0.0	$(62,279)	$(12,185)
CZ06	SCE	1,665	(9,923)	811	2.6	$4,396	$(39,160)	$313	0.0	0.0	$(49,470)	$(11,062)
CZ06	SCE	2,100 and 2,700 Avg.	(9,923)	811	2.6	$4,396	$(36,552)	$313	0.0	0.0	$(46,862)	$(11,062)
CZ07	SDG&E	1,665	(8,526)	629	1.8	$4,396	$(58,892)	$(4,086)	0.0	0.0	$(69,202)	$(15,461)
CZ07	SDG&E	2,100 and 2,700 Avg.	(8,526)	629	1.8	$4,396	$(54,311)	$(4,086)	0.0	0.0	$(64,621)	$(15,461)
CZ08	SCE	1,665	(9,040)	714	2.2	$4,396	$(37,108)	$(1,788)	0.0	0.0	$(47,418)	$(13,163)

Climate Zone	Utility	Prototype (square feet)	Annual Elec Savings (kWh)	Annual Gas Savings (therms)	Annual GHG Reductions (mtons)	Upfront Incremental Package Cost	Lifecycle Utility Cost Savings	Lifecycle $TDV Savings	B/C Ratio (On-Bill)	B/C Ratio (TDV)	NPV (On-Bill)	NPV (TDV)
CZ08	SCE	2,100 and 2,700 Avg.	(9,040)	714	2.2	$4,396	$(34,641)	$(1,788)	0.0	0.0	$(44,951)	$(13,163)
CZ09	SCE	1,665	(9,393)	745	2.3	$4,396	$(37,828)	$(2,160)	0.0	0.0	$(48,138)	$(13,535)
CZ09	SCE	2,100 and 2,700 Avg.	(9,393)	745	2.3	$4,396	$(34,334)	$(2,160)	0.0	0.0	$(44,644)	$(13,535)
CZ10	SCE	1,665	(10,835)	929	3.2	$4,396	$(40,724)	$4,715	0.0	0.4	$(51,034)	$(6,661)
CZ10	SCE	2,100 and 2,700 Avg.	(10,835)	929	3.2	$4,396	$(37,486)	$4,715	0.0	0.4	$(47,796)	$(6,661)
CZ10	SDG&E	1,665	(10,835)	929	3.2	$4,396	$(66,033)	$4,715	0.0	0.4	$(76,343)	$(6,661)
CZ10	SDG&E	2,100 and 2,700 Avg.	(10,835)	929	3.2	$4,396	$(61,781)	$4,715	0.0	0.4	$(72,091)	$(6,661)
CZ11	PG&E	1,665	(11,303)	924	3.0	$4,396	$(35,895)	$(398)	0.0	0.0	$(46,205)	$(11,773)
CZ11	PG&E	2,100 and 2,700 Avg	(11,303)	924	3.0	$4,396	$(33,240)	$(398)	0.0	0.0	$(43,550)	$(11,773)
CZ12	PG&E	1,665	(11,376)	944	3.1	$4,396	$(36,787)	$1,091	0.0	0.1	$(47,097)	$(10,285)
CZ12	PG&E	2,100 and 2,700 Avg.	(11,376)	944	3.1	$4,396	$(33,616)	$1,091	0.0	0.1	$(43,926)	$(10,285)
CZ12	SMUD	1,665	(11,376)	944	3.1	$4,396	$34,271	$1,091	3.0	0.1	$23,961	$(10,285)
CZ12	SMUD	2,100 and 2,700 Avg.	(11,376)	944	3.1	$4,396	$32,153	$1,091	2.8	0.1	$21,843	$(10,285)
CZ13	PG&E	1,665	(10,812)	897	3.1	$4,396	$(33,612)	$2,471	0.0	0.2	$(43,922)	$(8,905)
CZ13	PG&E	2,100 and 2,700 Avg.	(10,812)	897	3.1	$4,396	$(31,530)	$2,471	0.0	0.2	$(41,840)	$(8,905)
CZ14	SCE	1,665	(13,786)	1,277	4.7	$4,396	$(46,295)	$11,712	0.0	1.0	$(56,605)	$337
CZ14	SCE	2,100 and 2,700 Avg.	(13,786)	1,277	4.7	$4,396	$(42,860)	$11,712	0.0	1.0	$(53,170)	$337
CZ14	SDG&E	1,665	(13,786)	1,277	4.7	$4,396	$(77,204)	$11,712	0.0	1.0	$(87,514)	$337
CZ14	SDG&E	2,100 and 2,700 Avg.	(13,786)	1,277	4.7	$4,396	$(70,572)	$11,712	0.0	1.0	$(80,882)	$337
CZ15	SCE	1,665	(7,854)	571	1.6	$4,396	$(34,767)	$(2,941)	0.0	0.0	$(45,077)	$(14,316)
CZ15	SCE	2,100 and 2,700 Avg.	(7,854)	571	1.6	$4,396	$(34,815)	$(2,941)	0.0	0.0	$(45,125)	$(14,316)
CZ16	PG&E	1,665	(13,797)	902	2.5	$4,396	$(65,002)	$(21,729)	0.0	0.0	$(75,312)	$(33,105)
CZ16	PG&E	2,100 and 2,700 Avg	(13,797)	902	2.5	$4,396	$(63,366)	$(21,729)	0.0	0.0	$(73,676)	$(33,105)

Table 13 shows results of Scenario 4: a multifamily pool and spa heated year-round with a HPPH and electric resistance heater. The all-electric pool heating pathway is not cost effective in any climate zone except On-Bill savings for climate zone 4 (CPUA) and climate zone 12 (SMUD).

Table 13. Cost-Effectiveness: All-Electric Pool Heating (HPPH With Electric Resistance) Scenario 4 Multifamily Pool and Spa

Climate Zone	Utility	Prototype (square feet)	Annual Elec Savings (kWh)	Annual Gas Savings (therms)	Annual GHG Reductions (mtons)	Upfront Incremental Package Cost	Lifecycle Utility Cost Savings	Lifecycle $TDV Savings	B/C Ratio (On-Bill)	B/C Ratio (TDV)	NPV (On-Bill)	NPV (TDV)
CZ01	PG&E	6,960	(79,988)	6,097	19.3	$4,396	$(275,165)	$(77,227)	0.0	0.0	$(285,475)	$(88,602)
CZ02	PG&E	6,960	(74,499)	5,940	18.9	$4,396	$(238,089)	$(4,860)	0.0	0.0	$(248,399)	$(16,236)
CZ03	PG&E	6,960	(71,750)	5,766	18.4	$4,396	$(227,628)	$(3,080)	0.0	0.0	$(237,938)	$(14,456)
CZ04	CPAU	6,960	(70,864)	5,747	18.6	$4,396	$59,259	$794	5.2	0.1	$48,949	$(10,581)
CZ04	PG&E	6,960	(70,864)	5,747	18.6	$4,396	$(218,918)	$794	0.0	0.1	$(229,228)	$(10,581)
CZ05	PG&E	6,960	(74,714)	5,894	18.4	$4,396	$(244,080)	$(29,896)	0.0	0.0	$(254,390)	$(41,271)
CZ05	PG&E SoCalGas	6,960	(74,714)	5,894	18.4	$4,396	$(212,079)	$(29,896)	0.0	0.0	$(230,598)	$(41,271)
CZ06	SCE	6,960	(65,682)	5,194	15.9	$4,396	$(263,214)	$(10,456)	0.0	0.0	$(273,524)	$(21,831)
CZ07	SDG&E	6,960	(60,033)	4,681	14.4	$4,396	$(400,757)	$(11,894)	0.0	0.0	$(411,067)	$(23,270)
CZ08	SCE	6,960	(61,608)	4,637	13.5	$4,396	$(255,886)	$(13,639)	0.0	0.0	$(266,196)	$(25,014)
CZ09	SCE	6,960	(69,422)	5,295	15.9	$4,396	$(283,091)	$(13,101)	0.0	0.0	$(293,401)	$(24,476)
CZ10	SCE	6,960	(73,184)	5,419	15.8	$4,396	$(305,639)	$(18,278)	0.0	0.0	$(315,949)	$(29,654)
CZ10	SDG&E	6,960	(73,184)	5,419	15.8	$4,396	$(505,075)	$(18,278)	0.0	0.0	$(515,385)	$(29,654)
CZ11	PG&E	6,960	(78,754)	5,887	17.9	$4,396	$(263,966)	$(23,085)	0.0	0.0	$(274,276)	$(34,461)
CZ12	PG&E	6,960	(72,043)	5,569	17.2	$4,396	$(234,302)	$(10,144)	0.0	0.0	$(244,612)	$(21,520)
CZ12	SMUD	6,960	(72,043)	5,569	17.2	$4,396	$197,013	$(10,144)	17.3	0.0	$186,703	$(21,520)
CZ13	PG&E	6,960	(67,842)	5,078	15.1	$4,396	$(226,676)	$(15,806)	0.0	0.0	$(236,986)	$(27,181)
CZ14	SCE	6,960	(85,785)	6,782	21.1	$4,396	$(338,179)	$6,444	0.0	0.6	$(348,489)	$(4,932)
CZ14	SDG&E	6,960	(85,785)	6,782	21.1	$4,396	$(560,238)	$6,444	0.0	0.6	$(570,548)	$(4,932)
CZ15	SCE	6,960	(66,516)	4,698	13.0	$4,396	$(290,709)	$(23,613)	0.0	0.0	$(301,019)	$(34,989)
CZ16	PG&E	6,960	(104,278)	6,900	19.5	$4,396	$(426,589)	$(156,504)	0.0	0.0	$(436,899)	$(167,879)

5.2 All Electric Plus Solar Thermal Heating Systems Package

Table 14 shows results of Scenario 3: a single family pool that is heated seasonally and spa that is heated year-round with a HPPH and electric resistance heater plus solar thermal pool heating. The measure is cost effective in all climate zones using the TDV approach except climate zones 15 and 16. It is cost effective using the On-Bill approach for at least one prototypical building and utility tariff in climate zones 2, 4, 5, and 12.

Table 14. Cost-Effectiveness: All-Electric (HPPH With Electric Resistance) + Solar Pool Heating Scenario 3 Single Family Pool and Spa

Climate Zone	Utility	Prototype (square feet)	Annual Elec Savings (kWh)	Annual Gas Savings (therms)	Annual GHG Reductions (mtons)	Upfront Incremental Package Cost	Lifecycle Utility Cost Savings	Lifecycle $TDV Savings	B/C Ratio (On-Bill)	B/C Ratio (TDV)	NPV (On-Bill)	NPV (TDV)
CZ01	PG&E	1,665	(10,961)	1,388	5.8	$7,396	$(8,537)	$22,868	0.0	1.4	$(23,772)	$6,567
CZ01	PG&E	2,100 and 2,700 Avg	(10,961)	1,388	5.8	$7,396	$(8,670)	$22,868	0.0	1.4	$(23,906)	$6,567
CZ02	PG&E	1,665	(9,750)	1,806	8.5	$7,396	$34,951	$58,968	2.1	3.6	$19,715	$42,667
CZ02	PG&E	2,100 and 2,700 Avg	(9,750)	1,806	8.5	$7,396	$36,165	$58,968	2.2	3.6	$20,930	$42,667
CZ03	PG&E	1,665	(8,939)	1,366	6.0	$7,396	$9,807	$36,389	0.6	2.2	$(5,429)	$20,088
CZ03	PG&E	2,100 and 2,700 Avg	(8,939)	1,366	6.0	$7,396	$9,691	$36,389	0.6	2.2	$(5,544)	$20,088
CZ04	CPAU	1,665	(8,286)	1,410	6.4	$7,396	$52,185	$41,692	3.2	2.6	$36,950	$25,391
CZ04	CPAU	2,100 and 2,700 Avg.	(8,286)	1,410	6.4	$7,396	$48,940	$41,692	3.0	2.6	$33,704	$25,391
CZ04	PG&E	1,665	(8,286)	1,410	6.4	$7,396	$22,566	$41,692	1.4	2.6	$7,330	$25,391
CZ04	PG&E	2,100 and 2,700 Avg	(8,286)	1,410	6.4	$7,396	$23,445	$41,692	1.4	2.6	$8,209	$25,391
CZ05	PG&E	1,665	(8,666)	1,448	6.5	$7,396	$19,343	$40,023	1.2	2.5	$4,107	$23,722
CZ05	PG&E	2,100 and 2,700 Avg	(8,666)	1,448	6.5	$7,396	$19,207	$40,023	1.2	2.5	$3,972	$23,722
CZ05	PG&E SoCalGas	1,665	(8,666)	1,448	6.5	$7,396	$2,659	$40,023	0.0	2.5	$(12,577)	$23,722
CZ05	PG&E SoCalGas	2,100 and 2,700 Avg	(8,666)	1,448	6.5	$7,396	$2,615	$40,023	0.0	2.5	$(12,620)	$23,722
CZ06	SCE	1,665	(7,256)	1,236	5.6	$7,396	$6,139	$37,266	0.4	2.3	$(9,097)	$20,965
CZ06	SCE	2,100 and 2,700 Avg	(7,256)	1,236	5.6	$7,396	$7,438	$37,266	0.5	2.3	$(7,798)	$20,965
CZ07	SDG&E	1,665	(6,610)	951	4.1	$7,396	$(13,955)	$23,792	0.0	1.5	$(29,191)	$7,491
CZ07	SDG&E	2,100 and 2,700 Avg	(6,610)	951	4.1	$7,396	$(11,309)	$23,792	0.0	1.5	$(26,545)	$7,491
CZ08	SCE	1,665	(6,641)	1,109	5.0	$7,396	$3,862	$32,930	0.2	2.0	$(11,373)	$16,629
CZ08	SCE	2,100 and 2,700 Avg.	(6,641)	1,109	5.0	$7,396	$4,593	$32,930	0.3	2.0	$(10,643)	$16,629
CZ09	SCE	1,665	(7,168)	1,071	4.6	$7,396	$(1,564)	$28,163	0.0	1.7	$(16,800)	$11,862
CZ09	SCE	2,100 and 2,700 Avg.	(7,168)	1,071	4.6	$7,396	$(452)	$28,163	0.0	1.7	$(15,688)	$11,862

Climate Zone	Utility	Prototype (square feet)	Annual Elec Savings (kWh)	Annual Gas Savings (therms)	Annual GHG Reductions (mtons)	Upfront Incremental Package Cost	Lifecycle Utility Cost Savings	Lifecycle $TDV Savings	B/C Ratio (On-Bill)	B/C Ratio (TDV)	NPV (On-Bill)	NPV (TDV)
CZ10	SCE	1,665	(8,062)	1,331	6.0	$7,396	$4,201	$40,145	0.3	2.5	$(11,035)	$23,844
CZ10	SCE	2,100 and 2,700 Avg	(8,062)	1,331	6.0	$7,396	$5,570	$40,145	0.3	2.5	$(9,665)	$23,844
CZ10	SDG&E	1,665	(8,062)	1,331	6.0	$7,396	$(5,359)	$40,145	0.0	2.5	$(20,594)	$23,844
CZ10	SDG&E	2,100 and 2,700 Avg.	(8,062)	1,331	6.0	$7,396	$(2,538)	$40,145	0.0	2.5	$(17,774)	$23,844
CZ11	PG&E	1,665	(9,065)	1,236	5.2	$7,396	$6,558	$28,426	0.4	1.7	$(8,678)	$12,125
CZ11	PG&E	2,100 and 2,700 Avg	(9,065)	1,236	5.2	$7,396	$7,626	$28,426	0.5	1.7	$(7,609)	$12,125
CZ12	PG&E	1,665	(8,472)	1,384	6.2	$7,396	$20,086	$39,856	1.2	2.4	$4,850	$23,555
CZ12	PG&E	2,100 and 2,700 Avg	(8,472)	1,384	6.2	$7,396	$21,169	$39,856	1.3	2.4	$5,933	$23,555
CZ12	SMUD	1,665	(8,472)	1,384	6.2	$7,396	$71,381	$39,856	4.4	2.4	$56,145	$23,555
CZ12	SMUD	2,100 and 2,700 Avg.	(8,472)	1,384	6.2	$7,396	$69,263	$39,856	4.2	2.4	$54,028	$23,555
CZ13	PG&E	1,665	(8,442)	1,251	5.5	$7,396	$12,236	$33,496	0.8	2.1	$(2,999)	$17,195
CZ13	PG&E	2,100 and 2,700 Avg.	(8,442)	1,251	5.5	$7,396	$12,820	$33,496	0.8	2.1	$(2,415)	$17,195
CZ14	SCE	1,665	(10,754)	1,668	7.4	$7,396	$338	$47,421	0.0	2.9	$(14,898)	$31,120
CZ14	SCE	2,100 and 2,700 Avg	(10,754)	1,668	7.4	$7,396	$2,120	$47,421	0.1	2.9	$(13,115)	$31,120
CZ14	SDG&E	1,665	(10,754)	1,668	7.4	$7,396	$(12,803)	$47,421	0.0	2.9	$(28,039)	$31,120
CZ14	SDG&E	2,100 and 2,700 Avg.	(10,754)	1,668	7.4	$7,396	$(7,484)	$47,421	0.0	2.9	$(22,719)	$31,120
CZ15	SCE	1,665	(6,346)	776	3.0	$7,396	$(10,983)	$15,482	0.0	0.9	$(26,218)	$(819)
CZ15	SCE	2,100 and 2,700 Avg.	(6,346)	776	3.0	$7,396	$(11,483)	$15,482	0.0	0.9	$(26,719)	$(819)
CZ16	PG&E	1,665	(11,539)	1,172	4.5	$7,396	$(25,364)	$4,545	0.0	0.3	$(40,600)	$(11,756)
CZ16	PG&E	2,100 and 2,700 Avg.	(11,539)	1,172	4.5	$7,396	$(24,103)	$4,545	0.0	0.3	$(39,339)	$(11,756)

Table 15 shows results of Scenario 5: a multifamily pool and spa heated year-round with a HPPH and electric resistance heater plus solar thermal pool heating. The measure is cost effective using the TDV approach in all climate zones except 1, 15, and 16. It is cost effective using the On-Bill approach for at least one utility tariff in climate zones 4 and 12.

Table 15. Cost-Effectiveness: All-Electric (HPPH With Electric Resistance) + Solar Pool Heating Scenario 5 Multifamily Pool and Spa

Climate Zone	Utility	Prototype Ft^2	Annual Elec Savings (kWh)	Annual Gas Savings (therms)	Annual GHG Reductions (mtons)	Upfront Incremental Package Cost	Lifecycle Utility Cost Savings	Lifecycle $TDV Savings	B/C Ratio (On-Bill)	B/C Ratio (TDV)	NPV (On-Bill)	NPV (TDV)
CZ01	PG&E	6,960	(68,554)	6,097	21.1	$9,396	$(167,742)	$(26,145)	0.0	0.0	$(186,261)	$(45,730)
CZ02	PG&E	6,960	(62,025)	5,940	20.9	$9,396	$(119,760)	$54,718	0.0	2.8	$(138,279)	$35,133
CZ03	PG&E	6,960	(60,794)	5,766	20.2	$9,396	$(124,054)	$51,704	0.0	2.6	$(142,573)	$32,120
CZ04	CPAU	6,960	(59,995)	5,747	20.3	$9,396	$108,185	$55,928	5.5	2.9	$89,666	$36,343
CZ04	PG&E	6,960	(59,995)	5,747	20.3	$9,396	$(115,136)	$55,928	0.0	2.9	$(133,655)	$36,343
CZ05	PG&E	6,960	(62,747)	5,894	20.3	$9,396	$(131,002)	$29,630	0.0	1.5	$(149,522)	$10,045
CZ05	PG&E SoCalGas	6,960	(62,747)	5,894	20.3	$9,396	$(323,457)	$29,630	0.0	1.5	$(333,767)	$10,045
CZ06	SCE	6,960	(55,953)	5,194	17.5	$9,396	$(178,148)	$41,282	0.0	2.1	$(196,668)	$21,697
CZ07	SDG&E	6,960	(51,724)	4,681	15.8	$9,396	$(298,423)	$32,633	0.0	1.7	$(316,943)	$13,049
CZ08	SCE	6,960	(53,328)	4,637	14.9	$9,396	$(184,896)	$25,506	0.0	1.3	$(203,416)	$5,921
CZ09	SCE	6,960	(59,964)	5,295	17.4	$9,396	$(200,959)	$34,909	0.0	1.8	$(219,479)	$15,324
CZ10	SCE	6,960	(64,038)	5,419	17.2	$9,396	$(225,997)	$24,326	0.0	1.2	$(244,516)	$4,741
CZ10	SDG&E	6,960	(64,038)	5,419	17.2	$9,396	$(393,343)	$24,326	0.0	1.2	$(411,863)	$4,741
CZ11	PG&E	6,960	(69,524)	5,887	19.3	$9,396	$(176,895)	$23,652	0.0	1.2	$(195,414)	$4,068
CZ12	PG&E	6,960	(61,689)	5,569	18.8	$9,396	$(136,662)	$38,728	0.0	2.0	$(155,181)	$19,144
CZ12	SMUD	6,960	(61,689)	5,569	18.8	$9,396	$230,237	$38,728	11.8	2.0	$211,717	$19,144
CZ13	PG&E	6,960	(59,464)	5,078	16.4	$9,396	$(148,553)	$20,552	0.0	1.0	$(167,072)	$967
CZ14	SCE	6,960	(73,787)	6,782	22.8	$9,396	$(232,218)	$59,129	0.0	3.0	$(250,737)	$39,544
CZ14	SDG&E	6,960	(73,787)	6,782	22.8	$9,396	$(408,483)	$59,129	0.0	3.0	$(427,002)	$39,544
CZ15	SCE	6,960	(59,770)	4,698	14.0	$9,396	$(233,074)	$4,758	0.0	0.2	$(251,594)	$(14,827)
CZ16	PG&E	6,960	(90,319)	6,900	21.5	$9,396	$(295,168)	$(95,692)	0.0	0.0	$(313,687)	$(115,277)

6 Summary

This study evaluated the cost effectiveness of all-electric pool heating for single family pools and spas relative to the baseline of gas-fired pool and spa heating. The Reach Codes Team identified all-electric pool and spa heating systems that will provide similar amenity to gas-fired pool heaters, simulated energy use in a pool heating energy modeling software, gathered costs of the gas baseline system and all-electric system alternatives, and determined the cost effectiveness of multiple scenarios in all California climate zones. To develop a set of assumptions that are considered reasonable in the current market, the Reach Codes Team collaborated with multiple utilities, cities, pool equipment experts, and solar thermal experts to establish and refine assumptions.

Results of the analysis indicate that all-electric pool heating is more energy efficient than a minimally compliant gas-fired pool heating system and is cost effective in most climate zones through either the On-Bill or TDV metrics when compared to a gas-fired pool heater baseline.

For single family homes that have a pool that operates seasonally (no spa), the all-electric pool heating system of a single HPPH was found to be cost effective in all climate zones when using the TDV metric (scenario 1). For single family homes with a pool that operates seasonally and an in-ground spa that operates year-round, the all-electric pool heating system that includes a solar thermal system, a HPPH, and an electric resistance heater was cost effective using the TDV metric in all climate zones except 15 and 16 (scenario 3).

For multifamily buildings with a pool and spa that both operate year-round, the all-electric pool heating system that included a solar thermal system, a HPPH, and an electric resistance heater was cost effective using the TDV metric in all climate zones except 1, 15 and 16 (scenario 5).

Local jurisdictions may adopt ordinances that amend different Parts of the California Building Standards Code or may elect to amend other state or municipal codes. The decision regarding which code to amend will determine the specific requirements that must be followed for an ordinance to be legally enforceable. Reach codes that amend Part 6 of the California Building Code and require energy performance beyond state code minimums must demonstrate the proposed changes are cost-effective and obtain approval from the CEC.

Table 16. Summary of TDV Benefit to Cost Ratio Cost Effectiveness

Climate Zone	Electric Utility	Single Family Pool	Single Family Pool and Spa		Multifamily Pool and Spa	
		All Electric (HPPH)	All Electric (HPPH + Electric Resistance)	All Electric + Solar (Solar + HPPH + Electric Resistance)	All Electric (HPPH + Electric Resistance)	All Electric + Solar (Solar + HPPH + Electric Resistance)
CZ01	PG&E	5.8	0.0	1.4	0.0	0.0
CZ02	PG&E	8.5	0.7	3.6	0.0	2.8
CZ03	PG&E	8.0	0.6	2.2	0.0	2.6
CZ04	PG&E	5.1	0.0	2.6	0.1	2.9
CZ04-2	CPAU	5.1	0.0	2.6	0.1	2.9
CZ05	PG&E	5.9	0.0	2.5	0.0	1.5
CZ05-2	PG&E SoCalGas	5.9	0.0	2.5	0.0	1.5
CZ06	SCE	5.1	0.0	2.3	0.0	2.1
CZ07	SDG&E	3.3	0.0	1.5	0.0	1.7
CZ08	SCE	4.2	0.0	2.0	0.0	1.3
CZ09	SCE	4.1	0.0	1.7	0.0	1.8
CZ10	SDG&E	7.1	0.4	2.5	0.0	1.2
CZ10-2	SCE	7.1	0.4	2.5	0.0	1.2
CZ11	PG&E	5.8	0.0	1.7	0.0	1.2
CZ12	PG&E	5.9	0.1	2.4	0.0	2.0
CZ12-2	SMUD	5.9	0.1	2.4	0.0	2.0
CZ13	PG&E	6.4	0.2	2.1	0.0	1.0
CZ14	SDG&E	10.3	1.0	2.9	0.6	3.0
CZ14-2	SCE	10.3	1.0	2.9	0.6	3.0
CZ15	SCE	3.7	0.0	0.9	0.0	0.2
CZ16	PG&E	3.6	0.0	0.3	0.0	0.0

Table 17. Summary of On-Bill Benefit to Cost Ratio Cost Effectiveness

Climate Zone	Electric Utility	Single Family Pool	Single Family Pool and Spa		Multifamily Pool and Spa	
		All Electric (HPPH)	All Electric (HPPH + Electric Resistance)	All Electric + Solar (Solar + HPPH + Electric Resistance)	All Electric (HPPH + Electric Resistance)	All Electric + Solar (Solar + HPPH + Electric Resistance)
CZ01	PG&E	0.0	0.0	0.0	0.0	0.0
CZ02	PG&E	1.5	0.0	2.2	0.0	0.0
CZ03	PG&E	3.0	0.0	0.6	0.0	0.0
CZ04	PG&E	2.0	0.7	1.4	0.0	0.0
CZ04-2	CPAU	7.7	0.0	3.1	5.2	5.5
CZ05	PG&E	0.4	0.0	1.2	0.0	0.0
CZ05-2	PG&E SoCalGas	0.0	0.0	0.0	0.0	0.0
CZ06	SCE	1.1	0.0	0.4	0.0	0.0
CZ07	SDG&E	0.4	0.0	0.0	0.0	0.0
CZ08	SCE	0.7	0.0	0.3	0.0	0.0
CZ09	SCE	1.5	0.0	0.0	0.0	0.0
CZ10	SDG&E	1.2	0.0	0.3	0.0	0.0
CZ10-2	SCE	0.2	0.0	0.0	0.0	0.0
CZ11	PG&E	3.5	0.0	0.4	0.0	0.0
CZ12	PG&E	2.6	0.0	1.3	0.0	0.0
CZ12-2	SMUD	10.7	2.9	4.3	17.3	11.8
CZ13	PG&E	2.6	0.0	0.8	0.0	0.0
CZ14	SDG&E	2.2	0.0	0.1	0.0	0.0
CZ14-2	SCE	0.9	0.0	0.0	0.0	0.0
CZ15	SCE	0.7	0.0	0.0	0.0	0.0
CZ16	PG&E	0.0	0.0	0.0	0.0	0.0

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8 Appendices

8.1 Map of California Climate Zones

Climate zone geographical boundaries are depicted in Figure 6. The map in Figure 6 along with a zip-code search directory is available at: https://ww2.energy.ca.gov/maps/renewable/building_climate_zones.html.

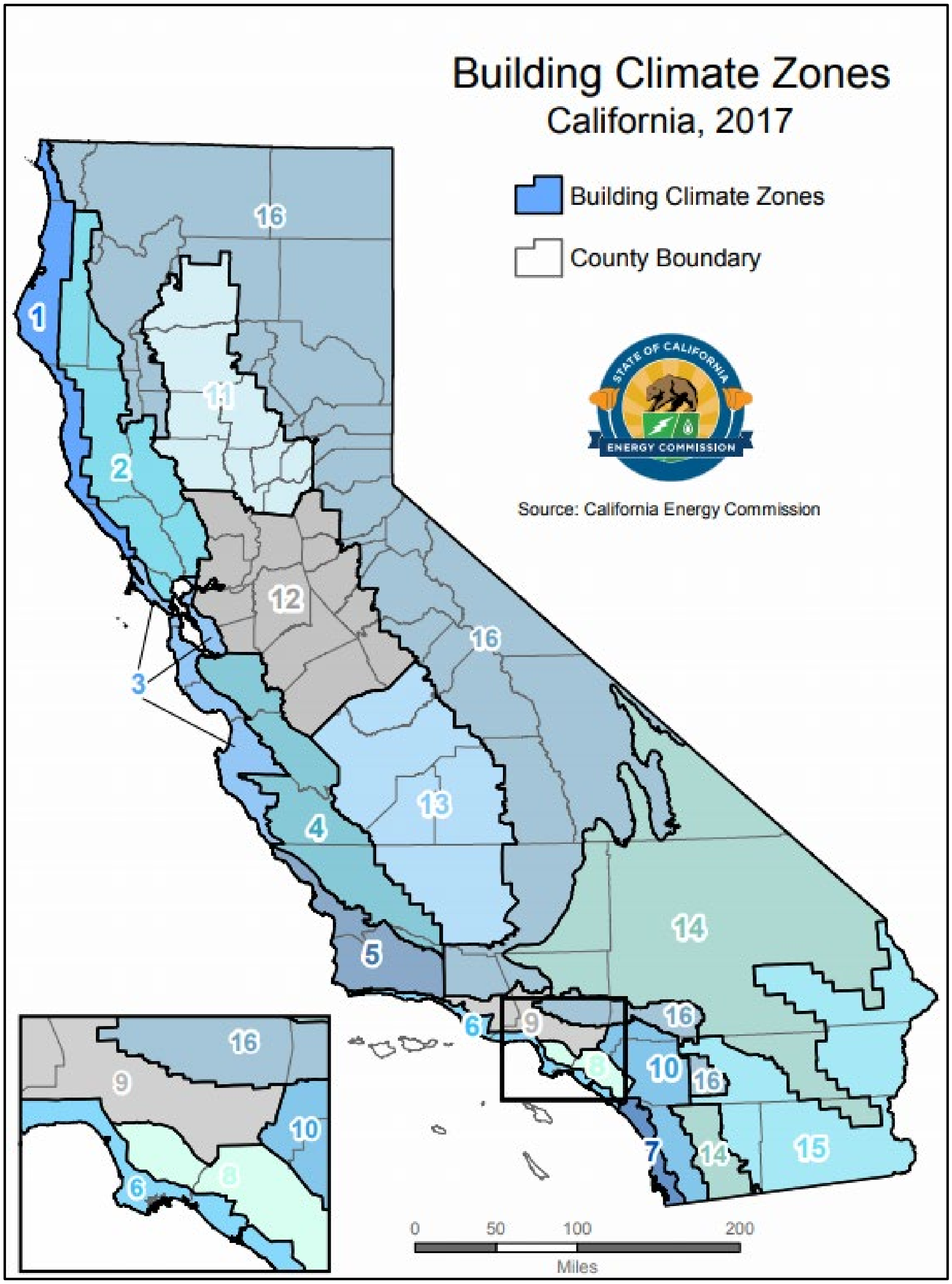

Figure 6. Map of California Climate Zones.

8.2 Utility Rate Schedules

The Reach Codes Team used the CA IOU and POU rate tariffs detailed below to determine the On-Bill savings for each package. The California Climate Credit was applied for both electricity and natural gas service for the IOUs using the 2022 credits shows below.[9] The credits were applied to reduce the total calculated annual bill, including any fixed fees or minimum bill amounts.

2022 Electric California Climate Credit Schedule

	April	May	June	July	Aug	Sept	Oct
PG&E	$39.30						$39.30
SCE	$59.00						$59.00
SDG&E					$64.17	$64.17	

Residential Natural Gas California Climate Credit

The 2022 Natural Gas California Climate Credit is distributed in April.

	2018‡	2019	2020	2021	2022	Total Value Received Per Household 2018-2022
PG&E	$30	$25	$27	$25	$47.83	**$154**
SDG&E	*	$34	$21	$18	$43.06	**$116**
Southwest Gas	$22	$25	$27	$28	$49.44	**$150**
SoCalGas	*	$50	$26	$22	$44.17	**$142**

8.2.1 Pacific Gas & Electric

The following pages provide details on the PG&E electricity and natural gas tariffs applied in this study. Table 16 describes the baseline territories that were assumed for each climate zone. A net surplus compensation rate of $0.0362 / kWh was applied to any net annual electricity generation based on a one-year average of the rates between April 2021 and March 2022.

[9] https://www.cpuc.ca.gov/industries-and-topics/natural-gas/greenhouse-gas-cap-and-trade-program/california-climate-credit

Table 18. PG&E Baseline Territory by Climate Zone

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

The PG&E monthly gas rate in $/therm was applied on a monthly basis for the 12-month period ending March 2022 according to the rates shown in Table 19.

Table 19. PG&E Monthly Gas Rate ($/therm)

Month	Procurement Charge	Transportation Charge		Total Charge	
		Baseline	Excess	Baseline	Excess
Jan 2022	$0.76338	$1.33589	$1.79545	$2.09927	$2.55883
Feb 2022	$0.73412	$1.33589	$1.79545	$2.07001	$2.52957
Mar 2022	$0.61773	$1.33589	$1.79545	$1.95362	$2.41318
Apr 2021	$0.22304	$1.19868	$1.68034	$1.42172	$1.90338
May 2021	$0.21063	$1.19868	$1.68034	$1.40931	$1.89097
June 2021	$0.21778	$1.20019	$1.68243	$1.41797	$1.90021
July 2021	$0.19109	$1.20019	$1.68243	$1.39128	$1.87352
Aug 2021	$0.22551	$1.20019	$1.68243	$1.4257	$1.90794
Sept 2021	$0.44379	$1.20019	$1.68243	$1.64398	$2.12622
Oct 2021	$0.68120	$1.20019	$1.68243	$1.88139	$2.36363
Nov 2021	$0.81218	$1.20019	$1.68243	$2.01237	$2.49461
Dec 2021	$0.82555	$1.20019	$1.68243	$2.02574	$2.50798

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

	Revised	Cal. P.U.C. Sheet No.	52702-E
Cancelling	Revised	Cal. P.U.C. Sheet No.	52397-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	
Summer				
Total Usage	$0.48814	(I)	$0.42470	(I)
Baseline Credit (Applied to Baseline Usage Only)	($0.09018)	(R)	($0.09018)	(R)
Winter				
Total Usage	$0.39106	(I)	$0.37373	(I)
Baseline Credit (Applied to Baseline Usage Only)	($0.09018)	(R)	($0.09018)	(R)
Delivery Minimum Bill Amount ($ per meter per day)	$0.34810	(I)		
California Climate Credit (per household, per semi-annual payment occurring in the April and October bill cycles)	($39.30)	(R)		

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

(Continued)

Advice	6509-E-A	*Issued by*	*Submitted*	February 25, 2022
Decision		***Robert S. Kenney***	*Effective*	March 1, 2022
		Vice President, Regulatory Affairs	*Resolution*	

Pacific Gas and Electric Company
U 39 San Francisco, California

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)

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

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

Summer (service from June 1 through September 30):

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

Off-Peak: All other times

Winter (service from October 1 through May 31):

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

Off-Peak: All other times

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

(Continued)

Advice	5759-E	*Issued by*	*Submitted*	February 14, 2020
Decision	D.19-07-004	***Robert S. Kenney***	*Effective*	March 1, 2020
		Vice President, Regulatory Affairs	*Resolution*	

8.2.2 Southern California Edison

The following pages provide details on are the SCE electricity tariffs applied in this study. Table 20 describes the baseline territories that were assumed for each climate zone. A net surplus compensation rate of $0.03339 / kWh was applied to any net annual electricity generation based on a one-year average of the rates between April 2021 and March 2022.

Table 20: SCE Baseline Territory by Climate Zone

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

Summer Daily Allocations (June through September)

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

Winter Daily Allocations (October through May)

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

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

Sheet 12 (T)

SPECIAL CONDITIONS

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

Southern California Edison — Revised Cal. PUC Sheet No. 73153-E
Rosemead, California (U 338-E) — Cancelling Revised Cal. PUC Sheet No. 72676-E

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

Sheet 2

RATES

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

	Delivery Service Total[1]	Generation[2] UG***	Generation[2] DWREC[3]
Option 4-9 PM / Option 4-9 PM-CPP			
Energy Charge - $/kWh			
Summer Season - On-Peak	0.31186 (I)	0.21245 (I)	0.00000
Mid-Peak	0.31186 (I)	0.11358 (I)	0.00000
Off-Peak	0.24154 (I)	0.08653 (I)	0.00000
Winter Season - Mid-Peak	0.31186 (I)	0.14750 (I)	0.00000
Off-Peak	0.24154 (I)	0.10679 (I)	0.00000
Super-Off-Peak	0.23317 (I)	0.08321 (I)	0.00000
Baseline Credit**** - $/kWh	(0.08844) (I)	0.00000	
Basic Charge - $/day			
Single-Family Residence	0.031		
Multi-Family Residence	0.024		
Minimum Charge** - $/day			
Single Family Residence	0.346		
Multi-Family Residence	0.346		
Minimum Charge (Medical Baseline)** - $/day			
Single Family Residence	0.173		
Multi-Family Residence	0.173		
California Climate Credit[10]	(59.00) (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 On-Peak Energy Credit - $/kWh		(0.15170)	
Maximum Available Credit - $/kWh**** Summer Season		(0.68554) (R)	

* Represents 100% of the discount percentage as shown in the applicable Special Condition of this Schedule.
** The Minimum Charge is applicable when the Delivery Service Energy Charge, plus the applicable Basic Charge is less than the Minimum Charge.
*** The ongoing Competition Transition Charge CTC of ($0.00020) per kWh is recovered in the UG component of Generation. (R)
**** The Baseline Credit applies up to 100% of the Baseline Allocation, regardless of Time of Use. The Baseline Allocation is set forth in Preliminary Statement, Part H.
*****The Maximum Available Credit is the capped credit amount for CPP Customers dual participating in other demand response programs.
1 Total = Total Delivery Service rates are applicable to Bundled Service, Direct Access (DA) and Community Choice Aggregation Service (CCA Service) Customers, except DA and CCA Service Customers are not subject to the DWRBC rate component of this Schedule but instead pay the DWRBC as provided by Schedule DA-CRS or Schedule CCA-CRS.
2 Generation = The Gen rates are applicable only to Bundled Service Customers. See Special Condition below for PCIA recovery.
3 DWREC = Department of Water Resources (DWR) Energy Credit – For more information on the DWR Energy Credit, see the Billing Calculation Special Condition of this Schedule.
4 Applied on an equal basis, per household, semi-annually. See the Special Conditions of this Schedule for more information.

(Continued)

(To be inserted by utility)	Issued by	(To be inserted by Cal. PUC)
Advice 4719-E	Michael Backstrom	Date Submitted Feb 15, 2022
Decision	Vice President	Effective Mar 1, 2022
2C8		Resolution

8.2.3 Southern California Gas

Following are the SoCalGas natural gas tariffs applied in this study. Table 21 describes the baseline territories that were assumed for each climate zone.

Table 21. SoCalGas Baseline Territory by Climate Zone

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

The SoCalGas monthly gas rate in $/therm was applied on a monthly basis for the 12-month period ending March 2022 according to the rates shown in Table 22. Historical natural gas rate data was only available for SoCalGas' procurement charges.[10] To estimate total costs by month, the baseline and excess transmission charges were assumed to be relatively consistence and applied for the entire year based on January 2021 and April 2021 costs. CARE rates reflect the 20 percent discount per the GR tariff.

Table 22. SoCalGas Monthly Gas Rate ($/therm)

Month	Procurement Charge	Transportation Charge		Total Charge	
		Baseline	Excess	Baseline	Excess
Jan 2022	$0.83569	$0.82487	$1.23877	$1.66056	$2.07446
Feb 2022	$0.60655	$0.82487	$1.23877	$1.43142	$1.84532
Mar 2022	$0.55921	$0.82487	$1.23877	$1.38408	$1.79798
Apr 2021	$0.31373	$0.80599	$1.20562	$1.11972	$1.51935
May 2021	$0.35684	$0.80599	$1.20562	$1.16283	$1.56246
June 2021	$0.39460	$0.80599	$1.20562	$1.20059	$1.60022
July 2021	$0.42622	$0.80599	$1.20562	$1.23221	$1.63184
Aug 2021	$0.44599	$0.80599	$1.20562	$1.25198	$1.65161
Sept 2021	$0.44425	$0.82487	$1.23877	$1.26912	$1.68302
Oct 2021	$0.57580	$0.82487	$1.23877	$1.40067	$1.81457
Nov 2021	$0.63799	$0.82487	$1.23877	$1.46286	$1.87676
Dec 2021	$0.65129	$0.82487	$1.23877	$1.47616	$1.89006

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

SOUTHERN CALIFORNIA GAS COMPANY	Revised	CAL. P.U.C. SHEET NO.	59651-G
LOS ANGELES, CALIFORNIA CANCELING	Revised	CAL. P.U.C. SHEET NO.	59610-G

Schedule No. GR — Sheet 1

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

APPLICABILITY

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

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

The GT-R rate is applicable to Core Aggregation Transportation (CAT) service to individually metered residential customers, as set forth in Special Condition 11.

The California Alternate Rates for Energy (CARE) discount of 20%, reflected as a separate line item on the bill, is applicable to income-qualified households that meet the requirements for the CARE program as set forth in Schedule No. G-CARE.

TERRITORY

Applicable throughout the service territory.

RATES	GR	GR-C	GT-R
Customer Charge, per meter per day:........................	16.438¢	16.438¢	16.438¢
For "Space Heating Only" customers, a daily Customer Charge applies during the winter period from November 1 through April 30[1/]:	33.149¢	33.149¢	33.149¢

8.2.4 San Diego Gas & Electric

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. A net surplus compensation rate of $0.04174 / kWh was applied to any net annual electricity generation based on a one-year average of the rates between April 2021 and March 2022.

Table 23. SDG&E Baseline Territory by Climate Zone

Climate Zone	Baseline Territory
CZ07	Coastal
CZ10	Inland
CZ14	Mountain

The SDG&E monthly gas rate in $/therm was applied on a monthly basis for the 12-month period ending March 2022 according to the rates shown in Table 24. CARE rates reflect the 20 percent discount per the G-CARE tariff.

Table 24.SDG&E Monthly Gas Rate ($/therm)

Month	Procurement Charge	Transportation Charge		Total Charge	
		Baseline	Excess	Baseline	Excess
Jan 2022	$0.83668	$1.43201	$1.70577	$2.26869	$2.54245
Feb 2022	$0.60727	$1.43201	$1.70577	$2.03928	$2.31304
Mar 2022	$0.55988	$1.43201	$1.70577	$1.99189	$2.26565
Apr 2021	$0.31401	$1.44464	$1.70732	$1.75865	$2.02133
May 2021	$0.35719	$1.44464	$1.70732	$1.80183	$2.06451
June 2021	$0.39498	$1.44464	$1.70732	$1.83962	$2.10230
July 2021	$0.42663	$1.44464	$1.70732	$1.87127	$2.13395
Aug 2021	$0.44642	$1.44464	$1.70732	$1.89106	$2.15374
Sept 2021	$0.44468	$1.44464	$1.70732	$1.88932	$2.15200
Oct 2021	$0.57637	$1.38238	$1.63573	$1.95875	$2.21210
Nov 2021	$0.63862	$1.38238	$1.63573	$2.02100	$2.27435
Dec 2021	$0.65194	$1.38238	$1.63573	$2.03432	$2.28767

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

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

SDGE
San Diego Gas & Electric Company
San Diego, California

Revised Cal. P.U.C. Sheet No. 35747-E
Canceling Revised Cal. P.U.C. Sheet No. 35358-E

SCHEDULE TOU-DR1

RESIDENTIAL TIME-OF-USE

Sheet 2

RATES

Total Rates:

Description – TOU DR1	UDC Total Rate		DWR BC + WF-NBC		EECC Rate + DWR Credit		Total Rate	
Summer:								
On-Peak	0.25074	I	0.00652	I	0.43976	I	0.69702	I
Off-Peak	0.25074	I	0.00652	I	0.19788	I	0.45514	I
Super Off-Peak	0.25074	I	0.00652	I	0.07083	I	0.32809	I
Winter:								
On-Peak	0.39008	I	0.00652	I	0.14857	I	0.54517	I
Off-Peak	0.39008	I	0.00652	I	0.08335	I	0.47995	I
Super Off-Peak	0.39008	I	0.00652	I	0.06442	I	0.46102	I
Summer Baseline Adjustment Credit up to 130% of Baseline	(0.10159)	R					(0.10159)	R
Winter Baseline Adjustment Credit up to 130% of Baseline	(0.10159)	R					(0.10159)	R
Minimum Bill ($/day)	0.350						0.350	

T

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

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

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

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

(1) Total Rates consist of UDC, Schedule DWR-BC (Department of Water Resources Bond Charge), and Schedule EECC (Electric Energy Commodity Cost) rates, with the EECC rates reflecting a DWR Credit of $0.00000 that customers receive on their monthly bills.
(2) Total Rates presented are for customers that receive commodity supply and delivery service from Utility. Differences in total rates paid by Direct Access (DA) and Community Choice Aggregation (CCA) customers are identified in Schedule DA-CRS and CCA-CRS, respectively.
(3) DWR-BC charges do not apply to CARE or Medical Baseline customers.
(4) Total Effective CARE Rate is presented for illustrative purposes only, and reflects the average effective CARE discount CARE customers receive which consists of (a) exemptions from paying the CARE Surcharge, DWR-BC, California Solar Initiative (CSI) and Vehicle-Grid Integration (VGI) Costs; (b) a 50% minimum bill relative to Non-CARE; and (c) a separate line-item bill discount for all qualified residential CARE customers.
(5) Current DWR-BC as presented is now used for collecting the California Wildfire Fund Charge effective Oct 1, 2020 (See Schedule WF – NBC). DWR BC will be renamed at implementation of SDG&E's new customer information system.

8.2.5 City of Palo Alto Utilities

Following are the CPAU electricity and natural gas tariffs applied in this study. The CPAU monthly gas rate in $/therm was applied on a monthly basis for the 12-month period ending April 2022 according to the rates shown in Table 25. The distribution charge was $0.4835/therm for Tier 1 and $1.0426/therm for Tier 2. The monthly service charge applied was $10.94 per month per the G-1 tariff in effect at the time of the analysis.

Table 25. CPAU Monthly Gas Rate ($/therm)

Effective Date	Commodity Rate	Cap and Trade Compliance Charge	Transportation Charge	Carbon Offset Charge	G1 Tier 1 Volumetric Totals	G1 Tier 2 Volumetric Totals
Jan 2022	$0.77140	$0.04860	$0.15000	$0.04000	$1.53900	$1.83144
Feb 2022	$0.53600	$0.04860	$0.15000	$0.04000	$1.30360	$1.81874
Mar 2022	$0.53700	$0.04860	$0.15000	$0.04000	$1.30460	$1.8565
Apr 2022	$0.59750	$0.07680	$0.14404	$0.04000	$1.38734	$1.8363
May 2021	$0.39010	$0.04860	$0.12200	$0.04000	$1.10450	$1.8889
June 2021	$0.39820	$0.04860	$0.12214	$0.04000	$1.11274	$1.89714
July 2021	$0.48000	$0.04860	$0.12274	$0.04000	$1.22034	$2.04394
Aug 2021	$0.54920	$0.04860	$0.12274	$0.04000	$1.28954	$2.11314
Sept 2021	$0.52170	$0.04860	$0.12274	$0.04000	$1.26204	$1.78012
Oct 2021	$0.71750	$0.04860	$0.12274	$0.04000	$1.45784	$1.83222
Nov 2021	$0.75050	$0.04860	$0.12274	$0.04000	$1.49084	$1.83472

Dec 2021	$0.63210	$0.04860	$0.12274	$0.04000	$1.37244	$1.80442

RESIDENTIAL ELECTRIC SERVICE

UTILITY RATE SCHEDULE E-1

A. APPLICABILITY:

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

B. TERRITORY:

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

C. UNBUNDLED RATES:

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

EXPORT ELECTRICITY COMPENSATION

UTILITY RATE SCHEDULE E-EEC-1

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

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

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

	Per kWh
Export electricity compensation rate	$0.1078

8.2.6 Sacramento Municipal Utilities District (Electric Only)

Following are the SMUD electricity tariffs applied in this study.

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

II. Firm Service Rates

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

	Effective as of October 1, 2021	Effective as of March 1, 2022	Effective as of January 1, 2023
Time-of-Day (5-8 p.m.) Rate (RT02)			
Non-Summer Season (October - May)			
System Infrastructure Fixed Charge *per month per meter*	$22.70	$23.05	$23.50
Electricity Usage Charge			
Peak *$/kWh*	$0.1494	$0.1516	$0.1547
Off-Peak *$/kWh*	$0.1082	$0.1098	$0.1120
Summer Season (June - September)			
System Infrastructure Fixed Charge *per month per meter*	n/a	$23.05	$23.50
Electricity Usage Charge			
Peak *$/kWh*	n/a	$0.3215	$0.3279
Mid-Peak *$/kWh*	n/a	$0.1827	$0.1864
Off-Peak *$/kWh*	n/a	$0.1323	$0.1350

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].

8.2.7 Fuel Escalation Assumptions

The average annual escalation rates in Table 26 were used in this study. These are based on assumptions from the CPUC 2021 En Banc hearings on utility costs through 2030 (California Public Utilities Commission, 2021a). Escalation rates through the remainder of the 30-year evaluation period are based on the escalation rate assumptions within the 2022 TDV factors. No data was available to estimate electricity escalation rates for CPAU and SMUD, therefore electricity escalation rates for PG&E and statewide natural gas escalation rates were applied.

Table 26. Real Utility Rate Escalation Rate Assumptions

Year	Statewide Natural Gas Residential Average Rate (%/year, real)	Electric Residential Average Rate (%/year, real)		
		PG&E	SCE	SDG&E
2023	4.6%	1.8%	1.6%	2.8%
2024	4.6%	1.8%	1.6%	2.8%
2025	4.6%	1.8%	1.6%	2.8%
2026	4.6%	1.8%	1.6%	2.8%
2027	4.6%	1.8%	1.6%	2.8%
2028	4.6%	1.8%	1.6%	2.8%
2029	4.6%	1.8%	1.6%	2.8%
2030	4.6%	1.8%	1.6%	2.8%
2031	2.0%	0.6%	0.6%	0.6%
2032	2.4%	0.6%	0.6%	0.6%
2033	2.1%	0.6%	0.6%	0.6%
2034	1.9%	0.6%	0.6%	0.6%
2035	1.9%	0.6%	0.6%	0.6%
2036	1.8%	0.6%	0.6%	0.6%
2037	1.7%	0.6%	0.6%	0.6%
2038	1.6%	0.6%	0.6%	0.6%
2039	2.1%	0.6%	0.6%	0.6%
2040	1.6%	0.6%	0.6%	0.6%
2041	2.2%	0.6%	0.6%	0.6%
2042	2.2%	0.6%	0.6%	0.6%
2043	2.3%	0.6%	0.6%	0.6%
2044	2.4%	0.6%	0.6%	0.6%
2045	2.5%	0.6%	0.6%	0.6%
2046	1.5%	0.6%	0.6%	0.6%
2047	1.3%	0.6%	0.6%	0.6%
2048	1.6%	0.6%	0.6%	0.6%
2049	1.3%	0.6%	0.6%	0.6%
2050	1.5%	0.6%	0.6%	0.6%
2051	1.8%	0.6%	0.6%	0.6%
2052	1.8%	0.6%	0.6%	0.6%

Get In Touch

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

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

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

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

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

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