

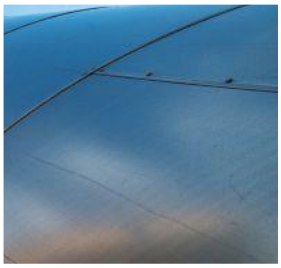


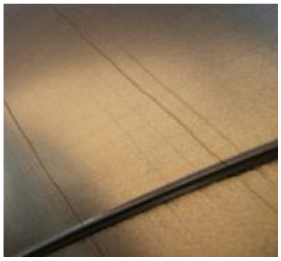

CALIFORNIA SOLAR INITIATIVE THERMAL (CSI–THERMAL) COST-EFFECTIVENESS

Final

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CSI-Thermal Working Group

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1 EXECUTIVE SUMMARY

The California Solar Initiative–Thermal (CSI-Thermal) Program provides financial incentives for the installation of solar thermal systems to offset natural gas or other fuels, primarily for water heating. The CSI-Thermal Program began in 2010 and is funded by California's ratepayers and managed by Program Administrators (PAs) representing California's large investor-owned utilities (IOUs). The PAs are Pacific Gas and Electric (PG&E), Southern California Gas (SCG), and the Center for Sustainable Energy (CSE), which implements the program for customers of San Diego Gas and Electric (SDG&E). The California Public Utilities Commission (CPUC) provides oversight and guidance on the CSI-Thermal Program.

Prior to the CSI-Thermal Program, the Solar Water Heating Pilot Program (SWHPP) began in July 2007 and was administered by CSE in SDG&E's service territory. One of the objectives of the pilot program was to inform the CPUC and the CSI PAs of the cost-effectiveness of solar water heating (SWH). An evaluation of solar thermal's cost-effectiveness, based on the SWHPP, found that with technology cost reductions and expected natural gas price increases, solar thermal could be cost-effective.[1] However, that study included a number of benefits that CPUC standard practices do not currently allow in cost-effectiveness evaluations, such as job creation, energy price hedging, price elasticity, and health benefits beyond those already captured in the avoided energy costs. California Assembly Bill (AB) 1470[2] launched the CSI-Thermal Program based, in part, on the findings from that evaluation.

This study is a retrospective evaluation of the cost-effectiveness of the CSI-Thermal Program and how well the program is meeting the program goals established by California AB 797.[3] It should be additionally noted that the program was originally designed to meet the goals of AB 1470 that focused on system installations, cost reductions, and market development with no explicit cost-effectiveness goals.

1.1 SOLAR THERMAL AS PART OF THE CSI-THERMAL PROGRAM

The CSI-Thermal Program has been providing incentives for solar-thermal systems since 2010. Installed system counts have risen steadily since that time and the program has evolved with the addition of commercial pools and then an enhanced focus on low-income and disadvantaged communities as a result

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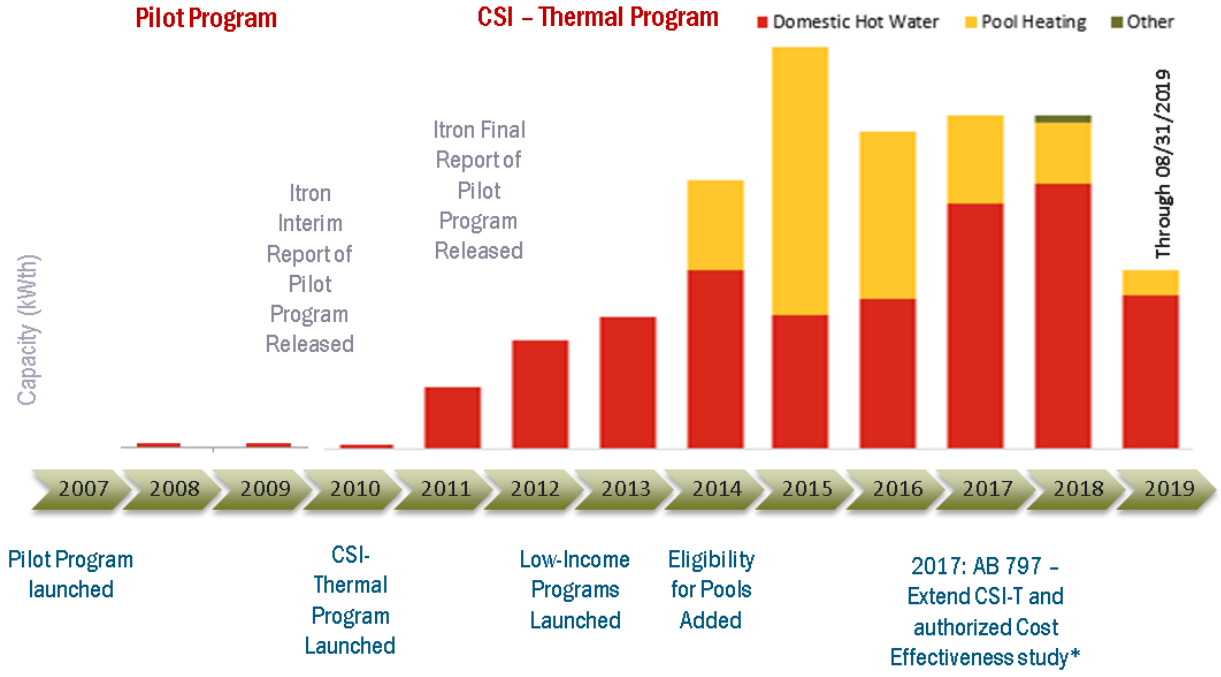
1 Itron, Inc., *Solar Water Heating Pilot Program: Interim Evaluation Report, ADDENDUM: Cost-Effectiveness Study Results*, April 1, 2009. Prepared for California Center for Sustainable Energy (now CSE).

2 Assembly Bill 1470 (Huffman, 2007). http://www.leginfo.ca.gov/pub/07-08/bill/asm/ab_1451-1500/ab_1470_bill_20071012_chaptered.html.

3 Assembly Bill 797 (Irwin, 2017). https://leginfo.legislature.ca.gov/faces/billTextClient.xhtml?bill_id=201720180AB797.

of AB 797. As shown in Figure 1-1, the program currently has a mix of end-uses such as Domestic Hot Water, Pool Heating and Other. The totals span single-family, multifamily, and commercial participants.

FIGURE 1-1: SOLAR THERMAL SYSTEMS INSTALLED THROUGH THE CSI-THERMAL PROGRAM*



* Based on systems installed through August 31, 2019.

1.2 COST-EFFECTIVENESS

The purpose of this analysis is to determine the cost-effectiveness of the CSI-Thermal Program and to further investigate the cost-effectiveness of the CSI-Thermal budget programs and technologies. This analysis follows the evaluation framework and methodology adopted by the CPUC in 2009 for assessing cost-effectiveness of distributed generation (DG) technologies.[4] The DG cost-effectiveness methodology is derived from the Standard Practice Manual (SPM) first published in the 1980s and used for several decades in evaluating energy efficiency technologies and programs.[5] The cost-effectiveness analysis

[4] CPUC, "Decision Adopting Cost-Benefit Methodology for Distributed Generation," Decision 09-08-026, August 20, 2009.

[5] CPUC, *California Standard Practice Manual: Economic Analysis of Demand-Side Programs and Projects*, October 2001: https://www.cpuc.ca.gov/uploadedFiles/CPUC_Public_Website/Content/Utilities_and_Industries/Energy_-_Electricity_and_Natural_Gas/CPUC_STANDARD_PRACTICE_MANUAL.pdf.

provides insights into the effects of impacts, measure costs, and incentives on the costs and benefits of technologies installed by the CSI-Thermal Program.

This analysis considered the cost-effectiveness of solar thermal using four distinct tests:

- The Participant Test (PCT) is the measure of the quantifiable benefits and costs to the customer due to participation in the program.
- The Ratepayer Impact Measure (RIM) Test measures what happens to customer bills or rates due to changes in utility revenues and operating costs caused by the program.
- The Total Resource Cost (TRC) Test measures the net costs of a program as a resource option based on the total costs of the program, including both the participants' and the utility's costs.
- The Program Administrator (PA) Cost Test measures the net costs of a program as a resource option based on the costs incurred by the PA (including incentive costs) and excluding any net costs incurred by the participants.

Section 3 describes each of these tests in more detail. If a program or measure meets or exceeds a benefit-cost ratio of 1.0 for a particular test, it is cost-effective for that test. The CPUC has deemed the TRC to be the most critical to evaluating the cost-effectiveness of a program since it best encompasses the measure or program from society's point of view. Other tests provide insights into how cost-effective the program is for different groups, such as participants, ratepayers, and program administrators. Table 1-1 lists examples of costs and benefits and how they are allocated across the different tests.

TABLE 1-1: EXAMPLE OF COSTS AND BENEFITS AND ALLOCATION AMONG COST TESTS

Cost/Benefit Inputs	TRC	PA	PCT	RIM
Administrative Costs	Cost	Cost		Cost
Avoided Cost of Electricity Saved (Increased)	Benefit (Cost)	Benefit (Cost)		Benefit (Cost)
Avoided Cost of Natural Gas Saved (Increased)	Benefit (Cost)	Benefit (Cost)		Benefit (Cost)
Electric Bill Savings (Increase)			Benefit (Cost)	Cost (Benefit)
Gas Bill Savings (Increase)			Benefit (Cost)	Cost (Benefit)
Measure Cost, Installation Cost, and incremental O&M	Cost		Cost	
Rebates/Incentives		Cost	Benefit	Cost
Tax Credit[6]	Cost Reduction		Benefit	

[6] For most systems, Itron will assume that the participant took the tax credit based on the installed cost minus the incentive. For Single-Family Low-Income participants, that means that Itron will assume that the participants did NOT take advantage of the tax credit because the program is intended to zero out the installed cost and many participants may not have sufficient tax liability to take advantage of the tax credit.

The four cost-effectiveness tests were applied to a variety of analyses involving CSI-Thermal water heating technologies. The different analyses were based on a combination of the following factors:

- Customer class (single-family, multifamily, commercial, pools).
- Budget program (customer class plus low-income and Disadvantaged Community (DAC)).
- Technology characteristics (technology size, system type).
- Customer rate (commercial, domestic rate, low-income or CARE rate).
- Other factors, such as coastal/inland for commercial pools, all systems versus low-cost systems, with and without higher incentives added to address the SCG storage facility incident.

Figure 1-2 presents the overall results of the four cost-effectiveness tests for the program. In general, the program was found to not meet the cost-effectiveness threshold of 1.0 for any of the SPM tests. The relatively low overall cost-effectiveness ratios are due to a combination of high measure costs and low benefits (relatively low savings and energy prices). Certain groups are more cost-effective than others; the larger size of commercial/multifamily systems appears to provide for some economies of scale and, therefore, more cost-effective systems. Additionally, lower cost installations through new business models or technologies could further increase this cost-effectiveness. However, for participants, the program as a whole is nearly cost-effective, and some budget programs and technologies do appear to be cost-effective for participants.

FIGURE 1-2: OVERALL COST-EFFECTIVENESS COST TEST RESULTS

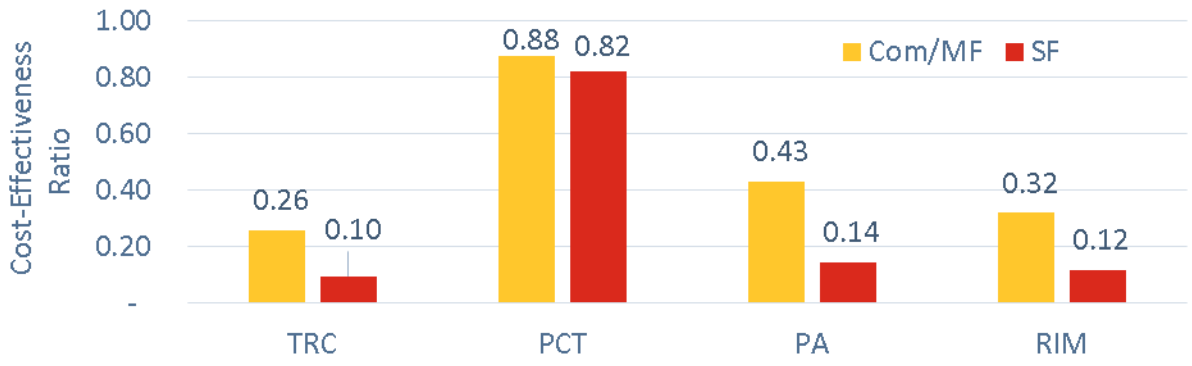
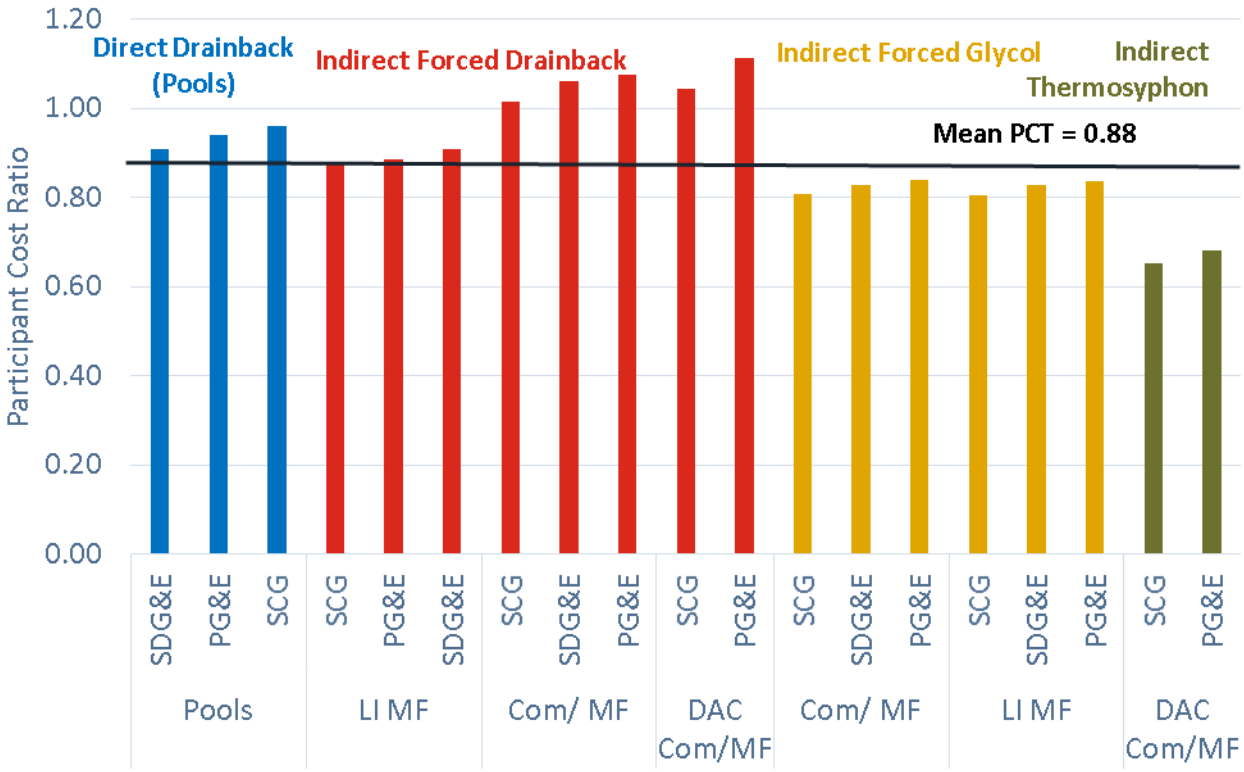


Figure 1-3 shows the participant cost tests across different technologies, programs, and utilities for commercial and multifamily sectors. In general, indirect drainback systems have the lowest reported cost per therm saved, so they tend to be the most cost-effective. Direct drainback pools also show high participant cost test ratios.

FIGURE 1-3: COMMERCIAL AND MULTIFAMILY PARTICIPANT COST TEST RATIOS*



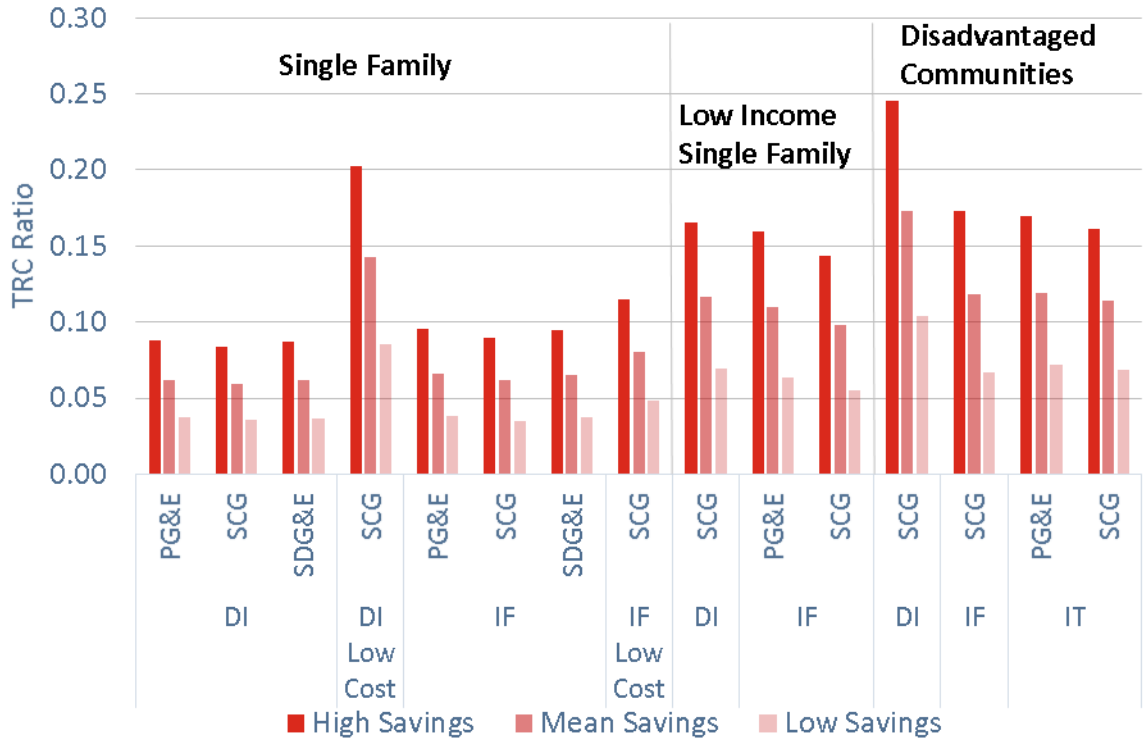
* LI = Low Income, MF = Multifamily, DAC = Disadvantaged Community, Com = Commercial

The evaluation team used estimates of savings based on the CSI-Thermal Impact Evaluation.[7] Due to several reasons discussed in that report, the gross realization results did not meet 90/10 confidence and precision results. Therefore, along with the mean value typically reported as the gross realization rate, the evaluation team reported the high savings value that met the upper limit of the 90 percent confidence interval and the low savings value to meet the lower limit.

7 2019 CSI Thermal Impact Evaluation posted to the CPUC CSI Thermal Program Evaluation webpage.

Figure 1-4 shows the high, mean and low cost-effectiveness tests for the single-family technology types and budget programs.

FIGURE 1-4: TOTAL RESOURCE COST RATIOS FOR SINGLE-FAMILY BUDGET PROGRAMS BY HIGH, MEAN AND LOW SAVINGS*



* DI = Direct Integral Collector, IF = Indirect Forced Circulation and IT = Indirect Thermosiphon

Single-family systems installed under the low-income program or in disadvantaged communities tended to have somewhat lower reported costs and, therefore, higher TRC ratios. That lower cost may be due in part to pre-negotiated system costs for low-income installations that spillover into disadvantaged communities. Additionally, higher incentive rates make these systems more cost-effective for participants as well. The low-cost systems are those installed by a recent market entrant that employs a vertically integrated business model and a neighborhood-based sales approach to offer significantly cheaper installed costs.[8]

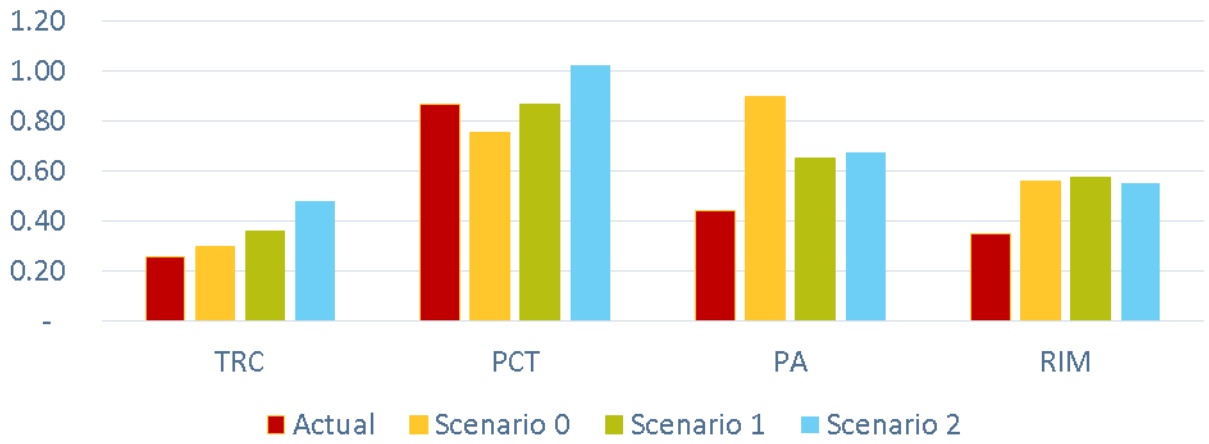
[8] These low-cost systems are assumed to have the same annual savings realization rates as other single-family systems.

The SPM cost-effectiveness tests draw from a variety of inputs. These inputs can reasonably be expected to vary over time. To investigate the potential impact of reasonable changes to those inputs, the evaluation team looked at three different scenarios:

- Scenario 0 incentives are set as they were in CPUC Decision 10-01-022.[9]
- Scenario 1 investigates results with lower administrative costs and higher avoided natural gas costs.
- Scenario 2 builds from Scenario 1 by reducing installed costs and operations and maintenance (O&M) costs.

Figure 1-5 shows the average cost-effectiveness ratios for each test and each of these scenarios. On average, none of the scenarios raise the TRC ratio to above 1.0. However, specific cases within Scenario 2 do exceed a TRC of 1.0 assuming a high savings value.

FIGURE 1-5: COMMERCIAL/MULTIFAMILY MEAN COST-EFFECTIVENESS RATIOS FOR DIFFERENT SCENARIOS



[9] CPUC Decision 10-01-022: Decision Establishing the California Solar Initiative Thermal Program to Provide Solar Water Heating Incentives, Date of Issuance 1/22/2010 in Rulemaking 08-03-008.

1.3 PROGRAM GOALS

In addition to evaluating cost-effectiveness, this study evaluated the program based on the four goals established by AB 797. Each of these goals and the assessment of the program in relation to each goal are listed below. More information on the approach and assessments can be found in Sections 5 and 6.

- *Promote solar thermal systems and other technologies that directly reduce demand for natural gas in homes and businesses*. The CSI-Thermal Program has incentivized the installation of thousands of solar thermal systems that drive natural gas savings for participants. Additionally, many of these participants report that the CSI-Thermal Program was a significant contributor in their decision to install solar thermal. The combination of those two factors makes it readily apparent that the CSI-Thermal Program has been promoting the installation of solar thermal systems that reduce participants' demand for natural gas.
- *Build a mainstream market for solar thermal systems that directly reduces demand for natural gas in homes, businesses, schools, industrial, agricultural, government buildings, and buildings occupied by nonprofit organizations.* The CSI-Thermal Program has helped build an active market of businesses and customers for solar thermal systems throughout California. It appears that the customers are less likely to be in the early adopter stage[10] of the adoption curve, suggesting that installations are moving toward a more sustainable market. The main barrier to participation is the initial cost of the system, which suggests that the market has not reduced costs sufficiently to be sustainable without the program incentive. Participants have reported satisfaction with the systems themselves and stakeholders believe that knowledge and satisfaction is increasing. Installation contractors, distributers, and manufacturers expressed concerns that their solar thermal business will be affected if the incentive is taken away, suggesting that the solar thermal market is not fully sustainable without the program at this time.
- *Solar thermal systems should be a cost-effective investment by gas customers.* Overall, it was found that the solar thermal systems were not cost-effective investments by gas customers except in some situations for single-family and multifamily technologies. There may be value in further evaluating the cases that are more cost-effective to determine if the business models or technologies could be deployed at larger scales.
- *Encourage the cost-effective deployment of solar thermal systems in residential, commercial, industrial, and agricultural markets and in each end-use application sector in a balanced manner.* The CSI Thermal Program encouraged solar thermal system installations across some segments but is not well-diversified across industrial and agricultural segments (see Figure 1-1 above). The installations were not found to be cost-effective through the evaluation period.

[10] Based on motivations being more financial than environmental.

1.4 FINDINGS AND RECOMMENDATIONS

- **Overall, the CSI-Thermal Program is not currently cost-effective for natural gas-displacing systems**. Relatively high installation costs combined with low natural gas prices and avoided costs make cost-effectiveness a challenge for solar thermal for many of the four tests. Of the four cost tests, the CSI-Thermal Program is most cost-effective for participants and some budget program and technology combinations are cost-effective for participants. This indicates that the program has set incentives such that they are sufficient to make solar thermal cost-effective for some participants. That is reflected in the program design that was targeted more towards growing the market in response to AB 1470 than being cost-effective as per AB 797.
- **The program is successfully promoting and encouraging the installation of solar thermal systems**. The program is helping to grow the solar thermal market across many sectors and, **therefore, is meeting some of the goals of AB 797**. However, the industrial and agricultural sectors are largely not being served by the program and the program is only nearing cost-effectiveness for participants and is not cost-effective for society (TRC), non-participating ratepayers (RIM), and program administrators (PA). The marketplace is growing, but without the program, this growth may be challenged to continue in the program's absence, given the limited cost-effectiveness.
- **To be more cost-effective, the program could focus on particular sectors and business models that are more cost-effective than others**. The larger size of commercial/multifamily systems appears to provide for some economies of scale and, therefore, more cost-effective systems. Lower cost installations through new business models or technologies could further increase this cost-effectiveness. Those approaches appear to show promise in the single-family sector and potentially could be adapted to the multifamily/commercial sectors. However, new models or technologies should be evaluated to ensure assumptions about savings are consistent and lower cost does not equate to lower savings.
- **Consider development and encouragement of new business models and approaches to solar thermal**. A handful of contractors are using lower cost models for manufacturing, such as vertical integration, and customer acquisition, such as targeting neighborhoods. Those approaches could be reviewed and applied elsewhere. In addition, solar thermal customers may tend to have more energy efficiency measures and many also have solar PV.[11] Leveraging those customer bases and sales channels could further reduce costs for customer acquisition and even system installation.

[11] The SWHPP evaluation found that solar thermal customers were more likely to have solar PV and energy efficiency measures than the general population. Surveys of current participants indicate that this may still be the case.

2 INTRODUCTION

The California Solar Initiative (CSI)-Thermal Program is the nation's largest solar thermal incentive program, with over 9,000 completed projects rebated since its inception in 2010 and almost 7 million therms of expected natural gas savings during 2019. This section provides an overview of the CSI-Thermal Program, identifies the study objectives, and describes the different sections of this report.

2.1 BACKGROUND AND HISTORY

California's history with solar thermal has been a blend of expansive growth followed by sudden and deep contractions in the industry. Due to plentiful solar resources, high energy prices, and attractive federal and state tax credits as well as utility rebates, many Californians were quick to adopt solar water heating (SWH) technologies in the late 1970s and 1980s.[12] The SWH industry in the state grew rapidly; however, this expansion was accompanied by growing pains. A number of poorly designed and installed systems were sold at excessive prices; and, failing to perform as expected, created a perception that SWH systems were both costly and inefficient.[13] In addition, with the sudden drop in fossil fuel prices in 1986 and loss of solar tax rebates, interest in SWH declined and the SWH industry largely disappeared. By 1990, over 95 percent of all SWH dealers nationwide went out of business.[14] SWH in California retreated for the next two decades into niche markets, such as pool heating and repairing solar systems.

Since 2000, increasing energy costs, growing concerns over greenhouse gas (GHG) emissions, and improvements in SWH technology led to a resurgent interest in SWH. In 2006, the California Public Utilities Commission (CPUC) launched a pilot program to investigate the likelihood of developing a statewide solar thermal program. The $2.59 million Solar Water Heating Pilot Program (SWHPP) began in July 2007 and was administered by the Center for Sustainable Energy (CSE) in the San Diego Gas and Electric (SDG&E) service territory. One of the objectives of the pilot program was to inform the CPUC and the CSI Program Administrators (PAs) of the cost-effectiveness of SWH. Based on positive results from the SWHPP, the CPUC expanded SWH incentives across the state in accordance with provisions specified under Assembly Bill (AB) 1470 (Huffman, 2007). This bill allowed for the establishment of a $250 million statewide natural gas rate payer-funded incentive program for SWH, where natural gas was used as the back-up water heater fuel.

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[12] California Energy Commission, *2006 Integrated Energy Policy Report Update*, CEC-100-2006-001-CMF, January 2007, p. 61.

[13] A. McDonald and J. Bills, "The Kentucky Solar Energy Guide: Chapter 6: A Brief History of the American Solar Water Heating Industry," out of print, but found at http://kysolar.org/ky_solar_energy_guide, p. 39.

[14] Sunvelope, *History of Solar Water Heating*, http://www.sunvelope.com/TechData.pdf.

On January 21, 2010, the CPUC established the CSI-Thermal Program in Decision (D.) 10-01-022,[15] allocating funds for both natural gas- and electric-displacing solar thermal system incentives, including SWH technologies in all investor-owned utility (IOU) territories. The CPUC established the incentive structure, the program administration details, and other key CSI-Thermal Program rules.

On October 4, 2017, California's former Governor Brown signed AB 797 (Irwin, 2017), which authorized the CSI-Thermal Program to continue operation from January 1, 2018 through July 31, 2020. AB 797 stated that the CPUC shall perform an assessment of the entire program through July 31, 2019, to be completed by no later than December 31, 2019. Objectives of the assessment are to determine both the cost-effectiveness of the program and the program's effectiveness in achieving program goals. Specific tasks of the evaluation include:

- Compiling, processing, and assessing solar thermal system costs and budget data.
- Preparing a Cost-Effectiveness report on the program covering program years 2010–2019.
- Evaluating the extent to which the program is achieving the program goals specified in AB 797.

2.2 STUDY OBJECTIVES

The objectives of this study are to determine both the cost-effectiveness of the program and the program's effectiveness in achieving program goals. Specific tasks of the evaluation included:

- Compiling, processing, and assessing solar thermal system costs and budget data.
- Preparing a Cost-Effectiveness report on the program covering program years 2010–2019.
- Evaluating the extent to which the program is achieving the program goals specified in AB 797.

2.3 COST-EFFECTIVENESS EVALUATION

The foundation of the cost-effectiveness evaluation is the cost tests described in the California Standard Practice Manual (SPM), which outlines the purpose for various cost-effectiveness tests and the factors that represent costs and benefits under these tests.[16] The following describes the tests and their purposes, the costs and benefits that are inputs to the different tests, and the individual technologies

[15] CPUC Decision 10-01-022: Decision Establishing the California Solar Initiative Thermal Program to Provide Solar Water Heating Incentives, Date of Issuance 1/22/2010 in Rulemaking 08-03-008.

[16] The California Standard Practice Manual is available on the CPUC's cost-effectiveness web page: http://www.cpuc.ca.gov/general.aspx?id=5267.

whose cost-effectiveness will be evaluated while determining the cost-effectiveness of the CSI-Thermal Program. Further description of the methodology and approach is provided in Section 3.

The SWHPP was previously evaluated for cost-effectiveness and the results from that study were used to establish some of the program goals as part of AB 1470. That study found that a 16 percent reduction in system costs, combined with inclusion of additional benefits such as job creation, price elasticity, energy price hedging and health benefits, could, over time, result in a cost-effective program. However, recent CPUC decisions have mandated that these additional benefits are not allowed to be included in the Total Resource Cost Test.[17]

This CSI-Thermal Program cost-effectiveness evaluation will focus on four cost-benefit tests describe in the SPM. The SPM provides guidelines for determining the cost-effectiveness of utility-sponsored DSM programs. The general definition of the four tests to be included in the CSI-Thermal framework includes the following:

- **Total Resource Cost Test (TRC):** This test examines efficiency from the combined point of view of the utility and the participant. The test compares the avoided supply costs due to the program with the costs for administering the program and the net incremental cost of the equipment. Passing the TRC implies that implementing the program/measure will provide more benefits than costs for the average customer.
- **Program Administrator Cost Test (PA):** The PA cost test measures the cost-effectiveness of the measure and program from the utility's or PA's viewpoint. The PA test benefits include the avoided supply costs while the costs include the administrative and incentive costs of the program. If the PA test benefits exceed the costs, the average costs to the utility decrease if the program or measure is implemented.
- **Participant Cost Test (PCT):** This test measures the benefits and costs of the measure and program to customers participating in the program. The PCT compares the bill and incentive savings with the cost of the measure. If the PCT's benefits exceed the costs, the customer's well-being is improved when they implement the measure or participate in the program.
- **Ratepayer Impact Measure (RIM) Test:** This test measures how a program's costs and benefits would be expected to impact a ratepayer's rates. If the utility's avoided costs or benefits associated with the program exceed the program and incentive costs and the reduction in utility revenue, then the ratepayer's rates could go down.

[17] Per CPUC direction, cost-effectiveness evaluations need to be in compliance with several Decisions in the IDER proceeding (R.14-10-003), particularly D.16-06-007 and D.19-05-019.

2.4 PROGRAM GOALS

The CSI-Thermal Program goals evaluated here are those set forth by AB 797. The CSI-Thermal Program was established nearly a decade before AB 797 and was structured to meet the goals established by the legislation that created the program, AB 1470. AB 797 sets forth the following goals:

- Promote solar thermal systems and other technologies that directly reduce demand for natural gas in homes and businesses.
- Build a mainstream market for solar thermal systems that directly reduces demand for natural gas in homes, businesses, schools, industrial, agricultural, government buildings, and buildings occupied by nonprofit organizations.
- Solar thermal systems should be a cost-effective investment by gas customers.
- Encourage the cost-effective deployment of solar thermal systems in residential, commercial, industrial, and agricultural markets and in each end-use application sector in a balanced manner.

The evaluation team pursued answers to whether the program had met these goals through several means:

- **Analysis of Program Tracking Data:** These data identified the uptake of solar thermal systems installed through the number and capacity of systems installed, as well as details on system types and costs. From these data, the team was able to analyze trends over time.
- **Market Surveys with Participants:** Telephone surveys were developed and performed with participants to determine participant assessments on topics like program influence, barriers to adoption, and satisfaction.
- **Market Surveys with Stakeholders:** Similar surveys were also performed with contractors or installers and manufacturers or distributors to determine similar results, as well as identify the stakeholder assessment on the market effects from the CSI-Thermal Program.

2.5 REPORT ORGANIZATION

This proposal is organized into six sections and four appendices, as described below:

- **Section 1** provides a summary of study results and findings.
- **Section 2** describes the purpose of the report and the organization of the report.
- **Section 3** describes our approach to evaluating the cost-effectiveness of the program.
- **Section 4** presents the cost-effectiveness results for the different budget programs and technologies that make up the program.
- **Section 5** describes our approach to evaluating how well the program is meeting the goals set forth in AB 797.
- **Section 6** presents our findings of how the program is meeting the goals in AB 797.
- **Appendix A** includes the survey instruments used.
- **Appendix B** contains the complete survey results that are summarized in Section 6.
- **Appendix C** presents the details of the different measure types that we chose to represent the program.
- **Appendix D** contains the complete details of the cost-effectiveness results summarized in Section 4.

3 COST-EFFECTIVENESS APPROACH

This section summarizes the sources of data and methodologies used in the cost-effectiveness component of this study. The discussion of the cost-effectiveness approach is divided into the following subsections:

- Overview of Approach
- Cost-Effectiveness Tests
- Key Inputs

3.1 OVERVIEW OF APPROACH

The purpose of this analysis is to determine the cost-effectiveness of the CSI-Thermal Program and to test the cost-effectiveness of the CSI-Thermal budget programs and technologies. The analysis reviews the specific elements that influenced the cost-effectiveness of the program, including the expected savings from the CSI-Thermal measures and the impact of increased rebates associated with the expansion of the program in response to an incident at a Southern California Gas (SCG) storage facility. The cost-effectiveness analysis provides insights into the effects of impacts, measure costs, and incentives on the costs and benefits of technologies installed by the CSI-Thermal Program.

In 2009, the CPUC adopted an evaluation framework and methodology for assessing cost-effectiveness of distributed generation (DG) technologies.[18] The DG cost-effectiveness methodology is derived from the SPM first published in the 1980s and used for several decades in evaluating energy efficiency technologies and programs.[19] The 2009 CPUC decision on DG cost-effectiveness provides specific guidance on the tests to be used, the costs and benefits to be included in each test, and the avoided cost inputs to be used when calculating program costs and benefits. While the 2009 CPUC decision on DG cost-effectiveness does not reference solar thermal, we have followed the guidance in this decision and adopted it accordingly for solar thermal.[20]

[18] CPUC, "Decision Adopting Cost-Benefit Methodology for Distributed Generation," Decision D.09-08-026, August 20, 2009.

[19] CPUC, *California Standard Practice Manual: Economic Analysis of Demand-Side Programs and Projects*, October 2001: https://www.cpuc.ca.gov/uploadedFiles/CPUC_Public_Website/Content/Utilities_and_Industries/Energy_-_Electricity_and_Natural_Gas/CPUC_STANDARD_PRACTICE_MANUAL.pdf

[20] This approach was implemented for the first time in the Itron 2015 SGIP Cost-Effectiveness Report: https://www.cpuc.ca.gov/WorkArea/DownloadAsset.aspx?id=7889

3.2 COST-EFFECTIVENESS TESTS

This analysis considered the cost-effectiveness of solar thermal using four distinct tests:

- The Participant Test (PCT) is the measure of the quantifiable benefits and costs to the customer due to participation in the program.
- The Ratepayer Impact Measure (RIM) Test measures what happens to customer bills or rates due to changes in utility revenues and operating costs caused by the program.
- The Total Resource Cost (TRC) Test measures the net costs of a program as a resource option based on the total costs of the program, including both the participants' and the utility's costs.
- The Program Administrator (PA) Cost Test measures the net costs of a program as a resource option based on the costs incurred by the PA (including incentive costs) and excluding any net costs incurred by the participants.

Table 3-1 lists examples of costs and benefits and how they are allocated across the different tests. A quick review of the different tests, and the costs and benefits associated with the alternative tests, helps to illustrate the diverse points of view reflected by each test. For example, some inputs are valued using different metrics (avoided supply or utility rates) while other inputs represent costs from one perspective and benefits from another (incentives are costs in the PA cost test but are benefits for the PCT). Calculating four different cost-effectiveness values aids in the development of a deeper understanding of how different stakeholders view, value, and react to the CSI-Thermal Program.

TABLE 3-1: EXAMPLE OF COSTS AND BENEFITS AND ALLOCATION AMONG COST TESTS

Cost/Benefit Inputs	TRC	PA	PCT	RIM
Administrative Costs	Cost	Cost		Cost
Avoided Cost of Electricity Saved (Increased)	Benefit (Cost)	Benefit (Cost)		Benefit (Cost)
Avoided Cost of Natural Gas Saved (Increased)	Benefit (Cost)	Benefit (Cost)		Benefit (Cost)
Electric Bill Savings (Increase)			Benefit (Cost)	Cost (Benefit)
Gas Bill Savings (Increase)			Benefit (Cost)	Cost (Benefit)
Measure Cost, Installation Cost, and incremental O&M	Cost		Cost	
Rebates/Incentives		Cost	Benefit	Cost
Tax Credit[21]	Cost Reduction		Benefit	

[21] For most systems, Itron will assume that the participant took the tax credit based on the installed cost minus the incentive. For Single-Family Low-Income participants, that means that Itron will assume that the participants did NOT take advantage of the tax credit because the program is intended to zero out the installed cost and many participants may not have sufficient tax liability to take advantage of the tax credit.

The May 2019 CPUC cost-effectiveness decision (D. 19-05-019) designated the TRC as the primary cost-effectiveness test and adopted modified versions of the TRC, PA, and RIM tests for all distributed energy resources starting July 2019.[22] The cost-effectiveness analysis undertaken for solar thermal is consistent with D. 19-05-019, highlighting the TRC and presenting results from the four distinct tests (TRC, PA, RIM and PCT).

The four cost-effectiveness tests listed above were applied to a variety of analyses involving CSI-Thermal water heating. The different analyses were based on a combination of the following factors:

- Customer class (single-family, multifamily, commercial, pools).
- Budget program (customer class plus low-income and Disadvantaged Community (DAC)).
- Technology characteristics (technology size, system type).
- Customer rate (commercial, domestic rate, low-income or CARE rate).
- Other factors, such as coastal/inland for commercial pools, all systems versus low-cost systems, with and without higher incentives added to address the SCG storage facility incident.

This cost-effectiveness analysis explores multiple combinations of these factors and quantifies the costs and benefits of each case using the four tests described above. The following subsections describe the key inputs to the cost-effectiveness tests in more detail.

3.3 KEY INPUTS

This subsection provides additional details on the following aspects of the cost-effectiveness analysis:

- Technology characteristics, including costs and savings.
- Customer retail rates.
- Customer incentives and tax credits.
- Utility avoided costs.
- Program administrator costs.
- Financing and discount rates.

[22] CPUC, Decision 19-05-019, Decision Adopting Cost Effectiveness Analysis Framework Policies for all Distributed Energy Resources, May 2019. http://docs.cpuc.ca.gov/PublishedDocs/Published/G000/M293/K833/293833387.PDF

3.3.1 Technology Characteristics

Several factors were considered when deciding the different technologies that best represented the CSI-Thermal Program population. The evaluation team first reviewed the type of technologies installed by budget program and chose the technologies that made up the majority of each program. The following budget program and SWH technologies were identified:[23]

- **Commercial Pools:** Direct Pools - Drainback.
- **Commercial/Multifamily Residential:** Indirect Forced Circulation – Drainback & Indirect Forced Circulation – Glycol.
- **Low-Income Multifamily Residential:** Indirect Forced Circulation – Drainback & Indirect Forced Circulation – Glycol.
- **Multifamily Residential – Disadvantaged Communities:** Indirect Forced Circulation – Drainback & Indirect Thermosyphon.
- **Single-Family Residential:** Direct Integral Collector Storage and Indirect Forced Circulation (all).
- **Low-Income Single-Family Residential:** Direct Integral Collector Storage and Indirect Forced Circulation (all).
- **Single-Family Residential – Disadvantaged Communities:** Direct **Integral** Collector Storage and Indirect Forced Circulation (all), and Indirect Thermosyphon.

The next step was to determine whether there were additional differences in savings or cost within each budget program and SWH technology that should result in a further breakout of each of these technologies. Potential variables included differences in capacity (kW_{th}), differences in saving or cost by location (inland versus coastal), and differences in costs by contractor installed. The evaluation team identified the combinations of system variables that resulted in the largest differences in the average expected therms saved, average cost per therm, and average incentives per therm. The final technologies and analysis variables are shown below in Table 3-2. Additional details about each technology number can be found in Appendix C. Additional inputs, such as Expected Useful Life (EUL), pump operation for active systems, and degradation and Operations and Maintenance (O&M) costs, can also be found in Appendix C.

[23] See Appendix C for more details on technology types.

TABLE 3-2: TECHNOLOGY DESCRIPTIONS BY TECHNOLOGY NUMBER

Tech Num.	Budget Program	System Type*	Coastal/Inland	kWth**	Other Notes
1	Com. Pools	DP	Coastal	all	
2	Com. Pools	DP	Inland	all	
3	Com./MF Res.	IF-G	All	LT10	Glycol Freeze Protection
4	Com./MF Res.	IF-G	All	GE10	Glycol Freeze Protection
5	Com./MF Res.	IF-D	All	LT10	Drainback Freeze Protection
6	Com./MF Res.	IF-D	All	GE10	Drainback Freeze Protection
7	LI MF Res.	IF-G	All	LT10	Glycol Freeze Protection
8	LI MF Res.	IF-G	All	GE10	Glycol Freeze Protection
9	LI MF Res.	IF-D	All	LT10	Drainback Freeze Protection
10	LI MF Res.	IF-D	All	GE10	Drainback Freeze Protection
11	MF Res. - DAC	IF-D	All	all	Drainback Freeze Protection
12	MF Res. – DAC	IT	All	LT10	
13a	SF Res.	DI	All	LT10	Does not include low-cost systems
13b	SF Res.	DI	All	LT10	Low-cost contractor only
14a	SF Res.	IF	All	LT10	Does not include low-cost systems
14b	SF Res.	IF	All	LT10	Low-cost contractor only
15	LI SF Res.	DI	All	LT10	
16	LI SF Res.	IF	All	LT10	
17	SF Res. - DAC	DI	All	LT10	
18	SF Res. – DAC	IF	All	LT10	
19	SF Res. - DAC	IT	All	LT10	

* DP: Direct Pools, IF: Indirect Forced Circulation, DI: Direct Integral Collector Storage, IT: Indirect Thermosyphon

** LT10 = Less than 10 kWth. GE10 = Greater or Equal to 10 kWth

The low-cost systems referenced in Table 3-2 (and elsewhere) are representative of a recent market entrant that employs a vertically integrated business model and a neighborhood-based sales approach to offer significantly cheaper installed costs.[24]

3.3.2 Retail Rates

Residential customers were modeled on the GR gas rate for SDG&E and SCG and on G1 for PG&E. For residential systems with an electric pump, customers were modeled on TOU DR1 for SDG&E participants, while SCG participant's electricity increase was valued using SCE's TOU-D (option 4-9pm) rate. For PG&E's residential systems with an electric pump, the TOU-B rate was applied. For customers in low-income and disadvantaged community programs, a CARE discount of 20 percent was applied to the rates.

[24] These low-cost systems are assumed to have the same annual savings realization rates as other single-family systems.

SDG&E's commercial and multifamily customers were modeled on tier 1 of SDG&E's GN3 rate, while PG&E's non-residential models used tier 1 of their G1 gas rate. SCG customers were modeled on tier 2 of GN-10. The decision to use the tier 1 rate for SDG&E and PG&E was based on their baseline values of 1,000 and 4,000 therms per month, respectively. SCG's baseline for moving from tier 1 to tier 2 was 250 therms per month. SCG's substantially lower baseline threshold justified moving to the second tier to develop the marginal rate curtailed by the program. For commercial technologies with electric pumps, TOUA2 was used for SDG&E's customers, A1-TOU for PG&E's customers, and SCE's TOU GS1 Option E for SCG customers.

3.3.3 Customer Incentives and Tax Credits

To understand the different incentive levels provided through the program, the team reviewed the incentives descriptions in the CSI-Thermal Program Handbook,[25] those from Advice Letter No. 4953, and the incentives listed in the tracking data. The CSI-Thermal incentive rates for the general market programs were designed to decline over the scope of the program as more systems were installed. The incentive rates for the low-income and disadvantaged community programs, however, were designed to remain at the highest step while funds for these programs remained available. The size of incentives was also capped by a maximum value for each step and incentives were not allowed to exceed the cost of the system. (See Table 3-3 for the incentive levels described in the CSI-Thermal handbook (May 2019)). The average incentives based on analysis of the tracking data vary somewhat from these values due to ongoing adjustments of incentives to match program needs, such as raising incentives to increase uptake.

TABLE 3-3: NATURAL GAS INCENTIVE LEVELS BY BUDGET PROGRAM ($/ANNUAL THERM)

	Single-Family Incentive	LI Single-Family Incentive	Single-Family DAC Incentive	MF/Com Incentive	LI MF/Com Incentive	MF/Com DAC Incentive	Com Pools
Step 1	$29.85	$36.90	$36.90	$20.19	$24.89	$20.19	$7.00
Step 2	$25.37			$17.16			$6.00
Step 3	$14.30			$10.15			
Step 4	$3.23			$3.13			

In addition to ongoing incentive adjustments, in response to an incident at a SCG storage facility, on April 29, 2016 the CPUC approved Advice Letter No. 4953 to temporarily shift SCG's funds from single-family and multifamily/commercial that were in Step 3 and 4 to Step 1. The Advice Letter also increased the Step 1 incentive level to $70/therm for single-family installations and $25/therm for multifamily/commercial applications (incentives were still capped at the cost of the system). The commercial pool rebate

[25] Located on the Go Solar California website. https://www.gosolarcalifornia.ca.gov/documents/CSI-Thermal_Handbook.pdf

restriction limiting rebates to 50 percent of the technology costs was also eliminated. The storage facility incident rebates were effective from April 15, 2016 to December 31, 2016.

Because the PAs have changed the incentives over time, the incentive levels used in the cost-effectiveness analysis represent the weighted average of incentives observed in the tracking data by Budget Program and Technology Type. The study used the average tracking data incentive to accurately reflect the cost-effectiveness of the program as the program was implemented. The average weighted incentive rates in $/therm used in the model can be found in Table 3-4 below. To calculate the average weighted incentive rates, the site-level incentive rates were weighted by the equivalent therm savings of each system and then averaged across all sites of that technology number.

TABLE 3-4: AVERAGE WEIGHTED INCENTIVE RATES [$2018/THERM]

Tech Num.	Budget Program	System Type	Wgt. Incentive [$2018/therm]
1	Com. Pools	DP	$5.93
2	Com. Pools	DP	$6.68
3	Com./MF Res.	IF-G	$16.79
4	Com./MF Res.	IF-G	$20.25
5	Com./MF Res.	IF-D	$18.39
6	Com./MF Res.	IF-D	$18.68
7	LI MF Res.	IF-G	$22.18
8	LI MF Res.	IF-G	$23.71
9	LI MF Res.	IF-D	$23.28
10	LI MF Res.	IF-D	$23.88
11	MF Res. – DAC	IF-D	$20.12
12	MF Res. – DAC	IT	$20.23
13a	SF Res.	DI	$31.45
13b	SF Res.	DI	$36.37
14a	SF Res.	IF	$52.29
14b	SF Res.	IF	$28.63
15	LI SF Res.	DI	$46.96
16	LI SF Res.	IF	$35.71
17	SF Res. – DAC	DI	$29.85
18	SF Res. – DAC	IF	$29.27
19	SF Res. – DAC	IT	$29.84

* DP: Direct Pools, IF: Indirect Forced Circulation, DI: Direct Integral Collector Storage, IT: Indirect Thermosyphon

The incentives in Table 3-4 include adjustments for inflation to 2018 dollars. In addition to CSI-Thermal incentives, the Federal Investment Tax Credit (ITC) is available to residential and nonresidential customers with solar thermal systems. The ITC is set to 30 percent of the after-incentive system costs. Customers also benefit from the 5-year Modified Accelerated Cost Recovery System (MACRS) which is applied to the

after-incentive system costs. The ITC and the MACRS are treated as federal tax benefits. Federal tax benefits are a cost reduction for the TRC Test and a benefit for the PCT.

3.3.4 Avoided Costs

Solar thermal systems utilize solar collectors to heat water, thereby reducing the customer's use of natural gas supplied from the utility. Select systems require electric pumps to move the water through the solar thermal system to the rooftop collectors, increasing the customer's use of electricity supplied by the grid.

The avoided costs are used to value the solar thermal system's reduction in natural gas usage and increase in electricity usage for the PA, TRC, and RIM tests. The gas avoided costs include the IOU-specific values of the natural gas commodity avoided, transportation, emissions, and losses for each month of the year. The electric avoided costs include the value of electricity purchases from central station power plants, emissions, generation capacity, T&D capacity, and ancillary services for every hour of the year. When solar thermal systems provide heated water to the water heating system, they reduce the natural gas required to heat the water and, therefore, result in utility natural gas avoided costs. When electricity is used to pump the water through the solar thermal systems, they increase utility load and, therefore, increase the utility electricity costs. For the solar thermal systems, the cost-effectiveness analysis incorporates both the reduction in natural gas costs and the increase in electricity costs.

The natural gas avoided costs are derived from the CPUC 2018 Natural Gas Avoided Cost Calculator (NGACC).[26] The 2018 NGACC was updated from the 2017 version using an updated commodity cost, CO_2 price forecast, and an updated inflation rate. The electric avoided costs are derived from the CPUC 2018 Electric Avoided Cost Calculator (EACC).[27] The CPUC updated the EACC in 2019 using updated GHG prices and other changes. The timing of this study did not allow us to use the 2019 version of the CPUC EACC.

The NGACC and the EACC produce a natural gas and electric avoided cost shape for each climate zone and IOU. We developed a single natural gas and electric avoided cost shape for each IOU based on the geographical distribution of installations within the CSI-Thermal population throughout the program. The avoided costs for each climate zone were weighted and combined into a single weighted average avoided cost stream for each IOU and energy source. Climate zones with a large proportion of the CSI-Thermal installations are given a greater weighting compared to climate zones with little or no CSI-Thermal systems.

26 https://www.cpuc.ca.gov/general.aspx?id=5267

27 Ibid.

3.3.5 Program Administrator Costs

PAs bear the cost of designing and managing the CSI-Thermal Program. These administrative costs are applied in the PA, RIM, and TRC tests. They are assigned on a $/therm basis using the average evaluated therms of the solar thermal systems. Advice Letter 5219-G assumes that program administration costs equal 18 percent of total incentive budget. In our model, we set PA administration costs to 18 percent of the CSI-Thermal incentive amount for each technology scenario.

3.3.6 Financing, Discount Rates, and Taxes

Below, we present several key inputs and global assumptions applicable throughout our modeling:

- The Federal marginal tax rate is 24 percent for residential customers and 21 percent for nonresidential customers.
- The California state tax rate is 9.30 percent for residential customers and 8.84 percent for nonresidential customers.
- All technologies are financed with debt/equity:
  - Residential customers finance with 40 percent equity and have a debt interest rate of 4.50 percent.
  - Nonresidential customers finance with 60 percent equity and have a debt interest rate of 4.52 percent.
- The utility discount rate is 5 percent and the societal discount rate is 4 percent.
- The inflation rate is 2.3 percent.

4 COST-EFFECTIVENESS RESULTS

This section summarizes the results from the cost-effectiveness analysis of the CSI-Thermal Program. The results are a retrospective review of the cost-effectiveness of the program since inception, starting in 2010 through 2018. In addition, the end of this section presents the findings of three scenarios where inputs were varied. This analysis does not attempt to forecast the cost-effectiveness of the program in the future. Cost-effectiveness results are divided into the following subsections:

- Single-Family Residential CSI-Thermal findings
- Commercial and Multifamily CSI-Thermal findings
- Different Input Scenario findings

A detailed discussion of the cost-effectiveness methodology and key assumptions was presented in Section 3. The cost-effectiveness results presented in this section represent the findings from over 375 distinct residential, commercial, and multifamily simulations based on combinations of budget programs, technology sizes, energy savings, and incentive levels. At times throughout this section, we present findings averaged across a group of simulations to present overall cost-effectiveness trends. Other times, we highlight individual simulations results to explore the influence of specific cost and benefit components. By selecting individual simulations results, we are not implying that these findings are representative of all other solar thermal systems. Instead, we select specific simulations for in-depth analysis as they allow us to highlight aspects of cost-effectiveness that we deem relevant or important.

The analyses below are shown for three different savings values: high, mean, and low. These values are based on the range of savings resulting from the CSI-Thermal Impact Evaluation. The evaluation calculated a gross realization rate (GRR) for each budget program, which is the actual savings of the budget program divided by the expected savings of the program and weighted by total savings of the stratum. Those are the mean savings value. Due to several reasons discussed in the CSI-Thermal Impact Report, the gross realization results did not meet 90/10 confidence and precision results. Therefore, along with the mean value typically reported as the GRR, the evaluation team reported the high savings value, which met the upper limit of the 90 percent confidence interval, and the low savings value to meet the lower limit.

4.1 SINGLE-FAMILY SOLAR THERMAL COST-EFFECTIVENESS

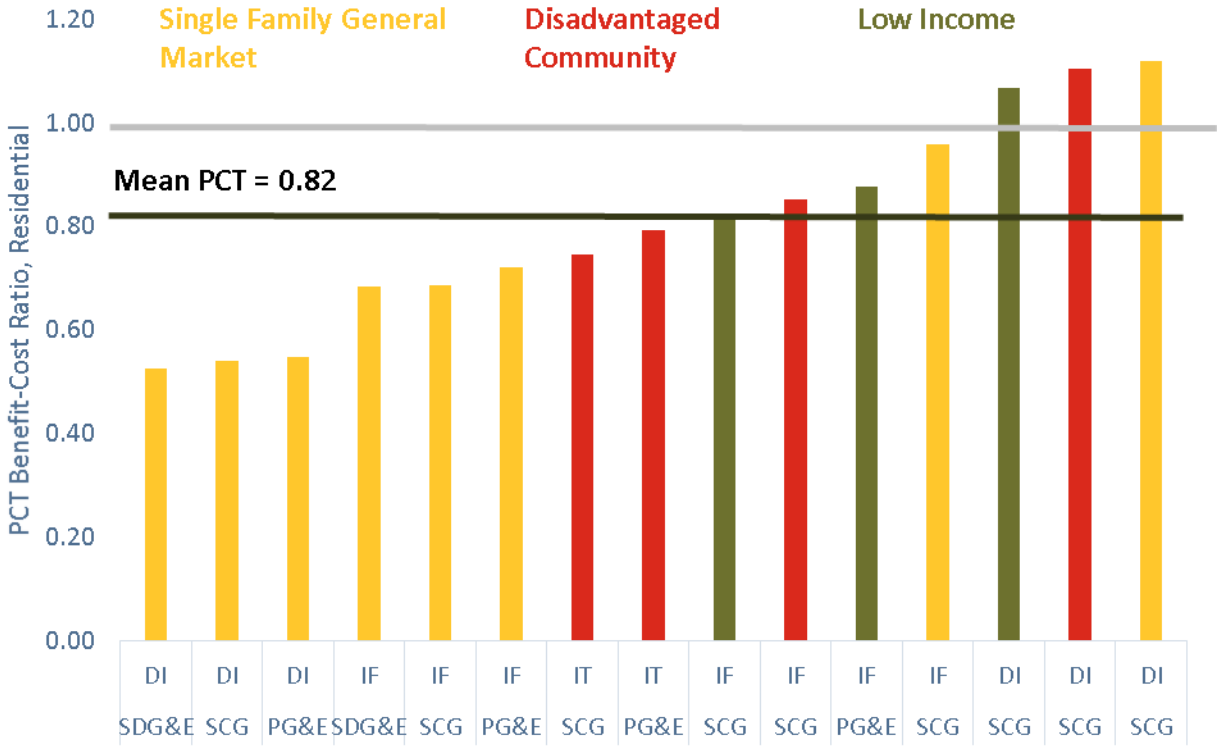
Figure 4-1 presents results of the Participant Cost Test (PCT) ratio for residential solar thermal customers using the mean realization rate to describe technology savings. The mean realization rate represents the

average savings by technology as derived from the CSI-Thermal evaluation report.[28] The graph presents the PCT for the different budget programs (low-income, disadvantaged communities, and general single-family), different technologies (direct integral collectors (DI), indirect forced circulation (IF), and indirect thermosyphon (IT)), with and without the increased Aliso Canyon rebates for SCG, and two pricing options observed for single-family systems (average cost of all non-low cost systems installed and low cost systems only). The PCT findings are calculated by IOU. If an IOU did not offer a budget program, technology, or cost configuration, the PCT is not calculated.

Recall that the PCT represents the cost-effectiveness from the perspective of the solar thermal customer. For the technologies presented in Figure 4-1, the average retrospective PCT over the course of the program was 0.82. The results in Figure 4-1 are color coded by budget program – the single-family PCT are shown in yellow, low-income single-family in green, and disadvantaged community single-family in red. In general, the single-family program technologies have the lowest PCT, but they also have the technology with the highest individual PCT. The single-family program PCT is typically lower than those for the single-family disadvantaged community or low-income programs because the incentives for the disadvantaged community and low-income programs typically represent a larger share of the measure cost than for the single-family program. Incentives are a benefit and measure costs are a cost for the PCT. The higher incentives in the low-income and disadvantaged community programs improve the PCT of these programs relative to the single-family program.

[28] Report is available on this page: https://www.cpuc.ca.gov/General.aspx?id=5430 and this link: https://www.cpuc.ca.gov/WorkArea/DownloadAsset.aspx?id=6442457978

FIGURE 4-1: PARTICIPANT COST TEST RESULTS FOR SINGLE-FAMILY CSI-THERMAL SYSTEMS BY TECHNOLOGY, BUDGET PROGRAM, AND IOU USING MEAN SAVINGS



The lowest PCT in Figure 4-1 is 52 percent for direct integral (DI) collection systems in SDG&E's single-family budget program, where the system's cost is the average weighted cost of all non-low cost installations in the tracking data. The highest PCT in Figure 4-1 is 115 percent, also for DI collection systems in SCG's single-family budget program but where the system's cost is the average weighted cost of low cost installations in the tracking data. The low-cost DI systems also have a higher average claimed saving than the higher cost DI systems. The CSI-Thermal incentives are based, in part, on anticipated savings; therefore, the low-cost DI systems also have higher incentives than the higher cost DI systems. Similarly, the indirect forced circulation (IF) single-family systems in SCG's territory with a high PCT were installed as low-cost systems, leading to higher PCT values. Note, the low-cost DI and IF systems were only installed in SCG's territory and only during the later years of the program.[29] The modeled results presented in

[29] The low-cost DI and IF systems installed in SCG's territory were installed by a single contractor and manufacturer. These systems were installed and manufactured by a vertically integrated firm that may be able to achieve cost savings not available in other business structures.

Figure 4-1 illustrate the importance of system cost, bill savings, and incentives when analyzing cost-effectiveness from the participant's point of view.

All residential technologies in Figure 4-1 with a PCT greater than 1.0, or all cost-effective technologies from the participants' point of view (when using the mean GRR), are direct integral collectors. These technologies were modeled as having received rebates close to 100 percent of their system costs from low-income or disadvantaged community incentives. These technologies are the direct integral collectors in all three of the SCG single-family budget programs. SDG&E and PG&E's CSI-Thermal programs did not incentivize direct integral collector systems within their low-income or disadvantaged community single-family programs and their single-family installations did not include the low-cost systems.

Figure 4-2 lists the four different cost-effectiveness tests and their benefits and cost components for a DI system in SCG's single-family low-income budget program, assuming a mean savings realization rate. This technology is represented by the olive bar in Figure 4-1 with the largest low-income single-family PCT ratio. Figure 4-2 clearly illustrates the importance of the rebate in calculating the customer benefits for the PCT test. The largest cost for the PCT and the Total Resource Cost (TRC) is the system or measure cost. Additional costs for both tests include the Operations and Maintenance (O&M) costs. The DI technology illustrated in Figure 4-2 was rebated under the low-income program, so the measure cost in the PCT and TRC ratios is very similar to the rebate costs in the Program Administrator (PA) and Ratepayer Impact Measure (RIM) cost tests. The high measure costs and rebate values relative to the relatively low bill and avoided cost savings are associated with the low TRC, PA, and RIM test values for the DI technology within the single-family low-income budget program. These low bill savings are due in part to historically low natural gas prices.

FIGURE 4-2: COST BENEFITS TEST COMPONENTS FOR DIRECT INTEGRAL SYSTEM, SINGLE-FAMILY LOW-INCOME BUDGET PROGRAM, MEAN REALIZED SAVINGS, SCG

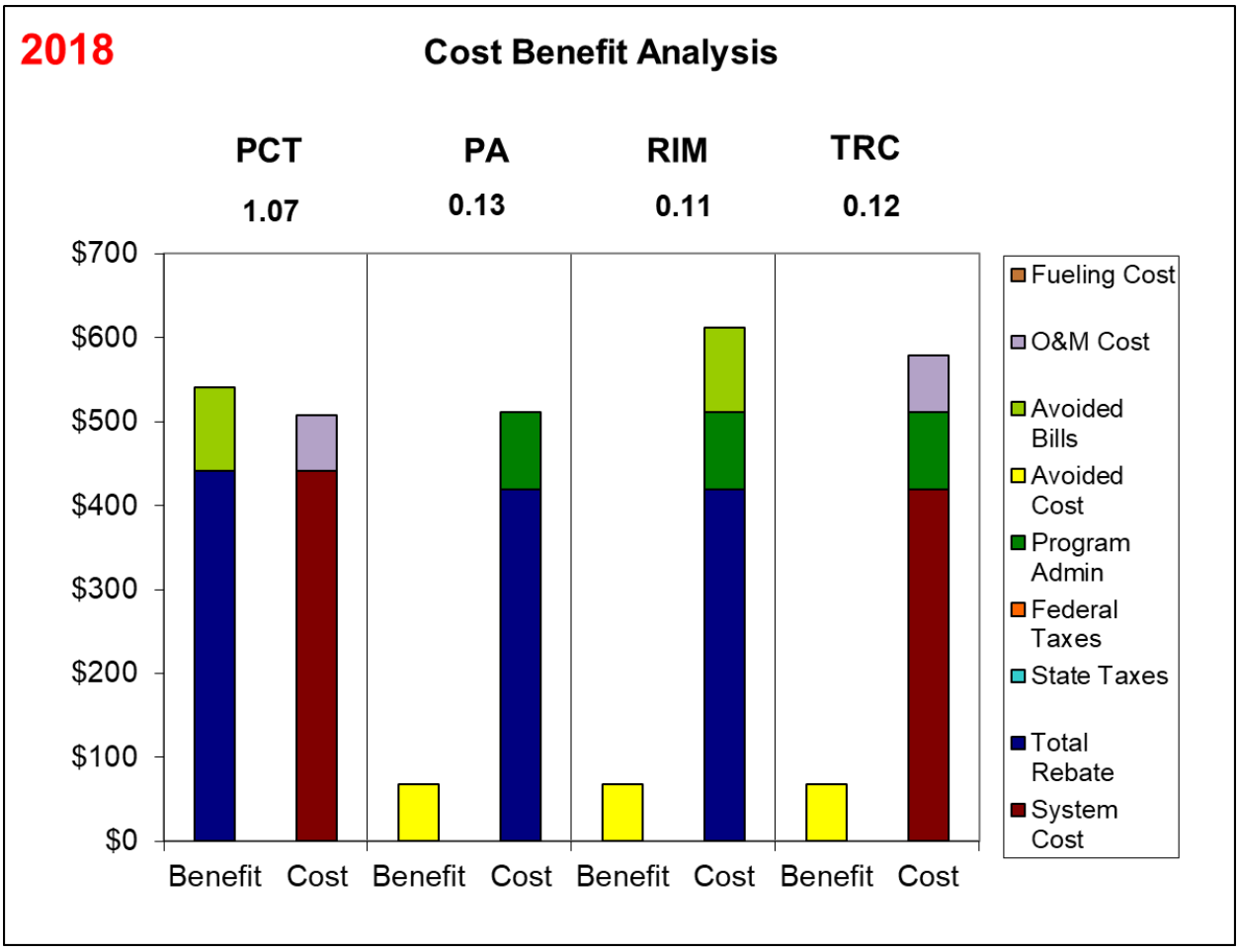


Figure 4-3 illustrates the PCT ratio when the savings from the solar thermal system within the single-family budget program are equivalent to the high, mean, and low realization rate from the CSI-Thermal Impact Evaluation. Modifications to the savings change the PCT ratio, but the high cost of the single-family systems relative to the bill savings, incentives, and ITC benefits do not make the average single-family system cost-effective from the participant's point of view.

FIGURE 4-3: AVERAGE SINGLE-FAMILY RESIDENTIAL PARTICIPANT COST TEST BY HIGH, MEAN, AND LOW REALIZATION RATE AND IOU

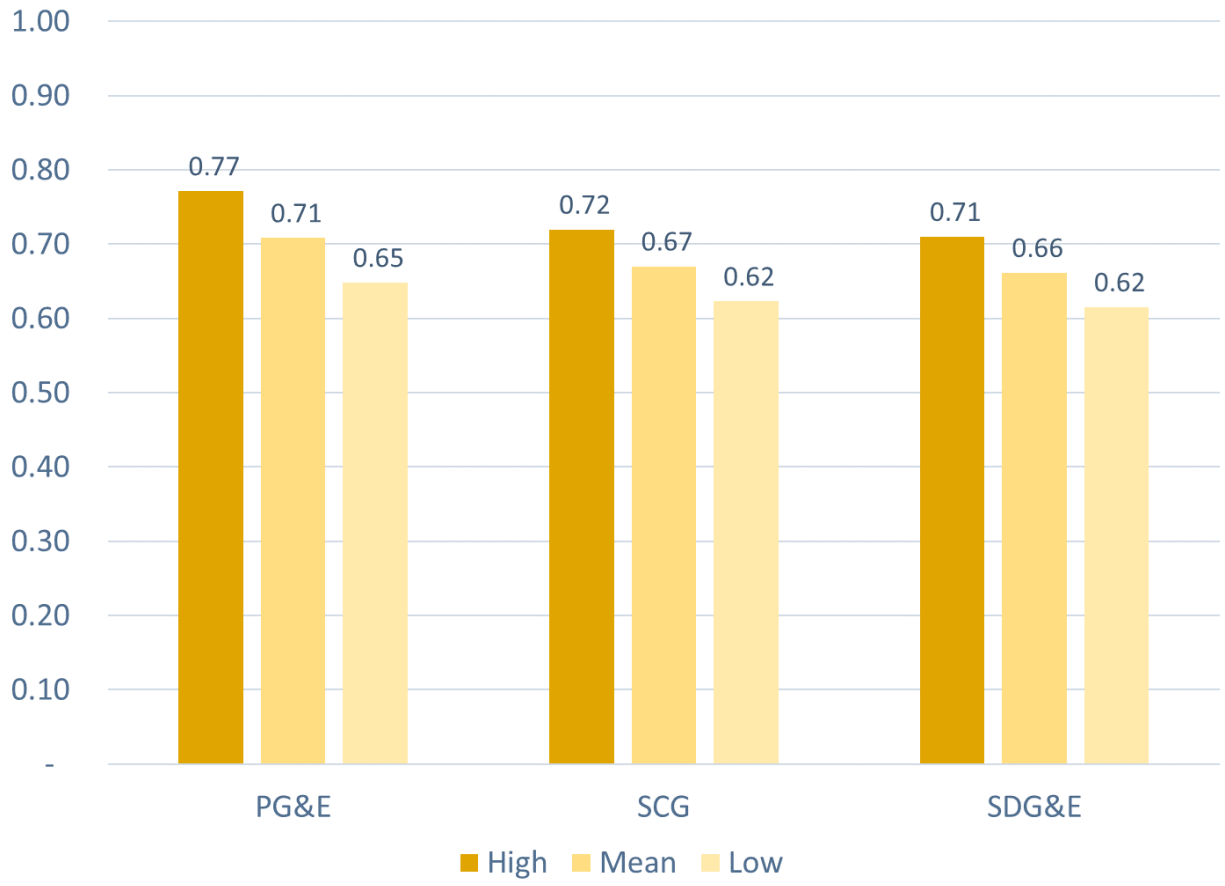


Figure 4-4 illustrates the PCT ratio by realization savings rate for the single-family low-income and disadvantaged community budget programs. SDG&E did not have significant participation in these budget programs. Under the high realization rate value, the PCT ratio for SCG's budget programs is 1.03. The PCT is higher for the low-income and disadvantaged community single-family programs than for the single-family program because the average price of the technology was typically lower for these programs and the incentives paid a higher share of the measure costs.

FIGURE 4-4: AVERAGE LOW-INCOME AND DISADVANTAGED COMMUNITY SINGLE-FAMILY RESIDENTIAL PARTICIPANT COST TEST BY HIGH, MEAN, AND LOW REALIZATION RATE AND IOU

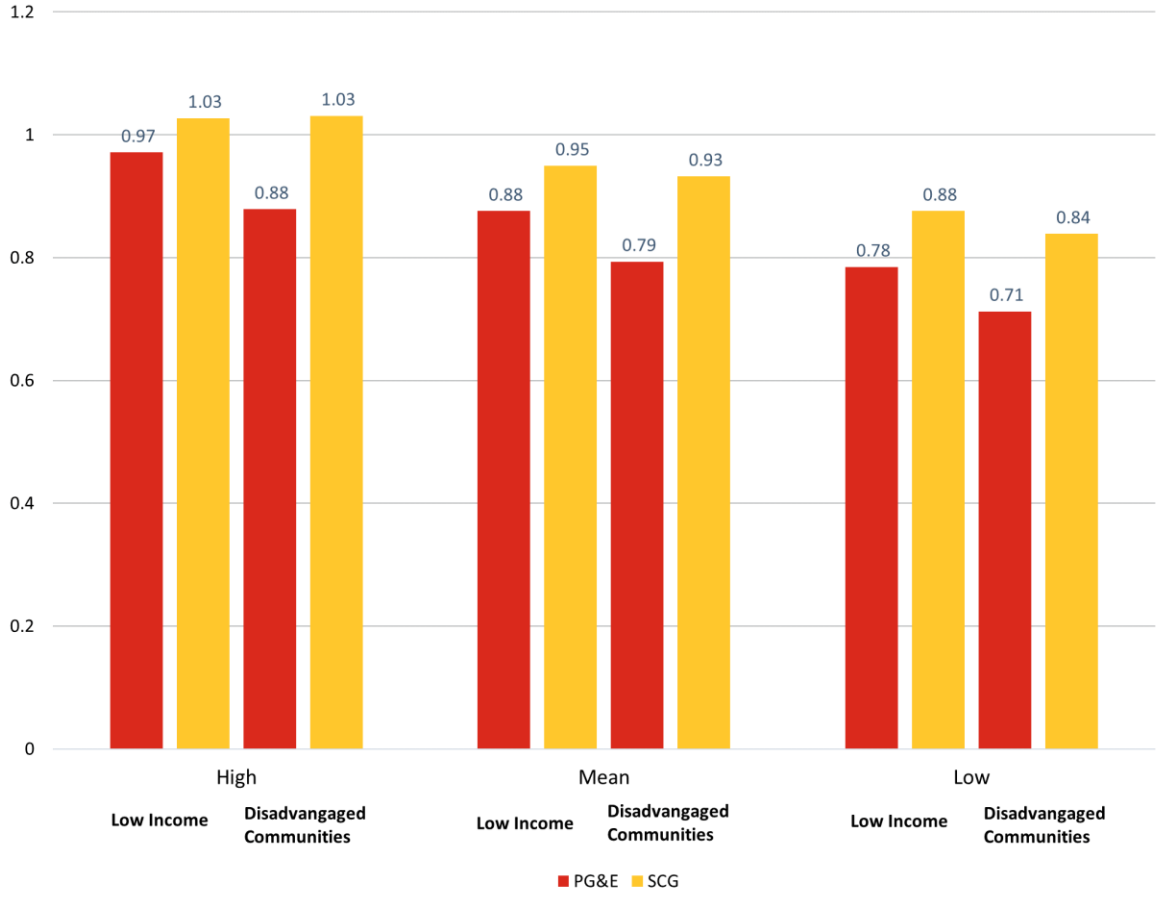


Figure 4-5 illustrates the TRC ratio for the three single-family budget programs. The results are presented by technology, IOU, and savings realization rate. This figure illustrates that the various CSI-Thermal single-family budget programs were not cost-effective from the point of view of society or the TRC test. The average TRC ratio across technologies and IOUs for the single-family programs (general population, low-income, and disadvantaged communities) is 0.10 at the mean savings realization rate. Increasing the savings realization rate to high increases the average TRC ratio across these programs to 0.14.

These results clearly illustrate the cost-effectiveness barriers facing the single-family budget programs. The relatively small savings, evaluated using the avoided cost values from 2018 E3 gas avoided cost calculator, are not large enough to cover the measure and administrative costs. Making the single-family technologies cost-effective from society's viewpoint is a formidable task, given the avoided cost values from the E3 2018 avoided cost calculator and the high measure costs.

FIGURE 4-5: AVERAGE TOTAL RESOURCE COST RATIOS FOR SINGLE-FAMILY BUDGET PROGRAMS BY HIGH, MEAN, AND LOW SAVINGS REALIZATION RATES

Figure 4-6 presents the average across single-family budget programs for the PA cost test ratio by IOU and savings realization rate. The average PA cost test ratio using the mean savings realization rate is 0.14. The PA ratio increases to 0.20 under the high savings realization rate. The PA ratio is slightly higher than the TRC because the PA ratio's costs include the incentives while the TRC ratio includes the measure costs. Both tests, however, illustrate the difficulty associated with reaching cost-effectiveness for the single-family budget programs. The sum of the relatively small and low valued gas savings does not currently exceed the burden of the incentives or measure costs.

FIGURE 4-6: SINGLE-FAMILY BUDGET PROGRAMS AVERAGE PROGRAM ADMINISTRATOR COST TEST BY IOU

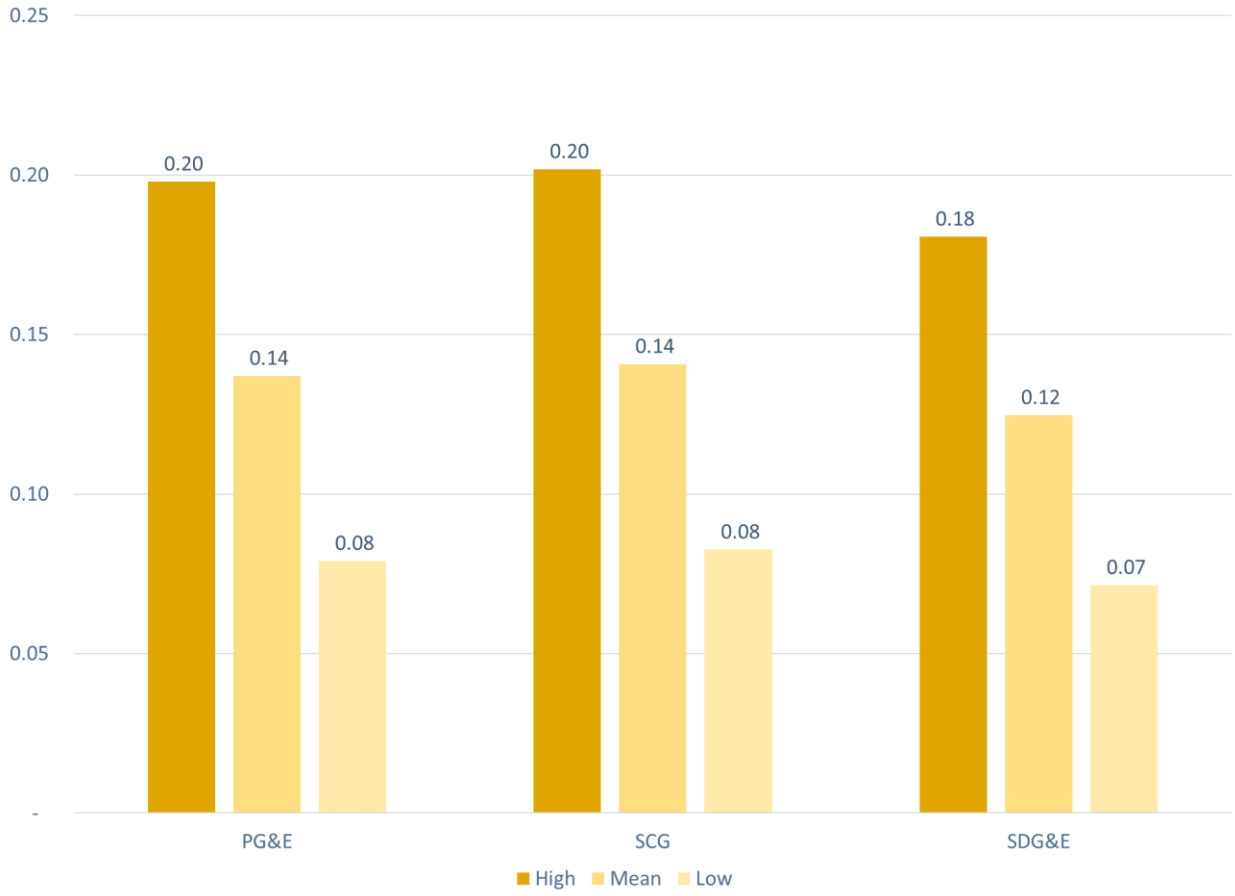
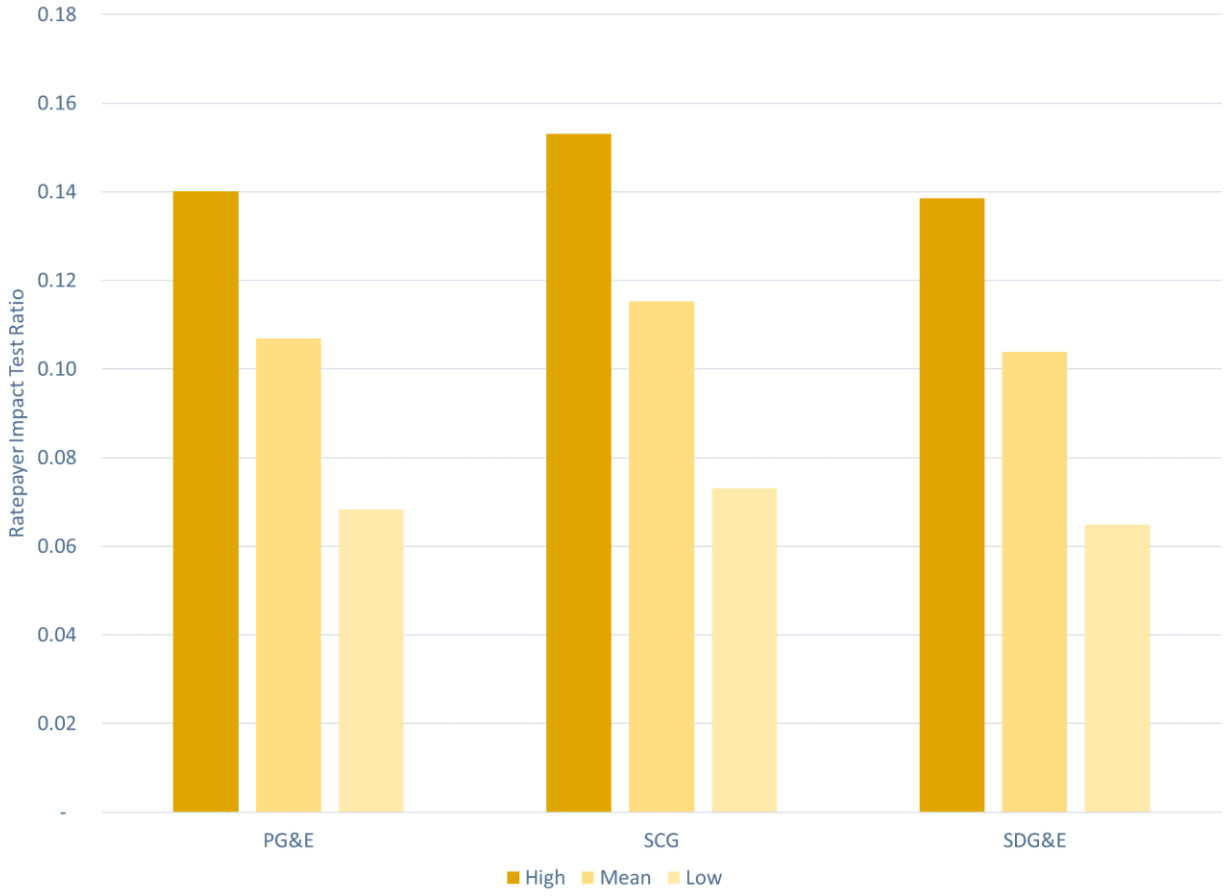


Figure 4-7 presents the average across single-family budget programs for the RIM cost test ratio by IOU and savings realization rate. The average PA cost test ratio using the mean savings realization rate is 0.12. The RIM ratio is slightly smaller than the PA ratio because the RIM ratio's costs include the customer bill savings. These tests illustrate the difficulty associated with reaching cost-effectiveness for these technologies.

FIGURE 4-7: SINGLE-FAMILY BUDGET PROGRAMS AVERAGE RATEPAYER IMPACT COST TEST BY IOU



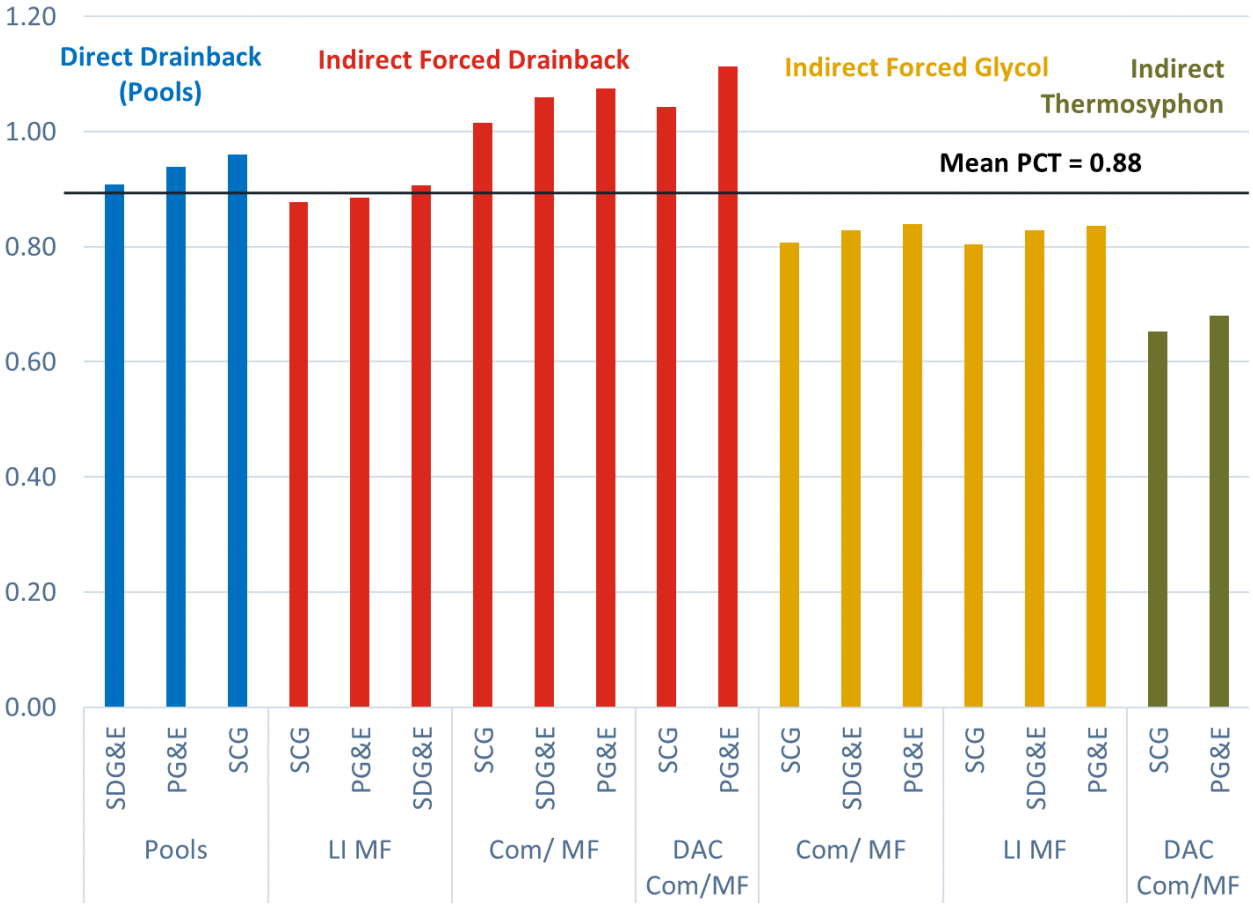
4.2 COMMERCIAL AND MULTIFAMILY SOLAR THERMAL COST-EFFECTIVENESS

Figure 4-8 presents the PCT for commercial and multifamily systems using the mean savings values. The graph shows the PCT for the different budget programs (low-income, disadvantaged communities, commercial pools, and the general multifamily/commercial community), different technologies (indirect forced drainback (IFD) and glycol collectors (IFG), direct drainback pools (DDP), and indirect thermosyphon (IT)), and with Aliso Canyon rebates for SCG. The PCT findings are calculated by IOU. If an IOU did not offer a budget program, technology, or cost configuration, the PCT is not calculated.

The PCT represents the cost-effectiveness of solar thermal projects from the point of view of the customers. It compares the customers' benefits, including bill savings, incentives, and tax benefits to the customer measure, insurance, and O&M costs. The average value for the PCT across all budget programs at the mean savings value is very close to 1 at 0.88. The results presented in Figure 4-8 are color coded by technology type. The blue bars in Figure 4-8 represent direct drainback pool systems, the red bars are indirect forced drainback systems (IFD), the yellow are indirect forced glycol (IFG), and the green are indirect thermosyphon (IT). The commercial and multifamily systems are color-coded by system type, not budget program (see Figure 4-1). For the single-family systems, incentive differences between the budget programs played a dominant role in determining the system's PCT ratio. While the commercial and multifamily incentives differ between the general and low-income programs, the differences in the average cost of the drainback, glycol, and thermosyphon systems differ more than the incentives. Therefore, given the relative importance of differences in system cost within the commercial and multifamily system PCT ratio, the graph is color coded by system type.

The results presented in Figure 4-8 illustrate that the IFD systems are cost-effective in the general commercial and multifamily communities and in the disadvantaged multifamily budget program. The IFD technologies are marginally not cost-effective from the participant's point of view for the low-income multifamily budget program. The average incentives from the tracking data are higher per therm saved for the low-income program than the general population budget program. However, the average measure cost is substantially higher per therm saved in the low-income program than in the general budget or disadvantaged communities programs. The higher average measure costs in the low-income program negatively impacts the PCT ratio, pushing the estimate average value below 1.0.

FIGURE 4-8: COMMERCIAL AND MULTIFAMILY PARTICIPANT COST TEST RATIO BY TECHNOLOGY, BUDGET PROGRAM, AND IOU, MEAN SAVINGS VALUES



The average PCT for commercial pools presented in Figure 4-8 is approaching 1.0. The cost-effectiveness of commercial pools was estimated separately for inland and coastal applications and the PCT ratio presented in Figure 4-8 represents a weighted average across the applications for an IOU. Looking at the inland and coastal applications separately, inland installations of solar pool systems are estimated to pass the PCT ratio for SDG&E and PG&E while coastal installation are typically not cost-effective for any of the IOUs.

The average PCT for IFG systems does not vary substantially by budget program; the low-income and the general population commercial multifamily programs have approximately the same PCT ratio of 0.82 (see Figure 4-8 above). The cost of the IFG system was approximately the same per therm of production for both the low-income and general program. The estimated average PCT ratio for the IT systems was lower than other systems and budget programs within the commercial and multifamily sectors. These systems

tend to be smaller and more expensive on a cost per-therm-saved basis, leaving smaller energy savings and incentives to cover the larger cost of the system.

Figure 4-9 lists the four different cost-effectiveness test and their benefits and cost components for an IFD system in PG&E's territory using a mean savings realization rate. This technology is one of the red bars illustrated in Figure 4-8 as an IFD system in the commercial/multifamily budget program. This graph clearly illustrates the importance of the rebate and avoided bills in calculating the customer benefits for the PCT test. Federal and state tax benefits, including the ITC, are also significant benefits for the PCT. The largest cost for the PCT and the TRC is the system or measure cost.[30] Additional costs for both tests include the O&M and fueling costs (to run the electric circulation pumps).[31] TRC costs also include the program administration costs. Figure 4-9 also clearly illustrates the importance of the incentives and avoided costs in the PA and RIM cost tests.

[30] The measure cost is lower in the TRC than the PCT due to the impact of the ITC. In the PCT, the ITC is a benefit to the customer but in the TRC the ITC is a reduction in the measure costs.

[31] Pump energy is estimated in the savings calculations but is not reported or tracked separately. The evaluated savings and gross savings realization rates only apply to fuel savings attributed to heating water, so electrical energy to run the pumps needs to be evaluated separately. For example, applying the single-family mean realization rate of 50 percent to a system that is expected to save 100 therms of natural gas results in a system with an actual natural gas savings of 50 therms. However, this does not take into account the electrical energy of the circulation pump(s), which might require, for example, the electrical energy equivalent of 10 therms to pump water through the system. For the cost-effectiveness calculations, the evaluation team made sure to take into account the electrical energy equivalent of the pump power, as pump power can be a significant energy draw of the entire system, especially for lower energy yielding systems. Appendix C has more information on pump energy estimates.

FIGURE 4-9: COST BENEFITS TEST COMPONENTS FOR INDIRECT FORCED DRAINBACK SYSTEM, COM/MF BUDGET PROGRAM, MEAN REALIZED SAVINGS, GREATER THAN 10 KWTH, PG&E

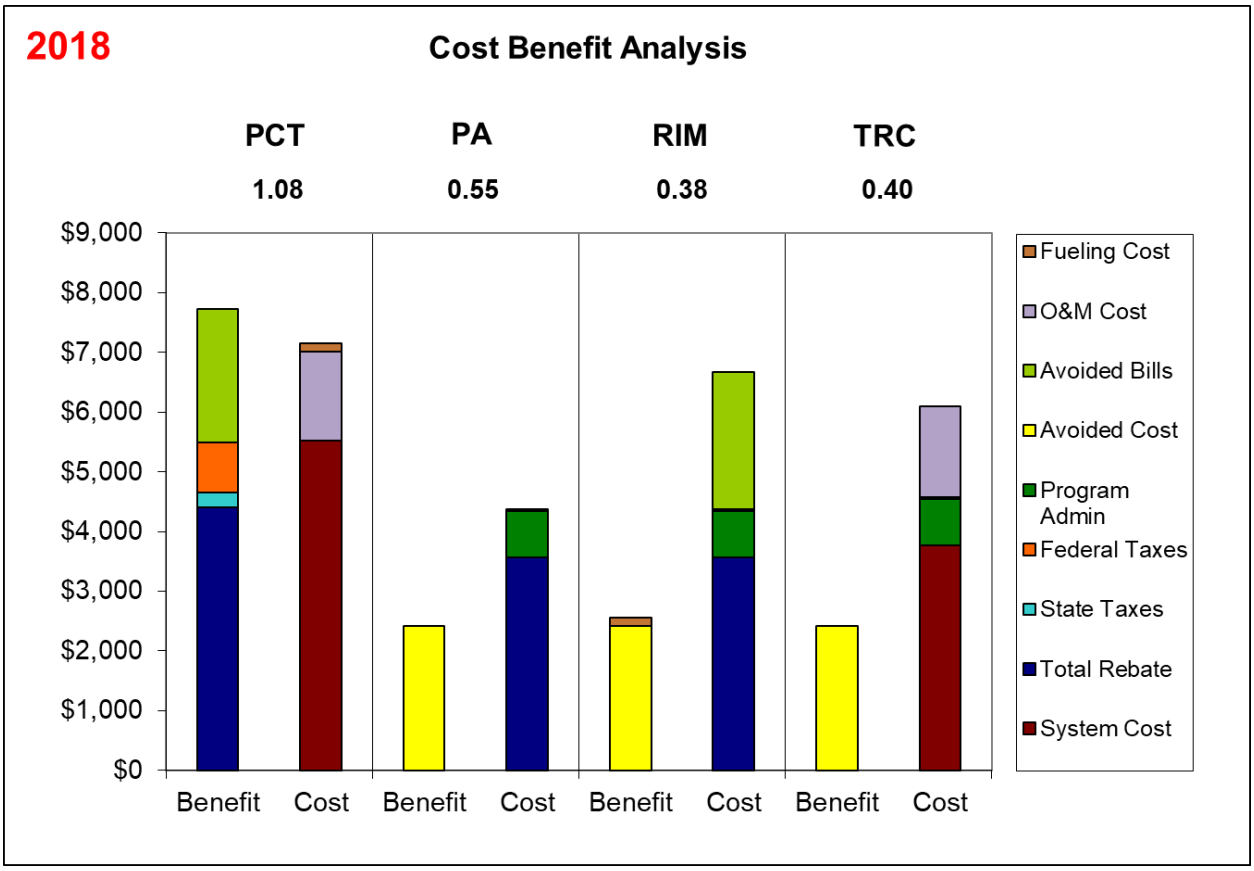
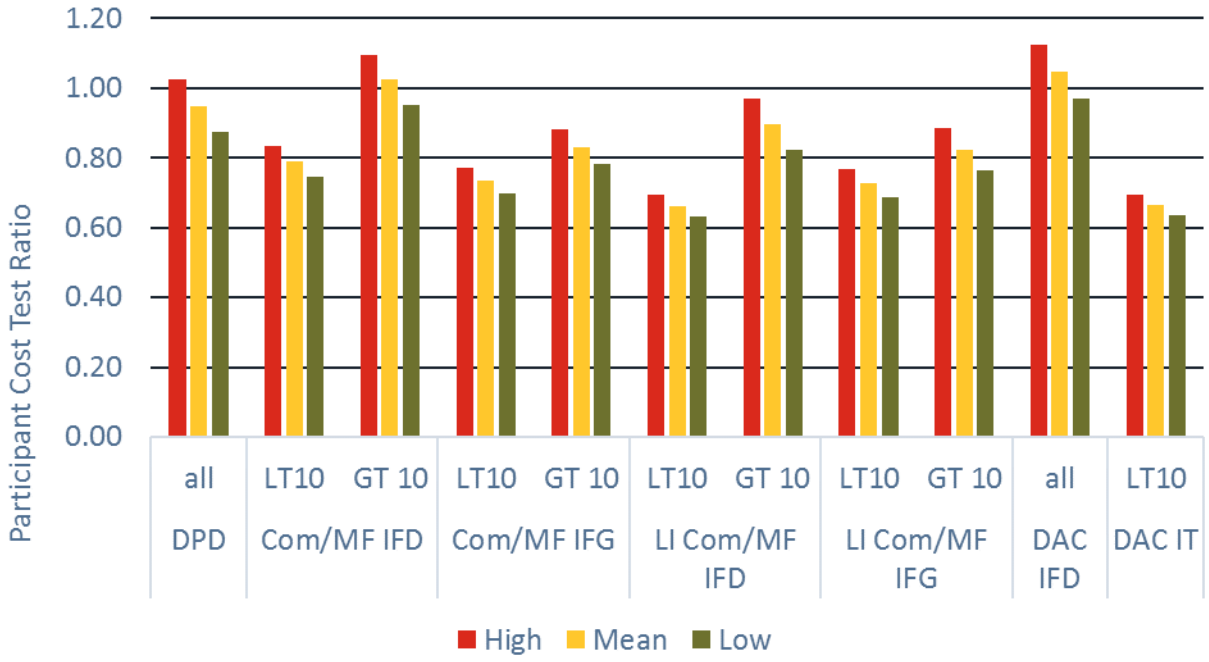


Figure 4-10 presents the commercial and multifamily PCT ratio by technology, budget program, high, mean, and low realization rate savings values, and two size groupings for many of the technologies (averaged across IOUs). These results reiterate the findings from Figure 4-8: that the commercial pools, commercial, and multifamily IFD systems, and the multifamily disadvantaged community IFD systems are associated with values where the average estimated PCT ratio exceeds 1.0. These systems have a higher PCT ratio due largely to their lower average measure cost per therm savings. The measure costs for this analysis were the average costs of the systems recorded in the tracking data by technology, budget program, and system size.[32]

[32] Appendix C includes information on the measure costs of the various technologies. Measure costs also varied by inland/coastal for commercial solar pool heating systems and contractor for some residential systems. The cost of systems installed in Aliso Canyon also differ slightly from other installations.

FIGURE 4-10: COMMERCIAL AND MULTIFAMILY PARTICIPANT COST TEST BY TECHNOLOGY, BUDGET PROGRAM, REALIZATION RATE AND TECHNOLOGY SIZE



The findings presented in Figure 4-10 illustrate that IFD systems larger than 10 kW_{th} drive the higher PCT values presented in Figure 4-8. Systems with less than 10 kW_{th} of capacity have a substantially higher cost per therm savings and substantially smaller anticipated therm and bill savings, leading the smaller IFD systems to have a lower PCT than the larger systems. This may be evidence of economies of scale for larger systems.

Figure 4-11 illustrates the average TRC ratio by budget program and IOU. The TRC estimates are generally less than 0.4. Viewing the individual technology TRC ratios, only IFD systems in the disadvantaged community and commercial/MF larger than 10 kW_{th}, with a high saving realization rate, have an estimated average TRC slightly larger than 0.50. The TRC cost-effectiveness test includes the PA's administrative costs and the participant's measure costs. The high measure costs relative to the avoided cost benefits of these systems are a barrier for the cost-effectiveness of solar thermal systems.

FIGURE 4-11: COMMERCIAL AND MULTIFAMILY TOTAL RESOURCE COST TEST RATIOS BY BUDGET PROGRAM AND IOU

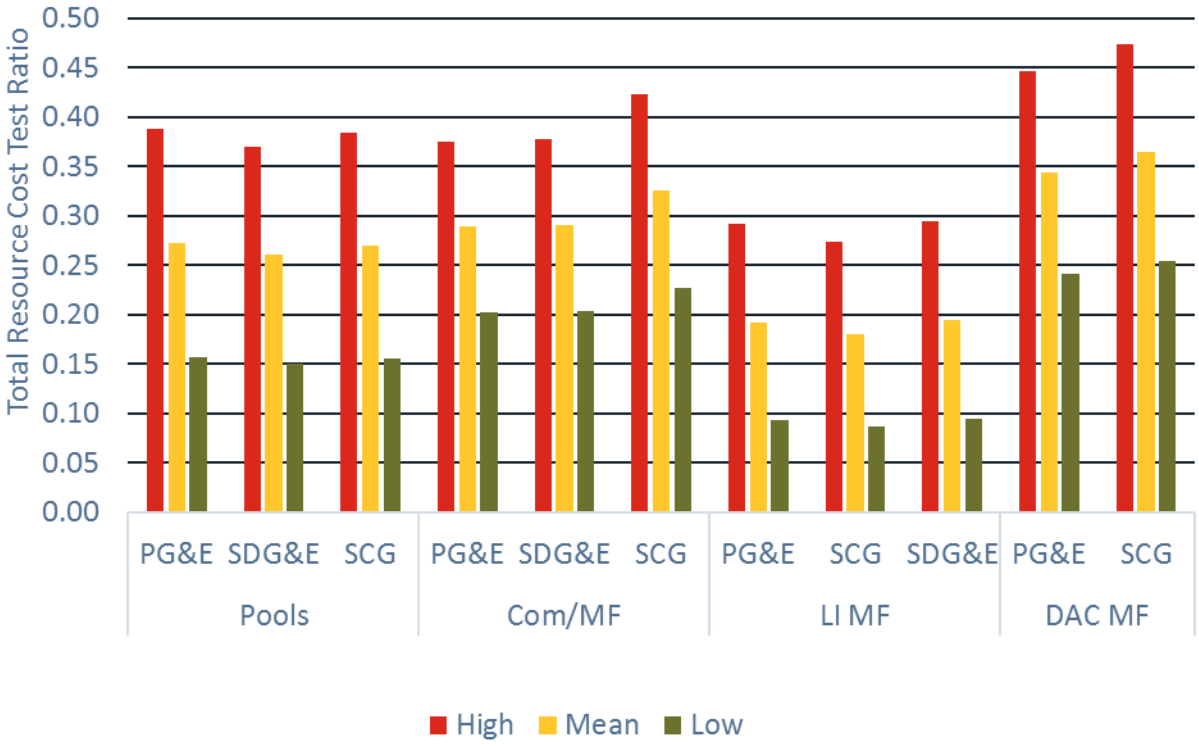


Figure 4-12 presents the commercial and multifamily PA cost test ratios by budget program, IOU, and savings realization rate. The costs for the PA cost-effectiveness ratio include the PA non-incentive and incentive costs. Typically, incentive costs are less than the measure costs, leading the PA test value to exceed the value of the TRC, as can be seen comparing Figure 4-11 and Figure 4-12. Values with a relatively high PA test ratio greater than or equal to 0.75 include the high savings estimates for smaller IFD measures with less than 10 kW_{th} capacity and larger IFG measures with more than 10 kWt_h capacity in the commercial/multifamily budget program.

FIGURE 4-12: COMMERCIAL AND MULTIFAMILY PROGRAM ADMINISTRATOR COST TEST RATIOS BY BUDGET PROGRAM AND IOU FOR THE HIGH, MEAN, AND LOW SAVINGS REALIZATION RATE

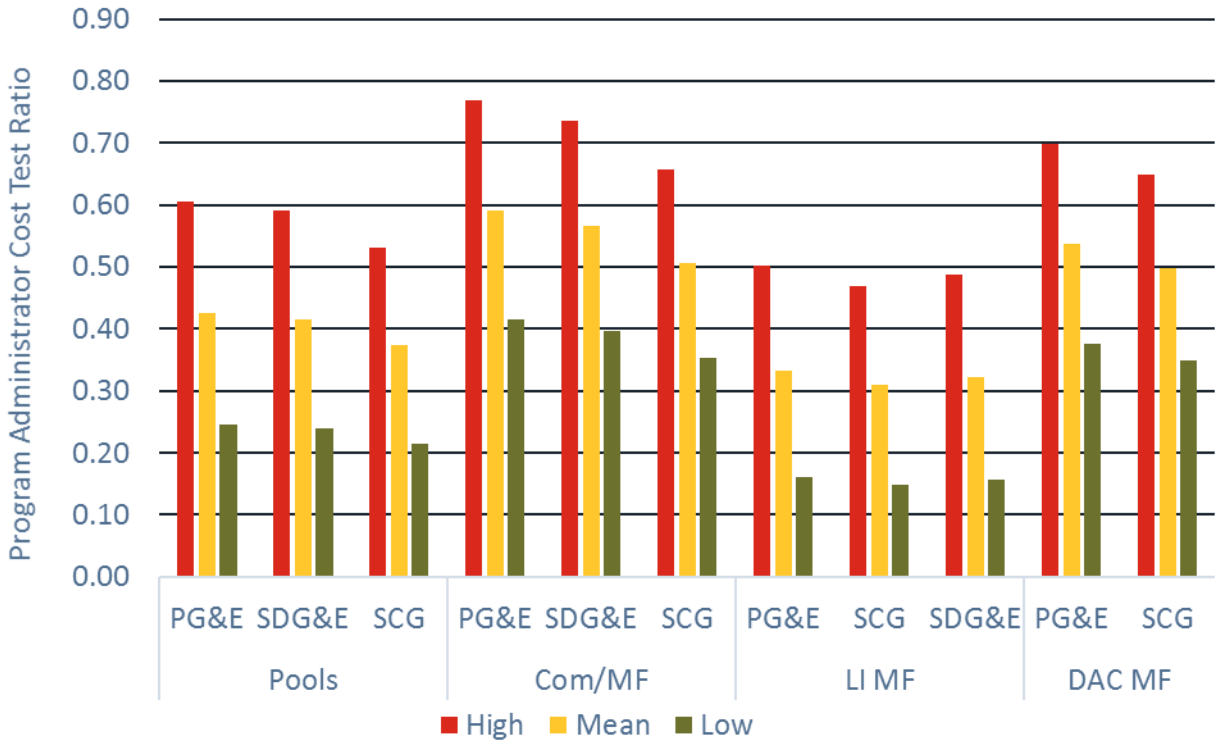


Figure 4-13 illustrates the PA cost test by technology, budget program, and technology size for the mean savings realization rate. The figure uses colors for technology similar to Figure 4-8, but groups the technologies by budget programs instead of technology type because the PA test ratios are closely related to budget program, not to technology type. The CSI-Thermal low-income program has a higher average incentive per therm savings than the other budget programs while offering technologies that have similar savings per average kW_{th}. The higher incentives in the low-income program contribute to the lower average PA ratios illustrated below.

FIGURE 4-13: COMMERCIAL AND MULTIFAMILY PROGRAM ADMINISTRATOR COST TEST BY TECHNOLOGY TYPE, BUDGET PROGRAM AND TECHNOLOGY SIZE, MEAN SAVINGS REALIZATION RATE

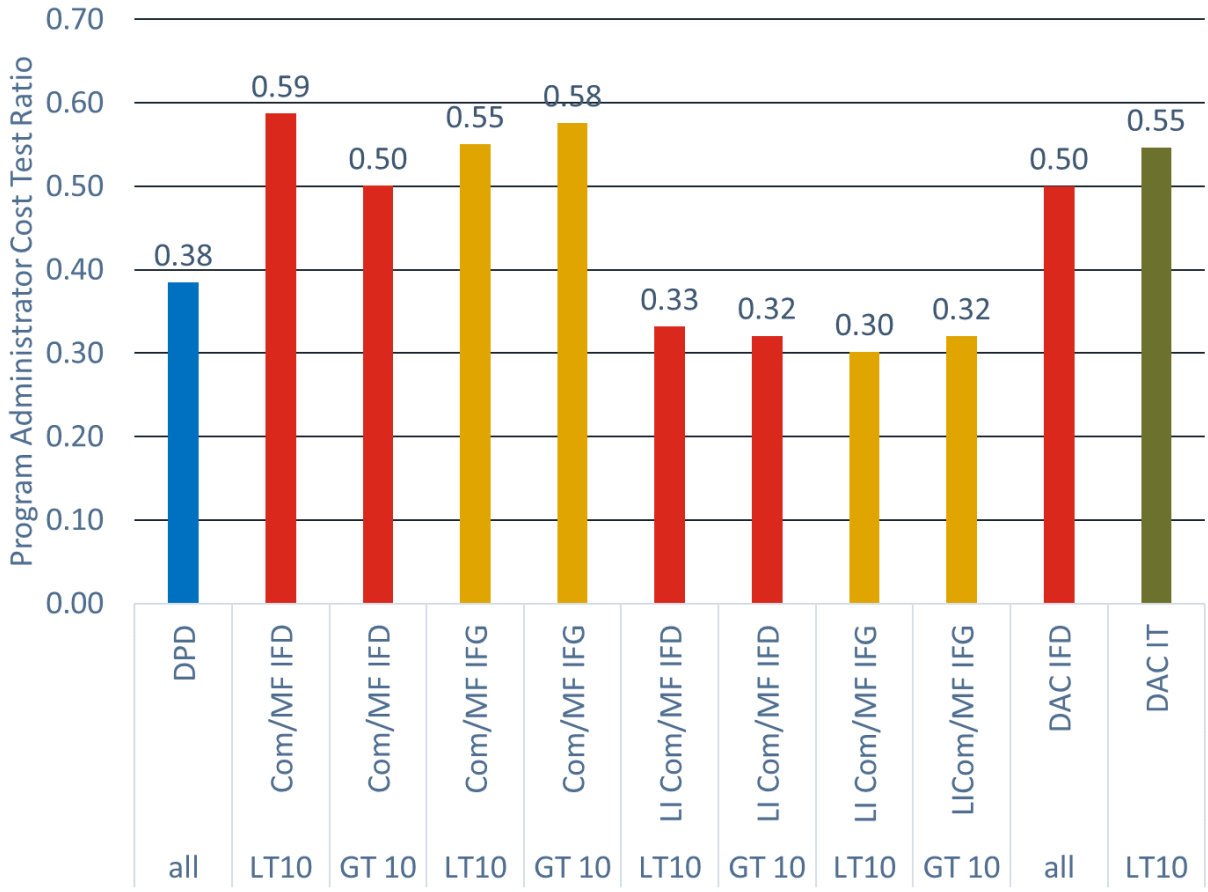
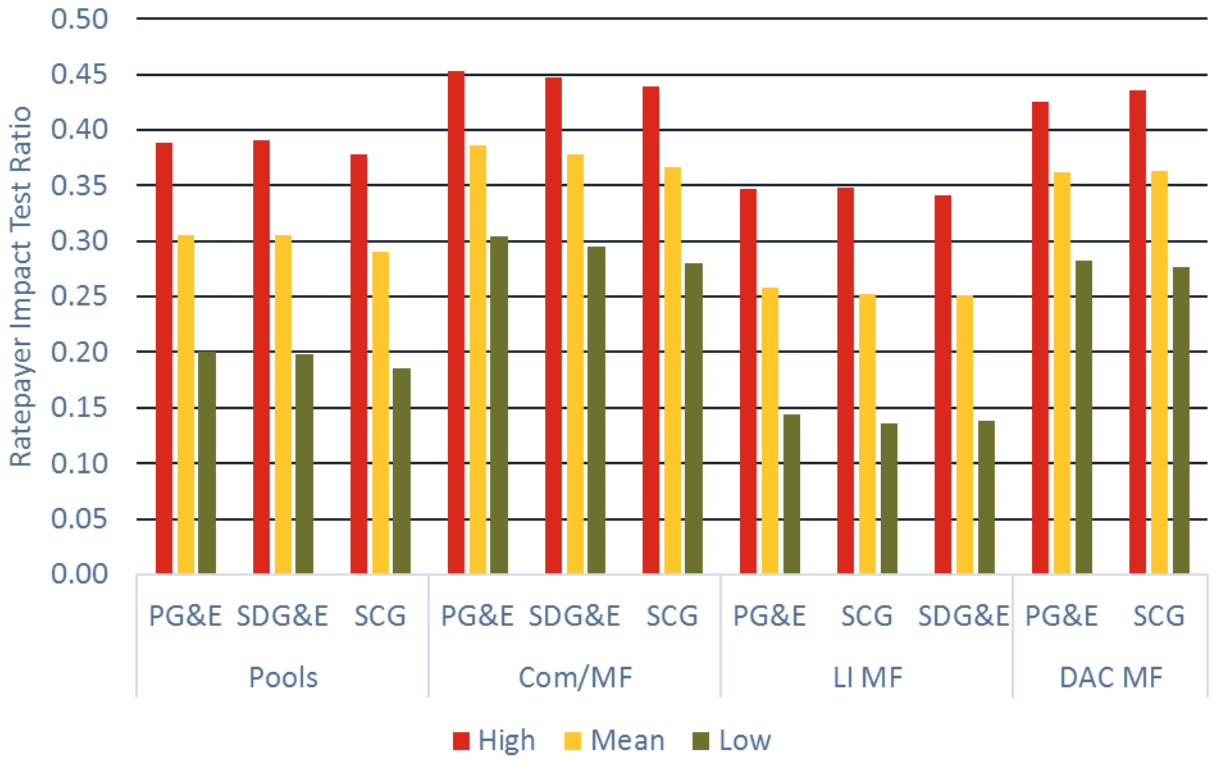


Figure 4-14 illustrates the RIM test ratios for the commercial and multifamily CSI-Thermal under the high, mean, and low realization rates. The RIM test presents the cost-effectiveness of the program from the non-participant's viewpoint. The test is like the PA test, while adding the cost of bill savings to the denominator of the cost-effectiveness ratio. As has been found for the other cost-effectiveness tests, the RIM test finds that the solar thermal water heating measures are not cost-effective.

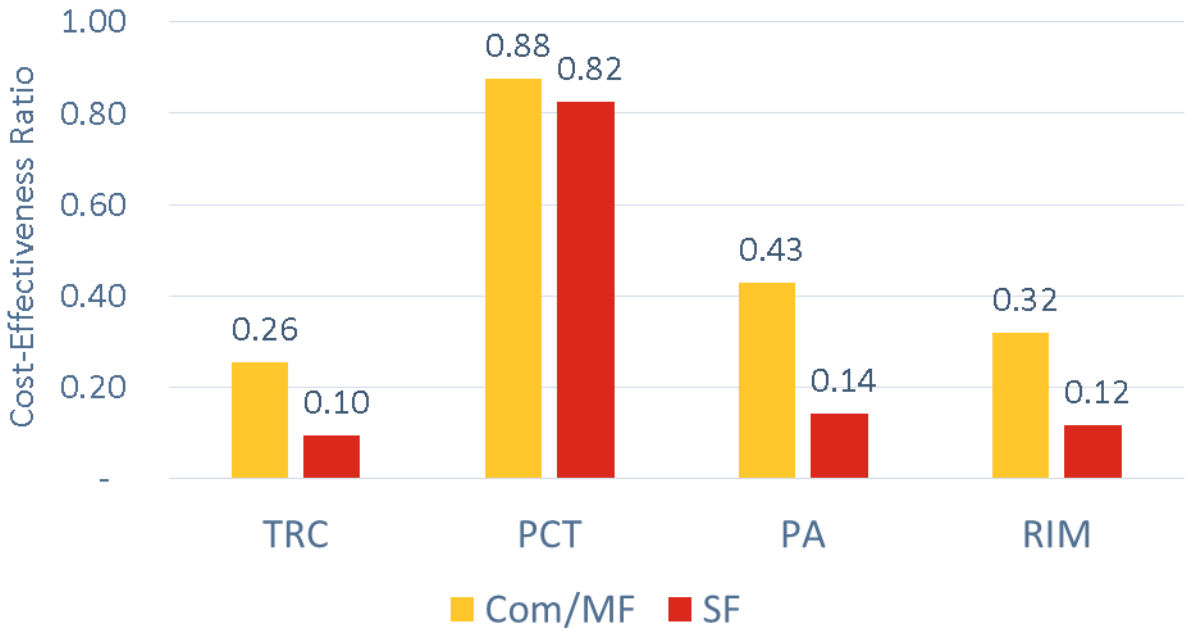
FIGURE 4-14: COMMERCIAL AND MULTIFAMILY RATEPAYER IMPACT COST TEST RATIOS BY BUDGET PROGRAM AND IOU FOR HIGH, MEAN AND LOW SAVINGS REALIZATION RATES



4.3 SUMMARY OF SOLAR THERMAL COST-EFFECTIVENESS FINDINGS

Figure 4-15 presents the average cost-effectiveness findings for the single-family and the commercial and multifamily budget programs at the mean savings realization rate. These findings indicate that the solar thermal measures are nearly cost-effective from the participant's point of view when averaged across all measures. The estimated average cost-effectiveness using the TRC, PA, or RIM test, however, does not approach cost-effectiveness when evaluated across all measures at the mean savings realization rate.

FIGURE 4-15: AVERAGE COST-EFFECTIVENESS RATIOS BY SINGLE-FAMILY AND COMMERCIAL AND MULTIFAMILY BUDGET PROGRAMS AT MEAN SAVINGS LEVEL



4.4 COST-EFFECTIVENESS SCENARIOS

The SPM cost-effectiveness tests draw from a variety of inputs. These inputs can reasonably be expected to vary over time. To investigate the potential impact of reasonable changes to those inputs, the evaluation team looked at three different scenarios:

- Scenario 0: In this scenario, incentives are set as they were in CPUC Decision 10-01-022; this scenario was intended to investigate how the cost-effectiveness of the program would have changed, had incentives been left at the levels in the decision that authorized the launch of the CSI-Thermal Program. Using those incentives and planned reductions over the course of the program, the weighted average incentive would have been $7.95 per expected annual therm

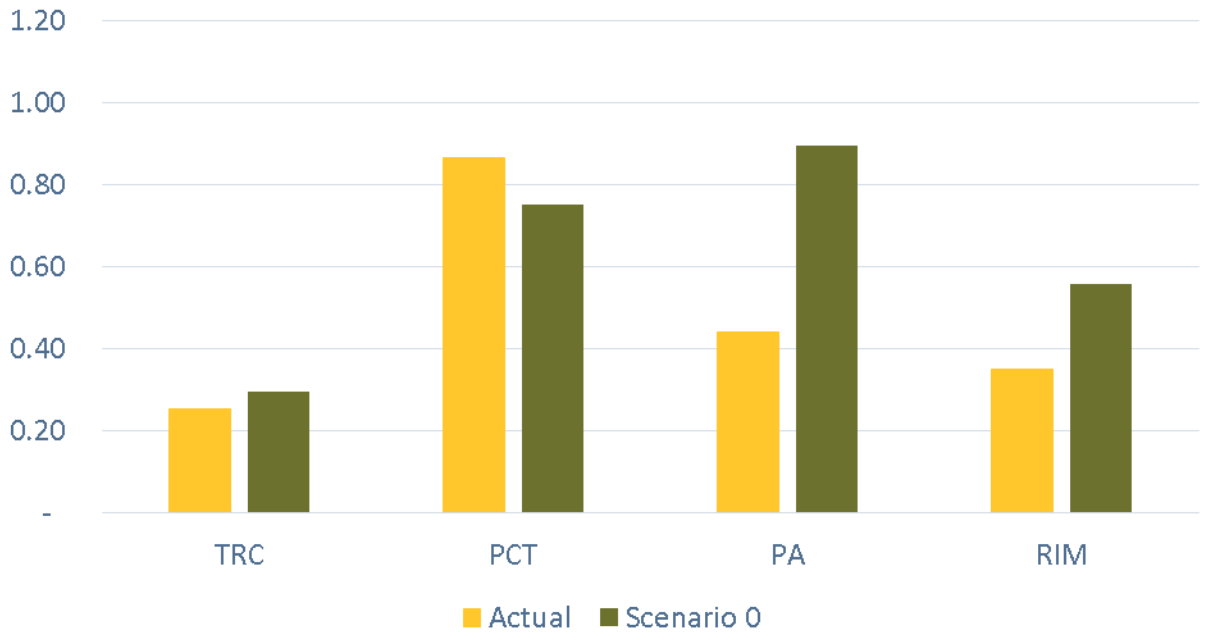
saved. Note that the decline in incentives also led to an increase in the ITC benefit available to participants.

- Scenario 1: The Self-Generation Incentive Program (SGIP) Cost-Effectiveness evaluation used a 7 percent of program budget administrative cost whereas the CSI-Thermal handbook lists an 18 percent of program budget administrative cost. Additionally, the avoided natural gas costs for 2019 are approximately 25 percent higher[33] than the 2018 avoided costs used in this evaluation. Scenario 1 investigates results with lower (7 percent) administrative costs and higher (2019) avoided natural gas costs.
- Scenario 2: This scenario builds from Scenario 1 by reducing installed costs by 30 percent and O&M costs by 50 percent. These are intended to investigate the impact or potentially lower cost or more efficient business models and technologies. Note, incentive levels were reduced where necessary to ensure that incentives are less than or equal to the measure cost.

The evaluation team focused on the commercial and multifamily budget programs for these scenarios, since those programs are closer to cost–effectiveness across the four different cost tests than other sectors and budget programs. Figure 4-16 presents cost-effectiveness results under the actual program versus the results under Scenario 0.

[33] The cover sheet for avoided natural gas for 2019 lists the following as changes from 2018 "updated commodity cost, CO2 price forecast and inflation rate."

FIGURE 4-16: SCENARIO 0 COMMERCIAL/MULTIFAMILY AVERAGE COST-EFFECTIVENESS RATIOS AT MEAN SAVINGS REALIZATION



Under Scenario 0, the impact of the lower incentives is evident, mostly in an increased PA cost ratio since most PA costs are due to incentives (either directly through participant incentives or indirectly through administrative costs associated with those incentives.) The TRC and RIM ratios both also rise in this scenario, but the PCT ratio declines. The RIM cost-effectiveness ratio increases because the fall in incentives is a reduction in costs similar to the PA cost-effectiveness ratio, while the TRC ratio increases because the decline in incentives leads to an increase in the ITC (which reduces the TRC costs). The lower incentives under this scenario would have made the program more cost-effective for some tests but the higher effective measure costs for the participant would likely have slowed enrollment and market growth. The program raised incentives from those in the original decision to drive more adoptions in response to slower-than-expected program uptake. Note that for this scenario, program administrative costs were left as they were in the handbook, which matches the decision at 18 percent of the total program budget.

Figure 4-17 presents the cost-effectiveness ratio results under Scenarios 1 and 2. TRC ratios are higher under both scenarios due to higher avoided costs and reduced program costs, and the reductions in measure and O&M costs further raise the TRC in Scenario 2. Although the mean TRC in Scenario 2 is still well below 1, the results presented in Figure 4-18 illustrate that for certain types of systems, and a high savings realization rate, the TRC can exceed 1. Scenario 1 does not change the PCT since avoided and administration costs do not factor into the PCT. Scenario 2 increases the PCT due to reduced installation and O&M costs. PA and RIM tests both increase in Scenario 1 as avoided costs increase and program administrative costs decrease. The PA ratio increases slightly in Scenario 2 because lower installation costs mean that incentives also declined as Scenario 2 constrained incentives to be less than or equal to the cost of the measure.

FIGURE 4-17: SCENARIO 1 & 2 COMMERCIAL/MULTIFAMILY AVERAGE COST-EFFECTIVENESS RATIOS, MEAN SAVINGS LEVEL

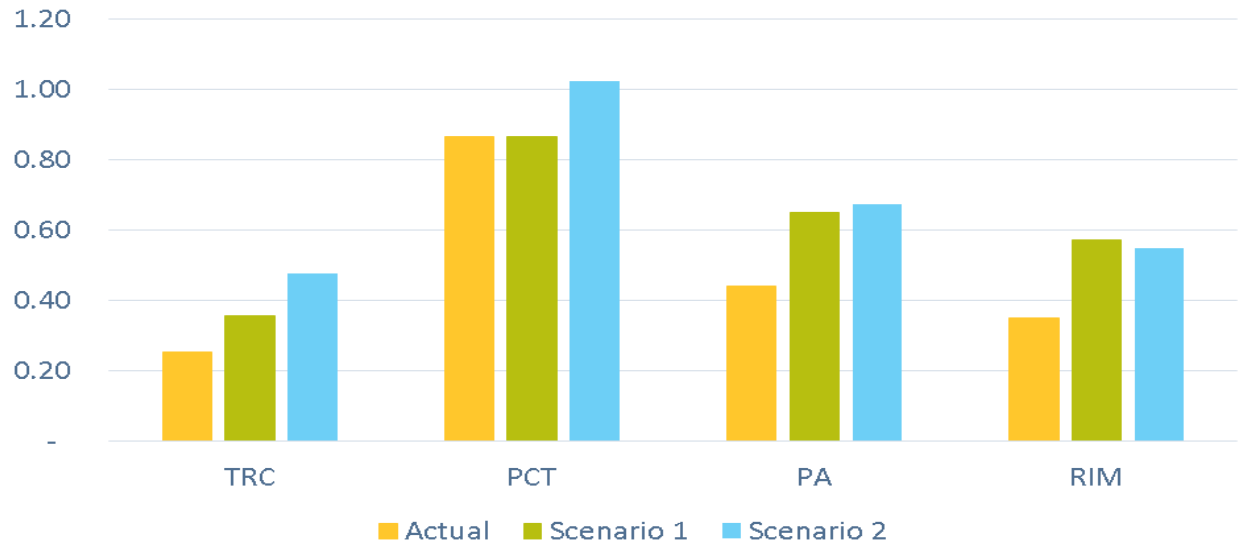
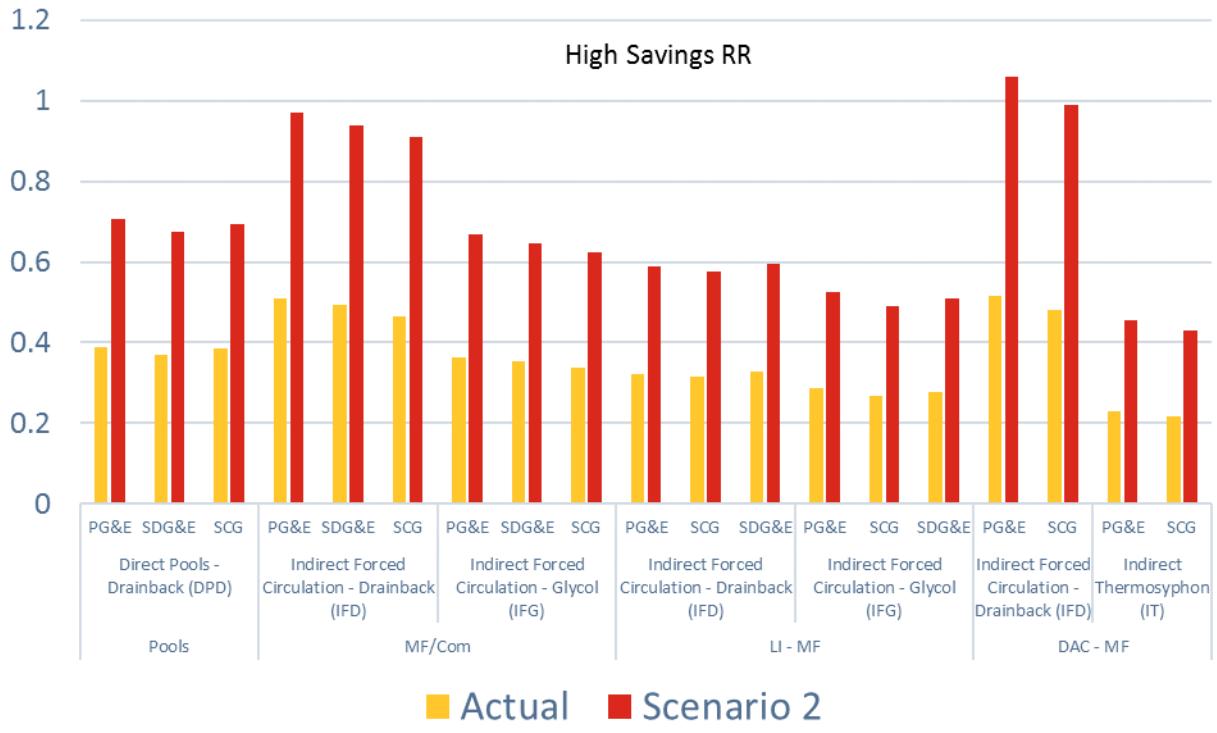


Figure 4-18 presents the technology-specific TRC ratios for Scenario 2 with high savings realization rates. Under this scenario, Drainback systems in Disadvantaged Communities (DAC) in PG&E territory have a TRC slightly larger than 1. Drainback systems across other utilities in both the general program and in DACs also show TRCs approaching 1. This indicates that high savings realization rates and updated avoided costs, coupled with targeting of lower cost technologies, reduced O&M costs, and lower administrative costs, can combine to approach cost-effectiveness in the TRC test.

FIGURE 4-18: SCENARIO 2 TOTAL RESOURCE COST TEST FOR HIGH SAVINGS REALIZATION RATE



5 PROGRAM GOALS APPROACH

This section presents the approach to evaluating the four CSI-Thermal Program goals as set forth by AB 797. The CSI-Thermal Program was established nearly a decade before AB 797 and was structured to meet the goals established by the legislation that created the program, AB 1470. AB 1470 authorized a $250 million incentive program to promote the installation of 200,000 solar thermal systems in homes and businesses that displace the use of natural gas by 2017. AB 797 built upon the goals originally set forth under AB 1470. The metrics used to assess the more recent goals will keep in mind the original intent of the program.

5.1 PROGRAM GOALS

The four program goals analyzed as part of this study shared data and approaches. Below we describe how those were applied to evaluate each goal.

5.1.1 Goal 1

Promote solar thermal systems and other technologies that directly reduce demand for natural gas in homes and businesses.

We reviewed the uptake of solar thermal systems installed via the CSI-Thermal Program using the program tracking datasets and the CSI-Thermal Impact Evaluation datasets.

- This goal was quantified by reviewing both the expected and achieved natural gas savings of solar thermal systems rebated through the program. These data were summarized and analyzed over time by the different sectors, including single-family residential, multifamily residential, commercial pools, commercial, and industrial.
- The quantity of systems installed via the program was compared to the overall market size for water heating. The market size was estimated using available datasets from the Residential Appliance Saturation Study (RASS),[34] of which the most recent was dated 2009. Due to the age of the available data, the size of the water heating market was estimated, but there is not conclusive evidence of the size of the solar thermal market.
- Further contextual information regarding the expansion of the solar thermal market was gathered and summarized via contractor and distributor surveys.

[34] https://webtools.dnvgl.com/rass2009/Query.aspx?QType=1&tabid=1

5.1.2 Goal 2

Build a mainstream market for solar thermal systems that directly reduces demand for natural gas in homes, businesses, schools, industrial, agricultural, government buildings, and buildings occupied by nonprofit organizations.

An active market includes many customers installing systems; an active business community supporting the manufacturing, distribution, and installation of systems; and systems whose costs have declined. We evaluated this goal based on analysis of program tracking data and the results of the surveys, which are described in detail below.

5.1.3 Goal 3

Solar thermal systems should be a cost-effective investment by gas customers.

This goal was evaluated based on the cost-effectiveness tests and results described earlier to determine if the current solar thermal systems that displace gas are also cost-effective to the gas customer.

5.1.4 Goal 4

Encourage the cost-effective deployment of solar thermal systems in residential, commercial, industrial, and agricultural markets and in each end-use application sector in a balanced manner.

One of the findings of the SWHPP Cost-Effectiveness Evaluation suggested that a program with a mix of participating sectors would be more cost-effective than a program aimed at single-family customers only. We evaluated this goal by determining whether the current mix of market participation is resulting in a cost-effective program by performing and summarizing the cost-effectiveness tests by each market sector. We then combined that with analysis of system installations across sectors.

5.2 DATA COLLECTION

The data used to support the assessment of the goals outlined in AB 797 are as follows

- Cost-effectiveness results from the cost-effectiveness modeling discussed earlier.
- Participation data as recorded by the utilities since the program's inception.
- Impact results from the impact study completed in 2019 to estimate savings.
- Participation surveys of customers who have installed a system since 2016. This includes residential, multifamily, and commercial participants.
- Stakeholder interviews of installation contractors, manufacturers, and distributors.

These surveys were used in combination with participation data and cost-effectiveness results to assess each of the four goals. Table 5-1 shows which goal each set of data was used to assess.

TABLE 5-1: PARTICIPANT SAMPLE DESIGN

Goal	Participation Data/Impact Results	Participation Surveys	Stakeholder Interviews	Cost-Effectiveness Modeling
Promote solar thermal to reduce natural gas	X	X	X	
Build a mainstream market to reduce natural gas usage	X	X	X	X
Solar thermal incentives to be cost-effective investment by gas customers				X
Encourage cost-effective development of solar thermal across end uses and sectors	X			X

5.3 SAMPLE DESIGN

To determine how well the CSI-Thermal Program accomplished promoting solar thermal systems and building a mainstream market for solar thermal systems, it was necessary to speak to participants and stakeholders to learn about their experiences with the program and its market.

5.3.1 Participant Surveys

To assess the solar thermal market, the study aimed to speak to 150 participants. These surveys asked questions to find out how the customers learned about solar thermal and the CSI-Thermal Program, what are the barriers to installing a solar thermal system, how participants overcame the barriers, the influence the program had on their participation, and satisfaction with the technology and the program. We compared these questions to participant surveys performed during the evaluation of the SWHPP in 2009, which asked similar questions. These surveys were planned to be broken out as follows:

TABLE 5-2: PARTICIPANT SAMPLE DESIGN

Participant Group	Sample	Population
Single-Family	64	1608
Low-Income Single-Family	80	2215
Single-Family - Disadvantaged Community	6	289*
Commercial/Multifamily	25	487
Low-Income Multifamily	25	332
Multifamily - Disadvantaged Community		100*
Commercial Pools	25	337

* Disadvantaged communities were not tracked until 2017.

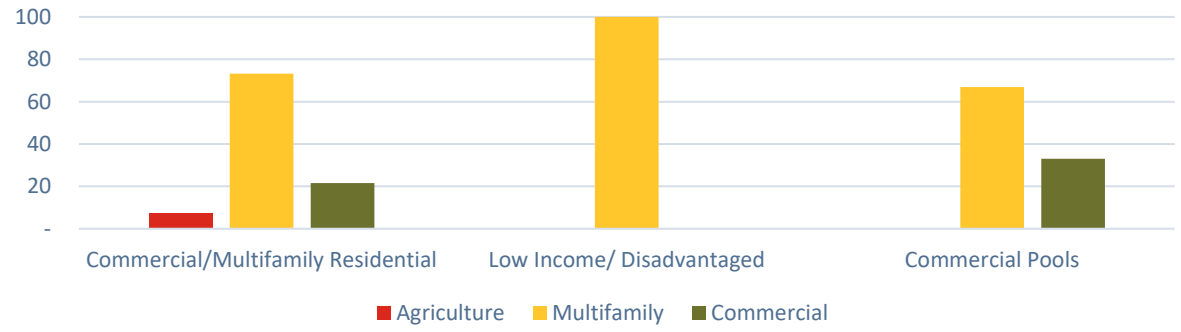
The surveys were performed across all IOUs proportional to their participation rates. The Single-Family, Low-Income Single-Family, and Single-Family Disadvantaged Communities surveys were performed proportionally based on the count of systems installed by each IOU. The survey results for Single-Family, Low-Income Single-Family, and Single-Family Disadvantaged Communities are presented with each respondent having an equal weight. The Commercial/Multifamily, Low-Income Multifamily, Multifamily Disadvantaged Community, and Commercial Pools surveys were performed proportionally based on the expected savings of the systems by IOU. The survey results were weighted to the population based on the sampling methodology for the Commercial/Multifamily, Low-Income Multifamily, Multifamily Disadvantaged Community, and Commercial Pools groups. Within each IOU, the count of surveys was further distributed to speak to participants representing large expected savings in addition to smaller expected savings. The number of surveys completed by utility were as follows:

TABLE 5-3: PARTICIPANT SURVEYS COMPLETED

Participant Group	SCG	SDG&E	PG&E
Single-Family	66	1	6
Low-Income Single-Family	64	0	7
Single-Family – Disadvantaged Community	6	0	0
Commercial/Multifamily	15	3	9
Low-Income Multifamily & Multifamily – Disadvantaged Community	12	3	10
Commercial Pools	16	3	3

Within the Commercial/Multifamily and the Commercial Pool participant groups, there was a mix of agriculture, commercial, and multifamily respondents, as shown in Figure 5-1. All respondents in the Low-Income and Disadvantaged Community participant groups were multifamily.

FIGURE 5-1: SECTORS WITHIN THE COMMERCIAL AND MULTIFAMILY PARTICIPANT GROUPS



5.3.2 Stakeholder Surveys

In addition to the participant surveys, the study also aimed to speak to 50 contractors/installers and manufacturers/distributors. These interviews asked questions to determine how the market has evolved since the program's inception. The surveyors asked questions about how stakeholders perceive the current state of the market and how it has evolved since they began participating in the program. The interview included questions about barriers to installing solar thermal and participating in the program. The interview also touched on training for employees and the permitting process, as these were initial goals set forth for the program. These questions determined the types of contractors participating and how they saw the outlook of solar thermal. Like with the participant surveys, responses to these interviews were compared to the in-depth interviews performed as part of the evaluation of the SWHPP.

The sample design for these surveys was as follows:

TABLE 5-4: STAKEHOLDER SAMPLE DESIGN

Stakeholder	Sample	Population
Contractors/Installers	30	126
Manufacturers	Census (attempted)	22

The completed surveys for the stakeholders were as follows:

TABLE 5-5: STAKEHOLDER SURVEYS COMPLETED

Stakeholder	Sample
Contractors/Installers	30
Manufacturers	10

6 PROGRAM GOALS RESULTS

This section evaluates each of the four program goals set forth by AB 797 in order to investigate how the CSI-Thermal Program has performed according to AB 797's performance metrics.

Each subsection presents or refers to the data and analysis used to evaluate the program based on the metrics for each goal. At the end of this section, some of the market characteristics that were found during the survey are presented in comparison to the Solar Water Heating Pilot Program (SWHPP) survey responses to give further insight into the overall market of solar thermal systems.

6.1 GOAL 1

Promote solar thermal systems and other technologies that directly reduce demand for natural gas in homes and businesses.

Is the CSI-Thermal Program promoting solar thermal systems that reduce natural gas consumption? Successful promotion would result in growth of solar thermal system installs coupled with evidence the program was responsible for much or all of that growth.

6.1.1 Assessment Approach

The uptake of solar thermal systems incentivized through the CSI-Thermal Program was reviewed using the program tracking datasets and the CSI-Thermal Impact Evaluation datasets. First, this goal was quantified by summarizing the reduction in demand for natural gas from program installations. Next, the results of the telephone surveys were used to determine if these systems were installed due to the program. The results of the telephone survey were compared to the telephone survey performed 10 years ago during the SWHPP. This comparison provides further insight to the program's influence over time.

6.1.2 Installation of Solar Thermal Systems

To assess this goal, the participation since the program's inception is shown in Figure 4-1 below. Initially, the program was only eligible for single-family and multifamily residential customers. In 2012 and 2013, low-income multifamily and single-family incentives were added to the program. In 2014, water heating for pools was added. The final change to the program occurred in 2017 when the focus on disadvantaged communities and low-income was increased as a result of AB 797.

Figure 6-1 shows that the participation increased in alignment with changes to the program offerings. This suggests that the program was successful in promoting solar thermal systems to these market segments.

FIGURE 6-1: CUMULATIVE SOLAR THERMAL SYSTEM INSTALLATION COUNTS

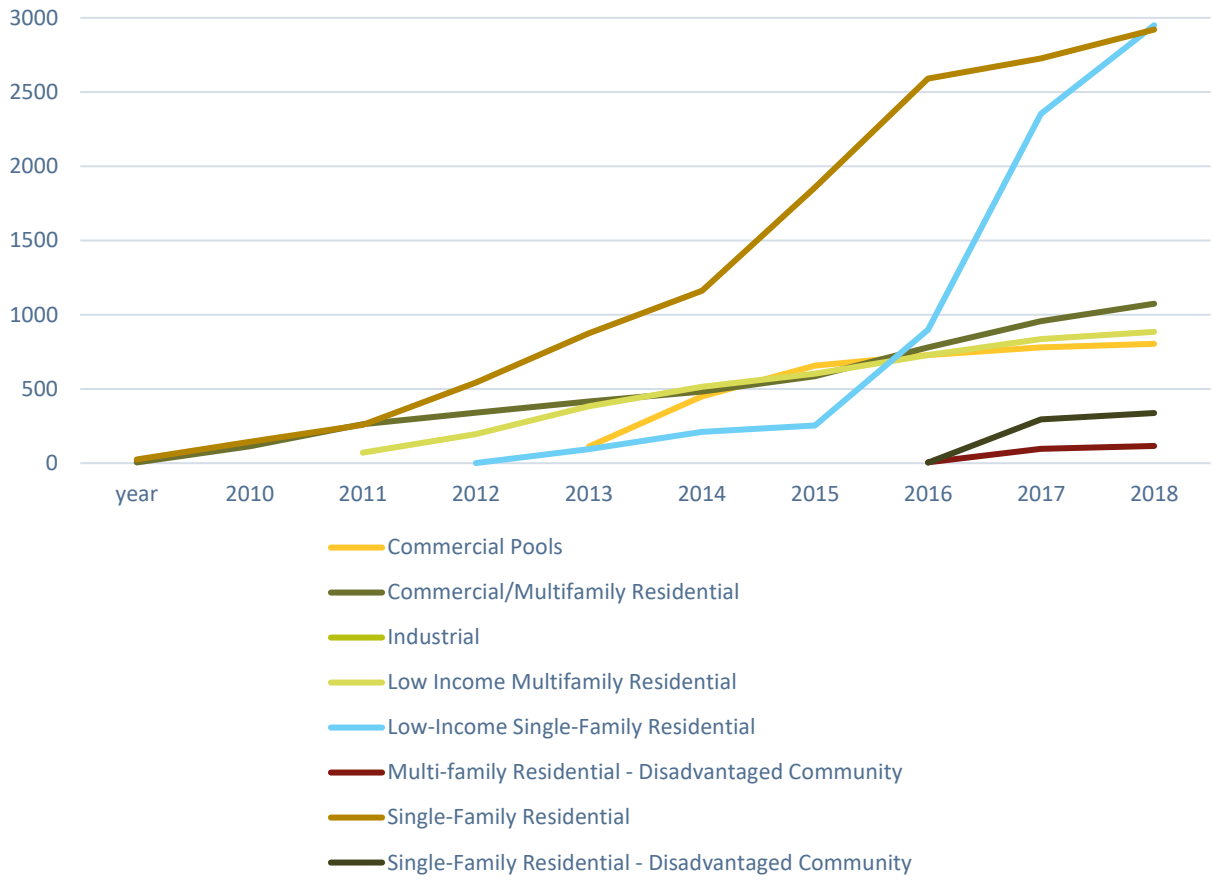
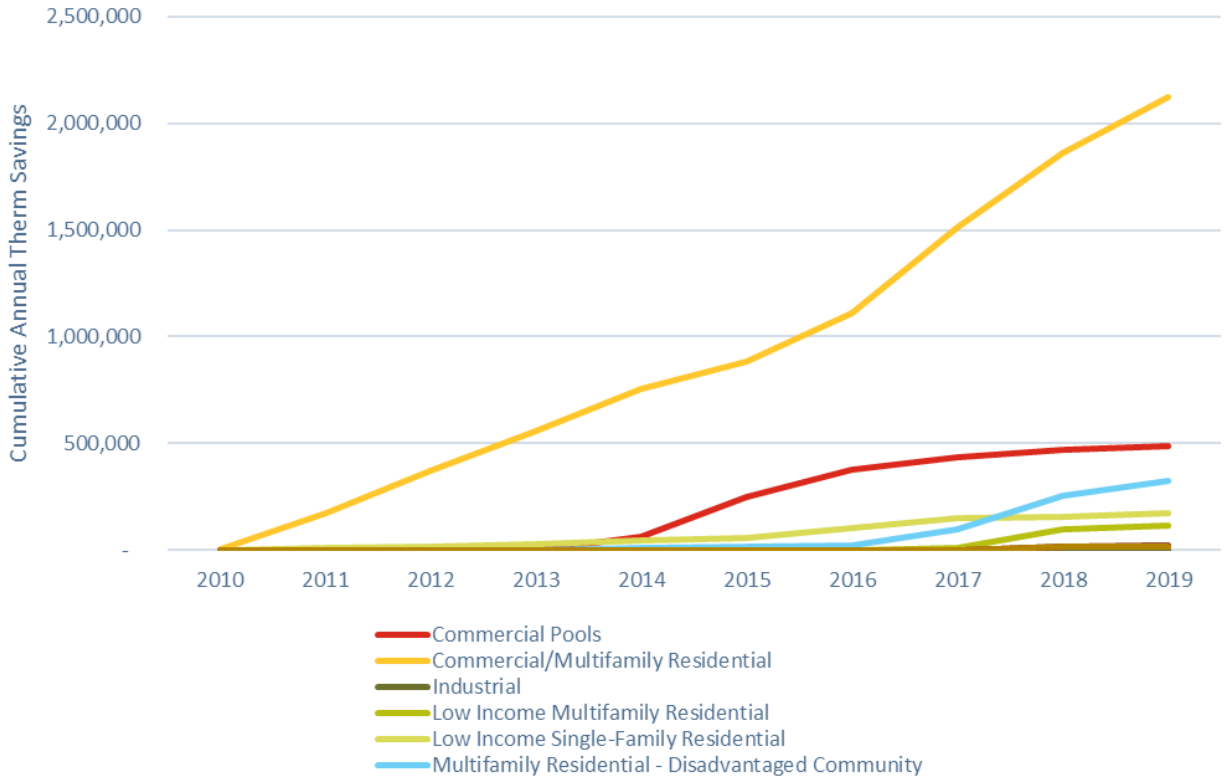


Figure 6-2 shows the cumulative solar thermal expected therm savings with the mean GRR applied.

FIGURE 6-2: CUMULATIVE ANNUAL SOLAR THERMAL SYSTEM ACTUAL THERMS SAVED



While the program was successful in achieving gas savings in the targeted markets, the program only encouraged solar thermal system installations in a relatively small portion of the California IOU populations. The overall market size for customers with gas water heating was estimated using available data from the RASS (cited in Section 5). This study was dated in 2009; therefore, the data do not provide conclusive evidence of the size of the solar thermal market itself. However, they do provide a reasonable estimate of the overall size of the water heating market. It should be noted that SWH installations have many specific requirements that can limit the viability of installation; therefore, it is not possible for 100 percent saturation. There are over 5.3 million single-family homes with gas water heating in the IOU territories of California. With a total of 6,209 single-family participants in the CSI-Thermal Program, approximately 0.12 percent of the population was touched by the program. At the time of the RASS in 2009, 6,163 customers were reported to have solar thermal in their homes. Therefore, the program adding 6,209 systems doubled the quantity of single-family solar thermal installed in California to over 12,000 systems. Comparing these counts to the market size showed that the California solar thermal market is still a small market. The population of multifamily buildings in California IOU territory with gas

water heating was approximately 215,000 at the time of the RASS. With 1,812 participating multifamily homes,[35] this is approximately 0.84 percent of the population. At the time of the RASS, 542 multifamily customers were reported to have solar thermal. Therefore, the program more than tripled the quantity of solar thermal systems installed in at multifamily locations in California.

6.1.3 Influence of the Program on Promoting Solar Thermal Installations

The program incentivized the installation of systems that directly save natural gas for customers. The next key question is how much influence did the program have on driving those installations? Additionally, for the goal of growing a solar marketplace, how has that influence changed over time since the SWHPP in San Diego a decade ago? Changes over time could indicate movement towards a more mainstream market.

Single-Family Residential Participant Groups

The influence of the CSI-Thermal Program has increased since the initial pilot program. As shown in Figure 6-3, less than 30 percent of participants in the current program year considered installing a solar thermal system prior to learning about the program, which is the opposite finding of the participants in the pilot program. This suggests that the pilot participant population contained more early adopters and the current participant population contained more participants who were unlikely to install solar thermal without the program.

[35] This includes all homes in the Low-Income Multifamily and Disadvantaged Communities participant groups and the multifamily participants in the Multifamily/Commercial group (i.e., identified using the reported load profiles of Apartment/Condos, Men's Dormitories, Women's Dormitories, Retirement/Nursing Homes, Military Barracks, and Coin Op Laundry).

FIGURE 6-3: HAD YOU BEEN CONSIDERING INSTALLING SOLAR THERMAL BEFORE HEARING ABOUT THE PROGRAM?

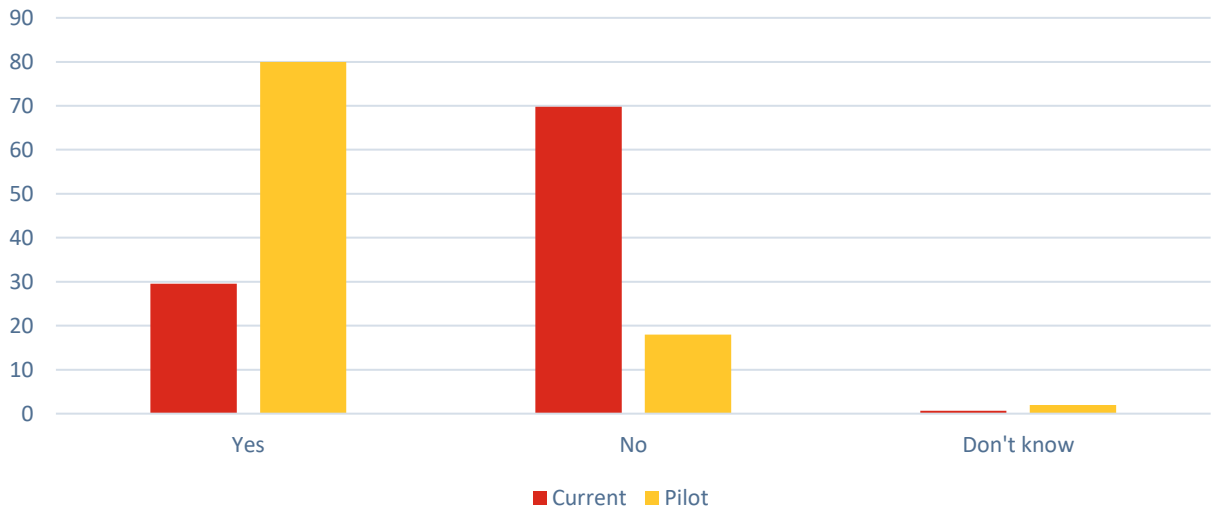
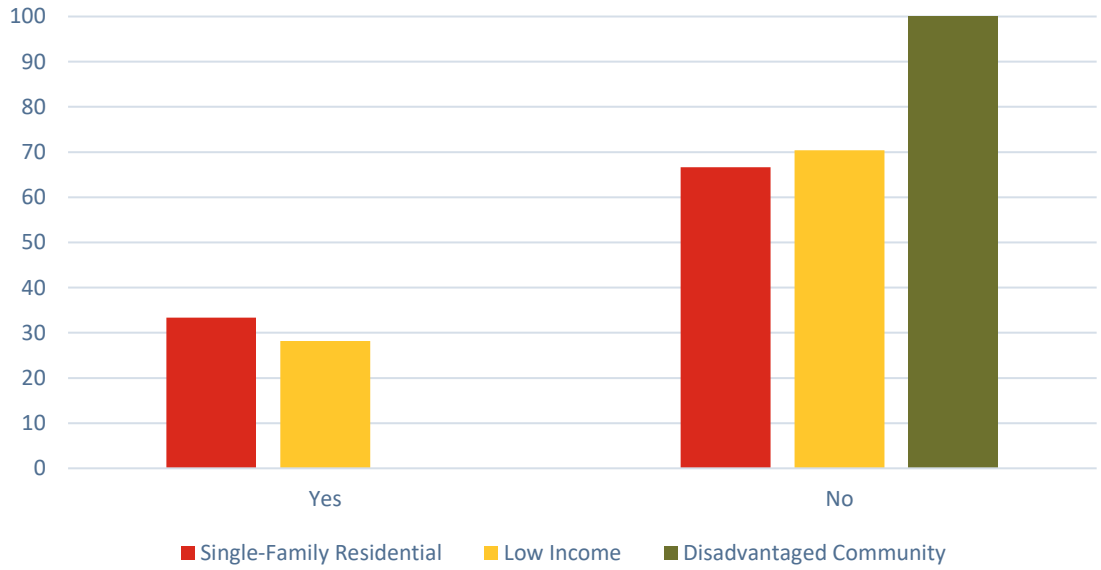


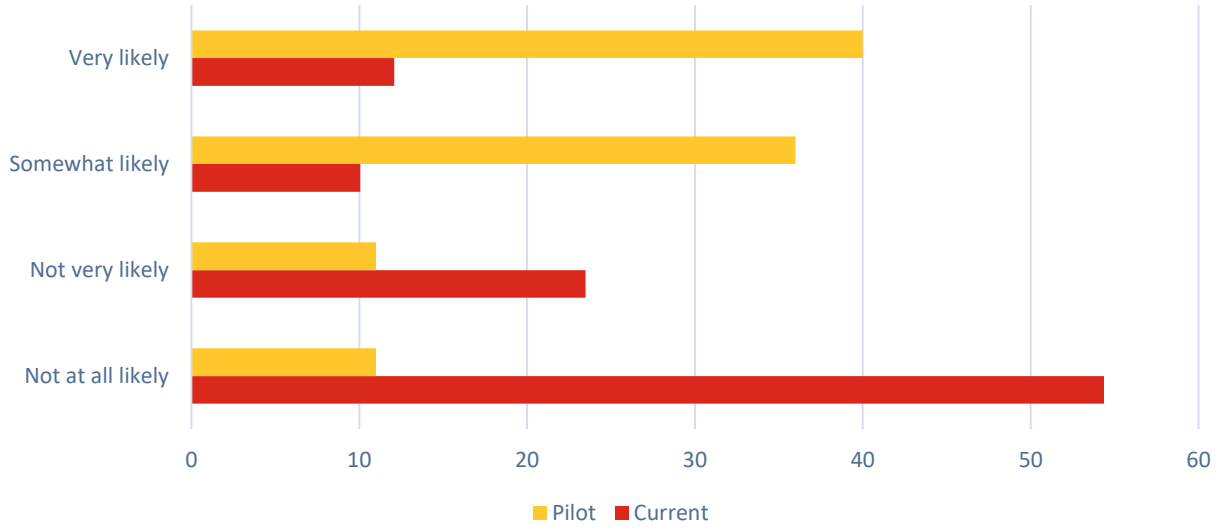
Figure 6-4 shows the results of the questions split up by participation group. The low-income and disadvantaged communities were the least likely to have been considering installing solar thermal before hearing about the program. These markets are sometimes considered "hard-to-reach" by energy programs.

FIGURE 6-4: HAD YOU BEEN CONSIDERING INSTALLING SOLAR THERMAL BEFORE HEARING ABOUT THE PROGRAM?



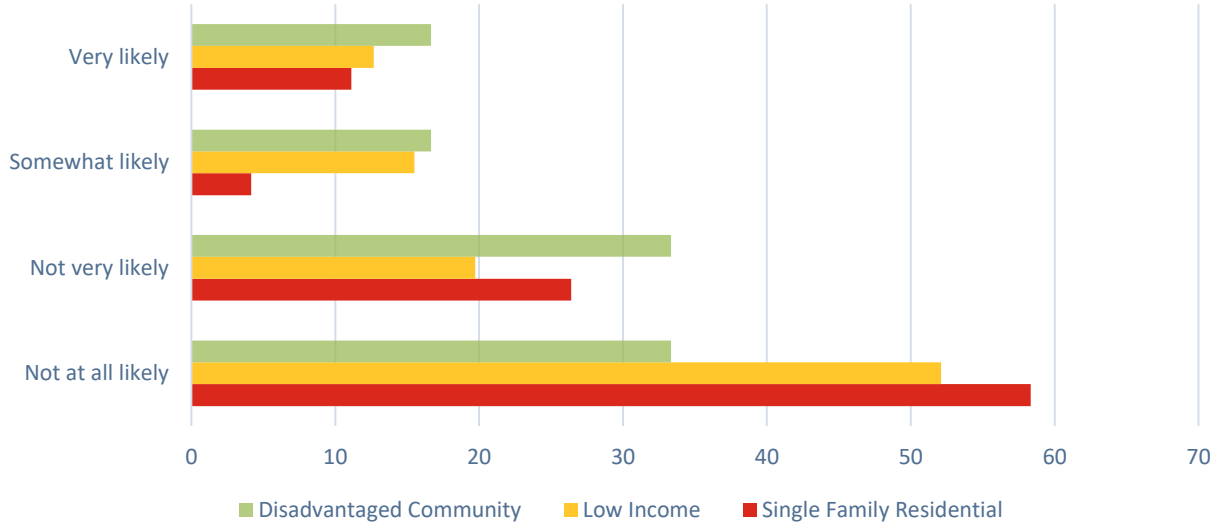
Given that the current participants include a harder-to-reach market, including low-income and disadvantaged communities, the findings in Figure 6-5 are not surprising. The figure shows that over 50 percent of current participants would not have installed solar thermal without the program. When asked how they first heard about the CSI-Thermal Program, almost 25 percent of participants responded that they learned about the program from a door-to-door representative. This suggests that the recent methods of capturing participation were aimed at reaching a target market that is not easily reached via other forms of marketing, such as internet/television/radio advertisements or even their contractors.

FIGURE 6-5: WITHOUT THE PROGRAM, HOW LIKELY WOULD YOU HAVE BEEN TO INSTALL SOLAR THERMAL?



Reviewing the likelihood to install solar thermal without the program by participant group, it is again shown that none of the three residential groups was very likely to install solar thermal without the program. While it seems that the disadvantaged communities are most likely to install without the program, it should be noted that only six participants were surveyed, and those results may not represent the full population of disadvantaged communities.

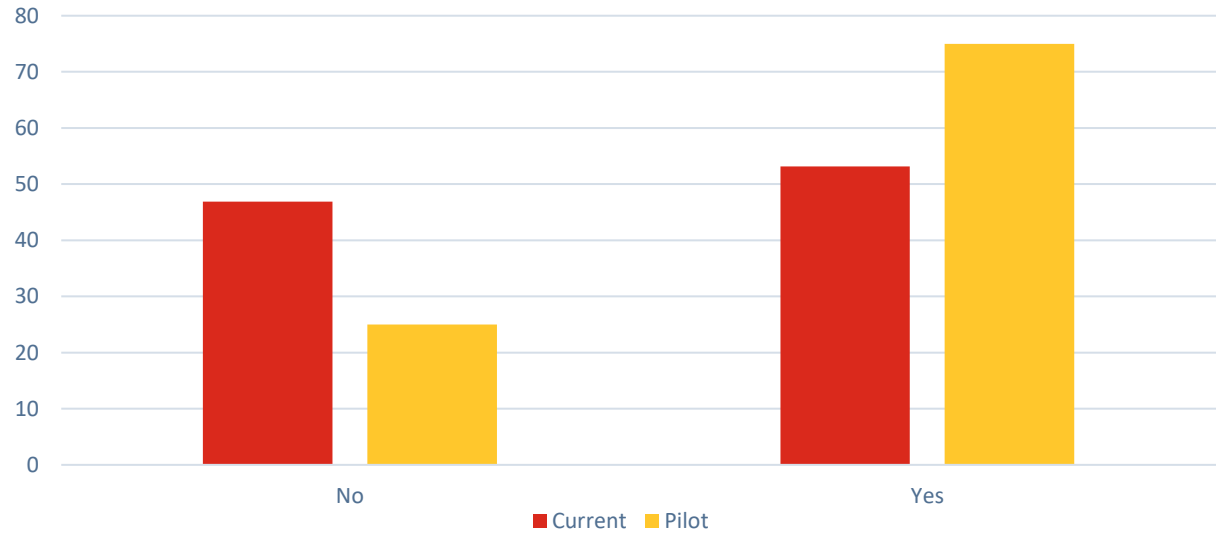
FIGURE 6-6: WITHOUT THE PROGRAM, HOW LIKELY WOULD YOU HAVE BEEN TO INSTALL SOLAR THERMAL?



Multifamily Residential/Commercial Pools Participant Groups

Like the single-family findings, fewer Multifamily and Commercial Pools participants were considering installing solar thermal before hearing about the program than the pilot program participants. This shows that the current program was also targeting a group of customers less likely to be early adopters in these participant groups.

FIGURE 6-7: HAD YOU BEEN CONSIDERING INSTALLING SOLAR THERMAL BEFORE YOU HEARD ABOUT THE PROGRAM?



Comparing the responses for current participants between participation groups, the low-income and disadvantaged communities were most likely to consider installing solar thermal before they heard about the program.

FIGURE 6-8: HAD YOU BEEN CONSIDERING INSTALLING SOLAR THERMAL BEFORE YOU HEARD ABOUT THE PROGRAM?

6.1.4 Goal Assessment

The CSI-Thermal Program has incentivized the installation of thousands of solar thermal systems that drive natural gas savings for participants. Additionally, many of these participants report that the CSI-Thermal Program was a significant contributor in their decision to install solar thermal. The combination of those two factors makes it readily apparent that the CSI-Thermal Program has been promoting the installation of solar thermal systems that reduce participants' demand for natural gas.

6.2 GOAL 2

Build a mainstream market for solar thermal systems that directly reduces demand for natural gas in homes, businesses, schools, industrial, agricultural, government buildings, and buildings occupied by nonprofit organizations.

Is the CSI-Thermal Program building a mainstream market for solar thermal systems? An active market should include many customers installing systems; an active business community supporting the manufacturing, distribution, and installation of systems; and systems whose costs have declined.

6.2.1 Assessment Approach

This goal is evaluated based on feedback from participants and stakeholders from each participant group over the last three program years. To assess how the program is building a mainstream market for solar thermal systems, the surveys were used to learn

- Why participants decided to install a solar thermal system – a mainstream market is more likely driven by financial motives.
- How the program addresses the barriers to installation – are the barriers being overcome?
- How satisfied the customers are with their systems – significant customer dissatisfaction could indicate that the market will be difficult to sustain and be mainstream.
- The perceived effects of the program on the market from the perspectives of the stakeholders – progress towards a mainstream market would mean a reduced need for incentives.

The results of the survey were further compared to the survey performed during the pilot program to assess how the market has changed over time. Pilot program surveys were completed in 2010.

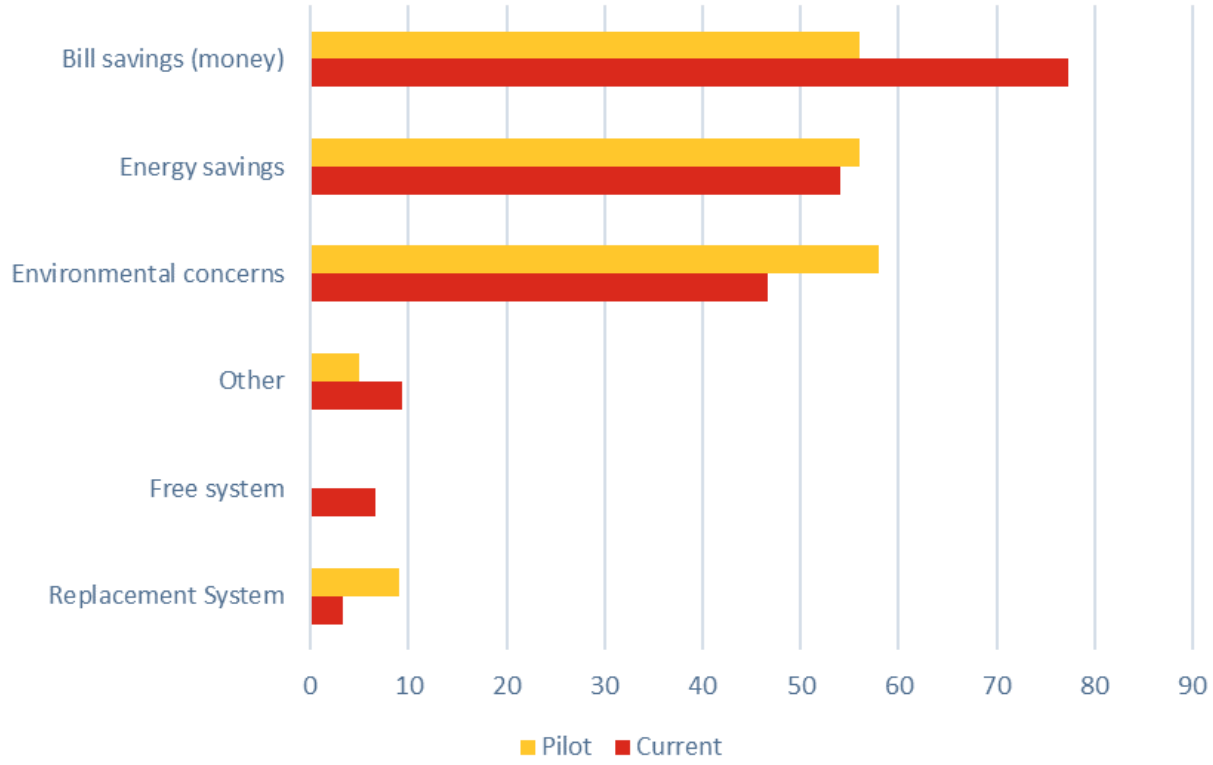
6.2.2 Installation Motives

Single-Family Residential Participant Groups

The Single-Family Residential participation groups were more driven by money savings and/or receiving a free system than the participants of the pilot program (see Figure 6-9 below). This finding indicates that pilot participants were more likely to be early adopters interested in environmental concerns and suggests that participation is moving beyond early adopters to a more mainstream market. It should be noted that bill savings, energy savings, and even environmental concerns are interrelated. Respondents were allowed to provide multiple responses during both the pilot survey and the current participant survey. Therefore,

an increase in the percentage who cited bill savings as a driver in the current survey indicates this is a more prevalent driver now than during the pilot.

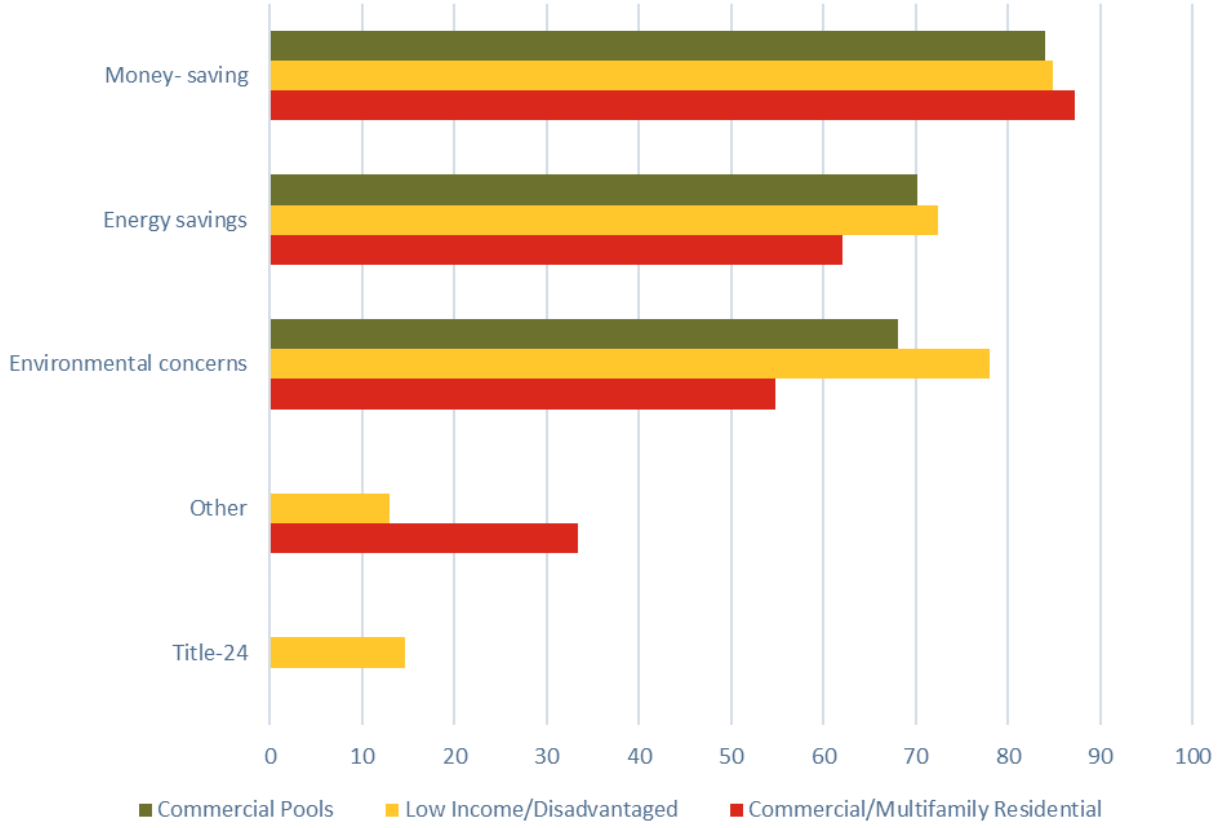
FIGURE 6-9: WHAT MADE YOU DECIDE TO INSTALL SOLAR THERMAL?



Multifamily Residential/Commercial Pools Participant Groups

All three non-single-family participation groups were most driven to install solar thermal to save money, followed by energy savings and environmental concerns. Again, this may indicate progress towards a self-sustaining market driven by economic forces as installations are moving beyond early adopters.

FIGURE 6-10: WHAT MADE YOU CONSIDER INSTALLING SOLAR THERMAL?



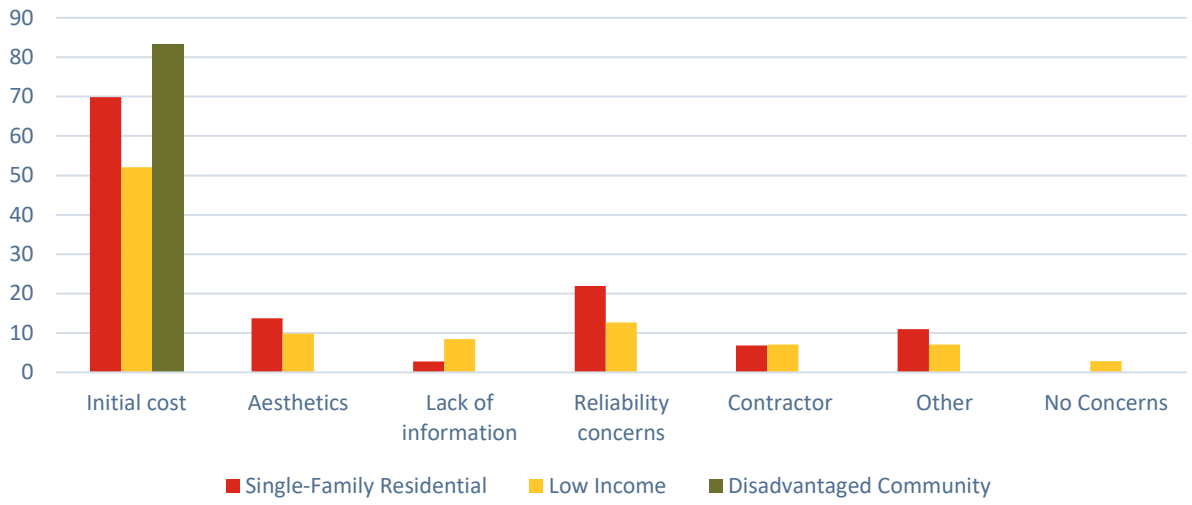
6.2.3 Barriers to Adoption

As part of the participant surveys, each participation group was asked about their concerns with installing a solar thermal system. These perceived barriers to adoption provide insight into what customers are thinking prior to installations and what the program needs to overcome to achieve a sustainable solar thermal market.

Single-Family Residential Participant Groups

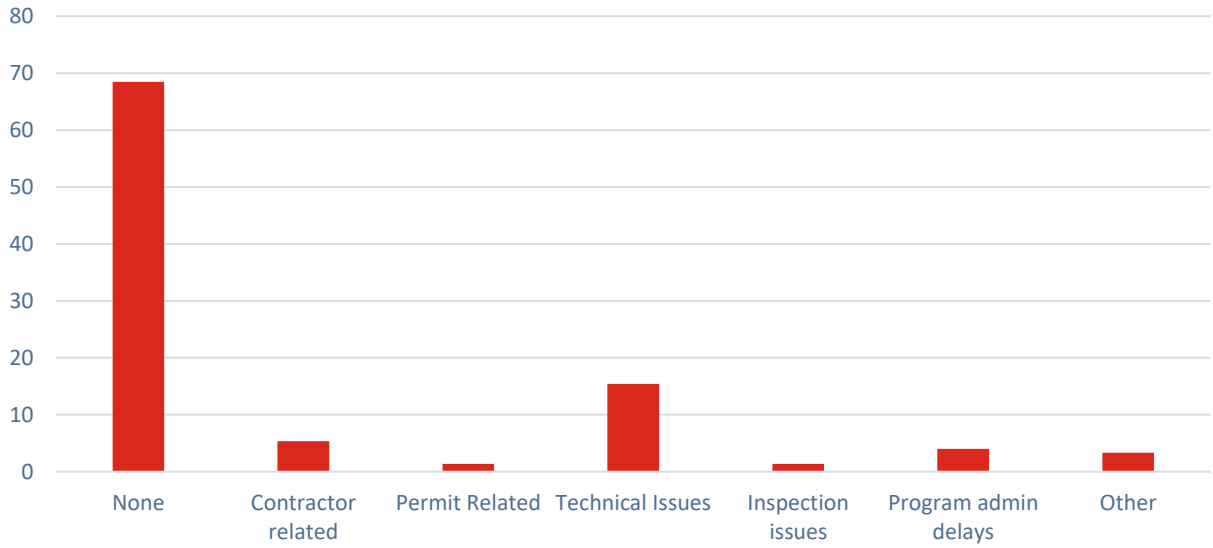
Across all Single-Family Residential participant groups, the greatest barrier to installing a solar thermal system was the initial cost. This concern was addressed by customers receiving more information through the program and/or their contractor about the incentive provided by the program to reduce this cost.

FIGURE 6-11: WHAT CONCERNS WERE ADDRESSED BY THE PROGRAM TO ENCOURAGE YOU TO INSTALL SOLAR THERMAL?



After deciding to participate in the program, most Single-Family Residential customers did not have any hurdles during the installation and rebate process. The most frequent hurdle was due to technical issues during the installation process that were resolved by their contractors. During the contractor interviews, the contractors expressed that their least favorite aspect of the program was the paperwork and program administration, suggesting that they maybe have taken the brunt of other types of issues.

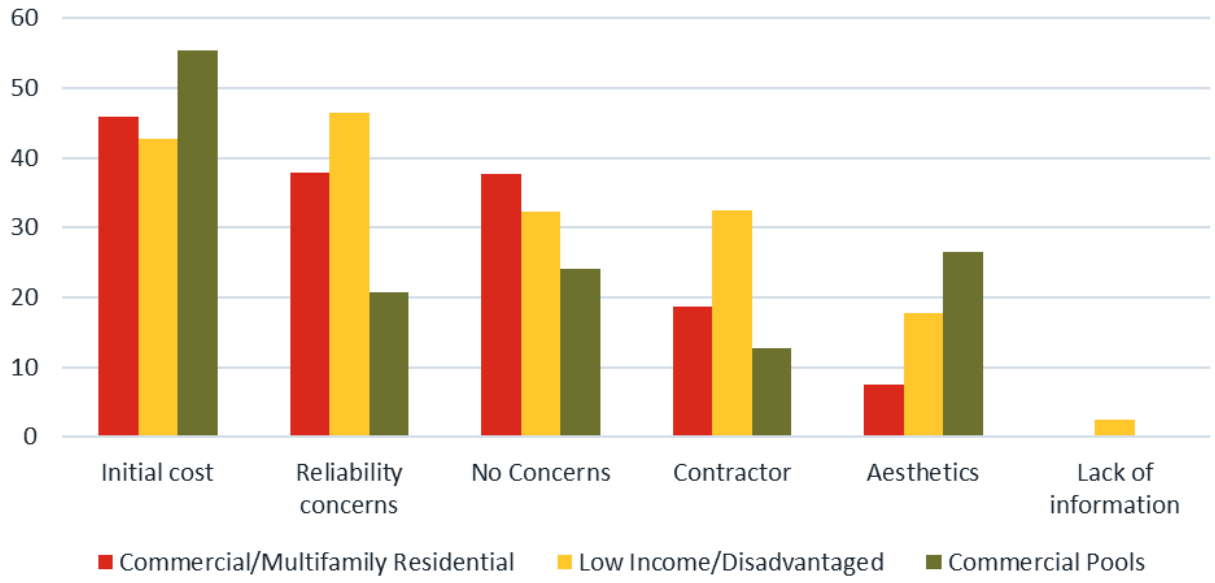
FIGURE 6-12: WHAT WERE THE BIGGEST HURDLES IN INSTALLING YOUR SOLAR THERMAL SYSTEM AND GOING THROUGH THE REBATE PROCESS?



Multifamily Residential/Commercial

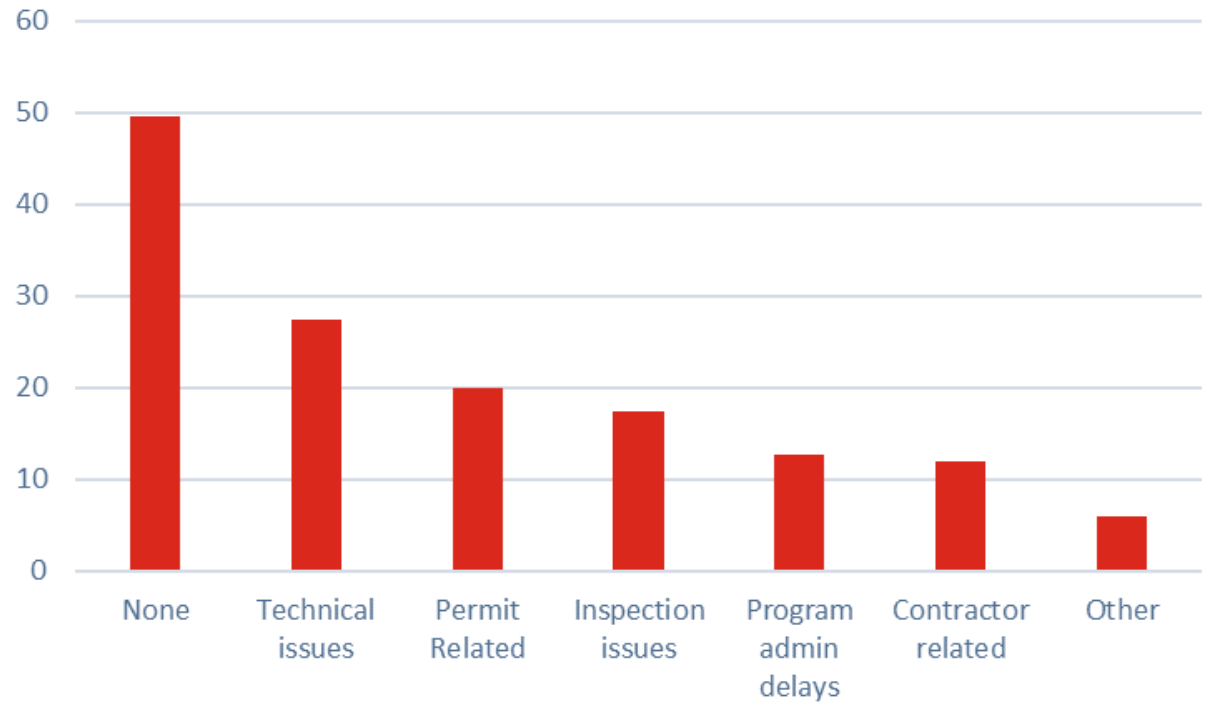
The Multifamily and Commercial participant groups were also concerned with the initial cost of the system, but they also had an increased concern on the reliability of the system, the contractor's experience, and the aesthetics of the system. This suggests that these participant groups' barriers are overcome by both the program incentive and increased education about the reliability of the systems and contractor experience.

FIGURE 6-13: WHAT CONCERNS WERE ADDRESSED BY THE PROGRAM TO ENCOURAGE YOU TO INSTALL SOLAR THERMAL?



During the installation of the system, over 25 percent of the customers in the Multifamily and Commercial segments had technical issues during the installation. Over 10 percent had issues with either their contractor, the permitting process, the inspection, or other program administrative issues. These were overcome mainly by the contractor handling the hurdle directly.

FIGURE 6-14: WHAT WERE YOUR BIGGEST HURDLES IN INSTALLING SOLAR THERMAL?



6.2.4 Participant Satisfaction

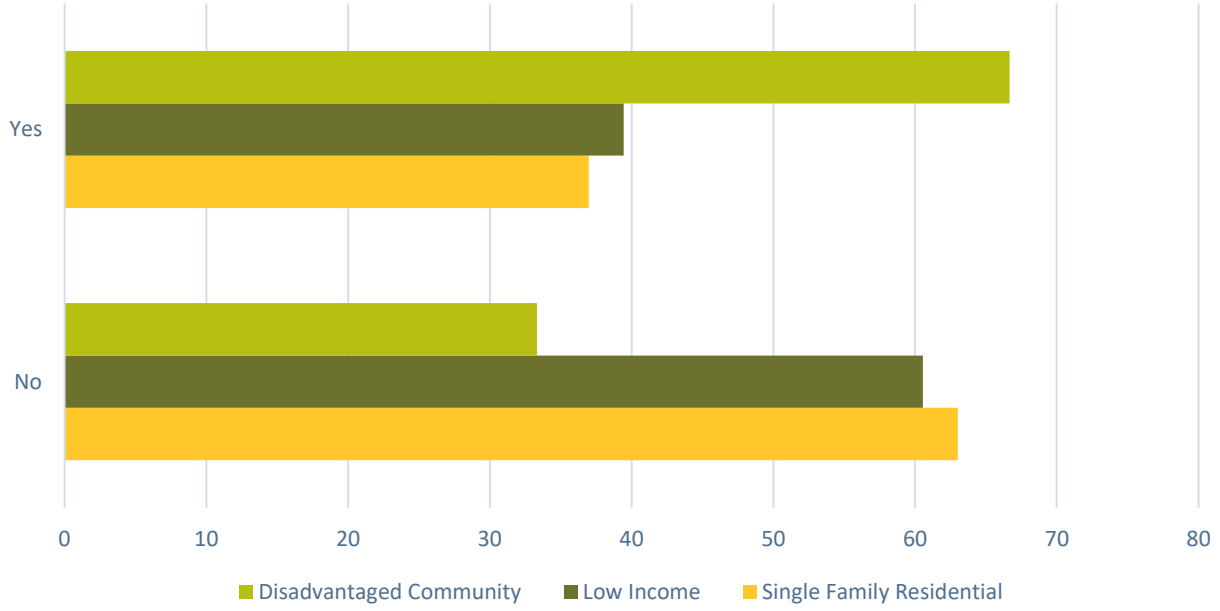
Participant satisfaction with the solar thermal technology is an important aspect to ensure that the solar thermal market would remain healthy in the absence of the program. Word of mouth and general consumer satisfaction is necessary to create a sustainable market for solar thermal systems. As discussed in the following sections, participants across all participant groups were generally satisfied with their solar thermal system.

Single-Family Residential Participant Groups

The Single-Family Residential participant groups were largely very satisfied with the technology. Of the single-family participant groups, those in the disadvantaged communities were most neutral. Over 60 percent of the disadvantaged communities' participants had issues with the solar thermal system after its installation. While this is a high percentage, the quantity of these homes surveyed was small and does not statistically represent all participants in this segment. Over 35 percent of the single-family and low-income single-family groups also encountered issues after the installation. Given the large number of issues, it is impressive that few participants were dissatisfied with their systems overall. This likely indicates that issues were resolved by the contractors in a satisfactory manner.

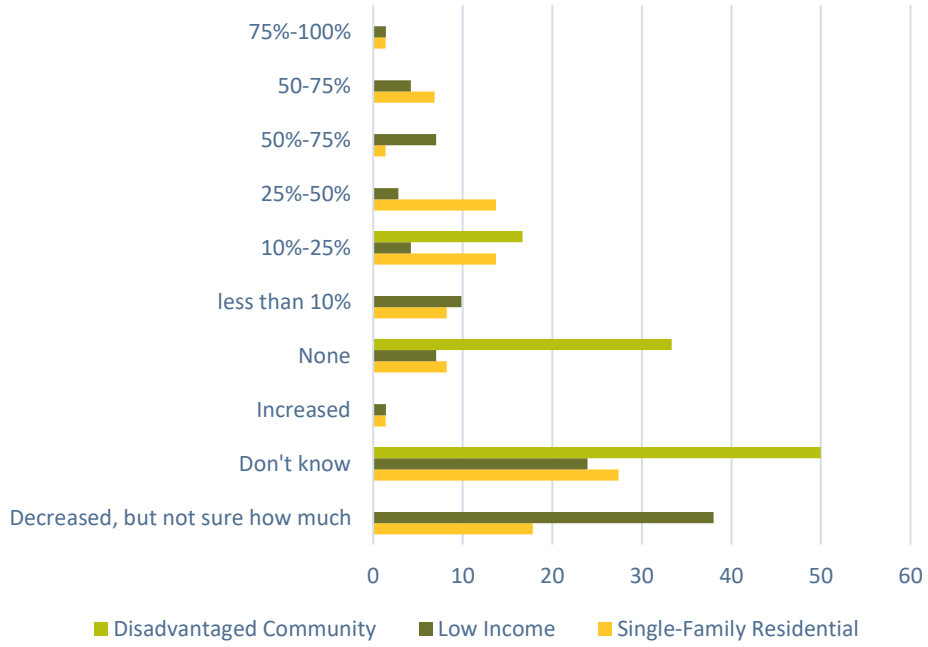
FIGURE 6-15: HOW SATISFIED HAVE YOU BEEN WITH YOUR SOLAR THERMAL SYSTEM?

FIGURE 6-16: HAVE THERE BEEN ANY PROBLEMS SINCE THE SOLAR THERMAL SYSTEM WAS INSTALLED?



Some of the reason for their satisfaction could be due to their bill savings; as shown in Figure 6-17, most customers reported seeing reductions in their bills.

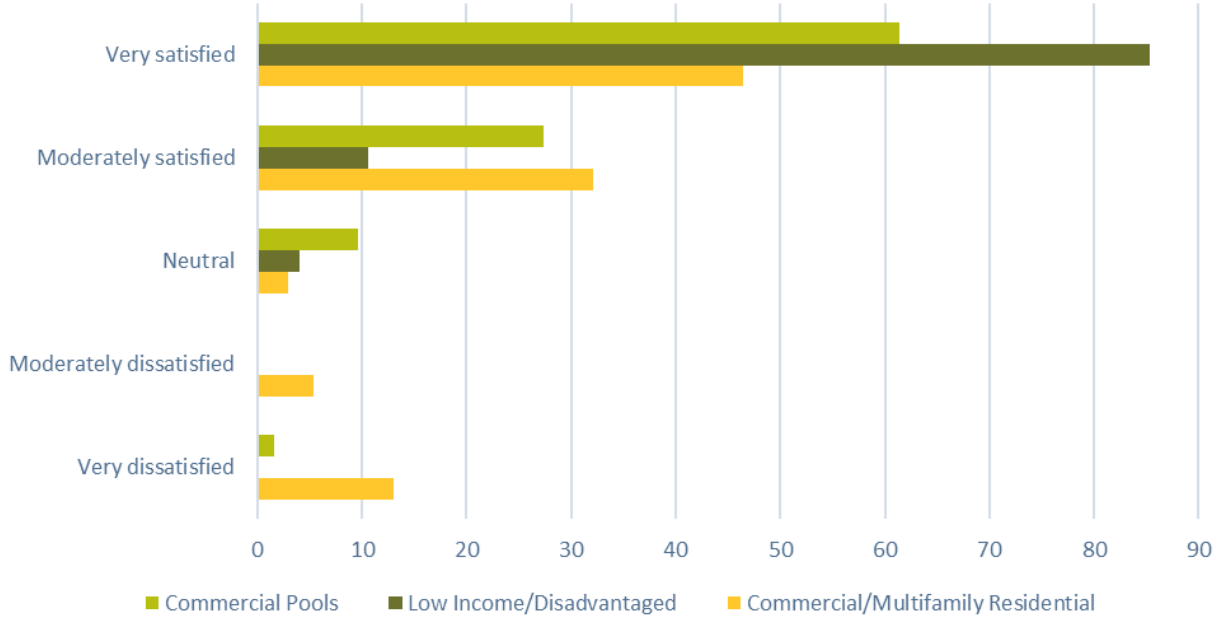
FIGURE 6-17: HOW MUCH DID YOUR BILL DECREASE (SINGLE-FAMILY PARTICIPANT GROUPS)?



Multifamily Residential/Commercial Pools Participant Groups

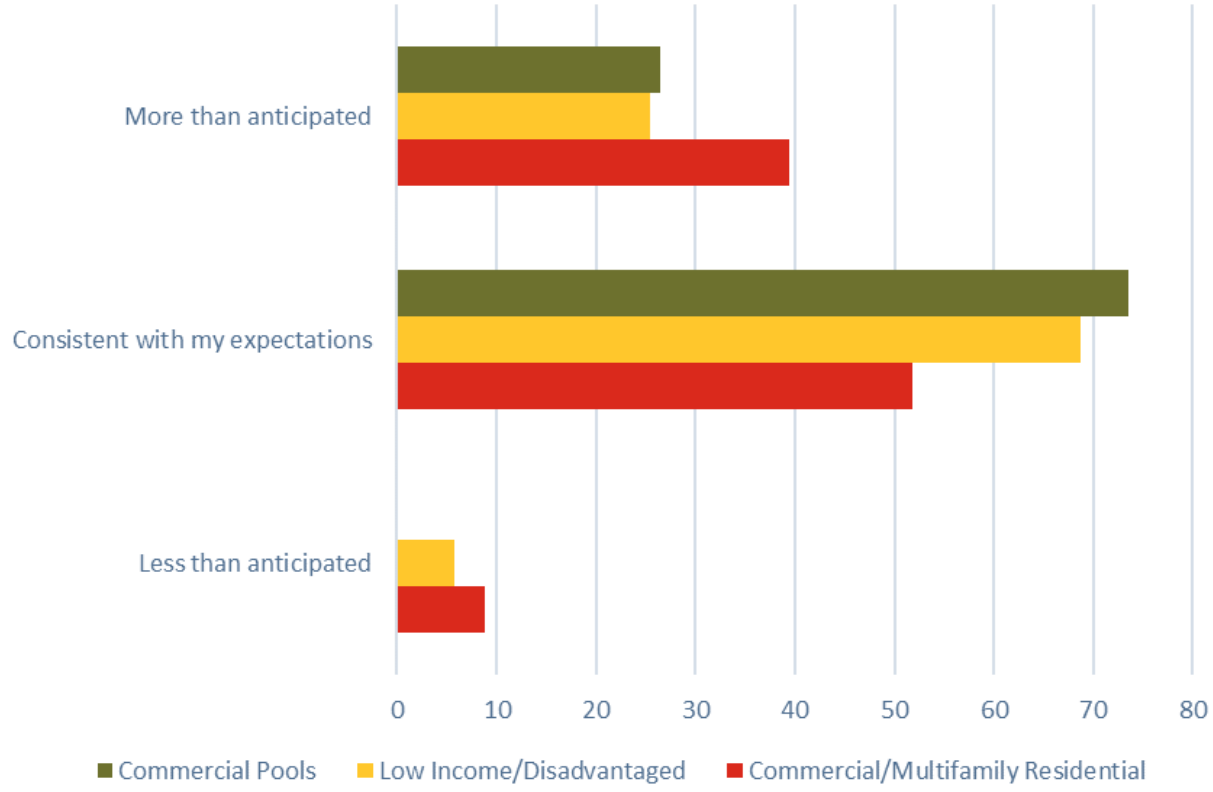
Similar to the Single-Family groups, the Multifamily and Commercial Pools participant groups were almost all moderately or very satisfied with their solar thermal system.

FIGURE 6-18: HOW SATISFIED HAVE YOU BEEN WITH YOUR SOLAR THERMAL SYSTEM?



After the installation of their solar thermal system, 58 percent of customers reported seeing a decrease in their bill. Of those who saw a decrease, most stated that the reductions were either more than anticipated or consistent with their expectations.

FIGURE 6-19: HOW MUCH DID YOUR BILL DECREASE? [36]



These findings show that participants are generally satisfied after the installation of their solar thermal systems.

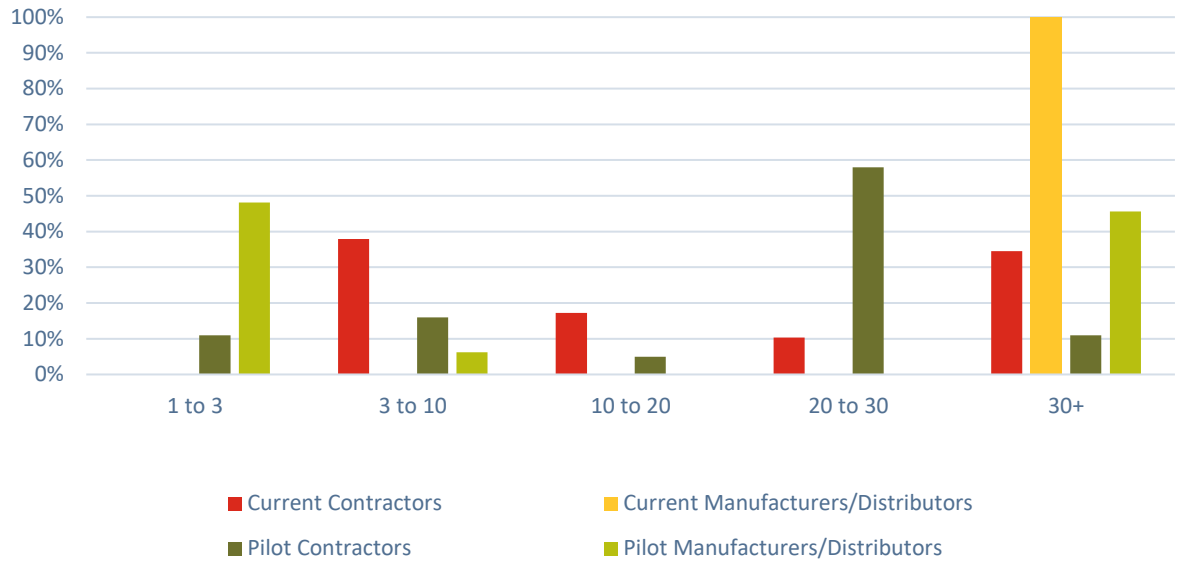
6.2.5 Effect of CSI-Thermal Program on the Market

An active solar thermal market is expected to create new businesses that provide training for employees in the solar thermal business. It is also expected that a thriving market has improved efficiencies in costs and installations including improving processes surrounding permitting and servicing.

[36] The wording of this question is different from the single-family surveys because it was kept consistent with the wording from the pilot program.

As shown in Figure 6-20, at the time of the pilot program, approximately 10 percent of contractors had been in business for 3 years or less and over 40 percent of the manufacturers/distributors had been in business for 3 years or less. This shows that businesses were created around the time of the pilot program and now there are more contractor firms in the 3- to 20-year range. All current manufacturers/distributors interviewed had been in business for over 30 years. Additionally, 90 percent of the manufacturers and distributors interviewed sell something other than solar thermal, suggesting that they have a diversified business.

FIGURE 6-20: NUMBER OF YEARS IN BUSINESS



A healthy market is expected to have training opportunities for employees to enhance the business offerings for stakeholders. During the surveys, all manufacturers/distributors reported that they offer training for installing contractors either on a regular schedule or as needed by the contractors. Over half of the contractors interviewed take part in the manufacturers' trainings and over 95 percent offer on-the-job training for employees as well.

Contractor/Installer Business Outlook

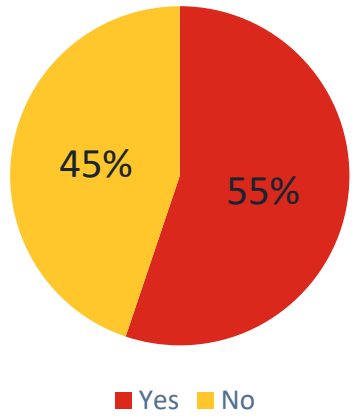
Approximately half of the contractors interviewed have recently expanded or plan to expand their business in the near future. However, 15 percent of those planning to expand will only do so if the program is extended. Additionally, half of those planning to expand will expand into non-solar thermal services (mainly PV). The other half do not plan to expand because they either want to stay small or because they rely on the program and they do not anticipate that it will continue. Approximately 40 percent of contractors install non-rebated solar thermal systems and most of those non-rebated systems are

ineligible for program rebates.[37] The overall perception of the contractors interviewed is that they do not see an expansion of the solar thermal market in the future without the program.

Contractor/Installer Program Feedback

Over half of contractors say that the incentive is the most important part of the program because it enables a larger market of solar thermal customers. Their least favorite aspect of the program is the paperwork and timeline to receive the incentive. Half believe that the satisfaction with the solar thermal technology has improved since the program's inception. The contractors also see that interest in solar thermal technology has increased in California since the inception of the program, mainly due to the influence of the rebate. They state that if they could change one thing about the program it would be increasing the incentive. Overall, the feedback received from contractors repeatedly confirmed the importance of the incentive in gaining customers for solar thermal installations.

FIGURE 6-21: INSTALLERS PERCEPTION – IS INTEREST IN SOLAR THERMAL INCREASING IN CALIFORNIA?



Manufacturer/Distributor Business Outlook

All manufacturers/distributors also reported that they sell something other than solar thermal technologies. Many sell PV, radiant flooring, pumps, HVAC, etc. 70 percent believe that the CSI thermal water heating program has increased their business, while 90 percent say that the program has had positive effects on their business outlook, although they acknowledge a level of caution in becoming dependent on a program.

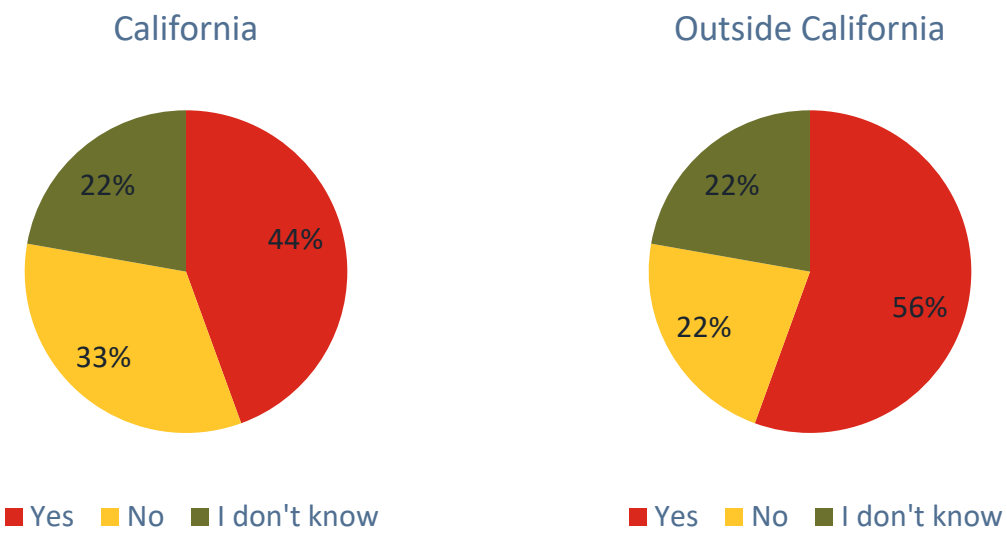
Manufacturer/Distributor Program Feedback

The manufacturers/distributors appreciate the positive impact that the incentive has on their business. Multiple manufacturers/distributors interviewed said low gas prices make solar thermal harder to sell without the rebate. They seem concerned that the program is ending and that will have a negative impact

[37] Many of the ineligible systems were electric displacing and installed after those incentives ran out.

on their ability to sell solar thermal systems. Half of those interviewed say that their equipment and installation costs have decreased due to the incentive program.

FIGURE 6-22: MANUFACTURER/DISTRIBUTER PERCEPTION – IS INTEREST OF SOLAR THERMAL INCREASING INSIDE VS. OUTSIDE CALIFORNIA?



6.2.6 Goal Assessment

The CSI-Thermal Program has helped build an active market of businesses and customers for solar thermal systems throughout California. The customers are no longer in the early adopter stage of the adoption curve, suggesting that installations are moving toward a more sustainable market. The main barrier to participation is the initial cost of the system, which suggests that the market has not reduced costs sufficiently to be sustainable without the program incentive. Participants have reported satisfaction with the systems themselves and stakeholders believe that knowledge and satisfaction is increasing. Installation contractors, distributers, and manufacturers expressed concerns that their solar thermal business will be affected if the incentive is taken away, suggesting that the solar thermal market is not fully sustainable without the program at this time.

6.3 GOAL 3

Solar thermal systems should be a cost-effective investment by gas customers.

6.3.1 Assessment Approach

The cost-effectiveness tests described in Section 3 were used to determine if the current solar thermal systems that displace natural gas are also cost-effective to the gas customer. The results of these tests are described in detail in Section 4.

6.3.2 PCT and RIM Tests

To determine if the solar thermal systems were cost-effective for gas customers that participate in the program, the Participant Cost Test (PCT) is the primary test to determine if the benefits are greater than the costs of the solar thermal system. In summary, it was found that the solar thermal systems were only cost-effective for some participant single-family groups installing direct integral systems and multifamily IFD (drainback) systems. The mean PCT for the modeled technologies overall for the program duration was 0.82 for single-family programs and 0.88 for multifamily and commercial programs. Both of these values are close to 1 (or cost-effective) with certain technologies and budget programs exceeding 1.

The Ratepayer Impact Measure (RIM) Test analyzes the cost-effectiveness for gas utility customers that did not participate in a program. For the CSI-Thermal Program, the RIM ratios were much lower, ranging from 0.12 for single-family programs to 0.32 for multifamily and commercial programs.

6.3.3 Goal Assessment

Overall, it was found that the solar thermal systems were not cost-effective investments by gas customers except in some situations for single-family and multifamily technologies. There may be value in further evaluating the cases that are more cost-effective to determine if the business models or technologies could be deployed at larger scales.

6.4 GOAL 4

Encourage the cost-effective deployment of solar thermal systems in residential, commercial, industrial, and agricultural markets and in each end-use application sector in a balanced manner.

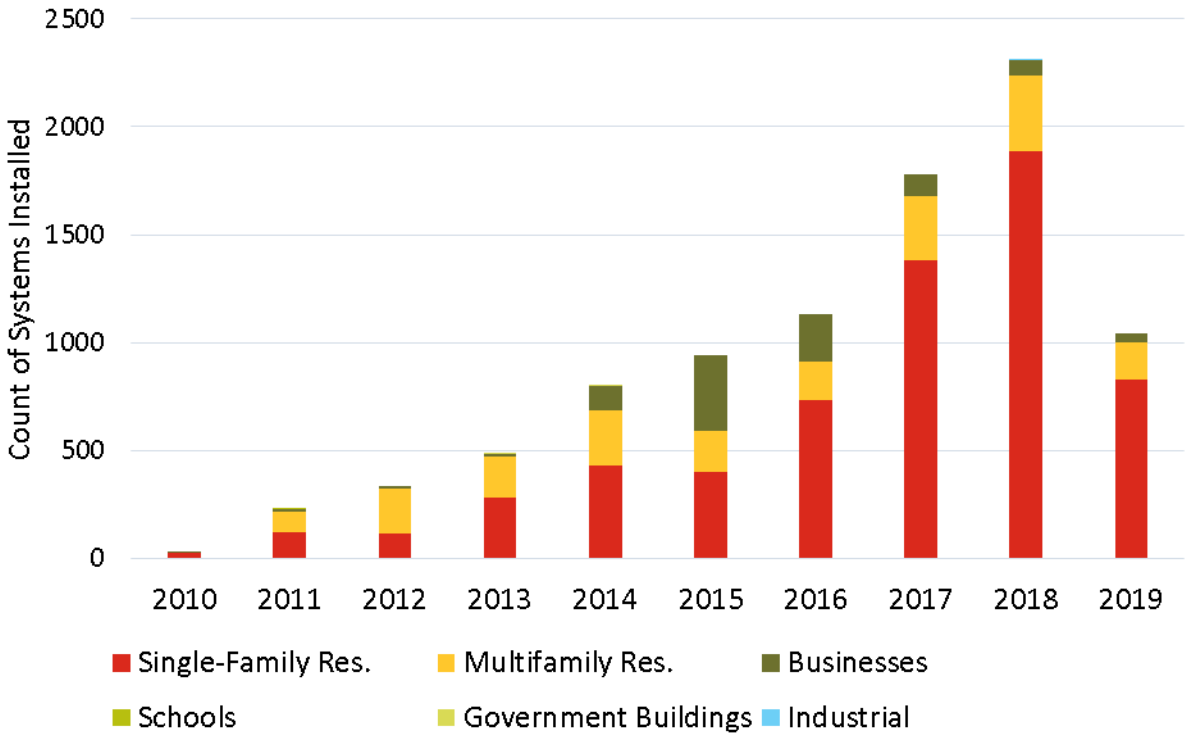
6.4.1 Assessment Approach

This goal expands the program's objective to be not just cost-effective but to do so across different segments and from different perspectives. This goal is assessed looking at the participation across segments as reported in the program tracking data. The cost-effectiveness results described in Section 4 also provide insight into the assessment of this goal.

6.4.2 Participation Across Sectors

One of the findings of the SWHPP Cost-Effectiveness Evaluation suggested that a program with a mix of participating sectors would be more cost-effective than a program aimed at single-family customers only. As shown in Figure 6-23, the program currently has a mix of Single-Family, Multifamily, and Commercial participants. There is minimal participation in the Industrial segment and none in the Agricultural segment, as reported in the tracking data. However, the telephone survey suggests that there may be some minimal agricultural participation, as shown in Figure 5-1, but not recorded as such in the tracking data. This could be due to solar installs outside of the program. The Commercial participants are spread among businesses, schools, and government buildings.

FIGURE 6-23: PARTICIPATION BY SEGMENT



The current program is aimed more for single-family residential and multifamily participation. The program calculator enables easier applications for some load shapes including single-family residential, apartment/condos, coin-op laundries, hotels/motels, schools, restaurants, dormitories, military barracks, office buildings, and retirement/nursing homes. While other segments, such as industrial and agriculture, are able to participate, they must use a customized calculator or performance-based payments and are not as straightforward to promote.

As discussed in detail in Section 4, the program is not cost-effective under most scenarios. The PCT does show some segments where it is cost-effective for the participant but there are no segments with a TRC, PAC, or RIM greater than 1. The main reasons for this are low gas prices and low avoided costs throughout the duration of the program.

6.4.3 Goal Assessment

The CSI-Thermal Program did encourage solar thermal system installations across some segments but is not well-diversified across industrial and agricultural segments. The installations were not found to be cost-effective through the duration of the program years.

APPENDIX A SURVEY INSTRUMENTS

The following survey instruments are presented in this appendix section:

- Residential Survey Instrument
- Commercial Survey Instrument
- Contractor Survey Instrument
- Manufacturer Survey Instrument

Residential Survey

Residential Survey

1. Name from Call List:

2. Hello, is this PROGRAM CONTACT? May I please speak with him/her? This is _____ from the Benningfield Group on behalf of the California Solar Initiative Thermal Program. My understanding is that you had a Solar Water Heating System/Pool Solar Water Heating system installed at your home at ADDRESS. Is this correct?

[If the program contact doesn't answer or is not available, try to speak with the person at home who is most knowledgeable about the program or find out when to call back]

- Yes, we participated and the address is correct
- There is no one here...
- Do not recall participating, but did install a solar water heater....
- No, this person no longer lives here
- No, this person is not available right now
- Refused
- Don't know
- No, other reason - Write In

We're calling to do a follow-up survey about your participation in the California Solar Initiative Thermal Program. The purpose of the survey is to assess how well the program met your needs and how well the program has met its goals.

[As needed]

The California Solar Initiative Thermal Program is sponsored by the California Public Utilities Commission and provides rebates to utility customers who install solar water heating systems at their homes.

This is a very important fact-finding survey among customers that have recently installed solar water heating systems and participated in the program sponsored by the California Public Utilities Commission. **Utility** is administering this program to encourage the growth of a solar thermal water heating market. We are NOT interested in selling anything, and responses will not be connected with you in any way. **Utility** wants to understand how program participants think about and manage their energy needs.

Residential Survey

LOGIC Show/hide trigger exists.

3. Do you recall participating in the Solar Water Heating program on or around **&SURV_DATE**?

- ○ Yes
- ○ No
- ○ Refused
- ○ Don't know

4. What made you decide to install a solar water heater?

- ☐ Environmental concerns
- ☐ Energy savings
- ☐ Bill savings (money)
- ☐ Other - Write In
- ☐ Refused
- ☐ Don't know

Residential Survey

Page entry logic:
This page will show when: #3 Question " Do you recall participating in the Solar Water Heating program on or around **&SURV_DATE**?" is one of the following answers ("Yes")

5. How did you first hear about the CSI Thermal Program?

- ○ Chosen Solar Water Heating Company
- ○ Different Solar Water Heating Company
- ○ Digital advertisement
- ○ Program Website
- ○ Print Advertisement (which one?)
- ○ Television (Solar Water Heater commercial, news stories, KPBS special, Rod Luck, Sustain San Diego special?)
- ○ Newspaper Article (which one?)
- ○ Radio (KPBS, Clear Channel, Sign on San Diego?)
- ○ Internet (which website? KPBS, Sustain San Diego, Craigslist, San Miguel Fire District?)
- ○ HVAC Contractor
- ○ PV Contractor
- ○ WH Contractor
- ○ OTHER (Specify)
- ○ Refused
- ○ Don't know

6. Had you been considering installing a Solar Water Heater before you heard about the program?

- ○ Yes
- ○ No
- ○ Refused
- ○ Don't know

7. Without the program, how likely would you have been to install the Solar Water Heater?

- ○ Not at all likely
- ○ Not very likely
- ○ Somewhat likely
- ○ Very likely
- ○ Refused
- ○ Don't know

8. What concerns were addressed by the program to encourage you to install a Solar Water Heater?

- ☐ Initial cost
- ☐ Aesthetics
- ☐ Lack of information
- ☐ Reliability concerns
- ☐ Contractor knowledge/experience
- ☐ OTHER (Specify)
- ☐ Refused
- ☐ Don't know

9. How were your concerns addressed?

- ☐ Received more information from the CSI Thermal Program
- ☐ Received more information from a contractor
- ☐ Received more information from a different source (Specify)
- ☐ OTHER (Specify)
- ☐ Refused
- ☐ Don't know

10. Without a financial incentive from the Program, would you have installed the Solar Water Heater anyway?

- ○ Same time
- ○ Later
- ○ Earlier
- ○ Not at all
- ○ Refused
- ○ Don't know

Residential Survey

11. How much has your gas bill decreased each month since installing a Solar Water Heater (as % of total bill)?

- ○ None
- ○ Other - Write In
- ○ Refused
- ○ Don't know

12. On a scale of 1 to 5 with 5 being the most satisfied and 1 being the least, how satisfied are you with your solar water heating system?

- Very dissatisfied
- Moderately dissatisfied
- Neutral
- Moderately satisfied
- Very satisfied
- Refused
- Don't know

13. Why do you say that?

LOGIC Show/hide trigger exists.

14. Have there been any problems with the solar water heater after it was installed and operating?

- Yes
- No
- Refused
- Don't know

LOGIC Hidden unless: #14 Question "Have there been any problems with the solar water heater after it was installed and operating?" is one of the following answers ("Yes")

15. What were the problems?

Residential Survey

Page entry logic:
This page will show when: #3 Question " Do you recall participating in the Solar Water Heating program on or around **&SURV_DATE**?" is one of the following answers ("Yes")

16. What were the biggest hurdles in installing your solar water heater and going through the rebate process?

- ○ None
- ○ Other - Write In
- ○ Refused
- ○ Don't know

17. Do you have any other comments or recommendations on improving the Program?

Residential Survey

18. Did the contractor seem knowledgeable about the Solar Water Heaters?

- ○ Yes
- ○ No
- ○ Refused
- ○ Don't know

LOGIC Hidden unless: #3 Question " Do you recall participating in the Solar Water Heating program on or around **&SURV_DATE**?" is one of the following answers ("Yes")

19. Did the contractor seem knowledgeable about the CSI Thermal Program?

- Yes
- No
- Refused
- Don't know

LOGIC Show/hide trigger exists.

20. Did the contractor suggest any other energy efficiency or solar technologies during the installation process?

- Yes
- No
- Refused
- Don't know

LOGIC Hidden unless: #20 Question "Did the contractor suggest any other energy efficiency or solar technologies during the installation process?" is one of the following answers ("Yes")

21. What did they suggest?

- PV
- Lighting
- Appliances
- Heating/cooling
- Other
- Refused
- Don't know

---

22. On a scale of 1 to 5 with 5 being the most satisfied and 1 being the least, how satisfied were you with the contractor you hired?

- Dissatisfied
- Moderately dissatisfied
- Neutral
- Moderately satisfied
- Very satisfied
- Refused
- Don't know

Residential Survey

23. Did you have a Solar Water Heater prior to this installation?

- Yes - at this residence
- Yes but at a prior residence
- No
- Refused
- Don't know

LOGIC Show/hide trigger exists.

24. Have you applied for rebates through other state energy efficiency programs for other types of equipment?

- Yes
- No
- Refused
- Don't know

LOGIC Hidden unless: #24 Question "Have you applied for rebates through other state energy efficiency programs for other types of equipment?" is one of the following answers ("Yes")

25. What type of equipment was that rebate for?

- lighting
- appliances (specify type)
- heating/cooling
- PV
- OTHER (Specify)
- Refused
- Don't know

26. Do you own or lease an electric plug in vehicle?

- Yes
- No
- Refused
- Don't know

Residential Survey

The next questions are about when and how hot water is used in your household.

27. How many people are in your household?

- Other - Write In
- Refused
- Don't know

28. What type of washing machine do you have (front or top loader?)

- top loader (not EnergyStar)
- top loader (EnergyStar)
- front loader
- NONE
- Refused
- Don't know

29. Do you have a dishwasher?

- Yes, EnergyStar
- Yes, not EnergyStar
- No
- Refused
- Don't know

LOGIC Show/hide trigger exists.

30. Has your water use pattern changed since installing a Solar Water Heater?

- Yes
- No
- Refused
- Don't know

LOGIC Hidden unless: #30 Question "Has your water use pattern changed since installing a Solar Water Heater?" is one of the following answers ("Yes")

31. How?

Thank You!

On behalf of the California Public Utilities Commission, the CSI Thermal Program, and **PROGRAM ADMINISTRATOR** we thank you for your time and thoughtful input on this important effort.

Commercial Participant Survey

Commercial Participant Survey

1. Name from call list:

LOGIC Show/hide trigger exists.

2. Hello, is this **PROGRAM CONTACT**? May I please speak with him/her? This is _____ from the Benningfield Group on behalf of the California Solar Initiative Thermal Program. My understanding is that you had a Solar Water Heating System/Pool Solar Water Heating system installed at your business at **ADDRESS**. Is this correct?

[If the program contact doesn't answer or is not available, try to speak with the person at home who is most knowledgeable about the program or find out when to call back. If the answer is No, Refused, or Don't know then thank them for their time and terminate the call]

- Yes, installed and aware of participation
- Yes, installed but not aware of participation
- No
- Refused
- Don't know

We're calling to do a follow-up survey about your participation in the California Solar Initiative Thermal Program. The purpose of the survey is to assess how well the program met your needs and how well the program has met its goals.

The California Solar Initiative Thermal Program is sponsored by the California Public Utilities Commission and provides rebates to utility customers who install solar water heating systems at their homes.

This is a very important fact-finding survey among customers that have recently installed solar water heating systems and participated in the program sponsored by the California Public Utilities Commission. **Utility** is administering this program to encourage the growth of a solar thermal water heating market. We are NOT interested in selling anything, and responses will not be connected with you in any way. **Utility** wants to understand how program participants think about and manage their energy needs.

Commercial Participant Survey

3. Where did you hear about SOLAR WATER HEATERS?

- ☐ Solar water heater contractor
- ☐ other contractor
- ☐ internet
- ☐ newspaper
- ☐ Television
- ☐ Radio
- ☐ Utility
- ☐ other

---

4. What made you consider installing a solar water heater?

- ☐ Environmental concerns
- ☐ Energy savings
- ☐ Money- saving
- ☐ Other - Write In

LOGIC Hidden unless: #2 Question "Hello, is this **PROGRAM CONTACT**? May I please speak with him/her? This is _____ from the Benningfield Group on behalf of the California Solar Initiative Thermal Program. My understanding is that you had a Solar Water Heating System/Pool Solar Water Heating system installed at your business at **ADDRESS**. Is this correct?

[If the program contact doesn't answer or is not available, try to speak with the person at home who is most knowledgeable about the program or find out when to call back. If the answer is No, Refused, or Don't know then thank them for their time and terminate the call]
" is one of the following answers ("Yes, installed and aware of participation")

5. Where did you hear about the CSI Thermal Program?

- chosen solar water heater contractor
- different solar water heater contractor
- digital advertisement
- program website
- print advertisement
- television
- newspaper
- radio
- internet
- HVAC contractor
- PV contractor
- water heater contractor
- Other - Write In

6. What were your concerns prior to you making the decision to install a SOLAR WATER HEATER?

- Initial cost
- aesthetics
- lack of information
- reliability concerns
- contractor knowledge/experience
- no other concerns

7. Of those concerns, what was your biggest concern prior to you making the decision to install (**Ask only if they chose more than one answer to the above question)**

- ☐ Initial cost
- ☐ Aesthetics
- ☐ Lack of information
- ☐ Reliability concerns
- ☐ Contractor knowledge/experience
- ☐ No other concerns

---

8. How was your concern overcome?

LOGIC Hidden unless: #2 Question "Hello, is this **PROGRAM CONTACT**? May I please speak with him/her? This is _____ from the Benningfield Group on behalf of the California Solar Initiative Thermal Program. My understanding is that you had a Solar Water Heating System/Pool Solar Water Heating system installed at your business at **ADDRESS**. Is this correct?

[If the program contact doesn't answer or is not available, try to speak with the person at home who is most knowledgeable about the program or find out when to call back. If the answer is No, Refused, or Don't know then thank them for their time and terminate the call]
" is one of the following answers ("Yes, installed and aware of participation")

9. Had you been considering installing a SOLAR WATER HEATER before you heard about the Program?

- ○ Yes
- ○ No

LOGIC Hidden unless: #2 Question "Hello, is this **PROGRAM CONTACT**? May I please speak with him/her? This is _____ from the Benningfield Group on behalf of the California Solar Initiative Thermal Program. My understanding is that you had a Solar Water Heating System/Pool Solar Water Heating system installed at your business at **ADDRESS**. Is this correct?

[If the program contact doesn't answer or is not available, try to speak with the person at home who is most knowledgeable about the program or find out when to call back. If the answer is No, Refused, or Don't know then thank them for their time and terminate the call]
" is one of the following answers ("Yes, installed and aware of participation")

10. Without the incentive from the program, how likely would you have been to install the SOLAR WATER HEATER? Would you say...

- Not at all likely
- Not very likely
- Somewhat likely or
- very likely

Commercial Participant Survey

For the following questions, please answer according to the following scale of 1-5, with

1 being dissatisfied
2 being moderately dissatisfied
3 being neutral
4 being moderately satisfied
5 being very satisfied

LOGIC Show/hide trigger exists.

11. How Satisfied were you with the contractor your hired?

- 1
- 2
- 3
- 4
- 5

LOGIC Hidden unless: #11 Question "How Satisfied were you with the contractor your hired?" is one of the following answers ("1","5")

12. Would you like to explain?

LOGIC Show/hide trigger exists.

13. How satisfied are you with the SOLAR WATER HEATER system?

- 1
- 2
- 3
- 4
- 5

LOGIC Hidden unless: #13 Question "How satisfied are you with the SOLAR WATER HEATER system?" is one of the following answers ("1","5")

14. Would you like to explain?

LOGIC Show/hide trigger exists.

15. How satisfied are you with your participation in the CSI Thermal Program?

- 1
- 2
- 3
- 4
- 5

LOGIC Hidden unless: #15 Question "How satisfied are you with your participation in the CSI Thermal Program?" is one of the following answers ("1","5")

16. Would you like to explain?

---

17. What were your biggest hurdles in installing a SOLAR WATER HEATER?

- ☐ None
- ☐ Contractor related
- ☐ Permit Related
- ☐ Technical issues
- ☐ Inspection issues
- ☐ Program admin delays
- ☐ Other - Write In

18. How were your hurdles resolved?

19. What were your biggest hurdles associated with going through the SOLAR WATER HEATER rebate process?

- ☐ None
- ☐ Contractor related
- ☐ Permit related
- ☐ Technical issues
- ☐ Inspection issues
- ☐ Program admin delays
- ☐ Other - Write In

20. How were your hurdles resolved?

LOGIC Show/hide trigger exists.

21. Do you pay your gas utility bill (PG&E, SCG, or SDG&E)?

- Yes
- No
- Unsure

LOGIC Show/hide trigger exists. Hidden unless: #21 Question "Do you pay your gas utility bill (PG&E, SCG, or SDG&E)?" is one of the following answers ("Yes")

22. After the installation of your SOLAR WATER HEATER system, did you see a reduction in your gas utility bill?

- Yes
- No
- Unsure

LOGIC Hidden unless: #22 Question "After the installation of your SOLAR WATER HEATER system, did you see a reduction in your gas utility bill?" is one of the following answers ("Yes")

23. Was the decline in your gas utility bill consistent with your expectations, more that anticipated, or less than anticipated?

- Consistent with my expectations
- More than anticipated
- Less than anticipated

Commercial Participant Survey

Now we would like to ask you a few questions about your backup water heating system.

LOGIC Show/hide trigger exists.

24. What type of BACKUP water heater(s) do you have?

- ☐ Tank- non-Energy Star (**default if energy star not known**)
- ☐ Tank- Energy Star
- ☐ Tankless
- ☐ None
- ☐ Other type of water heater- (**use this only if it is really different from the choices above, else categorize yourself**) Write In

LOGIC Hidden unless: #24 Question "What type of BACKUP water heater(s) do you have?" is one of the following answers ("Tank- non-Energy Star (**default if energy star not known**)","Tank- Energy Star","Tankless","Other type of water heater- (**use this only if it is really different from the choices above, else categorize yourself**) Write In")

25. What type of fuel do you use for your BACKUP water heaters?

- ○ Electric
- ○ Natural gas
- ○ Propane
- ○ Other type of fuel- Write In

Commercial Participant Survey

We are now going to ask a few questions about your facility

26. Do you have solar electric (PV) panels at your facility?

- ○ Yes
- ○ No

27. Does your facility have any other energy efficiency or renewable energy technologies?

- ☐ Energy efficient lighting
- ☐ Energy efficient windows
- ☐ Energy efficient HVAC system
- ☐ Energy Star Appliances
- ☐ Solar pool heating
- ☐ Electric vehicle charging
- ☐ Other - Write In

28. (**Only ask if SOLAR POOL HEATING is not checked above)** Other than the restrooms, what uses hot water at your facility?

- ○ There are no other uses
- ○ Record Other uses - Write In

29. [**Only ask if SOLAR POOL HEATING is not checked above**] Does your restroom include showers or bathing facilities?

- ○ Yes
- ○ No

30. What is the main business ACTIVITY at your facility?

- Apartment/Condo/Multifamily
- Office
- Retail (non-food)
- College/University
- School
- Grocery Store
- Resturant
- Health care
- Hospital
- Hotel or Motel
- Warehouse
- Construction
- Community Service/Church/Temple/Mosque
- Municipailty
- Industrial Process/Manufacturing/Assembly
- Other - Write In

31. How many square feet of heated or cooled floor area is your facility (excluding enclosed parking area)?

32. Does your business own, lease or manage the facility?

- Own
- Lease/Rent
- Manage

33. Please give me the email where you would like to receive your gift card.

Thank You!

On behalf of the California Public Utilities Commission, the CSI Thermal Program, and **PROGRAM ADMINISTRATOR** we thank you for your time and thoughtful input on this important effort.

Contractor Survey

Contractor Survey

1. Name from call list:

Hello, this is **&InterviewerName** from the Benningfield Group on behalf of the California Solar Initiative Thermal Program.

[**IF NEEDED, The California Solar Initiative Thermal Program is sponsored by the California Public Utilities Commission and administered by &Utility and provides rebates to utility customers who install solar water heating systems on their premises**]

The CSI Thermal tracking data indicates that you or this company helped with the installation of **&quantity** Solar Water Heating systems rebated by the Program. Do you recall installing these SOLAR WATER HEATER systems?

[**IF NOT, ask for the contact most familiar. Thank and Terminate if no one is familiar**]

Contractor Survey

2. How long has the company been installing SOLAR WATER HEATER systems?

3. How long have you been participating in the CSI Thermal Program?

LOGIC Show/hide trigger exists.

4. Besides SOLAR WATER HEATERs, what are your business' other primary technology offerings (in terms of revenue)? (**if needed read list: PV, pool SOLAR WATER HEATER, HVAC, WH, plumbing, etc**.)

- ☐ PV
- ☐ Pool solar water heater
- ☐ HVAC
- ☐ Water Heater
- ☐ Plumbing
- ☐ Other - Write In

5. What market sectors do you primarily work in? Single family, multi family, com, industrial, pool, disadvantaged communities?

LOGIC Show/hide trigger exists.

6. Have you recently expanded your business, or do you plan to expand your business in the near future?

- ○ Yes
- ○ No

LOGIC Hidden unless: #6 Question "Have you recently expanded your business, or do you plan to expand your business in the near future?
" is one of the following answers ("No")

7. Why not?

LOGIC Hidden unless: #6 Question "Have you recently expanded your business, or do you plan to expand your business in the near future?
" is one of the following answers ("Yes")

8. In what way will you expand your business (new services, new market sectors, etc.)?

LOGIC Hidden unless: #6 Question "Have you recently expanded your business, or do you plan to expand your business in the near future?
" is one of the following answers ("Yes")

9. How has the CSI Thermal Program helped in your efforts? (Training? Marketing?)

10. What are the aspects of the CSI Thermal Program that you like?

11. What are the aspects of the Program that you do not like?

[Probe, if needed] Requirements: Pull a permit, freeze protection, SRCC certification of parts & systems, QC, length of time to install the SOLAR WATER HEATERs

Contractor Survey

12. Have you informed the program administrator about the aspects of the program that you do not like or other concerns regarding the CSI Thermal Program? Has the program administrator been responsive to concerns regarding the CSI Thermal Program?

LOGIC Show/hide trigger exists.

13. Are there additional costs you incur from participating in the CSI Thermal Program?

LOGIC Hidden unless: #13 Question "Are there additional costs you incur from participating in the CSI Thermal Program?"

14. Are all of the above-mentioned costs passed on to the customer?

- ○ All of the costs
- ○ None of the costs
- ○ Some of the costs

15. From your perspective as a contractor, what are your biggest barriers for participation in the Program?

16. In your view, what are the greatest barriers for your customers considering SOLAR WATER HEATERs?

17. Do you think the CSI Thermal Program helps or hurts your sales of SOLAR WATER HEATERs? In what ways, if any?

18. In your view, has customer satisfaction with the SOLAR WATER HEATER technology changed since your initial participation in the Program?

19. How do you pass the rebate on to your customer? (send them a check later? Or decrease up-front cost?)

Contractor Survey

20. Prior to your initial participation in the Program, how many SOLAR WATER HEATER systems did you typically sell/install in a year?

21. Since participating in the CSI Thermal Program, how many SOLAR WATER HEATER systems do you typically sell/install in a year?

LOGIC Show/hide trigger exists.

22. Do you install any systems without applying for a rebate?

- Yes
- No

LOGIC Hidden unless: #22 Question "Do you install any systems without applying for a rebate?" is one of the following answers ("Yes")

23. Why?

24. Have you participated in any other SOLAR WATER HEATER incentive programs? (municipal, utility, or county programs)

25. Do you have any recommendations for the Program?

26. What might be done to stimulate interest in solar water heating systems more generally, either within the CSI Thermal Program or otherwise?

[Probe] Incentive levels, outreach & marketing, customer education, contractor training? And why?

Contractor Survey

LOGIC Show/hide trigger exists.

27. Have you seen or heard on the radio or newspaper any marketing for or information about the CSI Thermal Program?

- Yes
- No

LOGIC Hidden unless: #27 Question "Have you seen or heard on the radio or newspaper any marketing for or information about the CSI Thermal Program? " is one of the following answers ("Yes")

28. What ads or information did you see or hear and where?

29. Do you market SOLAR WATER HEATERs? How?
[Probe] Advertisements, radio, newspaper, websites, home shows, energy fair, word of mouth?

30.
Do you mention the CSI Thermal Program as part of your marketing efforts?

- Yes
- No

LOGIC Show/hide trigger exists. Hidden unless: #4 Question "Besides SOLAR WATER HEATERs, what are your business' other primary technology offerings (in terms of revenue)? (**if needed read list: PV, pool SOLAR WATER HEATER, HVAC, WH, plumbing, etc.**)
" is one of the following answers ("PV")

31. Do you market PV?

- Yes
- No

LOGIC Show/hide trigger exists. Hidden unless: #31 Question "Do you market PV?" is one of the following answers ("Yes")

32. Do you market PV the same way?

- Yes
- No

LOGIC Hidden unless: #32 Question "Do you market PV the same way? " is one of the following answers ("No")

33. How do you market PV and why do you market it differently?

LOGIC Show/hide trigger exists.

34. Do you feel that interest in SOLAR WATER HEATing is increasing in California?

- Yes
- No

LOGIC Hidden unless: #34 Question "Do you feel that interest in SOLAR WATER HEATing is increasing in California?" is one of the following answers ("Yes")

35. What do you think is the reason for the increase in interest?

36. What do you believe are the biggest recent breakthroughs in SOLAR WATER HEATing technology and why?

37. Do you believe that PV and SOLAR WATER HEATERs are competing or synergistic technologies (allow both, neither)?

- Competing
- Synergistic
- Both
- Neither

38. Do you feel it is possible to integrate SOLAR WATER HEATER systems with energy efficiency, or PV technologies effectively?

- Yes
- No

Contractor Survey

Page entry logic:
This page will show when: #4 Question "Besides SOLAR WATER HEATERs, what are your business' other primary technology offerings (in terms of revenue)? (**if needed read list: PV, pool SOLAR WATER HEATER, HVAC, WH, plumbing, etc**.)
" is one of the following answers ("PV")

Now, we have a few questions related to your installation of PV as it has influenced your SOLAR WATER HEATER sales.

39. How many PV systems do you install each year?

LOGIC Show/hide trigger exists.

40. Have you participated in any PV incentive programs (such as CSI or NSHP)?

- Yes
- No

LOGIC Hidden unless: #40 Question "Have you participated in any PV incentive programs (such as CSI or NSHP)?
" is one of the following answers ("Yes")

41. Which ones?

LOGIC Hidden unless: #40 Question "Have you participated in any PV incentive programs (such as CSI or NSHP)?
" is one of the following answers ("Yes")

42. Do you think PV incentive programs helped with SOLAR WATER HEATER sales?

- Yes
- No

43. Now that the PV incentive programs in California are largely over, do you think the SOLAR WATER HEATing incentive helps with PV sales?

- Yes
- No

Contractor Survey

Page entry logic:
This page will show when: #4 Question "Besides SOLAR WATER HEATERs, what are your business' other primary technology offerings (in terms of revenue)? (**if needed read list: PV, pool SOLAR WATER HEATER, HVAC, WH, plumbing, etc**.)
" is one of the following answers ("HVAC","Water Heater")

44. Do you cross sell or attempt to influence a customer to install a SOLAR WATER HEATER when discussing the sale of (HVAC/WH) equipment with a potential customer?

- Yes
- No

Contractor Survey

45. What is the average cost of a SOLAR WATER HEATER permit?

46. What is the average amount of time it takes to receive a permit after you submit the paperwork?

LOGIC Show/hide trigger exists.

47. Have you noticed a change in the approval time for permits associated with SOLAR WATER HEATERs since your initial participation in the Program?

- Yes
- No

LOGIC Hidden unless: #47 Question "Have you noticed a change in the approval time for permits associated

with SOLAR WATER HEATERs since your initial participation in the Program?
" is one of the following answers ("Yes")

48. Was the approval time better or worse?

- Better
- Worse

Contractor Survey

49. How many employees are there in your business, including yourself?

50. How many of your employees are experienced (more than one year) in SOLAR WATER HEATing technology?

51. What type of training do your employees go through? (Manufacturer training? Community college programs? On-the-job training? CalSEIA? Other?)

52. How long has the company been in business?

53. Which manufacturer's equipment do you install?

- ☐ GREENoneTEC Solarindustrie GmbH
- ☐ SunEarth Inc.
- ☐ Heliodyne, Inc.
- ☐ Alternate Energy Technologies
- ☐ Butler Sun Solutions, Inc.
- ☐ Sun Maxx Solar LLC
- ☐ Solene
- ☐ HTP, Inc.
- ☐ Solarhot
- ☐ Other - Write In

54. Do you have contact information for those manufacturers?

- [ ] GREENoneTEC Solarindustrie GmbH
- [ ] SunEarth, Inc.
- [ ] Heliodyne, Inc.
- [ ] Alternate Energy Technologies
- [ ] Butler Sun Solutions, Inc.
- [ ] SunMaxx Solar LLC
- [ ] Solene
- [ ] Stiebel Eltron
- [ ] HTP, Inc.
- [ ] Solarhot
- [ ] Other - Write In (Required)
- [ ] Other - Write In

55. Any additional comments/notes

56. Please give the email where you would like your gift card sent.

Thank You!

On behalf of the California Public Utilities Commission, the CSI Thermal Program, and **PROGRAM ADMINISTRATOR** we thank you for your time and thoughtful input on this important effort.

Manufacturer Survey

Manufacturer Survey

1. Name from call list:

Hello, this is **&InterviewerName** from the Benningfield Group on behalf of the California Solar Initiative Thermal Program.

[IF NEEDED, The California Solar Initiative Thermal Program is sponsored by the California Public Utilities Commission and administered by **&Utility** and provides rebates to utility customers who install solar water heating systems on their premises]

Do you have about 15 minutes to talk with me and answer a few survey questions? All of your answers will be kept confidential.

(If no, ask if somebody else in their company is knowledgeable. If a new contact is provided, get their contact information. If no new contact is provided, continue with the questions that don't require knowledge of the program.)

Manufacturer Survey

LOGIC Show/hide trigger exists.

2. Are you familiar with the CSI Solar Thermal Program?

- Yes
- No

3. In addition to manufacturing SOLAR WATER HEATER systems, do you have other primary business functions such as distribution and/or installation? (Primarily manufacturer? Distributor? Also install systems?)

4. How long have you been in business?

5. How many employees are there?

6. What types of SOLAR WATER HEATing equipment does your company manufacture/sell?

LOGIC Hidden unless: #2 Question "Are you familiar with the CSI Solar Thermal Program?" is one of the following answers ("Yes")

7. Do you believe the CSI Thermal Program has increased or decreased business for you?

- Increase
- Decrease
- I don't know
- Neither

LOGIC Hidden unless: #2 Question "Are you familiar with the CSI Solar Thermal Program?" is one of the following answers ("Yes")

8. What do you like/dislike about the Program?

9. Do you feel that knowledge of SOLAR WATER HEATing is increasing in California?

- Yes
- No
- I don't know

10. Do you feel that knowledge of SOLAR WATER HEATing is increasing outside of California?

- Yes
- No
- I don't know

LOGIC Hidden unless: (#9 Question "Do you feel that knowledge of SOLAR WATER HEATing is increasing in California? " is one of the following answers ("Yes") OR #10 Question "Do you feel that knowledge of SOLAR WATER HEATing is increasing outside of California?" is one of the following answers ("Yes"))

11. To what do you attribute this increase in knowledge?

12. How many SOLAR WATER HEATER systems do you typically manufacture/distribute in a year?

13. How many of those systems are installed in California?

14. Has that number been fairly constant over the past 10 years or has it changed over time?

- Constant
- Increased over the last 10 years
- Decreased over the last 10 years
- Fluctuated over the last 10 years

15. What do you believe the biggest market barriers are currently for SOLAR WATER HEATING in California?

16. Are there different market barriers to sales in northern versus southern California (if selling statewide)?

Manufacturer Survey

LOGIC Hidden unless: #2 Question "Are you familiar with the CSI Solar Thermal Program?" is one of the following answers ("Yes")

17. How has your business outlook changed since the inception of the statewide CSI Thermal Program in California?

LOGIC Hidden unless: #2 Question "Are you familiar with the CSI Solar Thermal Program?" is one of the following answers ("Yes")

18. Do you believe that incentive programs have an effect on equipment or installation costs?

- Increase
- Decrease
- I don't know
- Neither

LOGIC Hidden unless: #2 Question "Are you familiar with the CSI Solar Thermal Program?" is one of the following answers ("Yes")

19. Do you think wholesale prices have increased or decreased since the Program began?

- Yes
- No
- I don't know

LOGIC Hidden unless: #2 Question "Are you familiar with the CSI Solar Thermal Program?" is one of the following answers ("No")

20. What policies would you recommend to support the market for SOLAR WATER HEATERs?

LOGIC Hidden unless: #2 Question "Are you familiar with the CSI Solar Thermal Program?" is one of the following answers ("Yes")

21. What policy and program changes would you recommend to support the market for SOLAR WATER HEATERs?

LOGIC Hidden unless: #2 Question "Are you familiar with the CSI Solar Thermal Program?" is one of the following answers ("Yes")

22. Do you have any advice or concerns for the current incentive program?

LOGIC Show/hide trigger exists.

23. Do you make/sell any SOLAR WATER HEATER systems that are not SRCC-certified?

[Backround info: SRCC is the solar rating and certification corporation. They are the organization that provides ratings for different systems including the OG300. OG300 is the standard requirement for solar water heating systems to qualify for the program. It ensures that solar water heaters meet minimum requirements for safety, durability, and energy ratings]

- Yes
- No

LOGIC Hidden unless: #23 Question "Do you make/sell any SOLAR WATER HEATER systems that are not SRCC-certified?

[Backround info: SRCC is the solar rating and certification corporation. They are the organization that provides ratings for different systems including the OG300. OG300 is the standard requirement for solar water heating systems to qualify for the program. It ensures that solar water heaters meet minimum requirements for safety, durability, and energy ratings]
" is one of the following answers ("Yes")

24. Has the system been submitted for SRCC certification?

- Yes
- No

LOGIC Hidden unless: #23 Question "Do you make/sell any SOLAR WATER HEATER systems that are not SRCC-certified?

[Backround info: SRCC is the solar rating and certification corporation. They are the organization that provides ratings for different systems including the OG300. OG300 is the standard requirement for solar water heating systems to qualify for the program. It ensures that solar water heaters meet minimum requirements for safety, durability, and energy ratings]
" is one of the following answers ("Yes")

25. Have any sales been delayed because the customer is waiting for the system to be SRCC-certified?

- Yes
- No

LOGIC Show/hide trigger exists.

26. Do you sell any systems as an OG300 kit?

- Yes
- No

LOGIC Hidden unless: #26 Question "Do you sell any systems as an OG300 kit? " is one of the following answers ("Yes")

27. Do you know what the OG300 approved substitutions are for that system?

- Yes
- No

Manufacturer Survey

28. What type of warranties do you offer?

29. How do you market SOLAR WATER HEATER systems?

[Probe] Advertisements, radio, newspaper, websites, home shows, energy fair, word of mouth?

LOGIC Show/hide trigger exists.

30. Do you offer training for installers for the systems that you distribute/manufacture?

- Yes
- No

LOGIC Hidden unless: #30 Question "Do you offer training for installers for the systems that you distribute/manufacture?
" is one of the following answers ("Yes")

31. How often do you hold the training?

LOGIC Hidden unless: #30 Question "Do you offer training for installers for the systems that you distribute/manufacture?
" is one of the following answers ("Yes")

32. What is the average attendance at the training?

LOGIC Show/hide trigger exists. Hidden unless: #30 Question "Do you offer training for installers for the systems that you distribute/manufacture?
" is one of the following answers ("Yes")

33. Has attendance been increasing or decreasing?

- Increasing
- Decreasing
- Stays the same

LOGIC Hidden unless: #33 Question "Has attendance been increasing or decreasing? "

34. Why do you think that is?

LOGIC Hidden unless: #30 Question "Do you offer training for installers for the systems that you distribute/manufacture?
" is one of the following answers ("Yes")

35. Where are the trainings held?

LOGIC Hidden unless: #30 Question "Do you offer training for installers for the systems that you distribute/manufacture?
" is one of the following answers ("Yes")

36. In the training, do you review SRCC standards and certification?

- Yes
- No

LOGIC Hidden unless: #30 Question "Do you offer training for installers for the systems that you distribute/manufacture?

" is one of the following answers ("Yes")

37. Do you review the Uniform Solar Energy Code?

- Yes
- No

LOGIC Show/hide trigger exists.

38. Have you seen a change in any of your costs related to SOLAR WATER HEATERs over the last 10 years?

- Yes
- No

LOGIC Hidden unless: #38 Question "Have you seen a change in any of your costs related to SOLAR WATER HEATERs over the last 10 years?" is one of the following answers ("Yes")

39. Which costs and why? **[Probe to find out ways they decrease manufacturing costs]**

Manufacturer Survey

40. What do you believe are the biggest recent breakthroughs in SOLAR WATER HEATER technology and why?

41. What improvements to SOLAR WATER HEATER technology would you like to see over the next 10 years?

42. Are there any SOLAR WATER HEATER components that are limited in supply due to increasing demand?

LOGIC Show/hide trigger exists.

43. Do you sell other types of equipment?

- ☐ PV systems
- ☐ Solar pool heating systems
- ☐ Radiant flooring
- ☐ chillers
- ☐ pumps
- ☐ pipes
- ☐ metering equipment
- ☐ Other - Write In

LOGIC Show/hide trigger exists. Hidden unless: #43 Question "Do you sell other types of equipment? " is one of the following answers ("PV systems")

44. Do you spend the majority of your marketing resources on PV, SOLAR WATER HEATERs or Pool Heating (if they do solar pool heating)?

- PV
- Solar Water heating
- Pool heating

LOGIC Hidden unless: #44 Question "Do you spend the majority of your marketing resources on PV, SOLAR WATER HEATERs or Pool Heating (if they do solar pool heating)? "

45. Why?

LOGIC Hidden unless: #44 Question "Do you spend the majority of your marketing resources on PV, SOLAR WATER HEATERs or Pool Heating (if they do solar pool heating)? " is one of the following answers ("PV")

46. How many systems do you sell per year?

LOGIC Hidden unless: #43 Question "Do you sell other types of equipment? " is one of the following answers ("metering equipment")

47. What type of metering equipment do you sell? (flow, temp, data acquisition capability, etc.)

48. Please give me the email where you would like us to send your gift card.

Thank You!

On behalf of the California Public Utilities Commission, the CSI Thermal Program, and **PROGRAM ADMINISTRATOR** we thank you for your time and thoughtful input on this important effort.

APPENDIX B SURVEY RESULTS

B.1 COMMERCIAL

Where did you hear about SOLAR WATER HEATERS?

Q3	ALL	Commercial/ Multifamily Residential	Low Income/ Disadvantaged	Commercial Pools
Solar Water Heater Contractor	25.08	33.40	19.15	22.68
Other Contractor	15.09	11.11	21.18	12.98
Internet	2.15	-	-	6.44
Newspaper	8.02	11.11	2.08	10.86
Television	9.42	16.33	1.07	10.86
Radio	0.69	-	2.08	-
Utility	10.44	4.46	4.52	22.33
Other	54.04	51.49	59.84	50.80
n	74	27	25	22

What made you consider installing a solar water heater?

Q4	ALL	Commercial/ Multifamily Residential	Low Income/ Disadvantaged	Commercial Pools
Environmental Concerns	66.98	54.74	78.07	68.11
Energy Savings	68.23	62.06	72.47	70.16
Money Saving	85.39	87.24	84.87	84.07
Title-24	4.89	-	14.68	-
Other	15.46	33.37	13.02	-
n	74	27	25	22

Where did you hear about the CSI-Thermal Program?

Q5	ALL	Commercial/ Multifamily Residential	Low Income/ Disadvantaged	Commercial Pools
Friend/Family/Coworker	5.28	4.74	11.11	-
Independent Research	0.61	0.76	1.07	-
PV Contractor	7.61	1.32	15.94	5.58
Utility	11.92	13.42	-	22.33
Chosen Solar Water Heater Contractor	38.56	51.69	31.45	32.54
Different Solar Water Heater Contractor	8.37	14.25	-	10.86
Digital Advertisement	0.85	-	-	2.56
Facilities Manager/ Consultant	9.55	8.87	13.59	6.18
Internet	1.04	-	-	3.13
Print Advertisement	0.69	-	2.08	-
Program Website	1.02	3.06	-	-
Other	14.49	1.90	24.76	16.81
n	74	27	25	22

What were your concerns prior to you making the decision to install a SOLAR WATER HEATER?

Q6	ALL	Commercial/ Multifamily Residential	Low Income/ Disadvantaged	Commercial Pools
Initial Cost	48.00	45.87	42.80	55.33
Aesthetics	17.26	7.47	17.78	26.52
Lack of Information	0.83	-	2.48	-
Reliability Concerns	35.04	37.92	46.53	20.68
Contractor Knowledge/Experience	21.31	18.65	32.55	12.72
No Other Concerns	31.32	37.67	32.23	24.07
n	74	27	25	22

Of those concerns, what was your biggest concern prior to you making the decision to install?

Q7	ALL	Commercial/ Multifamily Residential	Low Income/ Disadvantaged	Commercial Pools
Initial cost	32.70	24.30	33.92	39.88
Aesthetics	7.29	4.70	-	17.16
Lack of Information	-	-	-	-
Reliability Concerns	14.75	14.17	28.51	1.57
Contractor Knowledge/Experience	13.76	15.34	13.19	12.75
n	74	27	25	22

Had you been considering installing a SOLAR WATER HEATER before you heard about the Program?

Q9	ALL	Commercial/ Multifamily Residential	Low Income/ Disadvantaged	Commercial Pools
No	46.88	50.95	31.79	57.89
Yes	53.12	49.05	68.21	42.11
n	74	27	25	22

Without the incentive from the program, how likely would you have been to install the SOLAR WATER HEATER? Would you say…

Q10	ALL	Commercial/ Multifamily Residential	Low Income/ Disadvantaged	Commercial Pools
Not at all likely	19.69	19.99	12.28	26.82
Not very likely	29.42	38.92	23.43	25.90
Somewhat likely	17.47	10.23	37.86	4.31
Very likely	33.42	30.85	26.44	42.97
n	74	27	25	22

How satisfied were you with the contractor you hired?

Q11	ALL	Commercial/ Multifamily Residential	Low Income/ Disadvantaged	Commercial Pools
Dissatisfied	4.25	11.11	-	1.64
Moderately Dissatisfied	1.79	5.36	-	-
Neutral	8.05	12.43	1.03	10.69
Moderately Satisfied	19.01	24.60	10.22	22.22
Very Satisfied	66.90	46.51	88.75	65.45
n	74	27	25	22

How satisfied are you with the SOLAR WATER HEATER system?

Q13	ALL	Commercial/ Multifamily Residential	Low Income/ Disadvantaged	Commercial Pools
Dissatisfied	4.87	13.01	-	1.61
Moderately Dissatisfied	1.79	5.36	-	-
Neutral	5.53	2.97	4.01	9.62
Moderately Satisfied	23.40	32.16	10.65	27.40
Very Satisfied	64.41	46.51	85.34	61.37
n	74	27	25	22

How satisfied are you with your participation in the CSI Thermal Program?

Q15	ALL	Commercial/ Multifamily Residential	Low Income/ Disadvantaged	Commercial Pools
Neutral	6.12	18.37	-	-
Moderately Satisfied	11.77	4.96	14.90	15.45
Very Satisfied	82.11	76.67	85.10	84.55
n	74	27	25	22

What were your biggest hurdles in installing a SOLAR WATER HEATER?

Q17	ALL	Commercial/ Multifamily Residential	Low Income/ Disadvantaged	Commercial Pools
None	49.50	55.77	27.17	65.55
Contractor Related	11.92	30.04	4.08	1.64
Permit Related	19.87	15.48	30.13	14.00
Technical Issues	27.44	29.18	38.24	14.91
Inspection Issues	17.36	12.21	37.18	2.70
Program Admin Delays	12.73	22.52	3.12	12.53
Other	5.96	3.27	1.03	13.58
n	74	27	25	22

What were your biggest hurdles associated with going through the SOLAR WATER HEATER rebate process?

Q19	ALL	Commercial/ Multifamily Residential	Low Income/ Disadvantaged	Commercial Pools
None	82.07	84.40	94.97	66.85
Contractor Related	4.66	12.33	-	1.64
Permit Related	-	-	-	-
Technical Issues	-	-	-	-
Inspection Issues	-	-	-	-
Program Admin Delays	6.57	4.49	-	15.23
Other	7.96	3.27	4.31	16.28
n	74	27	25	22

Do you pay your gas utility bill (PG&E, SCG, or SDG&E)?

Q21	ALL	Commercial/ Multifamily Residential	Low Income/ Disadvantaged	Commercial Pools
No	32.53	28.04	28.15	41.39
Yes	67.47	71.96	71.85	58.61
n	74	27	25	22

After the installation of your SOLAR WATER HEATER system, did you see a reduction in your gas utility bill?

Q22	ALL	Commercial/ Multifamily Residential	Low Income/ Disadvantaged	Commercial Pools
No	18.7427	29.472	0	28.5465
Unsure	22.8249	30.7192	33.5362	0
Yes	58.4324	39.8088	66.4638	71.4535
n	58	23	20	15

Was the decline in your gas utility bill consistent with your expectations, more than anticipated, or less than anticipated?

Q23	ALL	Commercial/ Multifamily Residential	Low Income/ Disadvantaged	Commercial Pools
Consistent with my Expectations	66.31	51.82	68.72	73.47
Less Than Anticipated	4.47	8.82	5.77	-
More Than Anticipated	29.23	39.36	25.51	26.53
n	33	11	12	10

What type of BACKUP water heater(s) do you have?

Q24	ALL	Commercial/ Multifamily Residential	Low Income/ Disadvantaged	Commercial Pools
Tank- non-Energy Star	24.05	23.44	31.42	17.29
Tank- Energy Star	44.89	39.21	52.20	43.26
Tankless	8.97	6.46	4.22	16.25
None	14.71	18.79	13.23	12.09
Other	11.44	12.11	-	22.22
n	74	27	25	22

What type of fuel do you use for your BACKUP water heaters?

Q25	ALL	Commercial/ Multifamily Residential	Low Income/ Disadvantaged	Commercial Pools
Natural gas	95.55	100.00	86.88	100.00
Other	4.45	-	13.12	-
n	61	19	22	20

Do you have solar electric (PV) panels at your facility?

Q26	ALL	Commercial/ Multifamily Residential	Low Income/ Disadvantaged	Commercial Pools
No	64.04	74.44	40.34	77.34
Yes	35.96	25.56	59.66	22.66
n	74	27	25	22

Does your facility have any other energy efficiency or renewable energy technologies?

Q27	ALL	Commercial/ Multifamily Residential	Low Income/ Disadvantaged	Commercial Pools
Energy Efficient Lighting	78.25	61.59	88.64	84.51
Energy Efficient Windows	63.62	39.31	82.81	68.75
Energy Efficient HVAC System	44.71	17.12	66.71	50.32
Energy Star Appliances	32.50	26.68	59.78	11.03
Solar Pool Heating	33.74	7.43	2.48	91.29
Electric Vehicle Charging	17.06	13.22	16.93	21.03
None	1.45	1.65	-	2.70
Other	20.28	35.23	14.48	11.11
n	74	27	25	22

Does your restroom include showers or bathing facilities?

Q29	ALL	Commercial/ Multifamily Residential	Low Income/ Disadvantaged	Commercial Pools
No	37.51	52.77	19.86	37.90
Yes	62.49	47.23	80.14	62.10
n	73	27	24	22

What is the main business ACTIVITY at your facility?

Q30	ALL	Commercial/ Multifamily Residential	Low Income/ Disadvantaged	Commercial Pools
Agricultural Food Processing	1.79	5.36	-	-
Apartment/ Condo/Multifamily	78.85	73.15	100.00	63.41
Commercial Laundry for Line	2.02	6.05	-	-
Dairy	0.63	1.90	-	-
HOA for Single-Family Neighborhood	0.54	-	-	1.61
Hotel or Motel	1.36	2.43	-	1.64
Mobile Home Park	0.64	-	-	1.93
Restaurant	3.70	11.11	-	-
School	5.43	-	-	16.28
Summer Camp	0.96	-	-	2.89
Timeshare Property	2.02	-	-	6.05
Public Pool	2.06	-	-	6.18
n	74	27	25	22

Does your business own, lease or manage the facility?

Q32	ALL	Commercial/ Multifamily Residential	Low Income/ Disadvantaged	Commercial Pools
Manage	21.62	8.63	6.52	49.73
Own	78.38	91.37	93.48	50.27
n	74	27	25	22

** Values are shown as percent of survey participants.*
** n is the number of respondents.*

B.2 RESIDENTIAL

What made you decide to install a solar water heater?

Q4	ALL	Single-Family Residential	Low Income	Disadvantaged Community
Environmental Concerns	46.67	52.05	42.25	33.33
Energy Savings	54.00	52.05	57.75	33.33
Bill Savings (Money)	77.33	72.60	81.69	83.33
Replacement System	3.33	6.85	-	-
Free System	6.67	6.85	7.04	-
Other	9.33	10.96	8.45	-
Refused	-	-	-	-
Don't Know	-	-	-	-
n	150	73	71	6

How did you first hear about the CSI Thermal Program?

Q5	ALL	Single-Family Residential	Low Income	Disadvantaged Community
Chosen Solar Water Heating Company	12.08	15.28	7.04	33.33
Digital Advertisement	0.67	1.39	-	-
Don't Know	2.01	-	2.82	16.67
Door to Door	24.16	5.56	43.66	16.67
Friend/Family/Coworker	18.79	25.00	11.27	33.33
HVAC Contractor	1.34	1.39	1.41	-
Internet (which website? KPBS, Sustain San Diego, Craigslist, San Miguel Fire District?)	2.69	2.78	2.82	-
Newspaper Article (which one?)	0.67	1.39	-	-
PV Contractor	14.09	27.78	1.41	-
Print Advertisement (which one?)	6.71	4.17	9.86	-
Program Website	0.67	1.39	-	-
Television (Solar Water Heater commercial, news stories, KPBS special, Rod Luck, Sustain San Diego special?)	0.67	1.39	-	-
Utility	4.03	-	8.45	-
WH Contractor	1.34	2.78	-	-
Other	10.07	9.72	11.27	-
n	149	72	71	6

Had you been considering installing a Solar Water Heater before you heard about the program?

Q6	ALL	Single-Family Residential	Low Income	Disadvantaged Community
No	69.80	66.67	70.42	100.00
Yes	29.53	33.33	28.17	-
Don't know	0.67	-	1.41	-
n	149	72	71	6

Without the program, how likely would you have been to install the Solar Water Heater?

Q7	ALL	Single-Family Residential	Low Income	Disadvantaged Community
Not at All Likely	54.36	58.33	52.11	33.33
Not Very Likely	23.49	26.39	19.72	33.33
Somewhat Likely	10.07	4.17	15.49	16.67
Very Likely	12.08	11.11	12.68	16.67
n	149	72	71	6

What concerns were addressed by the program to encourage you to install a Solar Water Heater?

Q8	ALL	Single-Family Residential	Low Income	Disadvantaged Community
No Concerns	1.33	-	2.82	-
Initial Cost	62.00	69.86	52.11	83.33
Aesthetics	11.33	13.70	9.86	-
Lack of Information	5.33	2.74	8.45	-
Reliability Concerns	16.67	21.92	12.68	-
Contractor Knowledge/Experience	6.67	6.85	7.04	-
Other	8.67	10.96	7.04	-
Refused	0.67	-	1.41	-
Don't Know	15.33	10.96	19.72	16.67
n	150	73	71	6

How were your concerns addressed?

Q9	ALL	Single-Family Residential	Low Income	Disadvantaged Community
Received more information from the CSI Thermal Program	26.00	17.81	33.80	33.33
Received more information from a contractor	39.33	50.68	26.76	50.00
Received more information from a different source	2.67	4.11	1.41	-
Other	9.33	4.11	15.49	-
Refused	-	-	-	-
Don't know	16.67	15.07	18.31	16.67
n	150	73	71	6

Without a financial incentive from the Program, would you have installed the Solar Water Heater anyway?

Q10	ALL	Single-Family Residential	Low Income	Disadvantaged Community
Earlier	0.67	-	1.41	-
Later	22.82	18.06	29.58	-
Not at all	67.11	72.22	60.56	83.33
Same time	5.37	6.94	2.82	16.67
Don't know	4.03	2.78	5.63	-
n	149	72	71	6

How much has your gas bill decreased each month since installing a Solar Water Heater (as % of total bill)?

Q11	ALL	Single-Family Residential	Low Income	Disadvantaged Community
None	8.67	8.22	7.04	33.33
less than 10%	8.67	8.22	9.86	-
10%-25%	9.33	13.70	4.23	16.67
25%-50%	8.00	13.70	2.82	-
50%-75%	4.00	1.37	7.04	-
50-75%	5.33	6.85	4.23	-
75%-100%	1.33	1.37	1.41	-
Decreased, but not sure how much	26.67	17.81	38.03	-
Increased	1.33	1.37	1.41	-
Don't Know	26.67	27.40	23.94	50.00
n	150	73	71	6

On a scale of 1 to 5 with 5 being the most satisfied and 1 being the least, how satisfied are you with your solar water heating system?

Q12	ALL	Single-Family Residential	Low Income	Disadvantaged Community
Very Dissatisfied	8.00	9.59	5.63	16.67
Moderately Dissatisfied	3.33	1.37	5.63	-
Neutral	8.00	8.22	5.63	33.33
Moderately Satisfied	26.00	21.92	30.99	16.67
Very Satisfied	54.00	58.90	50.70	33.33
Don't Know	0.67	-	1.41	-
n	150	73	71	6

Have there been any problems with the solar water heater after it was installed and operating?

Q14	ALL	Single-Family Residential	Low Income	Disadvantaged Community
No	60.67	63.01	60.56	33.33
Yes	39.33	36.99	39.44	66.67
n	150	73	71	6

What were the biggest hurdles in installing your solar water heater and going through the rebate process?

Q16_1	ALL	Single-Family Residential	Low Income	Disadvantaged Community
None	68.46	56.94	80.28	66.67
Contractor Related	5.37	5.56	4.23	16.67
Inspection Issues	1.34	2.78	-	-
Permit Related	1.34	1.39	1.41	-
Program Admin Delays	4.03	8.33	-	-
Technical Issues	15.44	18.06	12.68	16.67
Other	3.36	5.56	1.41	-
Don't Know	0.67	1.39	-	-
n	149	72	71	6

Did the contractor seem knowledgeable about the Solar Water Heaters?

Q18	ALL	Single-Family Residential	Low Income	Disadvantaged Community
No	8.73	8.22	8.57	16.67
Yes	83.22	87.67	80.00	66.67
Don't Know	8.05	4.11	11.43	16.67
n	149	73	70	6

Did the contractor seem knowledgeable about the CSI Thermal Program?

Q19	ALL	Single-Family Residential	Low Income	Disadvantaged Community
No	4.05	6.94	1.43	-
Yes	81.08	87.50	77.14	50.00
Refused	0.68	-	1.43	-
Don't Know	14.19	5.56	20.00	50.00
n	148	72	70	6

Did the contractor suggest any other energy efficiency or solar technologies during the installation process?

Q20	ALL	Single-Family Residential	Low Income	Disadvantaged Community
No	63.09	52.78	70.42	100.00
Yes	24.16	31.94	18.31	-
Don't Know	12.75	15.28	11.27	-
n	149	72	71	6

What did they suggest?

Q21	ALL	Single-Family Residential	Low Income	Disadvantaged Community
Appliances	2.78	-	7.69	-
Building Envelope	22.22	17.39	30.77	-
Heating/Cooling	8.33	8.70	7.69	-
Lighting	2.78	-	7.69	-
PV	38.89	52.17	15.38	-
Other	22.22	21.74	23.08	-
Don't Know	2.78	-	7.69	-
n	36	23	13	0

On a scale of 1 to 5 with 5 being the most satisfied and 1 being the least, how satisfied were you with the contractor you hired?

Q22	ALL	Single-Family Residential	Low Income	Disadvantaged Community
Dissatisfied	8.00	10.96	4.23	16.67
Moderately Dissatisfied	3.33	6.85	-	-
Neutral	5.33	1.37	8.45	16.67
Moderately Satisfied	22.67	16.44	26.76	50.00
Very Satisfied	60.00	64.38	59.15	16.67
Don't Know	0.67	-	1.41	-
n	150	73	71	6

Did you have a Solar Water Heater prior to this installation?

Q23	ALL	Single-Family Residential	Low Income	Disadvantaged Community
No	91.95	84.93	98.57	100.00
Yes - at this residence	8.05	15.07	1.43	-
n	149	73	70	6

Have you applied for rebates through other state energy efficiency programs for other types of equipment?

Q24	ALL	Single-Family Residential	Low Income	Disadvantaged Community
No	62.67	57.53	69.01	50.00
Yes	34.00	42.47	23.94	50.00
Don't Know	3.33	-	7.04	-
n	150	73	71	6

What type of equipment was that rebate for?

Q25	ALL	Single-Family Residential	Low Income	Disadvantaged Community
Lighting	2.67	1.37	2.82	16.67
Appliances	8.00	5.48	11.27	-
Heating/Cooling	3.33	4.11	2.82	-
PV	14.67	27.40	2.82	-
Other	6.67	4.11	8.45	16.67
Refused	4.00	2.74	4.23	16.67
Don't Know	-	-	-	-
n	150	73	71	6

Do you own or lease an electric plug in vehicle?

Q26	ALL	Single-Family Residential	Low Income	Disadvantaged Community
No	91.28	84.72	100.00	66.67
Yes	8.05	13.89	-	33.33
Don't Know	0.67	1.39	-	-
n	149	72	71	6

What type of washing machine do you have (front or top loader?)

Q28	ALL	Single-Family Residential	Low Income	Disadvantaged Community
None	2.00	2.74	1.41	-
Front Loader	40.00	45.21	36.62	16.67
Top Loader (EnergyStar)	36.67	39.73	32.39	50.00
Top Loader (not EnergyStar)	16.00	6.85	23.94	33.33
Don't Know	5.33	5.48	5.63	-
n	150	73	71	6

Do you have a dishwasher?

Q29	ALL	Single-Family Residential	Low Income	Disadvantaged Community
No	37.33	10.96	64.79	33.33
Yes, EnergyStar	42.67	63.01	21.13	50.00
Yes, not EnergyStar	15.33	17.81	12.68	16.67
Don't Know	4.67	8.22	1.41	-
n	150	73	71	6

Has your water use pattern changed since installing a Solar Water Heater?

Q30	ALL	Single-Family Residential	Low Income	Disadvantaged Community
Don't know	8.00	9.59	5.63	16.67
No	72.67	69.86	76.06	66.67
Yes	19.33	20.55	18.31	16.67
n	150	73	71	6

** Values are shown as percent of survey participants.*

** n is the number of respondents.*

APPENDIX C TECHNOLOGY TYPES AND INPUTS

This appendix highlights the steps taken to identify the technology types to be analyzed under the cost-effectiveness model, as well as the inputs like therms saved, operations and maintenance (O&M) costs, degradation assumptions, and equipment lifetimes.

C.1 IDENTIFYING TECHNOLOGY TYPES

One of the evaluation goals is to determine the cost-effectiveness of the different SWH technologies deployed under the program. The first step in identifying the different technologies to evaluate was to identify which technologies were rebated by budget program. Table C-1 below shows the share of system types by budget program that were installed through the program, as well as the total count of systems.

TABLE C-1: SHARE OF SOLAR WATER HEATING TECHNOLOGY BY BUDGET PROGRAM

Technology Type	DI	DP	IFD	IFG	IFO	IS	IT	Other	Total
Commercial Pools	-	100%	-	-	-	-	-	-	804
Industrial	-	-	-	-	-	-	-	100%	1
Com./MF Res	0.3%	-	42%	52%	0.2%	-	2%	4%	1,074
LI MF Res	1%	-	15%	84%	0.2%	-	0.3%	0.1%	885
MF Res. – DAC	-	-	59%	16%	-	-	26%	-	116
SF Res.	23%	-	10%	52%	4%	3%	7%	0.2%	2,921
LI SF Res	51%	-	10%	33%	4%	-	3%	-	2,950
SF Res. - DAC	52%	-	1%	29%	-	-	18%	-	338

* DI: Direct Integral Collector Storage, DP: Direct Pools, IFD: Indirect Forced Circulation – Drainback, IFG: Indirect Forced Circulation – Glycol, IFO: Indirect Forced Circulation – Other/Unknown, IS: Indirect Self-Pumped, IT: Indirect Thermosyphon

Based on share of systems, the evaluation team identified the SWH technologies that made up the majority of the installations within each budget program. The following budget program and SWH technologies were identified:

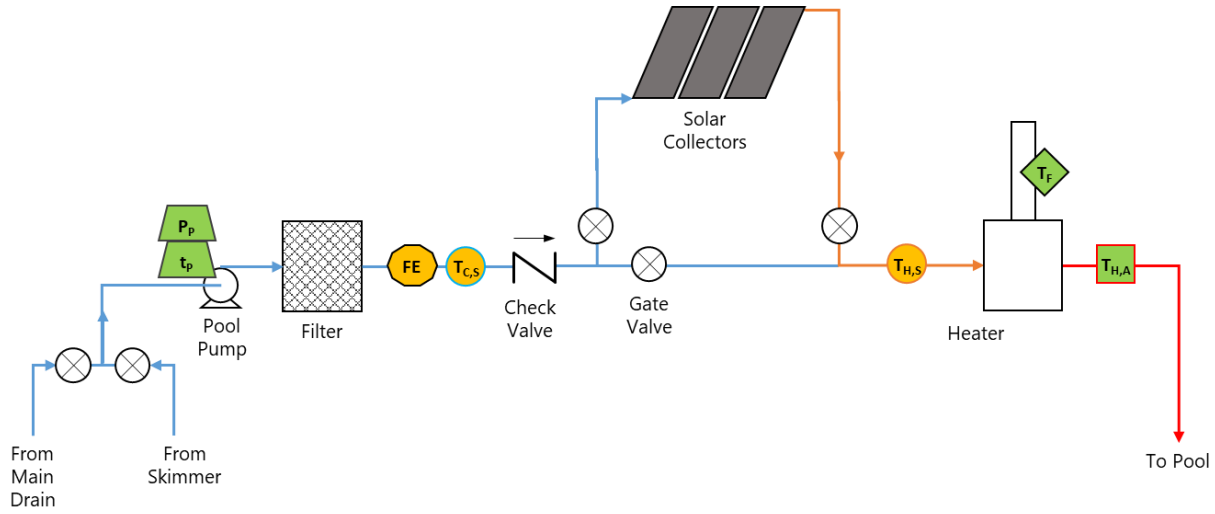
- **Commercial Pools:** Direct Pools.
- **Commercial/Multifamily Residential:** Indirect Forced Circulation – Drainback & Indirect Forced Circulation – Glycol.
- **Low-Income Multifamily Residential:** Indirect Forced Circulation – Drainback & Indirect Forced Circulation – Glycol.
- **Multifamily Residential – Disadvantaged Communities:** Indirect Forced Circulation – Drainback & Indirect Thermosyphon.
- **Single-Family Residential:** Direct Integral Collector Storage and Indirect Forced Circulation (all).

- **Low-Income Single-Family Residential:** Direct Integral Collector Storage and Indirect Forced Circulation (all).
- **Single-Family Residential – Disadvantaged Communities:** Direct Integral Collector Storage and Indirect Forced Circulation (all), and Indirect Thermosyphon.

Direct Pools

The majority of systems installed through the Commercial Pools budget program utilize direct pool heating with drainback freeze protection. Although direct forced circulation systems are largely disallowed in the CSI-Thermal Program, the Commercial Pool program is the exception as long as it is not used for freeze protection. For these systems, the pool water is circulated directly through the solar collectors and back into the pool; therefore, it requires either manual or automatic gravity draining to prevent the potential for freezing. Figure C-1 below shows an example of the direct forced circulation system designed for a pool.

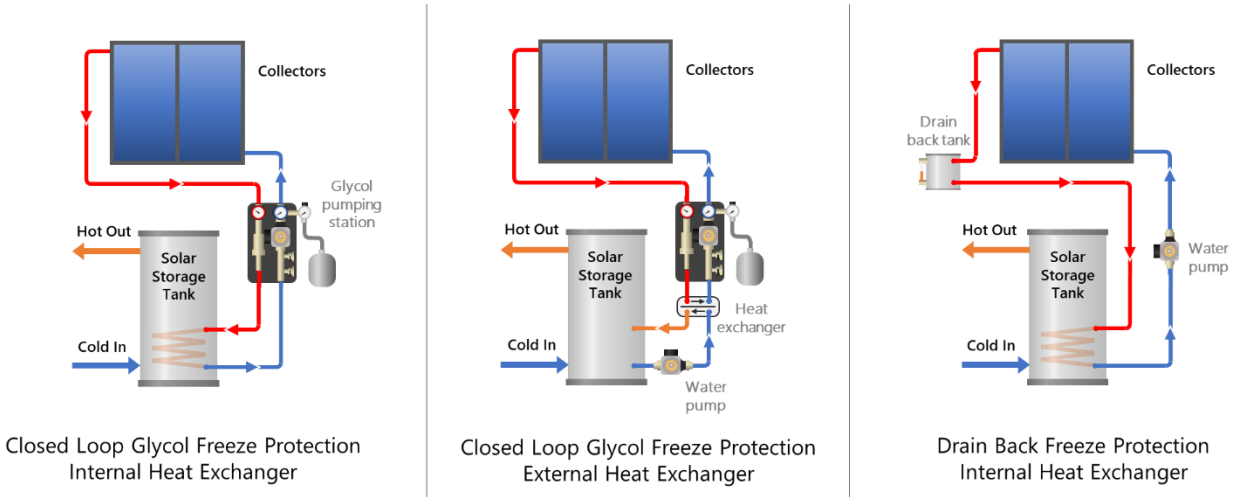
FIGURE C-1: DIRECT FORCED CIRCULATION DIAGRAM



Indirect Forced Circulation - Drainback and Glycol Freeze Protection

Indirect Forced Circulation systems made up the majority of all multifamily budget program system installations as well as a large share of the single-family budget program installations. These are closed systems with a heat exchanger that can be configured with either glycol (usually propylene glycol that serves as antifreeze) or drainback freeze protection. A pump circulates the heat transfer fluid from the panels to the heat exchanger, and a second pump may circulate water from the tank to a heat exchanger. Antifreeze systems use glycol as the heat transfer fluid, whereas drainback systems have an additional tank that allows water to drain out of the collectors to protect the system from freezing and overheating. An example of the different IFC configurations can be seen below in Figure C-2.

FIGURE C-2: INDIRECT FORCED CIRCULATION SYSTEM CONFIGURATIONS



Closed Loop Glycol Freeze Protection Internal Heat Exchanger

Closed Loop Glycol Freeze Protection External Heat Exchanger

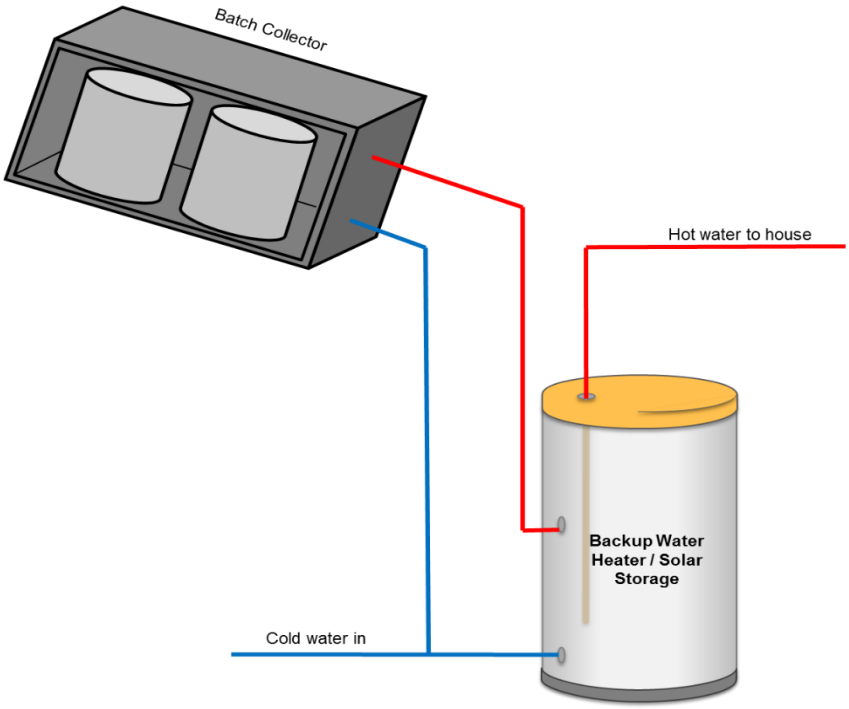
Drain Back Freeze Protection Internal Heat Exchanger

Direct Integral Collector Storage

Over half of the single-family budget program systems were identified as direct integral collector storage systems. These are passive systems, meaning that they do not require pumps or controls, and rely solely on natural convection to circulate the water. These are commonly known as a "batch" system and combine the collector and storage tank into a single unit. Large black tanks or tubes are housed in an insulated box, which preheat cold water from the municipal supply as it passes through on the way to the auxiliary water heater. These systems work best in warm climates with evening water heating loads as the hot water is stored outside and can quickly lose heat over night or during cloudy conditions.

Figure C-3 below shows an example of a direct integral collector storage system.

FIGURE C-3: DIRECT INTEGRAL COLLECTOR STORAGE DIAGRAM



Once the major system types for each budget program were identified, the next step was to determine whether there were additional differences within each budget program and SWH technology that should result in a further breakout of each of these technologies. Potential variables included differences in capacity (kW_{th}), differences in location (inland versus coastal), and differences in costs by contractor installed. The evaluation team reviewed the average expected therms saved, average cost per therms, and average incentives per therm for each of these different variables.

Additionally, the evaluation team reviewed each technology type to see whether the additional incentives (authorized in Advice Letter No. 4953 response to the methane leak at Alison Canyon) made a difference in the overall cost-effectiveness results of the program.

The final technologies within each budget program are described below.

C.1.1 Commercial Pools

The commercial pool sites were all made up of direct pool systems, which pump pool water directly through unglazed collectors, and then back into the pool. The majority of systems utilized drainback freeze protection, which a very small number were listed as glycol. Because glycol systems made up a

very small percentage of the commercial pool systems, the evaluation team decided to look only at drainback direct pool systems.

In the analysis of commercial pool systems, it was determined that there seemed to be a large difference in expected therms claimed when looking at inland versus coastal pools.[1] Therefore, the commercial pool budget program was split into two different technology types. The details for each system are shown in Table C-1, which includes Aliso Canyon results, and Table C-2, which excludes Aliso Canyon results.

TABLE C-1: COMMERCIAL POOL TECH. NUMBERS AND INPUTS – INCLUDES ALISON CANYON PROJECTS

Tech. Num.	System Type	kW_{th} Bucket	Qty.	Avg. kW_{th}	Avg. Exp. Therms	Wgt. Cost [$/therm]	Wgt. Incentive [$/therm]	Notes
1	Direct Pools	ALL	171	59.6	1,839	$12.54	$5.93	Coastal Only
2	Direct Pools	ALL	616	58.8	2,432	$8.71	$6.68	Inland Only

TABLE C-2: COMMERCIAL POOL TECH. NUMBERS AND INPUTS – EXCLUDES ALISON CANYON PROJECTS

Tech. Num.	System Type	kW_{th} Bucket	Qty.	Avg. kW_{th}	Avg. Exp. Therms	Wgt. Cost [$/therm]	Wgt. Incentive [$/therm]	Notes
1	Direct Pools	ALL	169	60	1,828	$12.63	$5.92	Coastal Only
2	Direct Pools	ALL	492	60	2,424	$9.02	$6.66	Inland Only

C.1.2 Commercial/Multifamily Residential & Low-Income Multifamily Residential

Indirect Forced Circulation systems made up 94 percent of the Commercial/Multifamily Residential systems. Over 50 percent of the systems in this budget program were identified as glycol freeze protection, while 42 percent of systems were identified as drainback freeze protection. For the Low-Income Multifamily Budget Program, over 80 percent of the systems were identified as glycol freeze protection and 15 percent as drainback. The cost of glycol systems is higher than that of drainback systems; therefore, the evaluation team separated the analysis into glycol versus drainback.

Commercial and multifamily systems can range greatly in size, from smaller multifamily facilities with just a few units to large multifamily complexes. An additional variable for capacity bucket (less than

[1] Coastal pools were defined as pools in building climate zones 1-7 while inland pools were defined as pools in building climate zones 8-16.

10kW$_{th}$ and greater or equal to 10 kW$_{th}$)[2] was created, as the cost per therm for these two system types varied significantly.

The details for each Commercial/Multifamily system are shown in Table C-3 and Table C-4, and for the Low-Income Multifamily Residential systems in Table C-5 below. The Low-Income Multifamily Program did not receive any increased incentives due to the Aliso Canyon leak.

TABLE C-3: COMMERCIAL/MULTIFAMILY RESIDENTIAL TECH. NUMBERS AND INPUTS – INCLUDES ALISO CANYON PROJECTS

Tech. Num.	System Type	kW$_{th}$ Bucket	Qty.	Avg. kW$_{th}$	Avg. Exp. Therms	Wgt. Cost [$/therm]	Wgt. Incentive [$/therm]	Notes
3	Indirect Forced Circulation	<10	13	7.5	375	$46.97	$16.79	Drainback
4		>= 10	435	49.0	2,664	$25.63	$20.25	Drainback
5	Indirect Forced Circulation	<10	62	5.7	293	$64.25	$18.39	Glycol
6		>= 10	498	50.8	2,438	$47.37	$18.68	Glycol

TABLE C-4: COMMERCIAL/MULTIFAMILY RESIDENTIAL TECH. NUMBERS AND INPUTS – EXCLUDES ALISO CANYON PROJECTS

Tech. Num.	System Type	kW$_{th}$ Bucket	Qty.	Avg. kW$_{th}$	Avg. Exp. Therms	Wgt. Cost [$/therm]	Wgt. Incentive [$/therm]	Notes
3	Indirect Forced Circulation	<10	13	8	375	$46.97	$16.79	Drainback
4		>= 10	399	48	2,575	$24.98	$19.50	Drainback
5	Indirect Forced Circulation	<10	59	6	289	$64.23	$18.02	Glycol
6		>= 10	455	51	2,443	$48.10	$17.96	Glycol

TABLE C-5: LOW-INCOME MULTIFAMILY RESIDENTIAL TECH. NUMBERS AND INPUTS

Tech. Num.	System Type	kW$_{th}$ Bucket	Qty.	Avg. kW$_{th}$	Avg. Exp. Therms	Wgt. Cost [$/therm]	Wgt. Incentive [$/therm]	Notes
7	Indirect Forced Circulation	<10	12	5.8	279	$105.91	$22.18	Drainback
8		>= 10	123	40.3	2,119	$35.63	$23.71	Drainback
9	Indirect Forced Circulation	<10	141	6.5	305	$61.04	$23.28	Glycol
10		>= 10	598	42.0	2,153	$46.70	$23.88	Glycol

[2] 10 kW$_{th}$ was established as a consistent large/small system dividing line based on examination of program participation data and other variables.

C.1.3 Multifamily Residential – Disadvantaged Communities

The two system types that made up the majority of the SWH system installations in the Multifamily Residential – Disadvantaged Communities budget program were the Indirect Forced Circulation – Drainback systems and Indirect Thermosyphon systems. There was a much smaller sample of systems in this budget program, so the team did not attempt to break out the Indirect Forced Circulation systems by kW_{th} bucket size. The Indirect Thermosyphon systems were all found to be under $10kW_{th}$. The details for the two Multifamily Residential – Disadvantaged Communities technologies are found below in Table C-6. This program did not receive any increased incentives due to the Aliso Canyon leak.

TABLE C-6: MULTIFAMILY RESIDENTIAL – DISADVANTAGED COMMUNITIES TECH. NUMBERS AND INPUTS

Tech. Num.	System Type	kW_{th} Bucket	Qty.	Avg. kW_{th}	Avg. Exp. Therms	Wgt. Cost [$/therm]	Wgt. Incentive [$/therm]	Notes
11	Indirect Forced Circulation	ALL	68	39.5	2,235	$22.18	$20.12	Drainback
12	Indirect Thermosyphon	<10	30	3.1	100	$62.80	$20.23	--

C.1.4 Single-Family Residential, Low-Income Single-Family Residential, and Single-Family Residential – Disadvantaged Communities

Indirect Forced Circulation systems and Direct Integral Collector systems made up the majority of the systems installed in the single-family budget programs. Unlike the commercial and multifamily budget programs, the difference between glycol and drainback Indirect Forced Circulation systems did not make up such a large change; therefore, all Indirect Forced Circulation systems were combined into a single tech. number for each single-family budget program. However, there was one significant difference for single-family systems. A single contractor made up a large portion of installations in the later years of the program. This contractor mostly installed a single system type, and the cost of these systems was much lower than the systems installed by other contractors. Therefore, the systems installed by the single contractor were split out from the other systems. The Single-Family Residential budget program saw increased incentive rates due to the Aliso Canyon leak, but the Low-Income Single-Family Residential and Single-Family Residential Disadvantaged Communities programs did not.

TABLE C-7: SINGLE-FAMILY RESIDENTIAL TECH. NUMBERS AND INPUTS – INCLUDES ALISO CANYON PROJECTS

Tech. Num.	System Type	kW_{th} Bucket	Qty.	Avg. kW_{th}	Avg. Exp. Therms	Wgt. Cost [$/therm]	Wgt. Incentive [$/therm]	Notes
13a	Direct Integral Collector Storage	<10	558	1.7	75	$143.47	$31.45	No low-cost projects
13b		<10	123	1.7	121	$37.12	$36.37	Low-cost contractor only
14a	Indirect Forced Circulation	<10	1,784	3.3	132	$75.86	$52.29	No low-cost projects
14b		<10	150	2.8	140	$29.15	$28.63	Low-cost contractor only

TABLE C-8: SINGLE-FAMILY RESIDENTIAL TECH. NUMBERS AND INPUTS – EXCLUDES ALISO CANYON PROJECTS

Tech. Num.	System Type	kW_{th} Bucket	Qty.	Avg. kW_{th}	Avg. Exp. Therms	Wgt. Cost [$/therm]	Wgt. Incentive [$/therm]	Notes
13a	Direct Integral Collector Storage	<10	522	2	73	$147.74	$27.76	No low-cost projects
13b		<10	102	2	121	$31.25	$30.41	Low-cost contractor only
14a	Indirect Forced Circulation	<10	772	4	123	$76.37	$23.62	No low-cost projects
14b		<10	150	3	140	$29.15	$28.63	Low-cost contractor only

TABLE C-9: LOW-INCOME SINGLE-FAMILY RESIDENTIAL TECH. NUMBERS AND INPUTS

Tech. Num.	System Type	kW_{th} Bucket	Qty.	Avg. kW_{th}	Avg. Exp. Therms	Wgt. Cost [$/therm]	Wgt. Incentive [$/therm]	Notes
15	Direct Integral Collector Storage	<10	1,497	1.7	126	$37.68	$46.96	--
16	Indirect Forced Circulation	<10	1,161	3.0	133	$40.78	$35.71	--

TABLE C-10: SINGLE-FAMILY RESIDENTIAL – DISADVANTAGED COMMUNITIES TECH. NUMBERS AND INPUTS

Tech. Num.	System Type	kW_{th} Bucket	Qty.	Avg. kW_{th}	Avg. Exp. Therms	Wgt. Cost [$/therm]	Wgt. Incentive [$/therm]	Notes
17	Direct Integral Collector Storage	<10	175	1.7	127	$30.45	$29.85	--
18	Indirect Forced Circulation	<10	101	2.8	130	$30.42	$29.27	--
19	Indirect Thermosyphon	<10	62	3.1	103	$60.37	$29.84	--

C.2 DETERMINING INPUTS

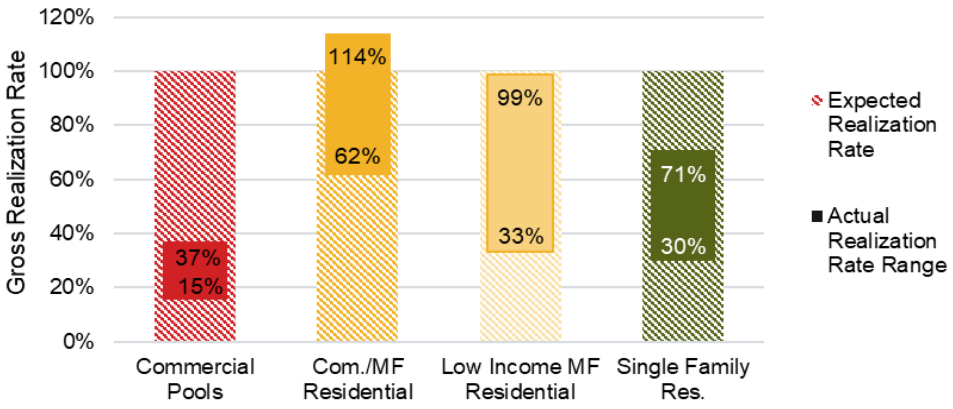
C.2.1 Average Therm Savings and Gross Realization Rates

One metric that enters the cost-effectiveness calculations is how much energy is being saved through the installation of SWH systems. The program tracking data identify the expected therms saved for each record. The evaluation team used these tracking data reported values to calculate an average of the expected therms saved for each tech. number, which is shown in Table C-1 through Table C-10 above.

However, the evaluation team also understood that the reported expected savings were not always the savings that were actually realized by the systems. The CSI-Thermal Impact Report calculated a gross realization rate (GRR)[3] for each budget program and found that, in general, actual savings were much lower than expected savings. The Impact Report chose a sample of sites to be statistically significant by Budget Program. The overall program results meet an 80/20 confidence and relative precision level. A confidence and relative precision of 80/20 means that there is an 80 percent probability that the actual energy savings for the program are within 20 percent of the actual mean evaluated savings. The higher the confidence level, and the smaller the relative precision, the better the evaluation findings are at predicting the results. However, results at all of the budget program levels were not statistically significant at the 80/20 level, and it is important to recognize the level of uncertainty surrounding those results. Figure C-4 displays the GRR for each budget program, including the error bars at 90 percent confidence. The graphic below demonstrates that while the report specifies the program realization rate as the average value, the error bars display potential range of realization rates for each budget program.

[3] The GRR is a metric to provide a comparison between actual and expected results and is defined as the ratio between the two. To develop program-level GRRs, the site-level results need to be weighted up to the population. More on this process can be found in the CSI-Thermal Impact Report, Section 3.

FIGURE C-4: GROSS REALIZATION RATE RANGE AT 90 PERCENT CONFIDENCE



For the cost-effectiveness evaluation, the evaluation team took the average expected therms saved for technology number, and multiplied it by the high, mean, and low GRR values. These represent high, mean, and low savings estimates. In doing so, the team was able to develop the cost-effectiveness models to better fit the evaluated program results. These final therms saved for each technology number are found below in Table C-11.

TABLE C-11: ACTUAL THERMS SAVED AND GROSS REALIZATION RATES BY TECHNOLOGY NUMBER

Tech. Num.	Budget Program	Gross Realization Rate			Actual Therms Saved		
		High	Mean	Low	High	Mean	Low
1	Com. Pools	37%	26%	15%	681	478	276
2	Com. Pools	37%	26%	15%	900	632	365
3	Com./MF Res.	114%	88%	62%	428	330	233
4	Com./MF Res.	114%	88%	62%	3,037	2,344	1,652
5	Com./MF Res.	114%	88%	62%	334	258	182
6	Com./MF Res.	114%	88%	62%	2,780	2,146	1,512
7	LI MF Res.	99%	66%	33%	276	184	92
8	LI MF Res.	99%	66%	33%	2,097	1,398	699
9	LI MF Res.	99%	66%	33%	302	201	101
10	LI MF Res.	99%	66%	33%	2,131	1,421	710
11	MF Res. - DAC	114%	88%	62%	2,548	1,967	1,386
12	MF Res. – DAC	114%	88%	62%	113	88	62
13a	SF Res.	71%	50%	30%	53	38	23
13b	SF Res.	71%	50%	30%	86	61	36
14a	SF Res.	71%	50%	30%	94	66	40
14b	SF Res.	71%	50%	30%	99	70	42
15	LI SF Res.	71%	50%	30%	89	63	38
16	LI SF Res.	71%	50%	30%	94	66	40
17	SF Res. - DAC	71%	50%	30%	90	63	38
18	SF Res. – DAC	71%	50%	30%	93	65	39
19	SF Res. - DAC	71%	50%	30%	73	52	31

C.2.2 Pump Operation

Active SWH systems utilize pumps to circulate water up to the roof, through the collectors, and back down into the storage tank. For many systems, these circulation pumps represent an additional energy load on the water heating system. The evaluation team accounted for this additional load in some of the models that were based on active SWH systems.[4]

The evaluation team took several steps to determine the additional load that the pump represented for each system.

- **Identify average pump runtime from metered data:** The evaluation team went back to the metered data collected for the CSI Thermal Impact Evaluation and created average hourly profiles by day type (weekend versus weekday) and month. From there, an average 8760 profile was created based on the percent run time of each hour, for single-family and commercial/multifamily facilities separately.
- **Determine average pump power:** The evaluation team went back to the onsite data used in the CSI Thermal Impact Evaluation and identified number of pumps and the make/model of each pump to determine pump wattage. For single-family pumps, the total wattage came out to 50 watts. For commercial/multifamily facilities with system sizes less than 10 kW_{th}, the average pump power was found to be 159 watts. For those with system sizes greater or equal to 10 kW_{th}, the average pump power was identified as 337 watts.
- **Calculate final pump energy:** The final pump energy was calculated as $Energy\ Consumption = \sum RunTimePercent_{hour} \times Pump\ Wattage \times Load\ Factor$

It should be noted that the expected savings for each site are based on a calculator that accounts for the additional pump power of the SWH systems. However, the evaluation team's GRR accounts for thermal savings but explicitly excludes additional electricity for pumps that might be accounted for in the expected savings. Therefore, the pump power was estimated based on observed behavior in the field.

C.2.3 Operations and Maintenance Costs

Although primary research on O&M costs for SWH is limited, several sources point to O&M costs between 0.5 percent and 2 percent of the initial system costs. The required maintenance is similar to

[4] Although Commercial Pool systems are considered active systems, it was determined that the pump utilized to circulate water through the collectors was usually the same pump that was used in the baseline pool to move water through the filter, and therefore no additional load was added to pools due to the circulation pumps.

that required for other hydronic heating loops, with regularly scheduled maintenance including a variety of tasks:[5]

- Checking the solar collectors, frames, and pipe connections for any damage or signs of corrosion.
- Examining the proper position of all valves and reviewing tightness of mounting connectors and repairing any bent or corroded mounting components.
- Inspecting and maintaining the pipe insulation and protective materials to minimize losses and maintain freeze protection.
- Determining if any new objects, such as vegetation growth, are shading the array and move them if possible.
- Annual cleaning of the array.
- Observing operational indicators of temperature and pressure to ensure proper operation of pumps and controls. Ensuring that the pump is running on a sunny day and not at night.
- Using an insolation meter to measure incident sunlight and simultaneously observe temperature and energy output on the controller faceplate. Comparing these readings with the original efficiency of the system (see ASHRAE handbooks for more tests).
- Checking status indicators of the controller faceplate and comparing indicators with measured values.
- Documenting all O&M activities in a workbook and making that workbook available to all service personnel.
- Flushing the potable water storage tank every year to remove sediment, flushing and filling heat transfer fluid ever 10 years, and flushing system to remove scaling.
- Replacing the sacrificial anode in the storage tank as needed.
- Possible replacement of storage tank, typically in excess of 10 years.

Another study[6] developed a breakdown of O&M costs and noted that maintaining solar fluid is the most relevant cost driver, indicating that active and indirect systems typically incurred higher O&M costs. Based on these findings, the evaluation team calculated O&M costs at the project level based

[5] Andy Walker, Solar Water Heating, National Renewable Energy Laboratory, 11/16/2016. https://www.wbdg.org/resources/solar-water-heating. Accessed on 10/02/2019.

[6] Schiebler, Bert, et al. "Reduction of Maintenance Costs for Solar Thermal Systems with Overheating Prevention." Solar Heating & Cooling Programme, International Energy Agency, Reduction of Maintenance Costs for Solar Thermal Systems with Overheating Prevention, Oct. 2018, task54.iea-shc.org/.

on the specifications found in Table C-12 below. The final O&M costs used in the model calculated an average total cost across each budget program and active/passive designation, and from there, identified a cost per kW_{th} for each technology number.

TABLE C-12: O&M COSTS

Budget Program	Active / Passive Systems	O&M Percentage of Initial System Cost
Commercial Pools	Active	1%
Com./MF	Active & Passive	1%
Single-Family	Active	1.5%
Single-Family	Passive	0.5%

C.2.4 System Degradation Rates

The evaluation team performed literature reviews in attempts to determine degradation rates for the systems. Similar to O&M costs, there is not much primary research on SWH system degradation, but the evaluation team uncovered some research indicating the system degradation varied between 0 percent and 1.5 percent. The evaluation team assumed the following degradation rates:

- 0.5 percent for passive and direct systems. These have the least amount of moving parts and breakable pieces.[7]
- 1.0 percent for active and indirect systems. These systems have more moving parts and therefore more pieces that can break than passive systems.[8]
- 1.5 percent for Commercial Pools. This higher value is assumed because UV light will cause the unglazed collectors to degrade quicker than glazed collectors and ongoing maintenance to plug leaks usually bypass small portions of the collectors.

C.2.5 Effective Useful Life

The effective useful life model assumptions were again based on a literature review of limited research. For Single-Family and Commercial/Multifamily DHW systems, several sources were identified, shown in Table C-13 below:

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[7] Based on Break-even Cost for Residential Solar Water Heating in the United States: Key Drivers and Sensitivities. NREL. February 2011.

[8] The Cadmus Group sent a memo highlighting a 1.0 percent degradation rate for SWH systems, citing the assumption used in the NREL Solar Advisor Model. https://www.solarthermalworld.org/sites/gstec/files/story/2015-06-20/pac_2013irp_memo_swh_20120815.pdf. The actual value from the NREL model could not be determined.

TABLE C-13: LIFETIME RESEARCH DOCUMENTATION

Document Title	Sector	Low Range	High Range	Link
High Performance Flat Plate Solar Thermal Collector Evaluation	Com/MF/SF	25	25	(1)
Comparison of Advanced Water Heating Technologies in the United States	Com/MF/SF	30	30	(2)
Scenarios to Decarbonize Residential Water Heating in California	Com/MF/SF	20	20	(3)
Hot Water Heaters	Com/MF/SF	15	30	(4)
Saving Money & Energy: How Solar Heating & Cooling is Paying Big Dividends for US Businesses.	Pools	15	15	(5)
Solar Swimming Pool Heaters	Pools	10	20	(6)
Low-Cost Solar Water Heating Research and Development Roadmap	Pools	10	20	(7)
Solar Pool Heating	Pools	15	20	(8)
Pool Info: Solar Pool Heaters	Pools	10	20	(9)
Show Me PACE. Appendix B: Eligible PACE Improvements and Expected Useful Life	Pools	20	20	(10)

(1) https://www.nrel.gov/docs/fy16osti/66215.pdf
(2) https://www.nrel.gov/docs/fy13osti/55475.pdf
(3) https://rael.berkeley.edu/wp-content/uploads/2017/07/Raghavan-Wei-Kammen-WaterHeating-_-ENergyPolicy-2017.pdf
(4) http://www.mnshi.umn.edu/kb/scale/hotwaterheaters.html
(5) https://www.seia.org/sites/default/files/resources/SHC_Case_Study_Report.pdf
(6) https://www.energy.gov/energysaver/solar-swimming-pool-heaters
(7) https://www.nrel.gov/docs/fy12osti/54793.pdf
(8) http://www.iea-shc.org/solar-applications-pool-heating
(9) https://www.poolcenter.com/solarHeaters
(10) http://www.showmepace.org/wp-content/uploads/2015/11/Program-Manual-Appendix-B.pdf

Based on the review of the sources below, effective lifetime research for commercial, multifamily, and single-family DWH systems ranges from 15 to 30 years. Pool system research was found to range between 10 and 20 years. Itron used the value of 25 years for all DHW systems and the value of 20 years for all pool systems in their model.

APPENDIX D COST-EFFECTIVENESS DETAILS

The following table provides the cost-effectiveness test ratios for each scenario by technology, budget program, utility, savings gross realization rate (GRR), geography (coastal, inland, or all), technology size bucket, and with or without special rebate installations in Aliso Canyon. Note that the Aliso Canyon "Yes" option is only applicable to SCG.

Tech. Num.	Budget Program	Utility	GRR	System Type	Coastal/Inland	kWth Bucket	Aliso Canyon	PTC Ratio	RIM Ratio	TRC Ratio	PA Ratio
4	Commercial/Multifamily Residential	PG&E	High	Indirect Forced Circulation - Drainback (IFD)	all	>= 10	No	1.17	0.45	0.51	0.72
4	Commercial/Multifamily Residential	PG&E	Mean	Indirect Forced Circulation - Drainback (IFD)	all	>= 10	No	1.08	0.38	0.40	0.55
4	Commercial/Multifamily Residential	PG&E	Low	Indirect Forced Circulation - Drainback (IFD)	all	>= 10	No	0.99	0.31	0.28	0.39
4	Commercial/Multifamily Residential	SCG	High	Indirect Forced Circulation - Drainback (IFD)	all	>= 10	No	1.08	0.45	0.48	0.67
4	Commercial/Multifamily Residential	SCG	Mean	Indirect Forced Circulation - Drainback (IFD)	all	>= 10	No	1.01	0.38	0.37	0.52
4	Commercial/Multifamily Residential	SCG	Low	Indirect Forced Circulation - Drainback (IFD)	all	>= 10	No	0.94	0.30	0.26	0.37
4	Commercial/Multifamily Residential	SDG&E	High	Indirect Forced Circulation - Drainback (IFD)	all	>= 10	No	1.15	0.44	0.50	0.70
4	Commercial/Multifamily Residential	SDG&E	Mean	Indirect Forced Circulation - Drainback (IFD)	all	>= 10	No	1.06	0.37	0.38	0.54
4	Commercial/Multifamily Residential	SDG&E	Low	Indirect Forced Circulation - Drainback (IFD)	all	>= 10	No	0.98	0.29	0.27	0.38
3	Commercial/Multifamily Residential	PG&E	High	Indirect Forced Circulation - Drainback (IFD)	all	<10	No	0.87	0.52	0.37	0.82
3	Commercial/Multifamily Residential	PG&E	Mean	Indirect Forced Circulation - Drainback (IFD)	all	<10	No	0.81	0.47	0.29	0.63
3	Commercial/Multifamily Residential	PG&E	Low	Indirect Forced Circulation - Drainback (IFD)	all	<10	No	0.76	0.39	0.20	0.44
3	Commercial/Multifamily Residential	SCG	High	Indirect Forced Circulation - Drainback (IFD)	all	<10	No	0.82	0.52	0.35	0.76
3	Commercial/Multifamily Residential	SCG	Mean	Indirect Forced Circulation - Drainback (IFD)	all	<10	No	0.78	0.45	0.27	0.59
3	Commercial/Multifamily Residential	SCG	Low	Indirect Forced Circulation - Drainback (IFD)	all	<10	No	0.74	0.36	0.19	0.41
3	Commercial/Multifamily Residential	SDG&E	High	Indirect Forced Circulation - Drainback (IFD)	all	<10	No	0.86	0.49	0.36	0.79

Tech. Num.	Budget Program	Utility	GRR	System Type	Coastal/Inland	kWth Bucket	Aliso Canyon	PTC Ratio	RIM Ratio	TRC Ratio	PA Ratio
3	Commercial/Multifamily Residential	SDG&E	Mean	Indirect Forced Circulation - Drainback (IFD)	all	<10	No	0.81	0.43	0.28	0.61
3	Commercial/Multifamily Residential	SDG&E	Low	Indirect Forced Circulation - Drainback (IFD)	all	<10	No	0.76	0.34	0.19	0.43
6	Commercial/Multifamily Residential	PG&E	High	Indirect Forced Circulation - Glycol (IFG)	all	>= 10	No	0.89	0.47	0.37	0.78
6	Commercial/Multifamily Residential	PG&E	Mean	Indirect Forced Circulation - Glycol (IFG)	all	>= 10	No	0.84	0.41	0.28	0.60
6	Commercial/Multifamily Residential	PG&E	Low	Indirect Forced Circulation - Glycol (IFG)	all	>= 10	No	0.79	0.33	0.20	0.42
6	Commercial/Multifamily Residential	SCG	High	Indirect Forced Circulation - Glycol (IFG)	all	>= 10	No	0.84	0.48	0.34	0.73
6	Commercial/Multifamily Residential	SCG	Mean	Indirect Forced Circulation - Glycol (IFG)	all	>= 10	No	0.80	0.41	0.27	0.56
6	Commercial/Multifamily Residential	SCG	Low	Indirect Forced Circulation - Glycol (IFG)	all	>= 10	No	0.76	0.32	0.19	0.40
6	Commercial/Multifamily Residential	SDG&E	High	Indirect Forced Circulation - Glycol (IFG)	all	>= 10	No	0.88	0.46	0.36	0.75
6	Commercial/Multifamily Residential	SDG&E	Mean	Indirect Forced Circulation - Glycol (IFG)	all	>= 10	No	0.83	0.39	0.28	0.58
6	Commercial/Multifamily Residential	SDG&E	Low	Indirect Forced Circulation - Glycol (IFG)	all	>= 10	No	0.78	0.31	0.19	0.41
5	Commercial/Multifamily Residential	PG&E	High	Indirect Forced Circulation - Glycol (IFG)	all	<10	No	0.78	0.52	0.29	0.76
5	Commercial/Multifamily Residential	PG&E	Mean	Indirect Forced Circulation - Glycol (IFG)	all	<10	No	0.74	0.46	0.22	0.58
5	Commercial/Multifamily Residential	PG&E	Low	Indirect Forced Circulation - Glycol (IFG)	all	<10	No	0.70	0.39	0.16	0.41
5	Commercial/Multifamily Residential	SCG	High	Indirect Forced Circulation - Glycol (IFG)	all	<10	No	0.75	0.50	0.27	0.70

Tech. Num.	Budget Program	Utility	GRR	System Type	Coastal/Inland	kWth Bucket	Aliso Canyon	PTC Ratio	RIM Ratio	TRC Ratio	PA Ratio
5	Commercial/Multifamily Residential	SCG	Mean	Indirect Forced Circulation - Glycol (IFG)	all	<10	No	0.72	0.43	0.21	0.54
5	Commercial/Multifamily Residential	SCG	Low	Indirect Forced Circulation - Glycol (IFG)	all	<10	No	0.69	0.35	0.15	0.38
5	Commercial/Multifamily Residential	SDG&E	High	Indirect Forced Circulation - Glycol (IFG)	all	<10	No	0.78	0.48	0.28	0.73
5	Commercial/Multifamily Residential	SDG&E	Mean	Indirect Forced Circulation - Glycol (IFG)	all	<10	No	0.74	0.41	0.21	0.57
5	Commercial/Multifamily Residential	SDG&E	Low	Indirect Forced Circulation - Glycol (IFG)	all	<10	No	0.70	0.34	0.15	0.40
8	Low Income Multifamily Residential	PG&E	High	Indirect Forced Circulation - Drainback (IFD)	all	>= 10	No	1.00	0.37	0.34	0.51
8	Low Income Multifamily Residential	PG&E	Mean	Indirect Forced Circulation - Drainback (IFD)	all	>= 10	No	0.91	0.28	0.23	0.34
8	Low Income Multifamily Residential	PG&E	Low	Indirect Forced Circulation - Drainback (IFD)	all	>= 10	No	0.83	0.18	0.11	0.17
8	Low Income Multifamily Residential	SCG	High	Indirect Forced Circulation - Drainback (IFD)	all	>= 10	No	0.95	0.36	0.32	0.48
8	Low Income Multifamily Residential	SCG	Mean	Indirect Forced Circulation - Drainback (IFD)	all	>= 10	No	0.88	0.27	0.21	0.32
8	Low Income Multifamily Residential	SCG	Low	Indirect Forced Circulation - Drainback (IFD)	all	>= 10	No	0.81	0.16	0.11	0.16
8	Low Income Multifamily Residential	SDG&E	High	Indirect Forced Circulation - Drainback (IFD)	all	>= 10	No	0.99	0.35	0.33	0.49
8	Low Income Multifamily Residential	SDG&E	Mean	Indirect Forced Circulation - Drainback (IFD)	all	>= 10	No	0.91	0.27	0.22	0.33
8	Low Income Multifamily Residential	SDG&E	Low	Indirect Forced Circulation - Drainback (IFD)	all	>= 10	No	0.83	0.16	0.11	0.16
7	Low Income Multifamily Residential	PG&E	High	Indirect Forced Circulation - Drainback (IFD)	all	<10	No	0.69	0.44	0.17	0.53

Tech. Num.	Budget Program	Utility	GRR	System Type	Coastal/Inland	kWth Bucket	Aliso Canyon	PTC Ratio	RIM Ratio	TRC Ratio	PA Ratio
7	Low Income Multifamily Residential	PG&E	Mean	Indirect Forced Circulation - Drainback (IFD)	all	<10	No	0.66	0.36	0.11	0.35
7	Low Income Multifamily Residential	PG&E	Low	Indirect Forced Circulation - Drainback (IFD)	all	<10	No	0.63	0.26	0.06	0.18
7	Low Income Multifamily Residential	SCG	High	Indirect Forced Circulation - Drainback (IFD)	all	<10	No	0.68	0.41	0.16	0.50
7	Low Income Multifamily Residential	SCG	Mean	Indirect Forced Circulation - Drainback (IFD)	all	<10	No	0.65	0.32	0.10	0.33
7	Low Income Multifamily Residential	SCG	Low	Indirect Forced Circulation - Drainback (IFD)	all	<10	No	0.63	0.21	0.05	0.17
10	Low Income Multifamily Residential	PG&E	High	Indirect Forced Circulation - Glycol (IFG)	all	>= 10	No	0.91	0.36	0.29	0.51
10	Low Income Multifamily Residential	PG&E	Mean	Indirect Forced Circulation - Glycol (IFG)	all	>= 10	No	0.84	0.28	0.20	0.34
10	Low Income Multifamily Residential	PG&E	Low	Indirect Forced Circulation - Glycol (IFG)	all	>= 10	No	0.77	0.17	0.10	0.17
10	Low Income Multifamily Residential	SCG	High	Indirect Forced Circulation - Glycol (IFG)	all	>= 10	No	0.86	0.36	0.27	0.47
10	Low Income Multifamily Residential	SCG	Mean	Indirect Forced Circulation - Glycol (IFG)	all	>= 10	No	0.81	0.27	0.18	0.32
10	Low Income Multifamily Residential	SCG	Low	Indirect Forced Circulation - Glycol (IFG)	all	>= 10	No	0.76	0.16	0.09	0.16
10	Low Income Multifamily Residential	SDG&E	High	Indirect Forced Circulation - Glycol (IFG)	all	>= 10	No	0.89	0.35	0.28	0.49
10	Low Income Multifamily Residential	SDG&E	Mean	Indirect Forced Circulation - Glycol (IFG)	all	>= 10	No	0.83	0.26	0.19	0.33
10	Low Income Multifamily Residential	SDG&E	Low	Indirect Forced Circulation - Glycol (IFG)	all	>= 10	No	0.77	0.15	0.09	0.16
9	Low Income Multifamily Residential	PG&E	High	Indirect Forced Circulation - Glycol (IFG)	all	<10	No	0.79	0.42	0.23	0.51

Tech. Num.	Budget Program	Utility	GRR	System Type	Coastal/Inland	kWth Bucket	Aliso Canyon	PTC Ratio	RIM Ratio	TRC Ratio	PA Ratio
9	Low Income Multifamily Residential	PG&E	Mean	Indirect Forced Circulation - Glycol (IFG)	all	<10	No	0.74	0.34	0.16	0.34
9	Low Income Multifamily Residential	PG&E	Low	Indirect Forced Circulation - Glycol (IFG)	all	<10	No	0.69	0.24	0.08	0.17
9	Low Income Multifamily Residential	SCG	High	Indirect Forced Circulation - Glycol (IFG)	all	<10	No	0.76	0.39	0.22	0.48
9	Low Income Multifamily Residential	SCG	Mean	Indirect Forced Circulation - Glycol (IFG)	all	<10	No	0.72	0.30	0.15	0.32
9	Low Income Multifamily Residential	SCG	Low	Indirect Forced Circulation - Glycol (IFG)	all	<10	No	0.68	0.20	0.07	0.16
9	Low Income Multifamily Residential	SDG&E	High	Indirect Forced Circulation - Glycol (IFG)	all	<10	No	0.78	0.37	0.23	0.49
9	Low Income Multifamily Residential	SDG&E	Mean	Indirect Forced Circulation - Glycol (IFG)	all	<10	No	0.74	0.29	0.15	0.33
9	Low Income Multifamily Residential	SDG&E	Low	Indirect Forced Circulation - Glycol (IFG)	all	<10	No	0.69	0.18	0.08	0.16
15	Low Income Single-Family Residential	SCG	High	Direct Integral Collector Storage (DI)	all	<10	No	1.15	0.15	0.17	0.19
15	Low Income Single-Family Residential	SCG	Mean	Direct Integral Collector Storage (DI)	all	<10	No	1.07	0.11	0.12	0.13
15	Low Income Single-Family Residential	SCG	Low	Direct Integral Collector Storage (DI)	all	<10	No	0.99	0.07	0.07	0.08
16	Low Income Single-Family Residential	PG&E	High	Indirect Forced Circulation (IF)	all	<10	No	0.97	0.18	0.16	0.24
16	Low Income Single-Family Residential	PG&E	Mean	Indirect Forced Circulation (IF)	all	<10	No	0.88	0.15	0.12	0.17
16	Low Income Single-Family Residential	PG&E	Low	Indirect Forced Circulation (IF)	all	<10	No	0.78	0.11	0.07	0.10

Tech. Num.	Budget Program	Utility	GRR	System Type	Coastal/Inland	kWth Bucket	Aliso Canyon	PTC Ratio	RIM Ratio	TRC Ratio	PA Ratio
16	Low Income Single-Family Residential	SCG	High	Indirect Forced Circulation (IF)	all	<10	No	0.90	0.19	0.16	0.23
16	Low Income Single-Family Residential	SCG	Mean	Indirect Forced Circulation (IF)	all	<10	No	0.82	0.15	0.11	0.16
16	Low Income Single-Family Residential	SCG	Low	Indirect Forced Circulation (IF)	all	<10	No	0.75	0.11	0.07	0.10
11	Multifamily Residential - Disadvantaged Community	PG&E	High	Indirect Forced Circulation - Drainback (IFD)	all	all	No	1.21	0.44	0.52	0.69
11	Multifamily Residential - Disadvantaged Community	PG&E	Mean	Indirect Forced Circulation - Drainback (IFD)	all	all	No	1.11	0.38	0.40	0.54
11	Multifamily Residential - Disadvantaged Community	PG&E	Low	Indirect Forced Circulation - Drainback (IFD)	all	all	No	1.02	0.30	0.28	0.38
11	Multifamily Residential - Disadvantaged Community	SCG	High	Indirect Forced Circulation - Drainback (IFD)	all	all	No	1.12	0.44	0.48	0.65
11	Multifamily Residential - Disadvantaged Community	SCG	Mean	Indirect Forced Circulation - Drainback (IFD)	all	all	No	1.04	0.37	0.37	0.50
11	Multifamily Residential - Disadvantaged Community	SCG	Low	Indirect Forced Circulation - Drainback (IFD)	all	all	No	0.97	0.29	0.26	0.35
12	Multifamily Residential - Disadvantaged Community	PG&E	High	Indirect Thermosyphon (IT)	all	<10	No	0.71	0.43	0.23	0.74
12	Multifamily Residential - Disadvantaged Community	PG&E	Mean	Indirect Thermosyphon (IT)	all	<10	No	0.68	0.37	0.18	0.57

Tech. Num.	Budget Program	Utility	GRR	System Type	Coastal/Inland	kWth Bucket	Aliso Canyon	PTC Ratio	RIM Ratio	TRC Ratio	PA Ratio
12	Multifamily Residential - Disadvantaged Community	PG&E	Low	Indirect Thermosyphon (IT)	all	<10	No	0.65	0.29	0.13	0.40
12	Multifamily Residential - Disadvantaged Community	SCG	High	Indirect Thermosyphon (IT)	all	<10	No	0.68	0.45	0.22	0.69
12	Multifamily Residential - Disadvantaged Community	SCG	Mean	Indirect Thermosyphon (IT)	all	<10	No	0.65	0.38	0.17	0.53
12	Multifamily Residential - Disadvantaged Community	SCG	Low	Indirect Thermosyphon (IT)	all	<10	No	0.63	0.29	0.12	0.38
1	Commercial Pools	PG&E	High	Direct Pools - Drainback (DPD)	Coastal	all	No	0.94	0.41	0.36	0.67
1	Commercial Pools	PG&E	Mean	Direct Pools - Drainback (DPD)	Coastal	all	No	0.86	0.33	0.26	0.47
1	Commercial Pools	PG&E	Low	Direct Pools - Drainback (DPD)	Coastal	all	No	0.79	0.22	0.15	0.27
1	Commercial Pools	SCG	High	Direct Pools - Drainback (DPD)	Coastal	all	No	0.87	0.42	0.33	0.61
1	Commercial Pools	SCG	Mean	Direct Pools - Drainback (DPD)	Coastal	all	No	0.82	0.32	0.23	0.43
1	Commercial Pools	SCG	Low	Direct Pools - Drainback (DPD)	Coastal	all	No	0.77	0.21	0.13	0.25
1	Commercial Pools	SDG&E	High	Direct Pools - Drainback (DPD)	Coastal	all	No	0.91	0.41	0.35	0.64
1	Commercial Pools	SDG&E	Mean	Direct Pools - Drainback (DPD)	Coastal	all	No	0.85	0.33	0.25	0.45
1	Commercial Pools	SDG&E	Low	Direct Pools - Drainback (DPD)	Coastal	all	No	0.78	0.21	0.14	0.26

Tech. Num.	Budget Program	Utility	GRR	System Type	Coastal/Inland	kWth Bucket	Aliso Canyon	PTC Ratio	RIM Ratio	TRC Ratio	PA Ratio
2	Commercial Pools	PG&E	High	Direct Pools - Drainback (DPD)	Inland	all	No	1.12	0.37	0.41	0.56
2	Commercial Pools	PG&E	Mean	Direct Pools - Drainback (DPD)	Inland	all	No	1.02	0.29	0.29	0.40
2	Commercial Pools	PG&E	Low	Direct Pools - Drainback (DPD)	Inland	all	No	0.92	0.19	0.17	0.23
2	Commercial Pools	SCG	High	Direct Pools - Drainback (DPD)	Inland	all	No	1.04	0.37	0.38	0.52
2	Commercial Pools	SCG	Mean	Direct Pools - Drainback (DPD)	Inland	all	No	0.97	0.29	0.27	0.37
2	Commercial Pools	SCG	Low	Direct Pools - Drainback (DPD)	Inland	all	No	0.89	0.18	0.16	0.21
2	Commercial Pools	SDG&E	High	Direct Pools - Drainback (DPD)	Inland	all	No	1.09	0.37	0.40	0.54
2	Commercial Pools	SDG&E	Mean	Direct Pools - Drainback (DPD)	Inland	all	No	1.00	0.29	0.28	0.38
2	Commercial Pools	SDG&E	Low	Direct Pools - Drainback (DPD)	Inland	all	No	0.91	0.18	0.16	0.22
13a	Single-Family Residential	PG&E	High	Direct Integral Collector Storage (DI)	all	<10	No	0.60	0.19	0.09	0.33
13a	Single-Family Residential	PG&E	Mean	Direct Integral Collector Storage (DI)	all	<10	No	0.55	0.15	0.06	0.23
13a	Single-Family Residential	PG&E	Low	Direct Integral Collector Storage (DI)	all	<10	No	0.50	0.11	0.04	0.14
13a	Single-Family Residential	SCG	High	Direct Integral Collector Storage (DI)	all	<10	No	0.56	0.20	0.08	0.32
13a	Single-Family Residential	SCG	Mean	Direct Integral Collector Storage (DI)	all	<10	No	0.52	0.16	0.06	0.22

Tech. Num.	Budget Program	Utility	GRR	System Type	Coastal/Inland	kWth Bucket	Aliso Canyon	PTC Ratio	RIM Ratio	TRC Ratio	PA Ratio
13a	Single-Family Residential	SCG	Low	Direct Integral Collector Storage (DI)	all	<10	No	0.49	0.11	0.04	0.13
13a	Single-Family Residential	SDG&E	High	Direct Integral Collector Storage (DI)	all	<10	No	0.56	0.21	0.09	0.33
13a	Single-Family Residential	SDG&E	Mean	Direct Integral Collector Storage (DI)	all	<10	No	0.53	0.16	0.06	0.23
13a	Single-Family Residential	SDG&E	Low	Direct Integral Collector Storage (DI)	all	<10	No	0.49	0.11	0.04	0.14
14a	Single-Family Residential	PG&E	High	Indirect Forced Circulation (IF)	all	<10	No	0.79	0.15	0.10	0.18
14a	Single-Family Residential	PG&E	Mean	Indirect Forced Circulation (IF)	all	<10	No	0.72	0.12	0.07	0.13
14a	Single-Family Residential	PG&E	Low	Indirect Forced Circulation (IF)	all	<10	No	0.66	0.09	0.04	0.08
14a	Single-Family Residential	SCG	High	Indirect Forced Circulation (IF)	all	<10	No	0.74	0.15	0.09	0.17
14a	Single-Family Residential	SCG	Mean	Indirect Forced Circulation (IF)	all	<10	No	0.69	0.12	0.07	0.12
14a	Single-Family Residential	SCG	Low	Indirect Forced Circulation (IF)	all	<10	No	0.64	0.09	0.04	0.07
14a	Single-Family Residential	SDG&E	High	Indirect Forced Circulation (IF)	all	<10	No	0.73	0.17	0.10	0.18
14a	Single-Family Residential	SDG&E	Mean	Indirect Forced Circulation (IF)	all	<10	No	0.68	0.14	0.07	0.13
14a	Single-Family Residential	SDG&E	Low	Indirect Forced Circulation (IF)	all	<10	No	0.64	0.11	0.04	0.08
19	Single-Family Residential - Disadvantaged Community	PG&E	High	Indirect Thermosyphon (IT)	all	<10	No	0.88	0.20	0.17	0.31

Tech. Num.	Budget Program	Utility	GRR	System Type	Coastal/Inland	kWth Bucket	Aliso Canyon	PTC Ratio	RIM Ratio	TRC Ratio	PA Ratio
19	Single-Family Residential - Disadvantaged Community	PG&E	Mean	Indirect Thermosyphon (IT)	all	<10	No	0.79	0.15	0.12	0.22
19	Single-Family Residential - Disadvantaged Community	PG&E	Low	Indirect Thermosyphon (IT)	all	<10	No	0.71	0.10	0.07	0.13
19	Single-Family Residential - Disadvantaged Community	SCG	High	Indirect Thermosyphon (IT)	all	<10	No	0.81	0.20	0.16	0.29
19	Single-Family Residential - Disadvantaged Community	SCG	Mean	Indirect Thermosyphon (IT)	all	<10	No	0.75	0.16	0.11	0.21
19	Single-Family Residential - Disadvantaged Community	SCG	Low	Indirect Thermosyphon (IT)	all	<10	No	0.68	0.10	0.07	0.12
17	Single-Family Residential - Disadvantaged Community	SCG	High	Direct Integral Collector Storage (DI)	all	<10	No	1.23	0.20	0.25	0.29
17	Single-Family Residential - Disadvantaged Community	SCG	Mean	Direct Integral Collector Storage (DI)	all	<10	No	1.10	0.16	0.17	0.21

Tech. Num.	Budget Program	Utility	GRR	System Type	Coastal/Inland	kWth Bucket	Aliso Canyon	PTC Ratio	RIM Ratio	TRC Ratio	PA Ratio
17	Single-Family Residential - Disadvantaged Community	SCG	Low	Direct Integral Collector Storage (DI)	all	<10	No	0.99	0.10	0.10	0.12
13b	Single-Family Residential	SCG	High	Direct Integral Collector Storage (DI)	all	<10	No	1.30	0.19	0.24	0.29
13b	Single-Family Residential	SCG	Mean	Direct Integral Collector Storage (DI)	all	<10	No	1.15	0.15	0.17	0.20
13b	Single-Family Residential	SCG	Low	Direct Integral Collector Storage (DI)	all	<10	No	1.02	0.10	0.10	0.12
18	Single-Family Residential - Disadvantaged Community	SCG	High	Indirect Forced Circulation (IF)	all	<10	No	0.94	0.22	0.19	0.28
18	Single-Family Residential - Disadvantaged Community	SCG	Mean	Indirect Forced Circulation (IF)	all	<10	No	0.85	0.17	0.13	0.20
18	Single-Family Residential - Disadvantaged Community	SCG	Low	Indirect Forced Circulation (IF)	all	<10	No	0.76	0.13	0.08	0.12
14b	Single-Family Residential	SCG	High	Indirect Forced Circulation (IF)	all	<10	No	1.08	0.19	0.20	0.29
14b	Single-Family Residential	SCG	Mean	Indirect Forced Circulation (IF)	all	<10	No	0.96	0.15	0.14	0.20
14b	Single-Family Residential	SCG	Low	Indirect Forced Circulation (IF)	all	<10	No	0.84	0.10	0.08	0.12
4	Commercial/Multifamily Residential	SCG	High	Indirect Forced Circulation - Drainback (IFD)	all	>= 10	Yes	1.09	0.44	0.47	0.65

Tech. Num.	Budget Program	Utility	GRR	System Type	Coastal/Inland	kWth Bucket	Aliso Canyon	PTC Ratio	RIM Ratio	TRC Ratio	PA Ratio
4	Commercial/Multifamily Residential	SCG	Mean	Indirect Forced Circulation - Drainback (IFD)	all	>= 10	Yes	1.02	0.37	0.36	0.50
4	Commercial/Multifamily Residential	SCG	Low	Indirect Forced Circulation - Drainback (IFD)	all	>= 10	Yes	0.95	0.29	0.26	0.35
3	Commercial/Multifamily Residential	SCG	High	Indirect Forced Circulation - Drainback (IFD)	all	<10	Yes	0.82	0.52	0.35	0.76
3	Commercial/Multifamily Residential	SCG	Mean	Indirect Forced Circulation - Drainback (IFD)	all	<10	Yes	0.78	0.45	0.27	0.59
3	Commercial/Multifamily Residential	SCG	Low	Indirect Forced Circulation - Drainback (IFD)	all	<10	Yes	0.74	0.36	0.19	0.41
6	Commercial/Multifamily Residential	SCG	High	Indirect Forced Circulation - Glycol (IFG)	all	>= 10	Yes	0.85	0.47	0.34	0.70
6	Commercial/Multifamily Residential	SCG	Mean	Indirect Forced Circulation - Glycol (IFG)	all	>= 10	Yes	0.81	0.39	0.27	0.54
6	Commercial/Multifamily Residential	SCG	Low	Indirect Forced Circulation - Glycol (IFG)	all	>= 10	Yes	0.77	0.31	0.19	0.38
5	Commercial/Multifamily Residential	SCG	High	Indirect Forced Circulation - Glycol (IFG)	all	<10	Yes	0.75	0.50	0.27	0.69
5	Commercial/Multifamily Residential	SCG	Mean	Indirect Forced Circulation - Glycol (IFG)	all	<10	Yes	0.72	0.43	0.21	0.53
5	Commercial/Multifamily Residential	SCG	Low	Indirect Forced Circulation - Glycol (IFG)	all	<10	Yes	0.69	0.35	0.15	0.38
8	Low Income Multifamily Residential	SCG	High	Indirect Forced Circulation - Drainback (IFD)	all	>= 10	Yes	0.94	0.36	0.32	0.48
8	Low Income Multifamily Residential	SCG	Mean	Indirect Forced Circulation - Drainback (IFD)	all	>= 10	Yes	0.88	0.27	0.21	0.32
8	Low Income Multifamily Residential	SCG	Low	Indirect Forced Circulation - Drainback (IFD)	all	>= 10	Yes	0.81	0.16	0.11	0.16
7	Low Income Multifamily Residential	SCG	High	Indirect Forced Circulation - Drainback (IFD)	all	<10	Yes	0.68	0.41	0.16	0.50

Tech. Num.	Budget Program	Utility	GRR	System Type	Coastal/Inland	kWth Bucket	Aliso Canyon	PTC Ratio	RIM Ratio	TRC Ratio	PA Ratio
7	Low Income Multifamily Residential	SCG	Mean	Indirect Forced Circulation - Drainback (IFD)	all	<10	Yes	0.65	0.32	0.10	0.33
7	Low Income Multifamily Residential	SCG	Low	Indirect Forced Circulation - Drainback (IFD)	all	<10	Yes	0.63	0.21	0.05	0.17
10	Low Income Multifamily Residential	SCG	High	Indirect Forced Circulation - Glycol (IFG)	all	>= 10	Yes	0.86	0.36	0.27	0.47
10	Low Income Multifamily Residential	SCG	Mean	Indirect Forced Circulation - Glycol (IFG)	all	>= 10	Yes	0.81	0.27	0.18	0.32
10	Low Income Multifamily Residential	SCG	Low	Indirect Forced Circulation - Glycol (IFG)	all	>= 10	Yes	0.76	0.16	0.09	0.16
9	Low Income Multifamily Residential	SCG	High	Indirect Forced Circulation - Glycol (IFG)	all	<10	Yes	0.76	0.39	0.22	0.48
9	Low Income Multifamily Residential	SCG	Mean	Indirect Forced Circulation - Glycol (IFG)	all	<10	Yes	0.72	0.30	0.15	0.32
9	Low Income Multifamily Residential	SCG	Low	Indirect Forced Circulation - Glycol (IFG)	all	<10	Yes	0.68	0.20	0.07	0.16
15	Low Income Single-Family Residential	SCG	High	Direct Integral Collector Storage (DI)	all	<10	Yes	1.15	0.15	0.17	0.19
15	Low Income Single-Family Residential	SCG	Mean	Direct Integral Collector Storage (DI)	all	<10	Yes	1.06	0.11	0.12	0.13
15	Low Income Single-Family Residential	SCG	Low	Direct Integral Collector Storage (DI)	all	<10	Yes	0.99	0.07	0.07	0.08
16	Low Income Single-Family Residential	SCG	High	Indirect Forced Circulation (IF)	all	<10	Yes	0.86	0.19	0.15	0.23
16	Low Income Single-Family Residential	SCG	Mean	Indirect Forced Circulation (IF)	all	<10	Yes	0.79	0.15	0.11	0.16
16	Low Income Single-Family Residential	SCG	Low	Indirect Forced Circulation (IF)	all	<10	Yes	0.73	0.11	0.06	0.10

Tech. Num.	Budget Program	Utility	GRR	System Type	Coastal/Inland	kWth Bucket	Aliso Canyon	PTC Ratio	RIM Ratio	TRC Ratio	PA Ratio
11	Multifamily Residential - Disadvantaged Community	SCG	High	Indirect Forced Circulation - Drainback (IFD)	all	all	Yes	1.12	0.44	0.48	0.65
11	Multifamily Residential - Disadvantaged Community	SCG	Mean	Indirect Forced Circulation - Drainback (IFD)	all	all	Yes	1.04	0.37	0.37	0.50
11	Multifamily Residential - Disadvantaged Community	SCG	Low	Indirect Forced Circulation - Drainback (IFD)	all	all	Yes	0.97	0.29	0.26	0.35
12	Multifamily Residential - Disadvantaged Community	SCG	High	Indirect Thermosyphon (IT)	all	<10	Yes	0.68	0.45	0.22	0.69
12	Multifamily Residential - Disadvantaged Community	SCG	Mean	Indirect Thermosyphon (IT)	all	<10	Yes	0.65	0.38	0.17	0.53
12	Multifamily Residential - Disadvantaged Community	SCG	Low	Indirect Thermosyphon (IT)	all	<10	Yes	0.63	0.29	0.12	0.38
1	Commercial Pools	SCG	High	Direct Pools - Drainback (DPD)	Coastal	all	Yes	0.88	0.42	0.33	0.61
1	Commercial Pools	SCG	Mean	Direct Pools - Drainback (DPD)	Coastal	all	Yes	0.82	0.32	0.24	0.43
1	Commercial Pools	SCG	Low	Direct Pools - Drainback (DPD)	Coastal	all	Yes	0.77	0.21	0.14	0.25
2	Commercial Pools	SCG	High	Direct Pools - Drainback (DPD)	Inland	all	Yes	1.06	0.37	0.39	0.52
2	Commercial Pools	SCG	Mean	Direct Pools - Drainback (DPD)	Inland	all	Yes	0.98	0.29	0.28	0.37
2	Commercial Pools	SCG	Low	Direct Pools - Drainback (DPD)	Inland	all	Yes	0.91	0.18	0.16	0.21

Tech. Num.	Budget Program	Utility	GRR	System Type	Coastal/Inland	kWth Bucket	Aliso Canyon	PTC Ratio	RIM Ratio	TRC Ratio	PA Ratio
13a	Single-Family Residential	SCG	High	Direct Integral Collector Storage (DI)	all	<10	Yes	0.58	0.18	0.08	0.28
13a	Single-Family Residential	SCG	Mean	Direct Integral Collector Storage (DI)	all	<10	Yes	0.54	0.14	0.06	0.20
13a	Single-Family Residential	SCG	Low	Direct Integral Collector Storage (DI)	all	<10	Yes	0.51	0.10	0.04	0.12
14a	Single-Family Residential	SCG	High	Indirect Forced Circulation (IF)	all	<10	Yes	0.74	0.15	0.09	0.17
14a	Single-Family Residential	SCG	Mean	Indirect Forced Circulation (IF)	all	<10	Yes	0.69	0.12	0.07	0.12
14a	Single-Family Residential	SCG	Low	Indirect Forced Circulation (IF)	all	<10	Yes	0.64	0.09	0.04	0.07
19	Single-Family Residential - Disadvantaged Community	SCG	High	Indirect Thermosyphon (IT)	all	<10	Yes	0.81	0.20	0.16	0.29
19	Single-Family Residential - Disadvantaged Community	SCG	Mean	Indirect Thermosyphon (IT)	all	<10	Yes	0.75	0.16	0.11	0.21
19	Single-Family Residential - Disadvantaged Community	SCG	Low	Indirect Thermosyphon (IT)	all	<10	Yes	0.68	0.10	0.07	0.12
17	Single-Family Residential - Disadvantaged Community	SCG	High	Direct Integral Collector Storage (DI)	all	<10	Yes	1.22	0.20	0.25	0.29

Tech. Num.	Budget Program	Utility	GRR	System Type	Coastal/Inland	kWth Bucket	Aliso Canyon	PTC Ratio	RIM Ratio	TRC Ratio	PA Ratio
17	Single-Family Residential - Disadvantaged Community	SCG	Mean	Direct Integral Collector Storage (DI)	all	<10	Yes	1.10	0.16	0.17	0.21
17	Single-Family Residential - Disadvantaged Community	SCG	Low	Direct Integral Collector Storage (DI)	all	<10	Yes	0.99	0.10	0.10	0.12
13b	Single-Family Residential	SCG	High	Direct Integral Collector Storage (DI)	all	<10	Yes	1.24	0.17	0.20	0.24
13b	Single-Family Residential	SCG	Mean	Direct Integral Collector Storage (DI)	all	<10	Yes	1.12	0.13	0.14	0.17
13b	Single-Family Residential	SCG	Low	Direct Integral Collector Storage (DI)	all	<10	Yes	1.00	0.09	0.09	0.10
18	Single-Family Residential - Disadvantaged Community	SCG	High	Indirect Forced Circulation (IF)	all	<10	Yes	0.90	0.22	0.18	0.28
18	Single-Family Residential - Disadvantaged Community	SCG	Mean	Indirect Forced Circulation (IF)	all	<10	Yes	0.81	0.17	0.13	0.20
18	Single-Family Residential - Disadvantaged Community	SCG	Low	Indirect Forced Circulation (IF)	all	<10	Yes	0.73	0.13	0.08	0.12
14b	Single-Family Residential	SCG	High	Indirect Forced Circulation (IF)	all	<10	Yes	0.99	0.12	0.11	0.15
14b	Single-Family Residential	SCG	Mean	Indirect Forced Circulation (IF)	all	<10	Yes	0.92	0.09	0.08	0.10

Tech. Num.	Budget Program	Utility	GRR	System Type	Coastal/Inland	kWth Bucket	Aliso Canyon	PTC Ratio	RIM Ratio	TRC Ratio	PA Ratio
14b	Single-Family Residential	SCG	Low	Indirect Forced Circulation (IF)	all	<10	Yes	0.85	0.06	0.05	0.06