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CPUC California Solar Initiative

2009 Impact Evaluation

Final Report
Executive Summary

Submitted to:

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and
California Public Utilities Commission
Energy Division

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Executive Summary

ES.1 Introduction

The California Solar Initiative (CSI) is the largest customer-owned solar incentive program in the history of the United States. The CSI program is overseen by the California Public Utilities Commission (CPUC) and provides solar incentives to customers in the investor-owned utility (IOU) territories of Pacific Gas & Electric (PG&E), Southern California Edison (SCE), and San Diego Gas & Electric (SDG&E). The CSI program has a budget of $2,167 million over ten years and the goal is to reach 1,940 MW of installed solar capacity by 2016, including 1,750 MW from the general market program and 190 MW from the two low-income residential programs.

Project Scope and Key Objectives of Study

The primary purpose of the 2009 CSI Impact Evaluation study is to assess the impact of the CSI program during the 2009 timeframe. This includes not only CSI solar systems installed during calendar year 2009, but also systems installed in 2007 and 2008 that were operational in 2009.[1]

Similar to the 2007-2008 CSI Impact Evaluation Report, the 2009 CSI Impact Evaluation Report examines the impacts of the CSI program on electricity energy production and peak demand reduction, performance relative to installed capacity, expected versus actual solar production, emissions reductions (CO_2, NOx, PM-10), and transmission and distribution system impacts.

In addition to the objectives of previous CSI reports, a primary objective for this report is to assess the extent to which the CSI participants have undertaken energy efficiency measures as a result of the energy audit required by the CSI program and to determine the level of integration between energy efficiency and solar. The research team also conducted billing and load profile analyses to further evaluate the impact of the CSI program on customer utility bills. Key objectives addressed in the evaluation include:

- Impacts on electricity energy production and demand reduction
- Performance relative to installed capacity
- Expected vs. actual solar production
- CO_2, NOx, and PM-10 emissions reductions associated with the solar installations

[1] This report does not consider solar installed under other programs or those systems installed for wholesale generation purposes.

- Transmission and distribution system impacts
- Energy use and daily energy profiles of CSI participants.
- Monitoring and maintenance impacts on PV performance
- Energy efficiency adoption and impacts of CSI participants
- Awareness and satisfaction of the CSI program and future opportunities

The sections of this report are organized in the following order:

- **Section 1** – Introduction.
- **Section 2** - Summary of the CSI program status through the end of 2009.
- **Section 3** - Describes the generation data sources and summarizes metered data collected for the evaluation.
- **Section 4** - Describes the phone survey data collected for CSI participants and nonparticipants, and data collected from our on-site inspections.
- **Section 5** - Discusses the 2009 impacts associated with CSI projects at the program level including impacts associated with energy delivery; peak demand reduction; effective capacity and GHG emissions reductions.
- **Section 6** - Discusses the 2009 impacts associated with CSI projects on the transmission and distribution systems.
- **Section 7** - Discusses the residential CSI participants' monthly impact on total energy usage through a billing analysis including the bill tiers.
- **Section 8** – Provides residential and nonresidential CSI participants' daily impacts through an analysis of individual load and generation profiles.
- **Section 9** - Reviews CSI participant activity impacting PV performance including use of monitoring equipment and the review of the behavior of top and bottom PV performers.
- **Section 10** - Discusses the CSI impact on participation in energy efficiency and the impact of different energy efficiency requirements in the CSI program.
- **Section 11** - Reviews the progress of the CSI program maturing through an analysis of the awareness and satisfaction of the CSI program and future growth expectations seen through the eyes of solar contractors.

ES.2 Update on CSI Program Status

Participation in the CSI program continued to grow with more PV systems and capacity installed in 2009 than any previous year under the CSI program. In the following tables and figures we summarize major data elements of the CSI program including business sectors growth, geographic location of systems, third party ownership in the residential market and the continued downward price trend of installed solar.

Program Statistics and Growth

As shown in Table ES-1, the 2009 CSI program installed 13,100 PV systems accounting for a rebated capacity of 146.7 MW CEC PTC AC.[2] This represented a 55 percent year-over-year growth rate of installed systems from the previous year. The systems installed in 2009 represented 52.4 percent of the total number of systems and 51.6 percent of the total capacity for the CSI program over its three-year lifetime. Over three years of the CSI program, almost 25,000 systems have been installed representing 284.5 MW of installed rebated capacity. This is a significant growth in capacity and systems given that from 1993 to 2006 there were 22,259 customer-owned systems installed, representing 157.3 MW of installed capacity within the IOU service territories.

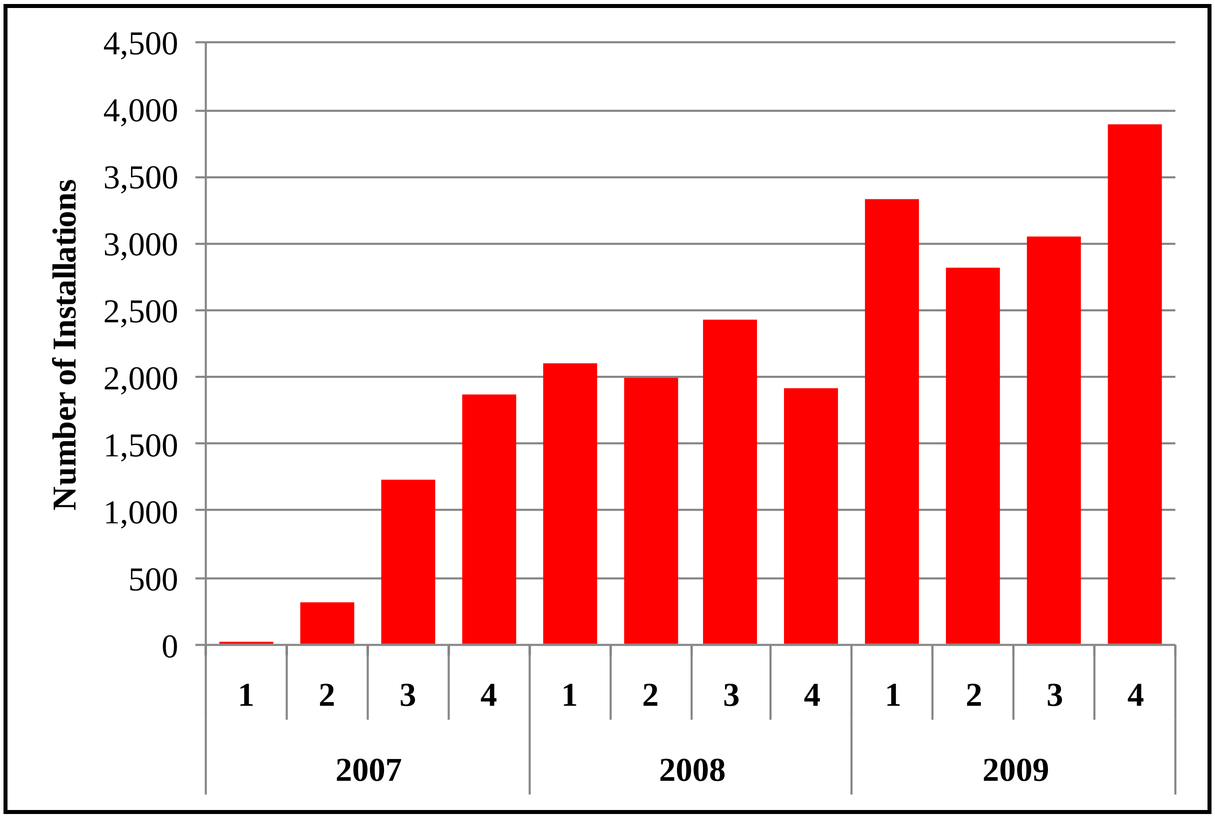
Table ES-1: CSI Installed Systems per Quarter

	2007		2008		2009		Total	
Quarter	**n**	**MW**	**n**	**MW**	**n**	**MW**	**n**	**MW**
Q1	13	0.3	2,102	27.1	3,335	59.7	5,450	87.1
Q2	321	1.7	1,993	23.5	2,820	28.3	5,134	53.5
Q3	1,232	7.6	2,428	27.6	3,053	25.0	6,713	60.2
Q4	1,875	15.7	1,919	34.3	3,892	33.7	7,686	83.7
Total	**3,441**	**25.3**	**8,442**	**112.6**	**13,100**	**146.7**	**24,983**	**284.5**
Percent	**13.8%**	**8.9%**	**33.8%**	**39.6%**	**52.4%**	**51.6%**	**100%**	**100%**

[2] The rebated capacity is the CEC PTC rating (AC) associated with the rebate (incentive) provided to the applicant and will be in CEC PTC AC unless specified.

Figure ES-1 illustrates the rapid growth by quarter, of the number of installed PV systems in California over the last three years. In 2009, there has been a material increase in the number of systems installed, primarily due to growth in residential system installations.

Figure ES-1: CSI Program Installed Systems by Year and Quarter



Geographically, the growth in PV installed capacity is distributed relatively equally throughout California, as Figure ES-2 illustrates. In 2007, systems were installed in population centers but with 2008 and 2009 there was an expansion of systems being installed in the north coast, northern and central valleys, and east of Los Angeles County. In short, the CSI is California-wide.

Figure ES-2: Evolution of CSI Incentive Program in California

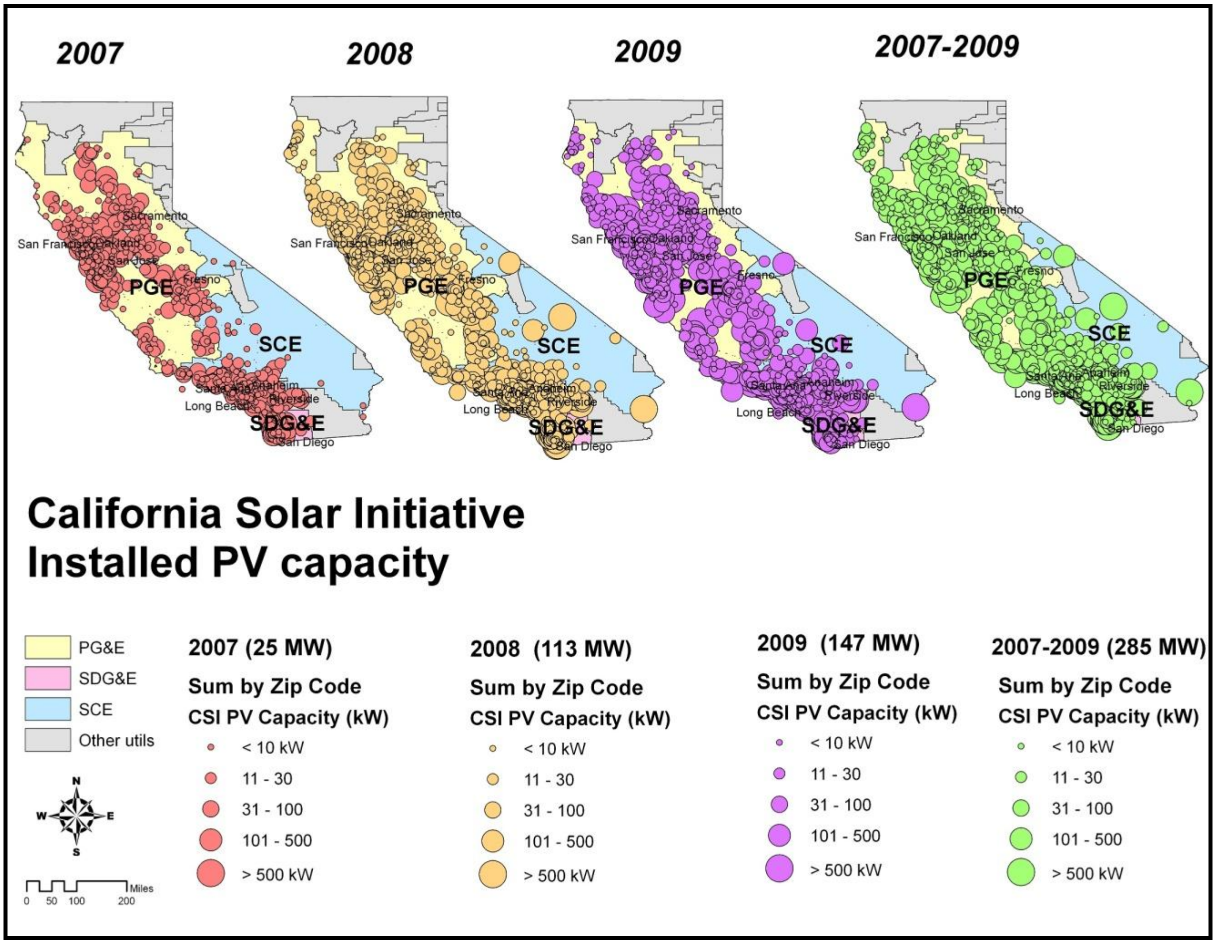
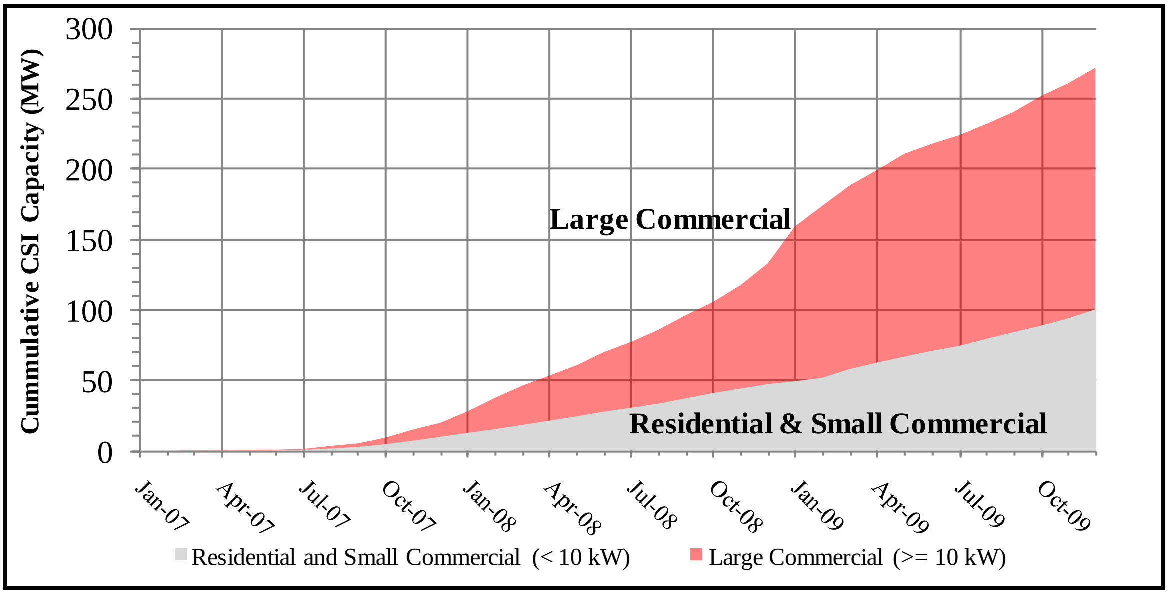


Figure ES-3 illustrates the cumulative installed capacity since the beginning of the CSI Program by sector. Approximately 40 percent of the total installed capacity is in the residential and small commercial market sectors for systems that are 10 kW and below.

Figure ES-3: Cumulative Completed and Active On-Line Capacity by Month



The different growth rates in these sectors can be seen in Table ES-2. In 2008, there was an increase in the percentage of MW installed for large commercial. This trend reversed itself as more residential systems were installed in 2009 and fewer commercial systems and MW were installed. Some of this change could be due to the January 1, 2009 change in the federal tax law removing the investment tax credit cap for residential systems.

Table ES-2: CSI Customer Grouping Percentages by Year of Installation

Customer Grouping	2007		2008		2009		Total	
	%n	% MW	%n	% MW	%n	% MW	%n	% MW
Residential	96.5%	59.4%	92.5%	31.7%	95.1%	40.5%	94.4%	38.7%
Small Commercial	1.5%	1.0%	2.3%	0.8%	1.8%	0.7%	1.9%	0.8%
Large Commercial	2.0%	39.5%	5.2%	67.5%	3.1%	58.8%	3.7%	60.5%

* Totals may not add due to rounding

Increases in Third Party Ownership

Table ES-3 shows that 12 percent of the systems, accounting for 40 percent of the MW, were owned by third parties, indicating that larger systems were more likely to be owned by third parties than smaller systems. The portion of systems owned by third parties out of the total number of systems installed was the same in 2007 and 2008 (~9%), but increased substantially in 2009 (~14%). However, in terms of capacity, the portion of third-party owned systems was the same in 2007 and 2009 (i.e. ~43%) but surprisingly, dropped to 34% in 2008. Overall, the share of capacity under third party ownership contracted in 2008 and then third party ownership grew in 2009 in terms of the share of capacity and portion of the number of systems.

Table ES-3: Third Party Ownership by Year—All Systems

Year	Total	Third Party Owned (n)	Third Party Owned (%)	Third Party Owned (MW)	Third Party Owned MW%	Average Third Party Owned System Size (kW)
2007	3,440	319	9.3%	16.5	42.9%	51.8
2008	8,443	762	9.0%	31.9	34.2%	41.9
2009	13,100	1,793	13.7%	65.0	42.5%	36.2
Grand Total	**24,983**	**2,874**	**11.5%**	**113.4**	**39.9%**	**39.5**

* Totals may not add due to rounding

The growth in the share of third party ownership in 2009 appears to come from the residential sector. For residential facilities, the portion of third-party owned systems (both number and capacity) was approximately the same in 2007 and 2008. However, third party ownership in the residential sector increased by 155% in 2009, while the entire residential sector grew by56%. The growth in third party ownership implies that third party financing may have resolved financial barriers of the high initial cost to expanded growth of PV into the residential market. For the commercial segment, as financial liquidity returns, it is expected that this market will return to levels before 2009.

Table ES-4: Third Party Ownership—Residential

Year	Total	Third Party Owned (n)	Third Party Owned (%)	Third Party Owned (MW)	Third Party Owned MW%	Average Third Party Owned System Size (kW)
2007	3,260	255	7.8%	1.1	7.2%	4.2
2008	7,944	627	7.9%	2.9	7.6%	4.6
2009	12,386	1,605	13.0%	8.0	13.9%	5.0
Grand Total	**23,590**	**2,487**	**10.5%**	**11.9**	**10.8%**	**4.8**

* Totals may not add due to rounding

We also examined third party ownership by Program Administrator (PA). Both CCSE and PG&E appear to have similar portions of PV systems owned by third parties. However, a substantially larger portion (both numerically and in terms of capacity) of systems is owned by third-parties in SCE territory.

Table ES-5: Third Party Ownership by PA—All Systems

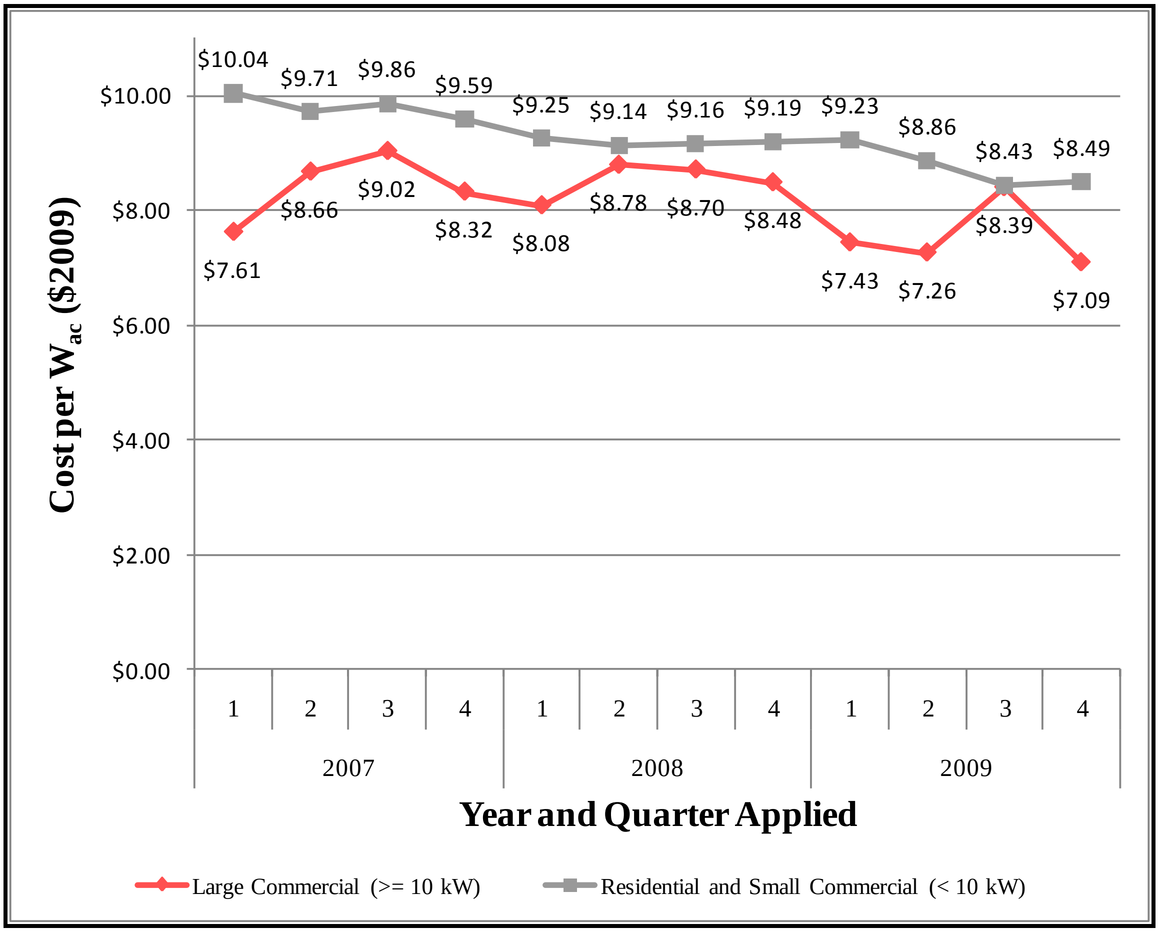
PA	Total	Third Party Owned (n)	Third Party Owned (%)	Third Party Owned (MW)	Third Party Owned MW%	Average Third Party Owned System Size (kW)
CCSE	3,139	311	9.9%	9.2	33.6%	29.6
PG&E	15,613	1,674	10.7%	56.0	34.1%	33.4
SCE	6,231	889	14.3%	48.2	51.8%	54.2
Grand Total	**24,983**	**2,874**	**11.5%**	**113.4**	**39.9%**	**39.5**

* Totals may not add due to rounding

Downward PV Price Trends

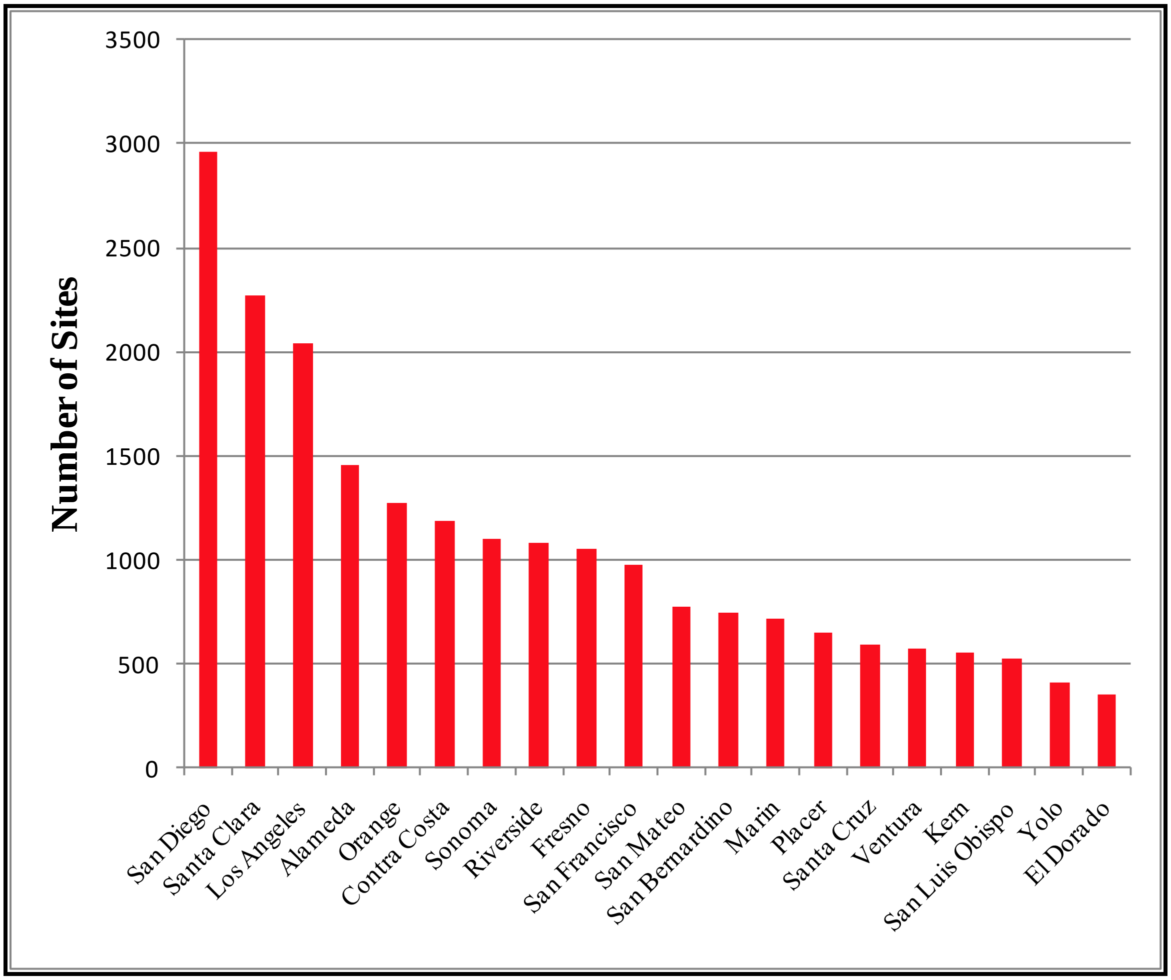
The research of systems rebated under the CSI program indicates that there is a downward trend in installed price per Watt for CSI systems, as displayed by the following figure.

Figure ES-4: Capacity Weighted Average System Cost by Quarter Applied for Completed Host-Owned Systems Installed by December 31, 2009



The evaluation team also examined the geographic distribution of PV systems by system count and MW throughout California. As we have seen previously, PV systems, particularly smaller residential systems are located in urban areas such as the San Francisco Bay Area, the Los Angeles metro Area, and San Diego County (see Figure ES-5). The team further broke this data down per capita by both systems and by MW (see Section 2 of the Evaluation Report).

Figure ES-5: CSI Systems Installed per County—Top 20



ES.3 CSI Impacts and Benefits at the Utility Scale

CSI projects generated over 390,000 MWh of electricity during 2009; over three times the amount generated in 2008[3]. That energy was enough to meet the electricity requirements of approximately 66,000 homes for a year.[4]

Energy Delivery at the PA Level

Table ES-6 provides annual energy impacts for CSI projects by PA for 2009, the corresponding number of solar systems installed by the end of 2009, and the estimated annual capacity factor.

Table ES-6: Estimated CSI Annual Energy Impacts by PA (MWh)

Program Administrator	PV Systems (n)	PV Systems (MW)	PV Generation (MWh)	Annual Capacity Factor (kWh/kWp)
PG&E	15,613	164.1	225,063	0.20
SCE	6,231	93.0	126,850	0.20
CCSE	3,139	27.4	38,837	0.21
Total	24,983	284.5	390,750	0.20

* The uncertainty on all of these estimates is better than 90/10 confidence
** CCSE is the program administrator of the CSI program in SDG&E's service area.

PV systems installed in the PG&E area are estimated to have supplied slightly over 58 percent of the total electricity delivered by CSI projects in 2009, whereas SCE and CCSE systems are estimated to have supplied approximately 32 percent and 10 percent, respectively. The magnitude of electricity delivery in the PG&E territory is not surprising given that PG&E had over 15,600 PV systems representing 164.1 MW in 2009; over 62 percent of all systems and nearly 58 percent of the installed capacity. The Capacity Factor for all three service areas is 0.20. Hourly Capacity Factor (CF) is defined as the energy generated during that hour (kWh) divided by the nominal rated AC capacity during ideal conditions (kWp.)

The 2009 average annual capacity factors in Table ES-6 are somewhat higher than those seen in the Self Generation Incentive Program (SGIP,) where the statewide average annual

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[3] 118,489 MWh were estimated to be generated by CSI systems in 2008.

[4] Assuming the typical home consumes approximately 5,914 kWh of electricity per year. From the California Statewide Residential Appliance Saturation Study Final Report, June 2004, www.energy.ca.gov/reports/400-04-009/2004-08-17_400-04-009ALL.PDF. Value derived from Figure 1 on page 3 of the Executive Summary.

capacity factor in 2009 for solar PV projects was 0.175. This difference could be due to a number of factors:

- System Degradation; the average age of CSI systems is one year whereas the average of SGIP systems is approximately four years.
- CSI systems are more likely to be tilted and more likely to be facing southwest. Near Flat and Tilted systems are in approximately a 1:1 ratio in the CSI program and a 3:1 ratio in SGIP.
- System technology and installation improvements may be resulting in more efficient systems.

Impacts of Peak Demand

Table ES-7 lists the CAISO annual system load and the peak date and time.[5] The peak was slightly below 46,000 MW whereas the system peak for both 2007 and 2008 was slightly above 46,000 MW.

Table ES-7: Loads and Dates of CAISO System Peak for 2009

Year	Peak Load (MW)	Date and Time
2009	45,994	September 3, 2:00 to 3:00 P.M. (PST)

Table ES-8 shows the number of systems that were online during the CAISO peak in 2009 and the overall CSI program impact on electricity demand coincident with the CAISO system peak loads in 2009.[6]

Table ES-8: Estimated Demand Impact Coincident with CAISO System Peak*

Program Administrator	PV Systems (n)	PV Systems (MW)	PV Generation (MWh)	Hourly Capacity Factor (kWh/kWp)
PG&E	12939	139.5	87.2	0.62
SCE	5005	82.8	43.3	0.52
CCSE	2198	22.6	13.6	0.60
All	20142	245.0	144.0	0.59

* The uncertainty on all of these estimates is better than 90/10 confidence

5 Unless otherwise stated, all time in this report are listed as Pacific Standard Time.

6 The number of on-line systems for both years is lower than the on-line number for at the end of the year. Approximately 4,800 more systems were installed between September t 3, 2009 and December 31, 2009. See table 2-5 for quarterly details.

In 2009, there were over 20,100 systems online at the time of the CAISO system peak.[7] These systems had a CEC AC capacity of approximately 245MW (nearly 4x the capacity online during the 2008 peak). Their generating output for that hour was estimated to be 144 MWh. Consequently, CSI systems had a peak hour capacity factor of 0.59 implying that 59 percent of the installed capacity (245 MW) was generating electricity for that hour (144 MWh). The peak hour capacity factor of SCE was somewhat lower than other areas for 2009. We believe this is correlated with the wild fires in the Los Angeles metropolitan area at this time (including the Station Fire).[8] The additional haze and soot on SCE CSI PV systems would impact their capacity factor.

In comparison, , the total rebated capacity of all on-line SGIP projects (solar PV, wind fuel cells, micro turbines, gas turbines and internal combustion engines) during the 2009 CAISO system peak was 349 MW. The total impact of the SGIP projects coincident with the CAISO peak load was estimated to be 165 MWh. The collective peak hour capacity factor of the SGIP projects on the CAISO 2009 peak was approximately 0.47 kW per kW of rebated capacity.

Figure ES-6 shows the estimated hourly impact of CSI projects during the 2009 CAISO system peak. Based on the available metered data, CSI system generating capacity increased steadily from 8 am to 11 am; remained fairly level from 11 am to1 pm and then declined steadily through the rest of the afternoon. This overall generation profile is typical of PV systems. The peak capacity factor at solar noon on the peak day in 2009 is approximately 0.72. This is less than 1 due to a number of possible reasons:

- The peak CAISO day load is usually driven by cooling demand on a hot day, when PV panels do not perform quite as efficiently as when tested at 20°C (68°F).
- In 2009, the CAISO peak fell relatively late in the year after most of the summer when dust and dirt builds up on panels (also referred to as soiling) reducing performance.
- The estimated production includes metered data for some systems that are not generating due to maintenance or other problems.

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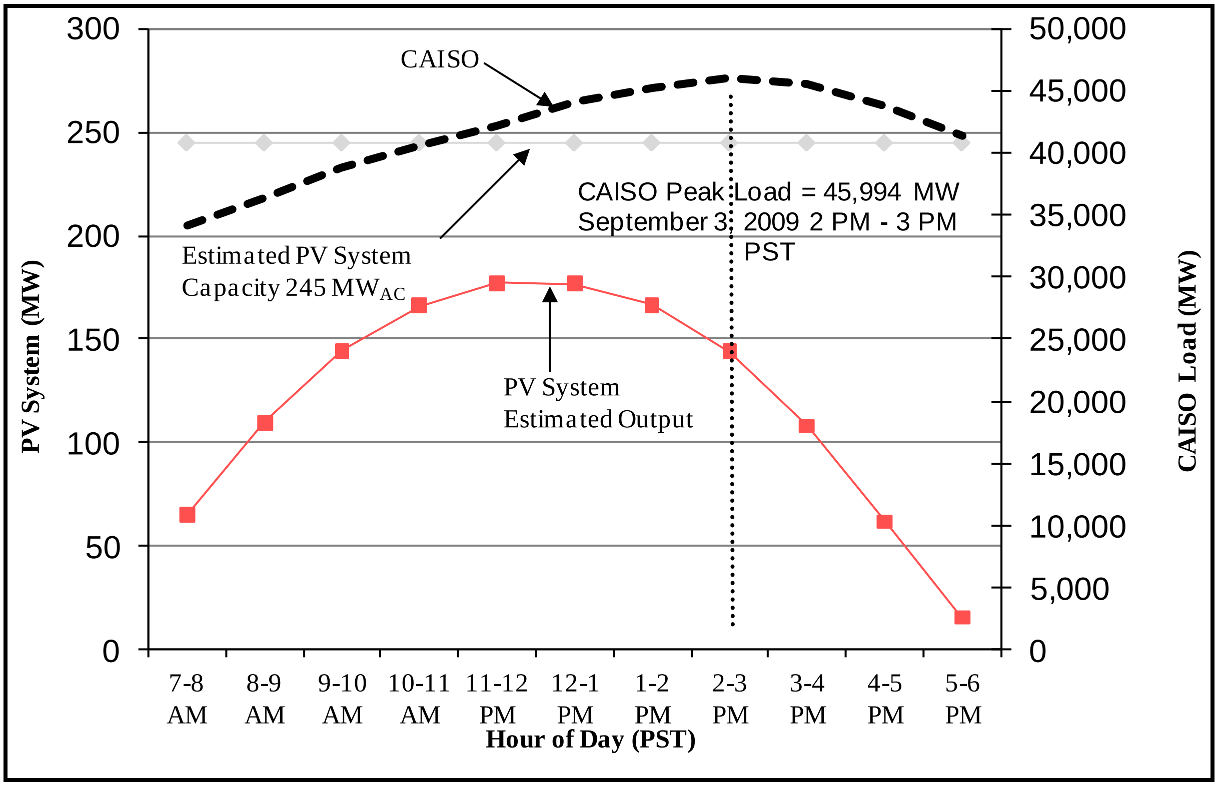
[7] The differences between the 20,142 and 24,983systems represents those systems that were estimated operational after September 3, 2009 and before January 1, 2010.

[8] The Station Fire burned 251 square miles in the Los Angeles metro area. It began August 26, 2009 and was 100% contained October 16, 2009.

Figure ES-6: Estimated Hourly CSI Impact on CAISO 2009 System Peak

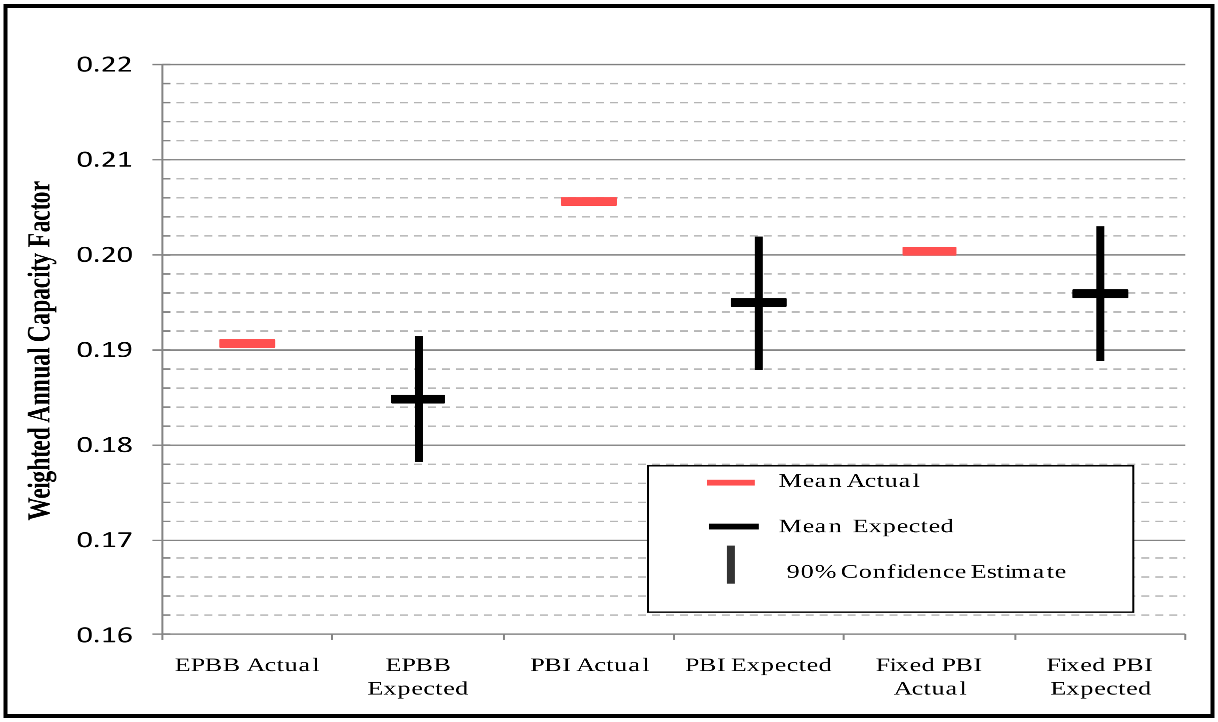


Comparison of Estimated to Expected Performance

The expected annual average output of CSI systems is currently calculated during the incentive application process. These expected average outputs are used to calculate incentive payments for EPBB systems and allow PAs to plan payments for PBI systems. Comparisons of estimated annual capacity factor based on estimates of system wide generation to expected annual capacity factor provide one way to assess actual performance of installed systems.

The 90 percent confidence level error bounds for actual and expected performance for 2009 are depicted graphically in Figure ES-7 for all EPBB Systems, all PBI Systems (including tracking systems), and all Fixed PBI Systems, which do not including tracking systems. The 90 percent confidence level error bounds for the expected performance are based on historical solar resource variation. The methodology for estimating uncertainty for actual performance is described in Appendix E.

Figure ES-7: Comparison of Estimated Actual and Expected Annual Capacity Factors for 2009 by Incentive Type



We can observe that the capacity factors for PBI systems are slightly above the uncertainty bounds in relation to the estimated annual capacity factor. When tracking systems are excluded, however, the annual performance of PBI systems is somewhat lower but is still better than expected. For EPBB systems, performance is above the expected average but still within the uncertainty bounds for the estimated annual capacity factor[9]. These differences could be due to a few reasons including:

- The solar insolation in 2009 may have been higher than the TMY2 (Typical Metrological Year Data) average used to estimate expected performance; or
- The metered systems used to estimate system wide performance currently are slightly out-performing their estimated annual capacity factors.

More information on these figures can be found in Section 5.

Environmental impacts

The evaluation team examined the impacts of CSI PV projects had on CO_2, NO_x, and PM_{10} emissions for 2009. The team estimated the avoided quantity of these three pollutants as they

9 EPBB systems are almost entirely fixed so excluding tracking systems from EPBB systems has no noticeable effect on annual capacity factors.

comprise the majority of the air and GHG pollutants associated with electrical generation. The estimated emissions impacts for 2009, is the cumulative CSI impact and therefore includes capacity installed from 2007 to 2009.

A variety of approaches exist to estimating GHG emissions and air pollutant reductions from the installation of PV systems. Three approaches are noted here, each of which gauges what type of generation would likely have produced electricity in lieu of the installed PV.

The first approach, referred to here as the Avoided Cost approach, is derived from the Avoided Cost calculator developed by Energy and Environmental Economics (E3) and uses hourly price data. The second approach, referred to here as the Plant Schedule approach, was developed by KEMA, and uses plant schedule data from the California Independent System Operator (CAISO). The third approach, referred to here as the Generator Bid approach, was developed by KEMA, and uses real-time generator bid data from the CAISO. Each method has its drawbacks and benefits, detailed in Section 5. The intent of using multiple approaches to estimate the CSI emissions impact is to draw from the benefits of each and to assess the extent of the different limitations and their impact on the emission results.

GHG, NOx and PM emissions

Table ES-9 illustrates the estimated emissions savings by emission type and by approach. The CO2 reductions for the Avoided Cost Approach are 180,136 tons of CO_2, which is equivalent to taking over 31,000 cars off of the road.[10]

Table ES-9: Estimated Emissions Reductions by Approach

Approach	Energy Impact (MWh)	CO_2 Emissions Avoided (tons)	PM_{10} Emissions Avoided (lbs)	NO_x Emissions Avoided (lbs)
Avoided Cost	390,750	180,136	24,280	39,649
Plant Schedule	390,750	208,704	20,817	34,132
Generator Bid	390,750	163,183	16,277	20,899

Additional analysis and discussion of these three methods and the results can be found in the second half of Section 5.

Influence on California's Transmission & Distribution System

In addition to providing electricity over the course of the year and during times of peak demand, CSI PV facilities impact the transmission and distribution (T&D) systems of

10 Based on 5.23 metric tons (5.77 short tons) of CO2 /vehicle/year from http://www.epa.gov/grnpower/pubs/calcmeth.htm#vehicles

California's electrical grid. CSI PV systems reduce loading on the distribution and transmission lines by displacing remote sources of electricity that would otherwise have to be delivered over the T&D systems to electricity customers. Reduced line loading at the time of peak demand potentially alleviates the need to expand or build new transmission and distribution infrastructure, thereby saving utility and ratepayer monies. Moreover, by reducing the amount of electricity that needs to be delivered by the grid, CSI PV facilities may potentially lower the risk of transmission overloads during many operating hours, which in turn may increase overall system reliability.

Transmission System Impacts[11]

The evaluation team has performed an independent analysis that shows the 2009 CSI impacts on the California transmission system. Depending on the dispatch adjustment method used in the modeling, the 2009 Transmission Capacity Benefit (TCB) on a statewide level is estimated to range between 500-900 MW. This is comparable to the delivery capability of a modern 230kV transmission line. Between 2008 and 2009 there was a 240 percent increase in both the statewide TCB and transmission loss savings (calculated at peak system load).

In the future when CSI penetration reaches twice the 2009 level, the modeling yields a projected 1000-1600 MW statewide TCB, which is comparable to the delivery capability of a 500kV transmission line. Furthermore, the analysis shows that when the CSI full capacity target (1,750 MW) is reached, the statewide TCB could grow to 4,000 MW or more. However, it is important to note that these capacity benefits are distributed statewide, rather than on any one 230kV or 500kV corridor. Thus, the incremental benefits on each individual transmission corridor within the state of California represent only a small percentage of the aggregate TCB.

Technical definitions, additional analysis, and findings on the transmission impacts can be found in the first half of Section 6 in the Impact Evaluation Report.

Distribution System Impacts

Based on the 2009 feeder case studies performed, the greatest level of benefits is generally expected to occur on feeders with one of more of the following characteristics:

- Longer distribution feeders
- Feeders located in inland areas
- Feeders that have their summer peak demand in the mid-afternoon hours

[11] Transmission system impacts were calculated using the best available estimates of CSI generation in operation at the time of 2008 and 2009 system peak demand levels. Therefore, part of the increase in benefits observed from 2008 to 2009 could be attributable to improvements in PV metering data and output estimates.

The 2009 CSI Impact Evaluation shows that positive benefits are generally expected for a range of PV penetration levels, but also observes that there can be decreasing (or even negative) benefits above certain penetration levels. Additional distribution analysis, findings, and recommendations can be found in the second half of Section 6.

ES.4 CSI Impacts and Benefits at the Customer Scale

As shown in the preceding section, the CSI has important impacts at the statewide and utility levels. Nonetheless, continued progress of the CSI to a broad-based and sustainable market is dependent on impacts at the customer level. Impacts that may strongly influence customer adoption of PV include impacts on realized energy savings or peak loads.

To assist the evaluation team in this portion of the evaluation the 2009 Impact Evaluation, activities were expanded to include substantial primary data collection. Seven distinct primary data collection efforts were dispatched to support objectives related to the program EE requirements and the performance of the PV systems. The primary data collection completed for this study includes phone survey of participants and nonparticipants, interviews with contractors installing program equipment, and on-site inspections at residential and nonresidential locations. Table ES-10 summarizes the primary data collection efforts, as well as planned and actual completed surveys. Detailed information on the process can be found in Section 4 and the Appendices.

Table ES-10: Summary of Additional Data Collection Efforts for CSI Evaluation

Market Sector	Participation Status	Data Collection Technique	Planned Completes	Actual Completes
Residential	Participant	Telephone Survey	600	639
		On-Site Inspection	140	143
	Nonparticipant	Telephone Survey	600	601
Nonresidential	Participant	Telephone Survey	400	420
		On-Site Inspection	114	114
	Nonparticipant	Telephone Survey	400	447
Contractors	Participant	Telephone Survey	50	50

CSI Residential Billing Analysis – Monthly Impacts and Benefits

The major objectives of the monthly billing and production data review in Section 7 were threefold:(1) analyze the impact of PV production on utility bills and total household consumption over time; (2) research the possible interaction of PV production, energy efficiency savings and consumption; and (3) provide feedback to the CPUC, program administrators and implementers for the purpose of improving the CSI program.

As part of this analysis, the evaluation team using billing data for a sample of CSI participants analyzed a number of different components of the energy bill and PV generation from CSI participants including but not limited to:

- Number of months participants were net exporters to the grid;
- Which months had the majority of net exports (April and May for all three IOUs);
- Shift in billing tiers pre and post solar installation; and
- Energy use pre and post PV installation.

For energy use, pre, and post PV installation, using the residential billing and PV generation data it was possible to calculate the household energy consumption for the 12 months prior to PV installation and for the 12 months after the solar system's installation. For the sites with 12 months of pre- and post-installation billing data and PV generation data, Table ES-11 lists the ratio of utility bills divided by the sum of post-utility bills and PV generation or the ratio of pre- and post-electricity consumption. If the household does not change its energy consumption following the installation of PV, the ratio of pre- and post-electricity consumption will be one. The ratio of pre- and post-installation consumption is greater than one for all three utilities. Therefore, the average 12 months of post-installation consumption are less than the energy consumption during the 12 months prior to PV installation.

Table ES-11: Ratio of Pre- and Post-Residential Electricity Consumption by Utility

IOU	Sites with 12 Months of Pre- and Post-Billing Data	Pre-Utility Bills Divided by Post-Utility Bills and Generation
PG&E	681	1.13
SCE	243	1.07
SDG&E	95	1.07

Table ES-12 lists the distribution of pre- and post-electricity consumption by utility. The results indicate that for PG&E and SDG&E over 40 percent of sites have pre- and post-PV electricity consumption that are within 10 percent of each other, while only approximately 27 percent of sites in SCE have pre-electricity consumption within 10 percent of post-consumption. For all three IOUs, it is more common for pre-consumption to exceed post-PV installation consumption.

Table ES-12: Pre- and Post-Residential Electricity Consumption Distribution by Utility

Utility	PG&E Site	PG&E % of Sites	SCE Site	SCE % of Sites	SDG&E Site	SDG&E % of Sites
Pre is Less than 50% of Post	6	0.9%	11	4.6%	1	1.1%
Pre is 50% to 90% of Post	140	20.6%	76	31.4%	14	14.7%
Pre- and Post are within 10%	292	42.9%	66	27.3%	44	46.3%
Pre is 110% to 150% of Post	196	28.8%	73	30.1%	33	34.7%
Pre is more than 150% of Post	47	6.9%	16	6.6%	3	3.2%

Billing Model – What Can Be Concluded about CSI Participants?

Comparison of the level of pre- and post-PV installation household electricity consumption, however, does not provide an explanation of why or how consumption changes. To determine the variables influencing changes in electricity consumption, the team estimated an SAE billing model. The model was designed to use utility electricity consumption, PV generation, energy efficiency savings, weather, household characteristics, major electrical measures within the household and a nonparticipant sample to try to determine the realization rate on PV generation, to determine if PV installation leads to statistically significant changes in consumption, and if it does lead to changes in consumption, how it influences electrical consumption.

The estimated realization rate for the quantity of energy generated by PV systems, indicates that the generation estimates are largely supported by the estimated coefficients, approximately 97-100 percent of the ex ante generation is realized in the billing analysis. The analysis finds that after the installation of PV systems, household energy use associated with central air conditioning (CAC) usage increases while the weather sensitivity of CAC usage falls for CSI households in SCE's and SDG&E's territory. Additional results on this model can be found in later half of Section 7

The use of billing analysis to analyze the influence of PV and possible behavioral post-PV influences on energy consumption is groundbreaking and important. Future analysis will also be impacted by legislation (AB920) allowing for the payment of excess generation from the utilities. Before the legislation, sites with PV had no monetary motivation to decrease their electrical usage and become net exporters. With this change, the use of CAC on hot days may decline more if CSI participants find compensation from the utilities for excess generation a more powerful motivator than being comfortable. Examining the motivation behind why customers "went solar" in Section 11 of this impact evaluation may provide insights in the likely future effects of current solar legislation.

CSI and Customer Load Profiles—Daily Impacts and Benefits

As with other generation resources, the value of PV generation is highest at the time of the system peak and at other hours where the system is strained. The main purpose of the evaluation team's analysis of customer profiles is to provide seasonal, climate zone, and time-of-day dimensions to the relationship between energy use and PV generation at the customer level, with an emphasis on high system demand hours.

Residential

On average, CSI program participants have much higher daily loads than the average utility customer without PV. The average CSI participating home in the sample was 2,525 square feet, about 40 percent larger than the 1,784 square feet of the average single-family detached home in California. However, customers with PV generation consume less energy from the grid during on-peak hours than their non-PV counterparts. The data also show that the impact at the time of system peak is not as pronounced as it is during other hours of the day, because the system peak occurs in the late afternoon and solar generation peaks in the early afternoon and then drops rapidly in the late afternoon hours.

The residential data from SDG&E and PG&E show that, even if customers use all of the energy generated by their PV system, they do not use it on an hour-by-hour basis. Rather, there are constant electricity exchanges with the grid (imports and exports) that eventually offset each other out on a net energy basis. On average, PG&E residential customers imported 24.9 kWh per day and exported 10 kWh per day, for a net use of 14.9 kWh per day from the grid. SDG&E customers imported 22.7 kWh and exported 8.3 kWh for a net use of 14.4 kWh per day from the grid. These offsets, made possible through Net Energy Metering (NEM), are an important component of the cost-effectiveness of PV, particularly for residential customers.

Residential PV systems in SDG&E's service territory supplied 55 percent of the energy used at SDG&E host premises in 2009. An average of 29 percent of the actual output of these systems was used at the premises in "real time." This varies with location: systems in the Coastal zone supply an average of 48 percent of the premises use, while systems in the Inland zone supply an average of 60 percent. This also varies with the season—in the summer's hottest months, PV systems produce a higher percentage of the premises needs (an average of 59 percent), compared to the winter (39 percent).

As mentioned earlier, implementation of AB 920 will enable households with excess annual PV production to sell the net surplus to the utility. The ability to sell the yearly excess will provide these households with an incentive to reduce their energy consumption and increase their supply of excess PV production to the grid.

Nonresidential

In general, load patterns of nonresidential customers are more consistent on a day-to-day basis than the residential load patterns since they are primarily driven by business hours, shifts, and industrial processes. The nonresidential data provided by SDG&E, PG&E, and SCE show that these customers are more likely to use all of the electricity generated on-site.

The observed nonresidential loads generally coincide with the PV generation during the daytime hours, and whether the customer exports the excess load in "real time" largely depends on PV capacity in relation to the load at the site.

More profile load and generation curve examples for residential and nonresidential CSI participants can be found in Section 8.

ES.5 CSI Participants—Generation and Energy Efficiency Impacts

Included in this impact evaluation was an examination of the PV performance monitoring and maintenance activity of the CSI participants and their energy efficiency activities before deciding to install solar and after installation of the panels. As we have seen, CSI participants do reduce their monthly energy consumption compared to a similar sample group.

Monitoring and Maintenance

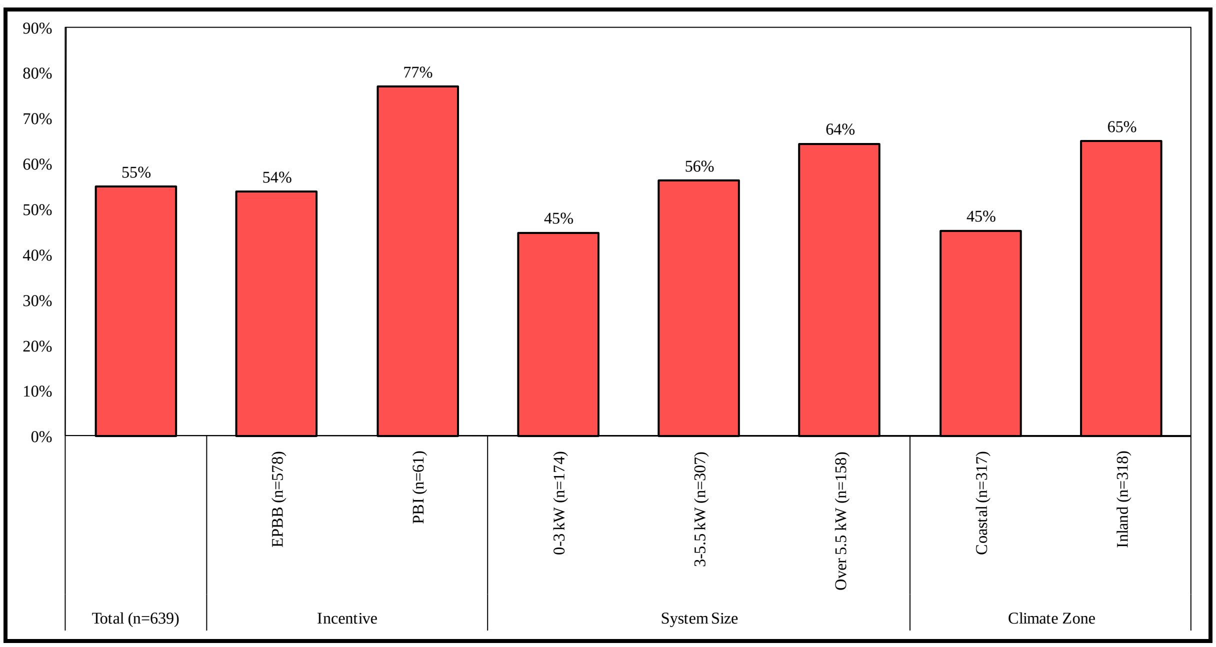
Performance monitoring is the act of logging the production of PV systems over periods of time. This can be accomplished through simple inverter display readings of instant or cumulative performance or through logging devices that can store or "stream" the data to local computers or over the internet to third party service providers. The data can also be at various levels of resolution and recorded with varying levels of customization depending on the host customer's motivation towards monitoring. The CSI program requires participants, unless exempt, to sign up with eligible providers that can monitor systems with a goal to ensuring maintenance. These minimum requirements were developed to increase owner knowledge of system performance and foster adequate system maintenance, thereby ensuring that ratepayer-funded incentives result in expected levels of solar generation.

The evaluation team found a strong correlation between those CSI participants that had performance monitoring and an active discussion from the Solar Contractor installing the system on performance monitoring. With performance monitoring, CSI participants are able to identify issues with their solar systems, correct the issue faster, and identify any maintenance issues.

The regular maintenance and cleaning of panels can go a long way in ensuring high yield of a system. This is particularly critical for systems that are more prone to collecting dust over the dry summer, which is typical in California and coincides with the highest production periods.

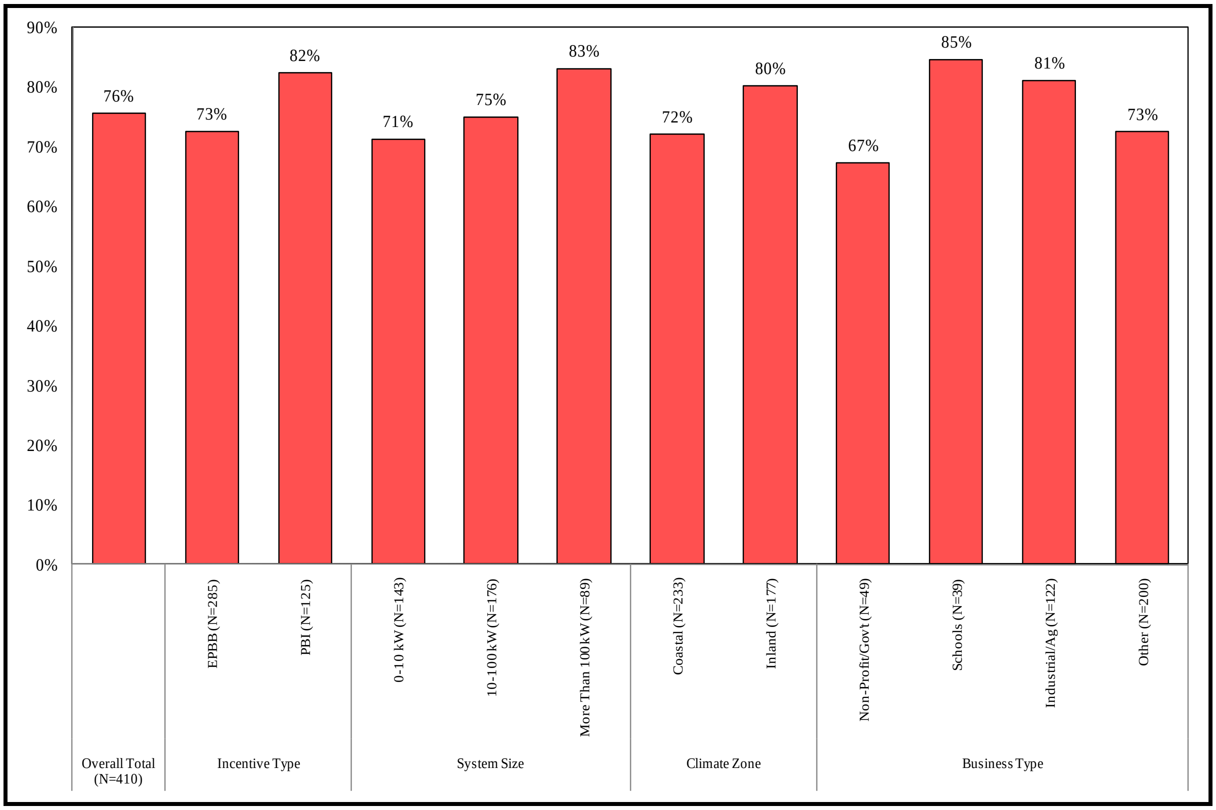
As shown in Figure ES-8, 55 percent of the residential phone survey participants reported regular maintenance and cleaning of panels. A higher percentage was reported under the PBI structure; those participants presumably have a bigger motivation to maximize their production for the related financial incentive benefit. The larger systems also tended to have a higher instance of maintenance, again with the motivation of larger investment and thus vested interest in high solar production. The inland and coastal climate difference in the level of maintenance was also notable, which may be attributed to the potential higher production benefit in the inland versus coastal climates.

Figure ES-8: Regular Maintenance Performed—Residential Customers



A similar trend was seen in the nonresidential phone survey participants (Figure ES-9); out of the 76 percent that reported regular maintenance and cleaning of panels, a higher percentage of PBI system owners performed regular maintenance. Larger systems reported more regular maintenance, as did the inland versus coastal systems.

Figure ES-9: Regular Maintenance Performed—Nonresidential Customers



Additional analysis on monitoring and maintenance can be found in Section 9

Energy Efficiency and PV

As part of this Impact Evaluation, the research team compared participation records from PowerClerk with the IOU rebate program tracking systems to ascertain the rate of rebated measure installation. Wherever the data indicated that a CSI participant had installed a rebated measure, the installation was verified during the phone survey.

Energy Efficiency Comparison between CSI Participants and Nonparticipants

Residential

From 2006-2009, CSI participants self-reported an average of 5 energy efficiency measures, compared with nonparticipants who reported an average of approximately 3.7 energy efficiency measures However, Figure ES-10 shows while CSI participants have adopted more energy efficiency measures overall from 2006 through 2009, they install similar numbers of IOU rebated measures as nonparticipants. Therefore, most of the difference in energy efficiency adoptions is due to the number of self-reported measures.

Figure ES-10: Measure Adoptions per Customer, Participants vs. Nonparticipants and Rebated vs. Self-Reported (2006-2009)

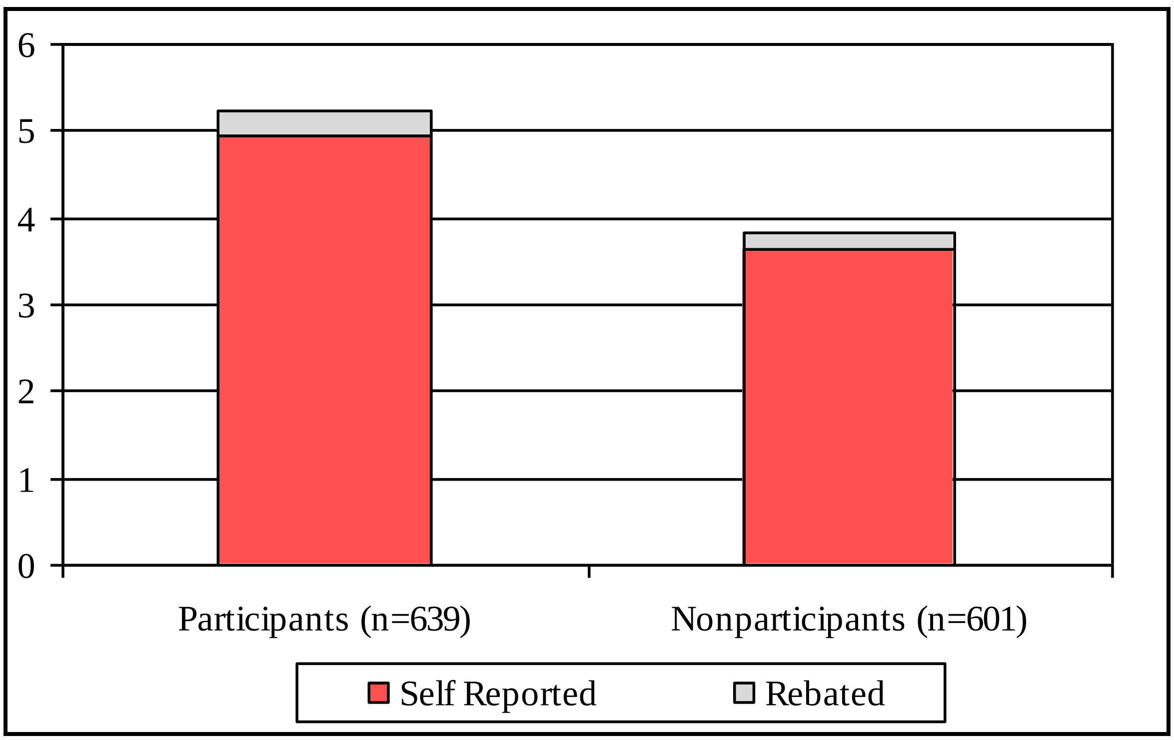
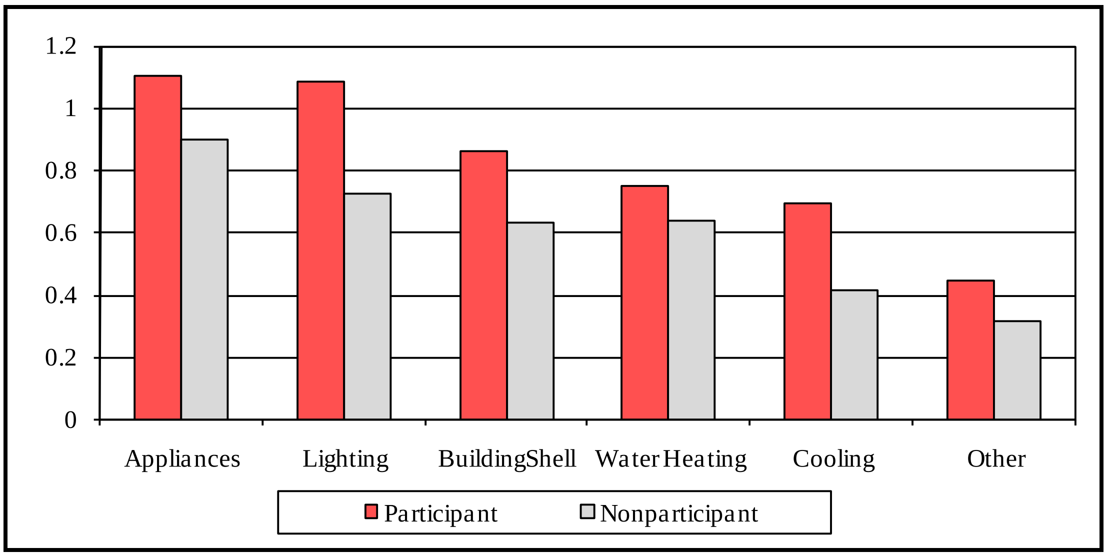


Figure ES-11 below further explores the type and frequency of energy efficiency measures installed by participants and nonparticipants over the 4 year analysis timeframe, 2006-2009. This graph shows all measures verified and reported in the phone survey. Approximately 1.1 appliance measures were reported installed by CSI participants, compared with 0.9 appliance measures by nonparticipants. Appliances include dishwashers, clothes washers, refrigerators, freezers, and unplugging or removing second refrigerators or freezers. Furthermore, the lighting end use category shows the biggest difference between participant and nonparticipant adoption rates, 1.1 versus 0.7, respectively.

Figure ES-11: Number of Measures Installed Per Participant by End Use, 2006-2009



Nonresidential

Both residential and nonresidential CSI participants are found to install more energy efficiency measures than nonparticipants. For the nonresidential market, however, participants are also installing a greater proportion through the IOU rebate programs.

Figure ES-12: Measure Adoptions per Nonresidential Customer, Participants Vs Nonparticipants

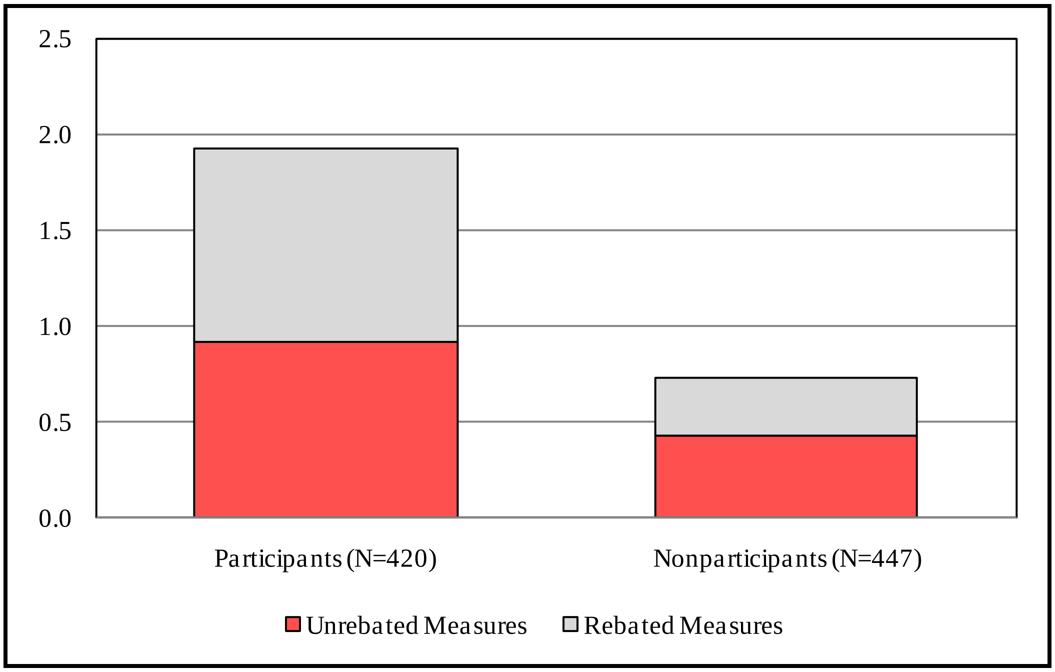
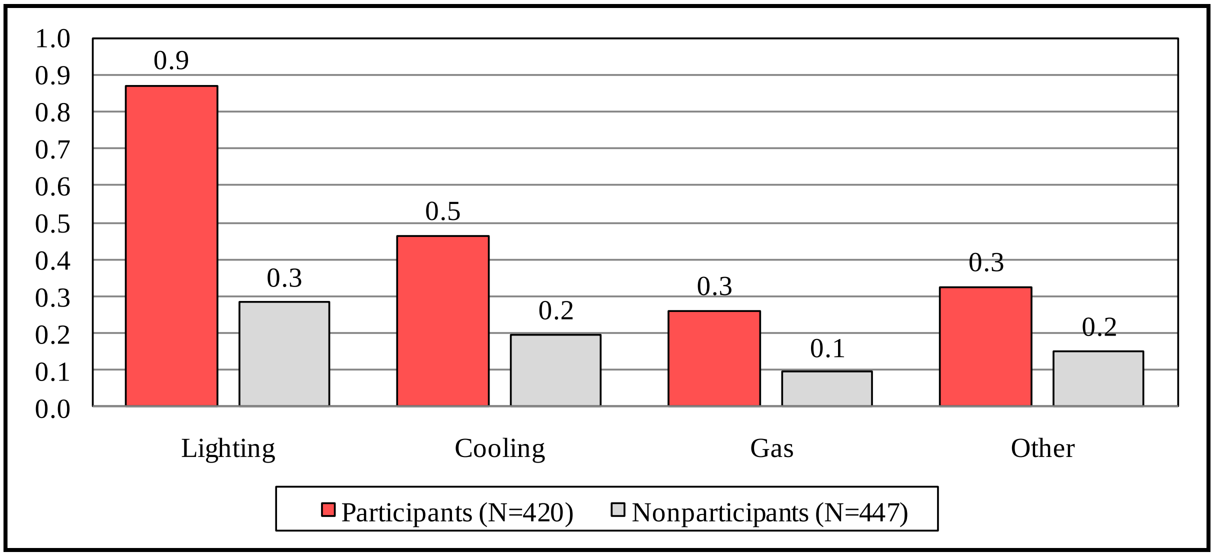


Figure ES-13 below presents a comparison of the nonresidential nonparticipant and participant measure adoption rates for each end use. Participants have higher adoption rates versus nonparticipants for each end use, though the greatest difference is for lighting, where the participant adoption rate is three times as high as nonparticipants.

Figure ES-13: Measure Adoptions per Nonresidential Customer, Participants versus Nonparticipants



For the Residential and Nonresidential markets more in-depth analysis of the types of energy efficiency measures adopted and their differential adoption between participants and nonparticipants in the CSI program can be found in Section 10

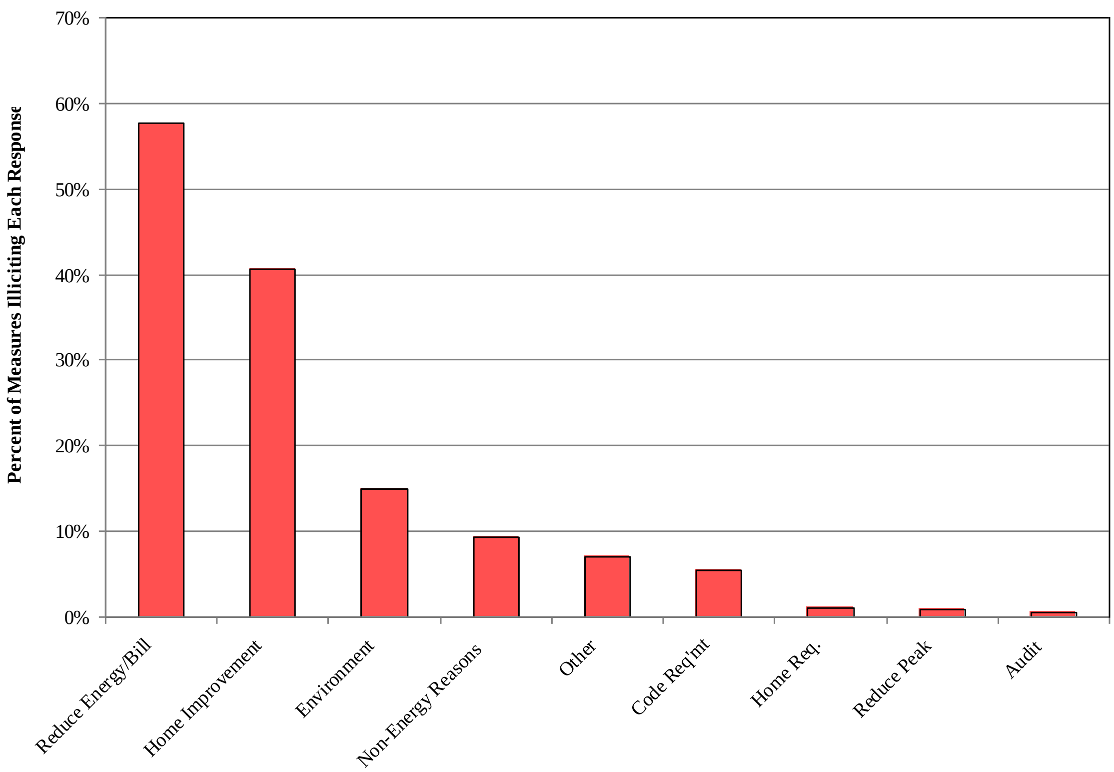
<u>Influence of the CSI audit</u>

The figures and tables above show that participants adopt more energy efficiency measures than nonparticipants. One reason for higher energy efficiency measure adoption rates may be due to CSI program requirements for an energy audit to be completed. The influence of the audit and other motivating factors behind the adoption of energy efficiency measures are explored and summarized below.

<u>Residential</u>

Figure ES-14 shows the reasons reported by participating customers for adopting energy efficiency measures. Measures were most likely to be adopted to reduce customer energy consumption and utility bills. The second most cited reason for adopting energy efficiency measures is related to home improvement reasons, followed distantly by a concern for the environment. Non-energy reasons that were mentioned included home comfort or replacement-in-kind of existing equipment. A minority of customers offered the audit as the primary reasons behind installation. This does not preclude the audit from having been influential through its provision of information relating to energy savings, which would be more likely cited as the reason for the installation.

Figure ES-14: Reasons for Installing Energy Efficiency Measures (n = 966)

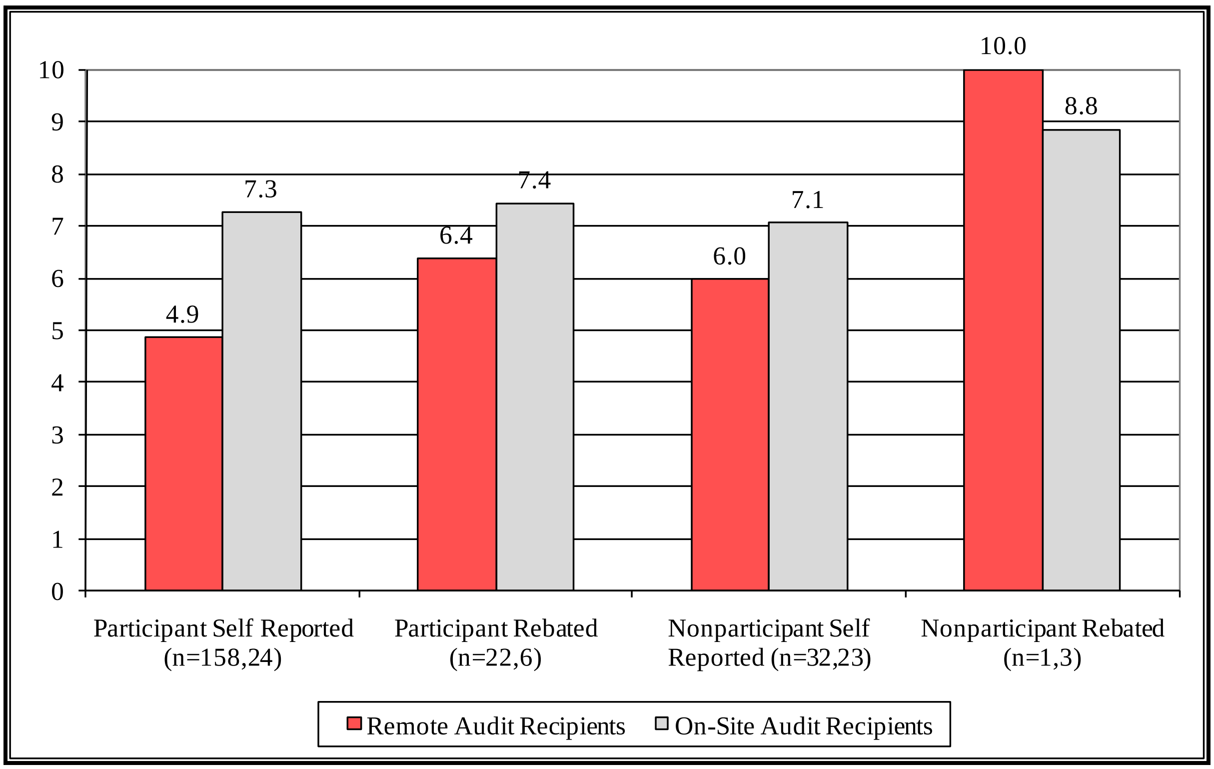


Reducing energy consumption and bills was most frequently cited for all types of measures, except for appliances. Participants who installed appliance measures were most likely to cite home improvement reasons for their decision.

Figure ES-15 compares the influence of a remote audit (e.g. mail-in or online audit) with an on-site audit on self-reported and rebated measures. The graph shows the average response to the following question: "On a scale of 0-10 (where 0 is not at all influential and 10 is extremely influential), how influential was the audit on your decision to make this action?"

Overall, on-site audits appear to have a higher influence on residential decisions to install energy efficiency measures. For participant self-reported measures (not rebated through an IOU program), the on-site audit is substantially more influential compared with a remote audit. Moreover, the audit has a higher average influence on rebated measure adoptions than non-rebated measure adoptions, especially for remote audit recipients. Among nonparticipants, the pattern more or less repeats; an on-site audit is more influential than a remote audit for self-reported measures, and audits are more influential for rebated measures than non-rebated.

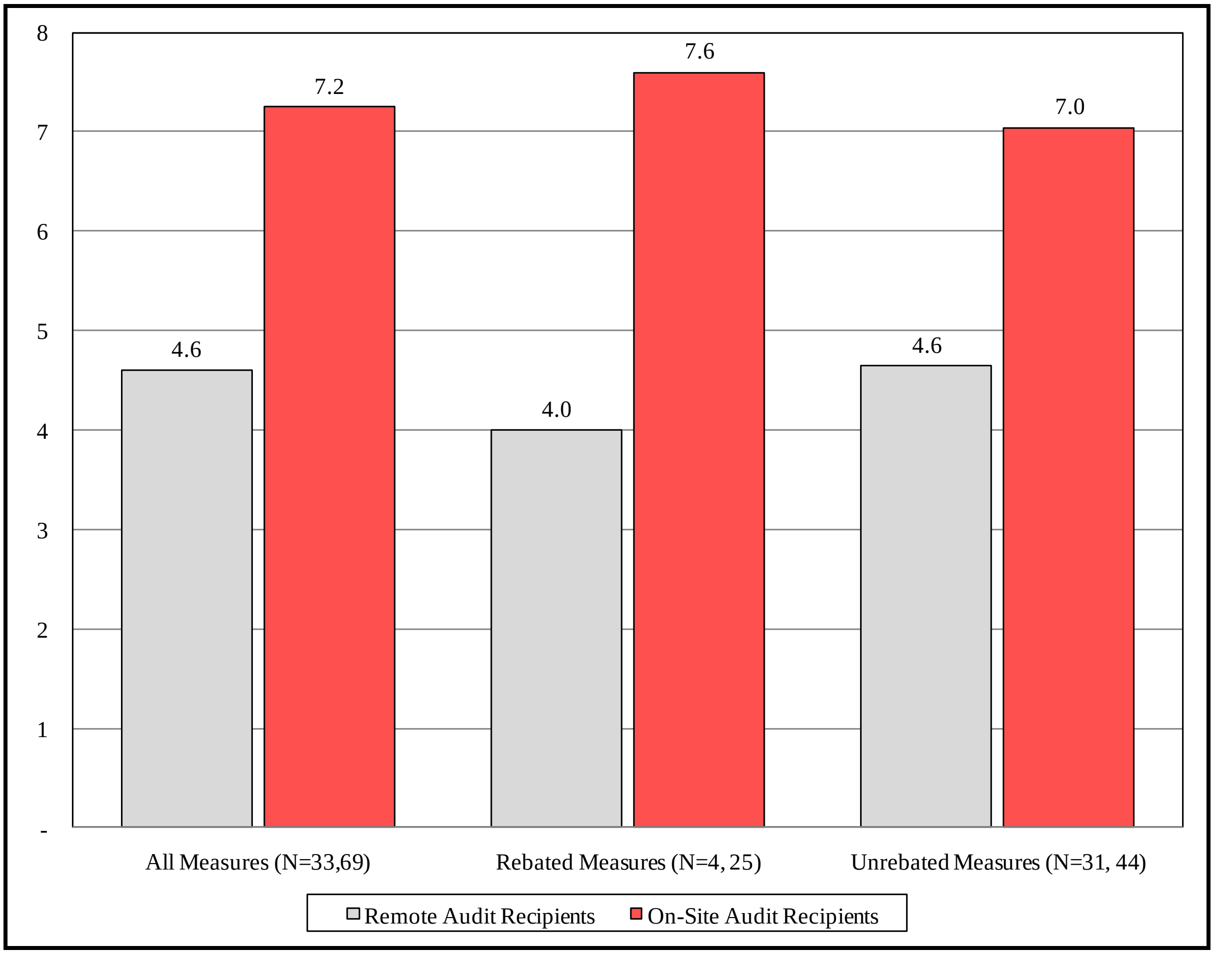
Figure ES-15: Average Audit Influence on Recommended Measure Adoptions (0 to 10 Scale) by Audit Delivery and Measure Rebate Status



Nonresidential

Figure ES-16 below shows the average influence score reported by nonresidential participants adopting audit recommended measures. The average influence is shown segmented by audit delivery and measure rebate status. Figure ES-16 shows a much higher mean influence for measures recommended during an on-site audit relative to a remote audit. In addition, measure recommendations that come with an IOU rebate are more influential than measures that do not. The most influential audit recommendations are made by an on-site auditor, where a successful reference to an IOU program rebate is made for the customer.

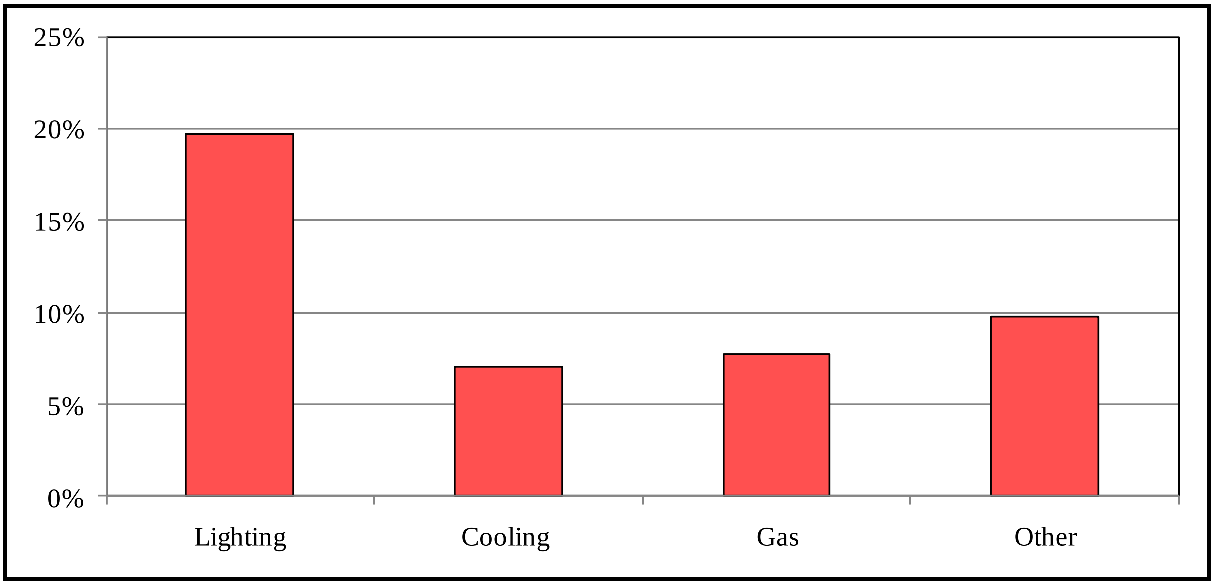
Figure ES-16: Average Audit Influence on Recommended Measure Adoptions (0 to 10 Scale) by Audit Delivery and Measure Rebate Status



The evidence above shows that lighting is the most commonly installed measure and the influence of the audit is highest among those that adopt lighting. However, because lighting is more frequently adopted than other types of measures, it is important to control for the differences in natural measure uptake rates when trying to hone in on the effects of the energy efficiency audit.

Figure ES-17 below presents the percent of customers adopting an audit-influenced measure[12] as a percent of customers adopting a measure. Figure ES-17 clearly shows lighting as the front runner in the relative portion of audit influenced adoptions, with almost one-fifth of customers that adopt lighting measures being affected by the energy efficiency audit in their lighting choices.

Figure ES-17: Customers Adopting an Audit-Influenced Measure as a Percent of Customers Adopting a Measure, by End-Use



In Section 10, more analysis is presented on the impact of the audit and the timing of energy efficiency measures as well as recommendations to improve the integration of energy efficiency and solar PV through the CSI program.

Contractor Behavior

Interviews were conducted with 50 solar installation contractors that are active in the CSI program participant markets. During this interview, contractors were asked to characterize the ways in which energy efficiency options are an integral part of the PV system installation and sizing process. More than 90 percent of the contractors surveyed state that they regularly discuss energy efficiency options with their PV customers. Residential customers generally confirm this, with just under 70 percent of survey respondents stating that their contractor had discussed the audit recommendations with them. Eighty percent of nonresidential participants stated that costs and benefits of energy efficiency had been made clear to them during the CSI application process. However, only about 25 to 30 percent of customers in

[12] Customers were asked to rank the influence of the audit on a scale of 0 to 10, where 0 is not at all influential and 10 is extremely influential. A ranking of 7 through 10 is considered ‘audit influenced’.

either market report their solar contractor discussed energy efficiency with them in the context of system sizing.

Recommendations

In Section 10, more analysis and data are provided on the solar contractors interaction with the CSI participants and the evaluation teams provides recommendations on how to improve the integration of energy efficiency with solar PV including:

- Appling the new Progressive Energy Audit Tool (PEAT) energy audit requirements
- Consider tiered incentives based on documented EE measures and reducing allowable size to 80 percent of annual load
- More heavily leverage and incentivize contractors as a channel for EE installations
- Expand training programs to increase the number of contractors that offer fully bundled services
- Focus on EE measures that are a success now
- Understand and leverage the role of home renovation

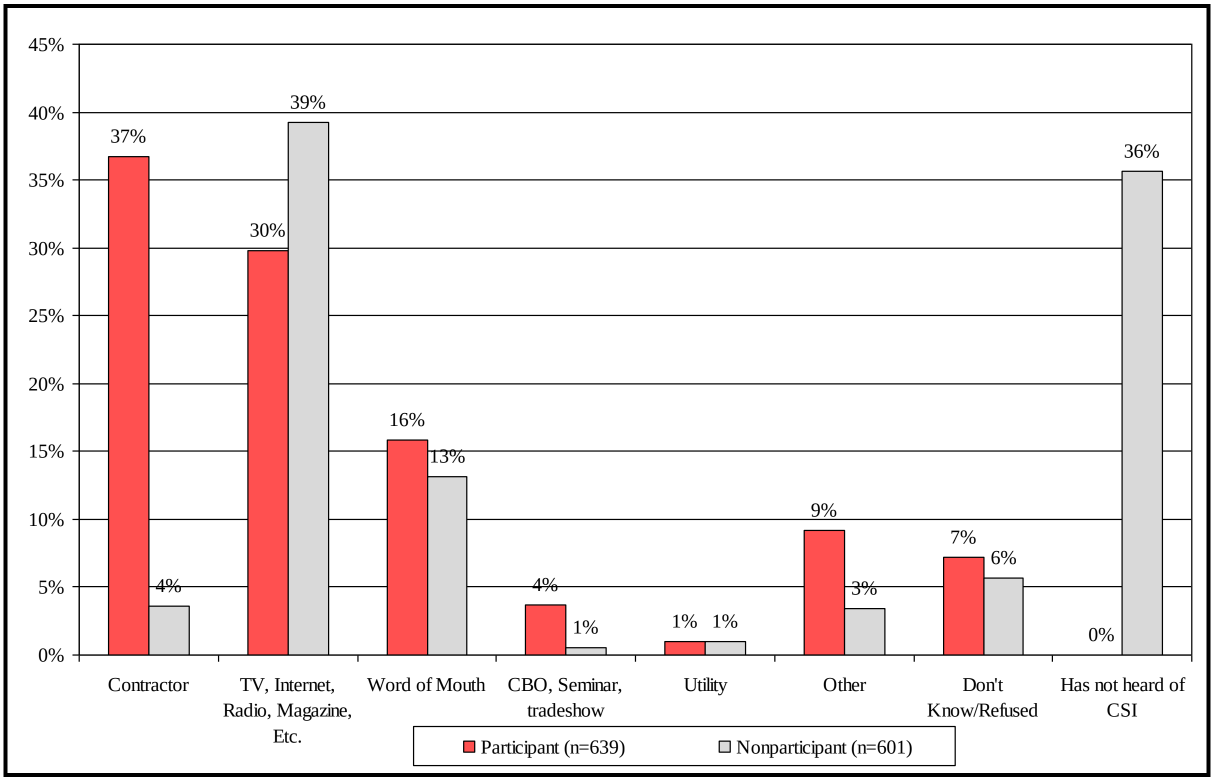
ES.6 CSI Awareness, Participant Motivation, and Satisfaction

One of the goals of the CSI program is to foster growth and transform the solar market in California to be sustainable in the absence of ratepayer subsidy. The CSI program is designed as a means to this end. In support of this goal, in the final Section of this Impact Evaluation, the team focused on the analysis of data collected from the participant, nonparticipant, and contractor phone surveys that are related to the measurement of progress towards awareness and program satisfaction. This final section (Section 11) also includes an investigation of the primary drivers to “go solar” and a discussion of solar contractors’ recent market experience and industry growth projections

Residential CSI Program Awareness

The phone surveys asked residential participants and nonparticipants how they first became aware of the program, shown in Figure ES-18. For participants, contractors are the most common source of information followed by traditional marketing channels such as television, radio, and print advertisements. Only 1 percent of the participants heard about the program through their utility. More than one-third of the residential nonparticipants have *not* heard of the CSI program. Traditional marketing channels are the most common source of program information for nonparticipants, with almost 40 percent of the survey respondents stating that they learned about the program through these channels. As seen with program participants, only 1 percent of nonparticipants gained awareness of the program through their utility.

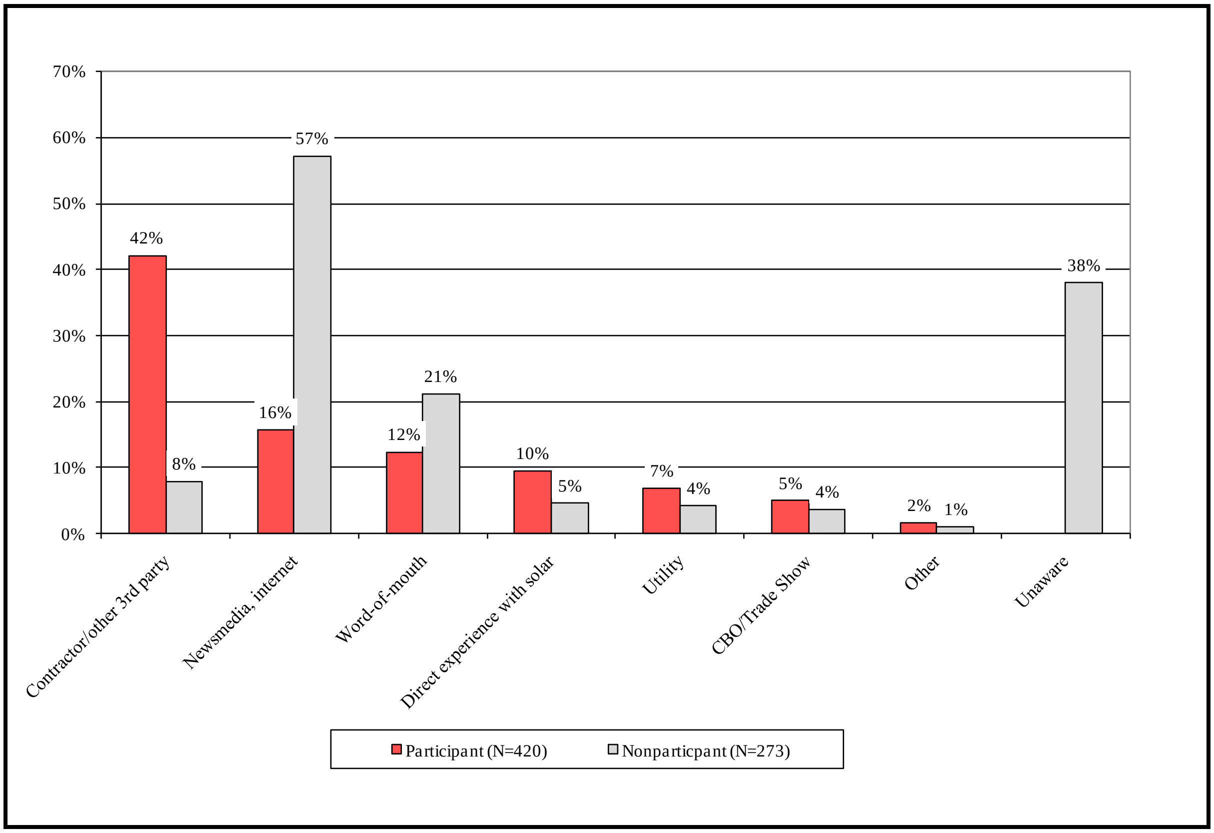
Figure ES-18: Source of Program Awareness—Residential



Nonresidential CSI Program Awareness

As shown in Figure ES-19 below, 42 percent of the nonresidential participants became aware of the CSI Program primarily through their contractor, while nonparticipants became aware through news media, such as television, printed media, or the internet. Utilities play a relatively small role in program awareness for both participants and nonparticipants. These findings are similar to the residential sector discussed above. Thirty-eight percent of nonparticipants have *not* heard of the CSI program.

Figure ES-19: Sources of Program Awareness—Nonresidential



Other sources and analysis of program awareness are explored in Section 11.

Nonparticipants reasons for not "Going Solar"

The phone survey asked residential and nonresidential nonparticipants who had not considered a PV system why they had not. The primary reason provided for not considering a PV system was the initial cost for both residential and nonresidential samples. The increase in third party-ownership models, such as PPAs and leases, and other financing opportunities, such as local Property Assessed Clean Energy (PACE) programs, are expanding to address this barrier.

The other factor commonly cited by residential nonparticipants is that they did not think they needed the PV system or did not think it would work. This finding (31 percent) illustrates that the CSI program has an opportunity to transition from the knowledgeable PV enthusiast and early PV adopters to the late PV adopters (mainstream consumers). Increased education and awareness through traditional marketing channels may address this barrier. Doubt about PV systems is especially high for nonparticipants in the highest income bracket. Indeed, doubt rather than financial reasons appears to be the reason why these nonparticipants did not consider a PV system.

Residential and Nonresidential Program Satisfaction

The Impact Evaluation's phone survey provided an opportunity to ask participants about their level of satisfaction with the program, with their solar contractors and with the size and performance of their solar PV system. Overall for both residential and nonresidential participants there is a high degree of satisfaction across.

Table ES-13: Residential and Nonresidential Satisfaction with CSI

Market Segment	Program	Contractor	System Size	System Performance
Residential	8.0	9.1	8.8	9.1
Nonresidential	7.8	8.6	8.5	9.0

In Section 11 there is a detailed analysis across a number of different attributes that are driving program satisfaction including quotes from a number of customers.

Contractor PV Growth Expectations

As mentioned above and detailed in Section 4, surveys were conducted with 50 installation contractors active in the CSI program. While there are more than 1,400 such active contractors, CSI program jobs, and installed capacity are concentrated in the top 74 firms. These top firms account for 80 percent of the program installed capacity, and are referred to as "high volume contractors" in the tables that follow; contractors less dominant in the field are referred to as "general contractors."

PV installation contractors were asked to comment on their business outlook over the next three years. The results are quite striking, with nearly 80 percent of the contractors reporting a positive business outlook, and only 4 percent expressing a negative outlook. General contractors are not quite as positive as high volume contractors, with 60 percent reporting a positive outlook.

The reasons offered for having a positive outlook are led by a growing market for solar (20 percent) and the continued availability of incentives and financing options. Sixteen percent mentioned incentives, and another 10 percent mentioned the advent of new programs, including some that offer financing options for customers. Others cite their own business practices, general concern for the environment, and an improving economy.

Table ES-14 below shows the percent change in full-time-equivalent (FTE) staff experienced over the past 12 months and expected over the next 12 months. Overall, the CSI program grew by 55 percent year over year from 2008 to 2009, and this growth is observed with the majority of contractors growing their FTEs in the past 12 months by an average of 28 percent. However, some firms experiencing cutbacks over the past 12 months reduced their FTEs substantially, possibly reflecting their own difficult economic conditions. Expectations for future growth are more optimistic. Among the surveyed contractors that expect growth, the average expected increase in FTE is nearly 60 percent.

Table ES-14: Percent Changes in Firm FTE, Past 12 Months and Expected Changes over the Next 12 Months—Solar Contractors

		Total		High Volume Contractors		General Contractors	
Description	**Change Description**	**Change in FTE**	**N**	**Change in FTE**	**N**	**Change in FTE**	**N**
Prospective/ Next 12 Months	Grow	59%	37	33%	28	140%	9
	Shrink	100%	1		0	100%	1
Retrospective/ Past 12 Months	Grew	28%	23	29%	20	23%	3
	Shrank	46%	14	39%	10	65%	4

This analysis and other findings can be found in Section 11 of the Impact Evaluation Report.