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CONNECTICUT
GREEN BANK

January 30, 2015

A Message from the President and CEO

The Connecticut Green Bank hired The Cadmus Group to conduct an independent evaluation of the Green Bank's Residential Solar Investment Program (RSIP) through which incentives for residential solar photovoltaic (PV) systems are provided for Connecticut electric ratepayers. The enclosed report, "Residential Solar Investment Program Evaluation" documents the findings of this evaluation.

One purpose of the evaluation was to provide to the Connecticut legislature an update on progress made toward RSIP's original 30 MW by 2022 goal. The data included in this analysis spanned the beginning of RSIP in March 2012 through June 2013, the end of the Green Bank's Fiscal Year (FY) 2013, by which time RSIP had reached 10 MW of approved, in progress or completed projects. Secondly, this evaluation was conducted to provide insights to the Green Bank to inform future RSIP development.

Since this study began, we have reached many milestones:

- The Clean Energy Finance and Investment Authority (CEFIA) was renamed the Connecticut Green Bank on June 6, 2014, with the vision: "to lead the green bank movement by accelerating private investment in clean energy deployment for Connecticut to achieve economic prosperity, create jobs, promote energy security, and address climate change."
- RSIP reached 30 MW of approved projects eight years ahead of schedule in July 2014.
- Installed costs and incentives continued to decrease, with calendar year 2014 average installed costs at $4.33/W and incentives just under $1/W, at $0.97/W.
- The Green Bank's residential financing products have taken off, with over 2500 applications across four products as of the end of calendar year 2014, and with investment of $37.7 million in approved or closed projects. This includes the CT Solar Loan, CT Solar Lease, the Smart-E and Cozy Loans.
- The www.GoSolarCT.com website was launched to help CT residents access financing options for residential solar PV systems.
- A residential solar PV customer segmentation analysis was conducted for Connecticut: www.GoSolarCT.com/solar_segmentation.
- The Green Bank completed its second Comprehensive Plan, for FY 2015 and FY 2016, and its first Comprehensive Annual Financial Report (CAFR), for FY 2014 (see www.ctgreenbank.com, "About Us").
- In February 2015, Governor Malloy will be announcing a policy proposal to expand the RSIP goal to 300 MW by 2022, along with creation of Solar Home Renewable Energy Credits (SHRECs) as a funding source for program costs.

We thank all our stakeholders for your support of the Residential Solar Investment Program and the Connecticut Green Bank as we continue to build on the successes of the past three years.

Bryan T. Garcia
President and CEO

Residential Solar Investment Program Evaluation

January 28, 2015

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Executive Summary

Cadmus has completed an evaluation of the Clean Energy Finance and Investment Authority's (CEFIA's)[1] Residential Solar Investment Program (RSIP). This program supports, through direct incentives, the installation of solar photovoltaic (PV) systems on Connecticut homes, with a goal of supporting 30 megawatts (MW) of PV installations by 2022. The RSIP has two incentive structures: the Expected Performance-Based Buydown (EPBB) is an up-front incentive payment made to offset the purchase price of a customer-owned PV system; the Performance-Based Incentive (PBI) provides an incentive tied to actual electricity generated, paid over a six-year period to owners of leased PV systems.

The Cadmus evaluation covered the first 18 months of the RSIP, from March 1, 2012, through June 30, 2013 (study period). In completing this evaluation, we conducted several key tasks, including:

- Extensive analysis of RSIP installation data, financial records, and program documentation
- Review of quality assurance (QA) inspection results
- Calculation of program-wide energy savings and capacity factor
- Survey of customer satisfaction, costs, and financial/purchasing decisions
- Survey of participating PV installers' experience with RSIP, workforce development metrics, operations and maintenance (O&M) practices, and customer acquisition and other soft costs
- Program cost-effectiveness calculations using the Utility Cost Test (UCT), also called the Program Administrator Cost Test (PACT).

Key Findings

Through this evaluation, we have identified several key findings and associated recommendations to help CEFIA improve future residential solar PV programs and products. In particular, the RSIP is:

- **On track to meet relevant statutory goals**. During the study period, the RSIP was responsible for approximately 10MW of nameplate PV system capacity, approximately one-third of CEFIA's "30MW by 2022" goal. At the present installation rate, CEFIA will achieve the 2022 target well ahead of schedule.
- **Making PV accessible to a wide range of Connecticut residents.** Survey results indicate that an up-front incentive to homeowners interested in installing solar PV can be the tipping point in whether an individual chooses to participate. Providing incentives for various ownership models (e.g., direct ownership, lease, and PPA) allows more homeowners to enter the market and choose the ownership model that suits their investment priorities.

[1] As of June 6, 2014, the Clean Energy Finance and Investment Authority (CEFIA) was renamed the Connecticut Green Bank.

- **Generating 5% more electricity than predicted by PowerClerk.** On an annual basis, the 1,419 PV systems funded during the study period are generating approximately 11,900 MWh of electricity. CEFIA uses the PowerClerk system to estimate annual electricity generation for each project. The actual electricity generation based on Cadmus' analysis of Locus solar PV system monitoring data is very similar, albeit slightly higher, than these predicted values.

- **Supporting PV systems that have simple paybacks of nine to 13 years.** Most RSIP-funded PV systems have simple payback periods of 11 to 13 years, after all relevant incentives are included. Projects also participating in the Solarize Connecticut program performed even better, achieving average simple payback times of nine to 11 years.

In addition to these achievements, we identified several other key findings:

- **PV system owners are paying 2% to 4% more for their systems than indicated in CEFIA records.** PV system owners (38%) and lessees (22%) reported costs in addition to the amount paid to their installer. These undocumented costs commonly include roof reinforcing, electrical upgrades, landscaping, and site clearing. For EPBB customers reporting additional costs, this adds approximately $4,028 to the ownership cost of PV and for PBI customers it adds $3,322. As a program-wide average, these undocumented costs increase the average ownership cost to participants by $743 to $1,544 per PV system.
- **QA inspections may not be capturing all relevant data for program verification purposes.** Though CEFIA inspects nearly all completed RSIP-funded PV projects, the inspections do not always include hands-on inspection of on-roof equipment, due to safety considerations and the inspection budget. Inspection reports from this evaluation period did not always include sufficient information to assess the accuracy of program data for equipment installed and design factors used in predicting electricity generation. The inspection report was updated in December 2013 to account for these aspects. PowerClerk was updated only in the event of inspection findings that reduced the incentive amount (e.g., fewer panels, more shading). When asked about the inspection process, some installers cited inconsistency among inspectors as an issue.
- **Both RSIP incentive structures pass the Program Administrator Cost Test (PACT).** Both incentives pass the PACT test with and without non-energy benefits (NEBs), with the EPBB passing by a greater margin. Using the program inputs and assumptions available for this evaluation, the PBI program demonstrated a benefit-cost (BC) ratio of 1.95 and the EPBB had a BC ratio of 2.07 both including NEBs. As incentive levels decrease with each subsequent program step, the BC ratio will increase further. This compares favorably with programs supporting energy efficiency. The MassSAVE program, for example, reported a BC ratio of 1.72.
- **Installer feedback was generally positive.** Installers are generally satisfied with the delivery and structure of the two RSIP incentive types, while reporting the areas for improvement around incentive payment timing and expediting inspections. PV installers reported spending the majority of their customer acquisition time giving installation quotes and doing site visits, and

reported customer acquisition costs ranging from $0.25 per watt to $0.50 per watt, amounting to approximately 4% to 10% of installed cost. Installers were in agreement that EPBB customers chose the EPBB program because they wanted to own their system, whereas PBI participants were attracted by the lack of upfront payment required to obtain solar through a lease or power purchase agreement. When asked to break down the overall PV system cost into specified cost components, PV modules (27% of cost) were followed by installation labor cost (15%) as the two top areas. Hardware costs contributed 52% of total installed system cost.

- **LOCUS energy production monitoring is providing valuable data but can be time-consuming for installers.** The data from LOCUS proved very useful for evaluating energy savings for the RSIP, but some installers raised concerns about the labor required to keep the data-acquisition system operational and reporting. Overall, 62% of installers listed the data acquisition system as one of their most frequently repaired system components. Repair costs were as high as $500, with an average of $175 per repair.[2]
- **Many PBI customers choose to prepay 20-year leases, possibly as an alternative to ownership.** One out of three customers leasing PV systems through the PBI program chose to fully prepay their 20-year lease up front. Based on customer responses, the main motivation for this was a desire to minimize monthly costs. Customers also appear to place a high premium on the maintenance and performance guarantees included in solar leases, rather than bearing the cost and responsibility of maintenance on self-owned PV systems. Most EPBB installers do not offer a standardized maintenance package beyond the five-year warranty required by CEFIA.

Recommendations

Though the RSIP is proving to be a very successful program and is on track to meet and exceed statutory goals early, we have identified several opportunities for improvement.

Explore Broader Cost-Effectiveness

While the Program Administrator Cost Test (PACT) used in this report was recommended by Cadmus as the most relevant cost-effectiveness test for determining the benefit/cost ratio of the RSIP from CEFIA's perspective, there are other cost-effectiveness tests that could provide additional insights. Examining other cost-effectiveness tests, such as the Total Resource Cost Test, the Participant Cost Test, and the Rate-Payers Impact Test, would give a robust picture of the benefits and costs of the program from additional perspectives. Examples of additional factors that could be included in a value of solar calculation are load shapes and seasonal variations, energy and capacity cost savings, and transmission and distribution infrastructure cost savings.

[2] Newly installed LOCUS systems use cellular technology for data transmission, which is expected to reduce downtime and burden on installers. Approximately 528 of these systems have been installed since January 2014 and CEFIA expects to have approximately 2300 deployed by June 30, 2015.

Provide More Support for LOCUS

To facilitate the gathering of ongoing generation data, CEFIA should consider providing installers with additional support in setting up and maintaining the LOCUS monitoring systems, if the budget allows. This could be done through a dedicated LOCUS service plan, which could improve data recovery rates and reduce the burden on installers who may lack the expertise to deal with communications and data issues.

Bolster QA Process to Gather More Data and Spur Improvement

We observed significant variability and missing data in reviewing QA inspection reports for the RSIP. CEFIA should consider further codifying the QA inspection process and requiring more thorough review of the entire installation, particularly roof-mounted arrays that are not currently covered during all inspections despite representing a major part of the system. As of December 2013, CEFIA has required a standard report format from all inspectors, which will likely address some consistency issues, but we recommend careful oversight to ensure that all inspectors are inspecting systems to the same standard. CEFIA should also ensure that inspection results provide feedback to PowerClerk and program tracking databases.

Ensure that Undocumented Costs are Eligible for CEFIA Financing Products

Customers reported out-of-pocket costs of 2%-4% beyond the contractual installation costs. These costs commonly include site preparation, electrical upgrades, and roof repair and ideally would be eligible for financing as part of the overall installation costs. Customers report that they typically pay for the majority of their out of pocket costs, including undocumented costs, using cash. The documentation for current loan offerings, such as the Smart-E Loan or Sungage's Solar Loan, does not explicitly state whether these costs are eligible for financing. We recommend that CEFIA work to revise the instructions for these, and future, financing products to clarify the eligibility of these relevant non-installation costs.

Introduction

Evaluation Goals

Cadmus' evaluation focused firstly on providing an update on the status of the RSIP to the Connecticut legislature, and secondly, a broader analysis of factors important to CEFIA, with the goal of summarizing findings into meaningful data points, conclusions, and recommendations to inform CEFIA's decision-making and direction for future iterations of the RSIP and other CEFIA programs. We designed our evaluation approach to allow CEFIA to assess the following:

- Quantify the RSIP's progress toward internal long- and short-term goals.
- Measure the true costs and benefits of the RSIP from customers' and CEFIA's perspectives.
- Identify opportunities for improving future program iterations based on evaluation findings and recommendations from Cadmus, informed by experience from working with other residential solar programs.
- Analyze key differences between the Performance-Based Incentive (PBI) and Expected Performance-Based Buydown (EPBB) Programs.

Background and History of CEFIA

Mission and Vision

CEFIA was created by the Connecticut legislature as part of Public Act 11-80, *An Act Concerning the Establishment of the Department of Energy and Environmental Protection and Planning for Connecticut's Energy Future*, and is the successor organization to the Connecticut Clean Energy Fund (CCEF). CEFIA aims to attract and deploy capital to:

- Finance the clean energy goals of Connecticut.
- Develop and implement strategies that lower the cost of clean energy.
- Reduce reliance on grants, rebates, and other subsidies.
- Move toward innovative low-cost financing for clean-energy deployment.

These goals support CEFIA's vision to help ensure Connecticut's energy security and community prosperity by realizing its environmental and economic opportunities through clean-energy finance and investment.

Legislative Authority

CEFIA is led by a board of directors composed of 11 voting and two non-voting members, each with knowledge and expertise in matters related to the purpose of the organization. CEFIA is governed by its bylaws adopted August 3, 2011, revised September 29, 2011, and amended periodically. A joint standing

committee of CEFIA and the Connecticut Energy Efficiency Fund (CEEF) was established to coordinate programs and activities.[3]

CEFIA's Green Bank Approach

One of CEFIA's primary goals is to grow the state's residential solar PV industry to a point where the market can operate subsidy-free, and be supported by innovative clean-energy loan and lease products. CEFIA now provides support for long-term loan (CT Solar Loan and the Smart-E Loan) and lease (CT Solar Lease) financing products for solar PV installations. These products were launched after the period included in this evaluation, and will be discussed in a future progress report.

Residential Solar Investment Program (RSIP) Description

The RSIP consists of two nearly independent programs that use different incentive mechanisms to support residential PV installations in Connecticut. Each of these two programs, the Expected Performance-Based Buydown (EPBB) and the Performance-Based Incentive (PBI), is summarized below.[4]

EPBB Program Description

Through the EPBB, CEFIA effectively provides a rebate, paid to the installer upon completion of a project, which is then passed on to the homeowner, thus lowering the total price of the solar PV installation. The incentive is calculated on a per-watt basis, up to 10 kW, based on the system's PVUSA Test Conditions (PTC) rating as opposed to the standard test conditions (STC) or nameplate rating.[5] The incentive calculation also takes into consideration the design factor of the system, to account for shading and orientation. Incentive-based systems under steps 1 and 2 are de-rated by multiplying the percent of optimal production by the PTC rating. Step 3 systems that are designed to meet at least 87% of optimal production receive the listed dollar-per-watt incentive. Incentives for systems with a design factor below 87% of optimal are reduced accordingly. The first 60% or 70%[6] of the incentive is disbursed

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[3] As of June 6, 2014, CEFIA was renamed the Connecticut Green Bank.

[4] As of July 11, 2014, CEFIA launched a new incentive, the Homeowner Performance Based Performance Incentive (HOPBI), to replace the EPBB as a solution to CT legislation passed June 6, 2014, that inadvertently prevented EPBB customers from benefitting from net metering.

[5] PTC is an alternative PV module rating scheme that differs from Standard Test Conditions (STC) used for module "nameplate" values. The PTC rating, which is generally lower than the STC rating, is recognized to be a more realistic measure of PV output because the test conditions better reflect real-world conditions. The PTC rating is used by programs in California, Connecticut, and elsewhere as the basis of incentive calculations. PTC refers to PVUSA Test Conditions, which were developed to test and compare PV systems as part of the PVUSA or Photovoltaics for Utility Systems Applications (formerly Photovoltaics for Utility Scale Applications) project. PTC are defined as 1,000 watts per square meter solar irradiance, 20 degrees Celsius *air* temperature, and wind speed of 1 meter per second at 10 meters above ground level. STC are based on 25 degrees Celsius *cell* temperature. The PTC rating differs in that its test conditions of ambient temperature and wind speed will result in a PV cell temperature of about 50 degrees Celsius, instead of the 25 degrees Celsius assumed for STC. Consequently, for crystalline silicon PV systems with a power degradation due to temperature of -0.5% per degree Celsius, the PV module PTC power rating is generally about 88% of the PV module STC or nameplate rating.

[6] In Steps 1 and 2, a 60% milestone payment was provided upon equipment delivery. This was changed to 70% beginning in Step 3.

following delivery of the equipment to the homeowner, and the remaining incentive after the PV system is installed and has passed all inspections. The EPBB is designed to support local installers and homeowners who want to own their solar PV system. Only PV systems that are owned by the homeowner are eligible to receive the EPBB.

The EPBB was designed so that incentive levels would be reduced in a series of steps. During the period of this evaluation, the incentives have progressed from step 1 to step 3, with step 3 providing the lowest incentive levels. For each step, CEFIA has provided a higher dollars-per-watt incentive for the first five kW of installed capacity, and a lower incentive for additional, installed capacity greater than five kW and less than 10 kW.

EPBB incentives are not provided for capacity beyond 10 kW[7], and are available only up to the PV capacity necessary to meet the home's load. The system can still have a capacity that is larger than necessary for the load; however, no incentives are provided for this extra capacity.

EPBB incentive levels since inception of RSIP, steps 1 through 3, are listed in Table 1.

Table 1. EPBB Incentive Levels Since Inception of RSIP ($/W)

Step	EPBB Incentive ≤ 5 kW	EPBB Incentive > 5 kW and ≤ 10 kW
1	$2.450	$1.250
2	$2.275	$1.075
3	$1.750	$0.550

PBI Program Description

The PBI supports third-party financiers who work with homeowners who want to lease their PV system. Similar to the EPBB, the PBI decreases over the life of the program. However, unlike the EPBB, CEFIA bases the PBI incentive on the kWh output of the PV system, rather than the kW capacity. CEFIA began the program by offering $0.30 per kWh and has reduced the incentive levels in steps as for EPBB.

Unlike the EPBB, which CEFIA pays at the completion of the project, the PBI is disbursed quarterly over six years. By disbursing the incentive payments over time, CEFIA avoids requiring a large initial source of funds. The PBI incentive levels since inception of RSIP are listed in Table 2.

Table 2. PBI Incentive Levels since Inception of RSIP ($/kWh)

Step	PBI Incentive ≤ 10 kW
1	$0.300
2	$0.300
3	$0.225

[7] This changed with RSIP step 5 which began September 1, 2014 in which the capacity limit was increased to 20kW, though the incentive provided for the portion of capacity between 10kW and 20kW was half that provided for the capacity up to 10kW.

The PBI has two primary models:

- **Power Purchase Agreement.** In a power purchase agreement (PPA), the customer signs a contract with a third-party system installer/owner to purchase power over a long period of time (10 or 20 years, for example) at a fixed or escalating rate. In the case of an escalating rate, the customer may have a starting rate 5% to 20% lower than their current utility rate, but the PPA rate will rise over time. So long as the rising PPA rate remains below the prevailing utility rate, the customer will continue to save money.
- **Lease.** Though the lease is similar to a PPA, it is a fixed payment schedule that often does not include an escalation. However, the dataset analyzed here did have lease projects with escalating rates. There are many variants on the leasing model, and customers usually have the option of prepaying their leases, if desired.

With either model, customers may have the option to make a down payment or prepay a portion or all of the costs of the contract with the third-party owner. The incentive for customers to pre-pay is that pre-paying a sufficient amount will lock in a dollar-per-kWh rate, with no annual escalation to the rate. For this analysis, we have chosen to segment PBI participants into those who made an up-front payment sufficient to result in a 0% annual escalation rate, and those who did not make a down payment (or made a modest down payment such as $500) and received an annual escalation rate.

Funding and Incentive Levels

The EPBB and the PBI incentive budget totaled approximately $12 million during the study period[8] and CEFIA disbursed $8.4 million in RSIP incentives. Of the $8.4 million in disbursed incentives, $4.7 million were funded by System Benefit Charge (SBC)[9] income, with the remainder funded through an allocation of funds from Regional Greenhouse Gas Initiative (RGGI) auction proceeds.[10]

RGGI is a cooperative market-based regulatory program among the states of Connecticut, Delaware, Maine, Maryland, Massachusetts, New Hampshire, New York, Rhode Island, and Vermont to cap and reduce carbon dioxide emissions from the power sector.[11] In Connecticut, RGGI is implemented and auction proceeds are distributed as provided in:

- Section 22a-200c of the Connecticut General Statutes, "Implementation of Regional Greenhouse Gas Initiative. Regional Greenhouse Gas account. Auctioning of allowances"[12]

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[8] Based on one-third of total SBC income between March 2012 and June 2013.

[9] The System Benefit Charge is a small charge added to the electric bills of Connecticut customers of Connecticut Investor Owned Utilities (IOUs), Connecticut Light and Power (a Northeast Utilities Company) and United Illuminating.

[10] CEFIA obtained permission from CT DEEP, on May 3, 2013, to allocate $3.7 million in auction proceeds to RSIP incentives.

[11] See http://www.rggi.org for more information about RGGI.

[12] http://www.cga.ct.gov/2012/sup/chap446c.htm#Sec22a-200c.htm

- Section 22a-174-31 of the Regulations of Connecticut State Agencies[13]

If the RSIP meets its internal goals, CEFIA will achieve more than 50 MW of residential solar, over a 10-year period, using less than half of the allowable incentives, while working toward achieving a payback period between five and seven years for residential customers.

CEFIA designed the level of incentives for each step based on a target capacity, associated dollar amount to be disbursed, and the final cost to the customer. The target capacity and incentive level for each incentive step are approved by the CEFIA board of directors (BOD) and the incentive level is also approved by the Commissioner of DEEP before it becomes official. Beginning in Step 2, CEFIA structured the target capacity as a “Race to the Rooftop,” in which a portion is allotted to EPBB projects and a portion to PBI projects, and the remaining portion is reserved to be allotted to the incentive structure that reaches its target capacity first. For this reason, the EPBB and PBI incentives do not always move from one step to the next on the same date.

Once approximately 50% of the target capacity for a particular step has been subscribed, CEFIA begins designing and planning for the next incentive step. Because CEFIA tracks and reviews RSIP costs on a regular basis, changes in cost (such as cost reductions) can be and are considered when determining an appropriate incentive level for the next step. During the planning phase, CEFIA also solicits input from solar PV installers, another source of information about current market conditions and trends.

Once CEFIA proposes and receives approval of the new incentive level(s) from the CEFIA BOD and DEEP, CEFIA announces the new incentive level(s) to installers. CEFIA sends an e-mail to all installers at least two weeks in advance of the effective date of the new incentive level(s) to provide information, including a deadline submission date for the current incentive level and the beginning date for the new incentive levels and capacity targets.

Along with seeking input from installers before the new incentive level is finalized, the official notification is preceded by earlier communications with installers to let them know what the anticipated, new incentive level(s) will be, so that installers are not surprised when the official announcement is released. Additionally, installers and other stakeholders can stay informed about developments around incentive levels by monitoring the Market Watch reports on the EnergizeCT website and the CEFIA Board of Director meeting minutes on the CEFIA website.[14] Because the PBI is disbursed over six years, funds will be allotted for the five years after all steps have been completely subscribed.

[13] http://www.ct.gov/deep/lib/deep/air/regulations/mainregs/22a-174-31.pdf

[14] The EnergizeCT website came online in January 2013 to consolidate information about Connecticut energy programs and resources in one place. As of January 2013, information on the RSIP, including the Market Watch Report, was available on both the CEFIA website and the EnergizeCT website. As of December 2013, most RSIP information on the CEFIA website has been removed; the CEFIA website now points to the EnergizeCT website for all RSIP information excepting a contractor portal on the CEFIA website. However, CEFIA-specific information, such as all CEFIA Board materials, still resides on the CEFIA website.

Evaluation Activities

During this evaluation, Cadmus used several methods to collect, analyze, and report relevant information about the RSIP.

Records Review

Cadmus conducted a thorough review of CEFIA RSIP records, including:

- Incentive application data and system characteristics data in PowerClerk
- Program marketing materials, such as e-mails and newsletters
- Program-related websites and online content
- Quality Assurance (QA) inspection reports
- Energy generation reports from LOCUS monitoring system.

Savings Analysis

In order to measure the amount of electricity generated by RSIP-funded PV systems, the program requires that all participants monitor and report electricity generation data through an automated data acquisition system (DAS). Each RSIP-funded PV system is required to include a revenue-grade meter from a program-approved Performance Data Provider (PDP) that can transmit data from the revenue-grade meter either directly to the LOCUS platform or through an Application-Programming Interface (API). CEFIA has an agreement with each contractor giving CEFIA access to all the generation data for the useful life of each PV system. Cadmus analyzed the generation records for eligible reporting PV systems and calculated weather-normalized energy generation compared with pre-installation estimates made using PowerClerk.

Customer Survey

Cadmus deployed an online survey to RSIP program participants to collect data on customer purchasing decisions, satisfaction, undocumented costs, financing decisions, and demographics.

PV Installer Survey

In addition to the customer survey, we deployed an online survey for RSIP-participating PV installers. The survey collected data on installer satisfaction with the RSIP, repair and maintenance activities, customer acquisition costs, and firmographics.

Cost-Effectiveness Analysis

Cadmus applied the Program Administrator Cost Test (PACT) to calculate the benefit/cost ratio of the RSIP. This ratio includes the benefits associated with energy generation and savings, as well as the costs of running the program.

Overview of RSIP Goals and Achievements

Statutory and CEFIA Organizational Goals

Table 3 outlines the statutory and CEFIA organizational goals for the RSIP in the short and long terms. In several instances, CEFIA's organizational goals are beyond what is mandated by the statute. Section 106 of Public Act 11-80 established several goals for the RSIP, and Cadmus measured the RSIP's substantial progress toward these goals, as shown in Table 4.

The RSIP has led to significant growth in the installation of residential solar PV. As of June 30, 2013, CEFIA has:

- Approved or paid incentives for a total installed capacity of 10 MW, which is estimated to generate over 11,900 MWh of electricity for Connecticut residents annually.
- Disbursed $8.4 million in incentive payments to 1,419 Connecticut homeowners to purchase PV systems, with funds originating from the following two sources:
    - $4.7 million from funds collected through the SBC, representing 13% of the $36 million of SBC funds collected by CEFIA during the 16-month period of this evaluation
    - $3.7 million from Regional Greenhouse Gas Emissions Initiative (RGGI) auction proceeds transferred to CEFIA by Connecticut's Department of Energy and Environmental Protection (DEEP).
- Provided transparent insight into the RSIP through a range of outreach avenues such as weekly Market Watch reports, installer training sessions, and regular e-mail communications to solar PV installers and other stakeholders.

The typical system supported by the RSIP is approximately 7 kilowatts (kW), at a cost of approximately $5.00 per watt, or $35,000. After all incentives, this translates to a $2.10 per watt out-of-pocket cost for customers, or $14,700. Most customers receiving an EPBB will recoup this investment in 11 to 13 years.

Table 3. Statutory and CEFIA Organizational Goals for RSIP

Metric	Statutory Goals	Internal Goal (Near Term)	Internal Goal (Long Term)
Installed Capacity	30 MW by end of 2022		50 MW by 2022
Customer Payback	"Reasonable"	Nine years	Five to seven years by 2022
RSIP Procurement	Less than one-third of SBC intake (~$100 M)		50% of statutory procurement target (~$50 M)
Cost Reduction		20%, $4.00/watt Standard Testing Conditions	20-40%
Incentives Leveraged			4:1 leverage ratio
Customer Acquisitions			7,500 customers
Model Communities			Demonstrate communities with 5% residential solar PV system penetration
Energy-Efficiency Participation		Demonstrate cost-effectiveness	
Workforce Development	Identify barriers and support training		Increase the trained solar workforce in Connecticut
Public Awareness			Increase awareness of solar PV systems
Accessibility			Demonstrate that solar PV systems are accessible to all income levels

Progress Toward Goals

The RSIP has led to significant growth in the installation of residential solar PV. As of June 30, 2013, CEFIA has:

- Approved or paid incentives for a total installed capacity of 10 MW, which is estimated to generate more than 11,900 MWh of electricity for Connecticut residents annually.
- Disbursed $8.4 million in incentive payments to 1,419 Connecticut homeowners to purchase PV systems, with funds originating from the following two sources:
    - $4.7 million from funds collected through the SBC, representing 13%[15] of the $36 million of SBC funds collected by CEFIA during the 16-month period of this evaluation

[15] This 13% is less than the statutory one-third expenditure limit for SBC funds applied to RSIP, per PA 11-80. If RGGI funds had not been available, as described below, and all of the incentives had been funded by the SBC, the $8.4 million would have represented 23% of the SBC funds.

    - $3.7 million from Regional Greenhouse Gas Emissions Initiative (RGGI) auction proceeds transferred to CEFIA by Connecticut's Department of Energy and Environmental Protection (DEEP)[16]
- Provided transparent insight into the RSIP through a range of outreach avenues such as weekly Market Watch reports, installer training sessions, and regular e-mail communications to solar PV installers and other stakeholders.

The typical system supported by the RSIP is approximately 7 kilowatts (kW), at a cost of approximately $5.00 per watt, or $35,000[17]. After all incentives, this translates to a $2.10 per watt out-of-pocket cost for customers, or $14,700. Most customers receiving an EPBB incentive will recoup this investment in 11 to 13 years.

Table 4. RSIP Progress Toward Statutory Goals

RSIP Statutory Goal	Progress Achieved Through June 30, 2013
Fund installation of 30 MW by 2022	10 MW in completed, in progress or approved projects in the first 16 months
Achieve reasonable customer payback periods	Expected simple payback of 11-13 years for EPBB
Use one-third or less of collected SBC revenues	$36 million in SBC funds collected and $8.4 million in RSIP incentives disbursed[18], of which $4.7 million originated from SBC, representing 13% of SBC funds devoted to RSIP incentives for the study period[19]
Identify barriers and support training for workforce development	Responsibility for workforce development has shifted to the Connecticut Energy Workforce Development Consortium (CTEWDC) but CEFIA is continuing two initiatives, E-Houses and support of community college programs, both begun by CCEF

CEFIA is currently on track to meet or exceed the statutory goals of the RSIP.

Incentives and Installed Capacity

CEFIA uses PowerClerk to process applications for incentives and as the primary repository for program data. Cadmus accessed PowerClerk for a variety of the data used in this report, including for calculating the installed capacity from EPBB- and PBI-funded projects. In addition, CEFIA provided accounting data on incentives paid during the study period. Table 5 summarizes the total nameplate capacity supported by the RSIP during the study period. This total includes completed projects, projects approved for incentives by CEFIA, and projects in progress. The incentive amounts shown in Table 5 reflect actual

[16] See Section 3.2.7 of this report. RGGI is a regional market-driven program to reduce greenhouse gas emissions.
[17] This is an approximate value that varies considerably based on incentive step level, refer to Program Participant Economics section of report for more detailed discussion of costs and simple payback.
[18] Disbursal of incentives is presented here on a cash, versus accrual, accounting basis.
[19] The other $3.7 million of the $8.4 million in RSIP incentives was provided from RGGI funds, as explained in Section 3.2.7. If RGGI funds had not been available, and all of the incentives had been funded by the SBC, the $8.4 million would have represented 23% of the SBC funds.

incentive payments made by CEFIA during the March 1, 2012 through June 30, 2013 study period. This includes full incentive payments for completed projects, as well as milestone payments, either 60% or 70% of the incentive total,[20] made for projects that have delivered equipment to the site (though installation, interconnection, or other tasks may still be in process). The incentives paid also do not reflect future PBI payments, which will be made over time. As a result, Table 5 reflects payments made during the study period but not necessarily the full cost of incentives provided to the 1,419 projects, totaling 10MW, completed or approved within the study period.

Table 5. Summary of Total RSIP Installed Capacity and Incentive Payments

Source	Number of Projects	Nameplate Capacity (kW)	Incentive Paid
EPBB	999	7,047	$8,345,696
PBI	420	2,938	$96,628
Total	**1,419**	**9,985**	**$8,442,324**

The total installed nameplate capacity approved or completed as of June 30, 2013, is 9,985 kW. This puts CEFIA at nearly one-third of the goal of 30MW by the end of 2022, in the first 16 months of the program. If the trend continues, we expect that CEFIA will meet or exceed this goal well in advance of the statutory target date. In addition to being on target to meet or exceed this installed capacity goal, RSIP projects included in this study period are expected to generate approximately 11,900 MWh annually.

Use of System Benefit Charge Funds

According to CEFIA's accounting records, from March 2012 through June 2013, CEFIA collected $36,064,171 in system benefit charges (SBCs). During the same period, CEFIA paid $8,442,324 in incentives for completed and approved projects. Of this $8.4 million, $4.7 million of RSIP incentives were provided from SBC funds. Based on this, CEFIA used 13% of the SBC income to fund RSIP incentives during the study period covered by this evaluation, meeting its goal to spend less than one-third of the SBC income on RSIP incentives. As noted in section 1.1, the other $3.7 million of RSIP incentives were provided from RGGI funds.[21]

Market Penetration

After analyzing customer data from PowerClerk, the data showed that RSIP participants are dispersed proportionately through the state. Based on the number of completed RSIP projects and the number of

[20] In Steps 1 and 2 of the incentive, a 60% milestone payment was provided upon equipment delivery. This was changed to 70% beginning in Step 3.

[21] CEFIA received $5,999,374 in RGGI allowance proceeds from March 14, 2012 through June 30, 2013. As of May 3, 2013, CEFIA obtained permission from DEEP to allocate $3,734,253 of RGGI allowance proceeds to incentives for residential solar PV projects provided through RSIP. If RGGI funds had not been available, as described below, and all of the incentives had been funded by the SBC, the $8.4 million would have represented 23% of the SBC funds.

households[22] by town, 55% of communities have a penetration rate between 0.10% and 1.00% through the RSIP program. Only nine communities have no solar PV systems installed through the RSIP.[23] Overall, Durham, Connecticut had the highest penetration rate and the most systems installed through the RSIP, at approximately 5% penetration and 126 installations. Table 6 displays the communities with the highest RSIP penetration rates and greatest number of systems installed under the RSIP during the evaluation period. Durham, Fairfield, Mansfield, Westport, and Portland were all part of the Solarize CT program. A majority of the installations in those communities captured in this study period (March 1, 2012 through June 30, 2013) were driven by participation in that program.

Table 6. RSIP Community Level Penetration

Penetration Rate by Town		Installations by Town	
Town	**Penetration Rate**	**Town**	**Number of Installations**
Durham	4.99%	Durham	126
Portland	1.32%	Fairfield	89
Mansfield	0.71%	Westport	58
Canaan	0.67%	Portland	48
Cornwall	0.65%	Mansfield	43

Transparency

Transparency and reporting is specifically identified as a priority in the RSIP Program Plan. CEFIA achieves this transparency in several ways: regular website updates on the market status, providing installer trainings on how to use the RSIP and associated tools and resources, notifying stakeholders of any program changes as soon as possible, and making resources and information about RSIP available to stakeholders through several avenues.

Information Available on the CEFIA Website

The CEFIA website (http://www.ctcleanenergy.com) directs visitors to the www.EnergizeCT.com website to learn more about the RSIP.[24] EnergizeCT provides an overview of the program and its goals, high-level

[22] Number of households by town was obtained from U.S. Census Community Survey data. Data collection period: 2007-2011. Data was obtained via e-mail from CERC on October 23, 2013.

[23] Nine municipalities without an installation through the RSIP at the time of this study period include Bozrah, Bridgewater, Goshen, Morris, Norwich, Seymour, Sterling, Voluntown, and Wallingford.

[24] The EnergizeCT website came online in January 2013 to consolidate information about Connecticut energy programs and resources in one place. As of January 2013, information on the RSIP, including the Market Watch Report, was available on both the CEFIA website as well as on the EnergizeCT website. As of December 2013, most RSIP information on the CEFIA website has been removed; the CEFIA website now points to the EnergizeCT website for all RSIP information excepting a contractor portal on the CEFIA website. However, CEFIA-specific information, such as all CEFIA Board materials, still resides on the CEFIA website.

steps for homeowners who are interested in participating, and an overview of incentives for different project configurations (third-party-owned versus homeowner-owned system). The program page also describes the basic specifications for sites that are eligible to participate, such as orientation, roof tilt, shading, and more. Lastly, the program page describes several financing options, including CEFIA's CT Solar Lease, CT Solar Loan, and the Smart-E Loan. Links are provided for each financing product and program.

The *Incentives* page of the EnergizeCT website includes a spreadsheet of all the residential PV projects participating in the program. According to the website, it is updated monthly. This information is publicly available, easy to locate, and easily digestible for the various stakeholders using this data to inform decision making.

The EnergizeCT website also provides a weekly RSIP Market Watch Report, which gives an overview of residential PV installations over varying timeframes and progress toward regulatory and organizational goals, such as total installed residential capacity. The Market Watch Report also includes tables of aggregate data about the total number of incentive applications received, costs of incentives, and various cost and production averages. One table includes these metrics for the current incentive step, and another table shows the combined historical program data. Lastly, the report provides estimates of the program's impact on the environment, job creation, and workforce development.

The EnergizeCT website provides information that is accessible to homeowners who are new to the subject matter and are interested in installing a solar PV system. The RSIP web pages outline high-level steps for the process, which include first having an energy-efficiency audit performed, then selecting an eligible contractor, and finally having the PV system installed. The site notes that the RSIP incentives pass through the installer. The RSIP web pages provide a link to the list of eligible contractors, with the contact information and utility area served for each installer. Homeowners could use this information to find a local installer or perform background research on potential installers, or they could use a spreadsheet of residential solar PV installations in Connecticut (provided on the website along with the Market Watch Report) to determine which installers are the most experienced in the state, or which has the lowest installation costs.

The CEFIA website houses a contractor portal, where RSIP forms and information are available through a login interface. Additionally, this page gives contractors a brief overview of the EPBB and PBI, the application to become an eligible contractor, and links to available financing options, including CEFIA's CT Solar Loan, Smart-E Loan, CT Solar Lease.

The EnergizeCT website provides numerous resources for installers to learn about the RSIP and how it functions. The spreadsheet of individual installations shows which areas in the state are developing most quickly, as well as which installers are installing projects and at what cost.

Data Available for Stakeholder Decision Making

The publicly available spreadsheet includes individual project-level information, detailing whether the project received the EPBB or PBI, the date the incentive was applied for, and the date the project was completed, in addition to listing the interconnecting utility, facility location, installer, system financing, system size, system costs, installation cost per watt, estimated annual production, and total amount of incentive approved. As of a given week, a stakeholder could view and analyze data on all the installed capacity under the EPBB and PBI, find the highest volume installers in their area, and estimate the cost of installing a PV system based on the cost of other PV systems in the area.

Clarity of Incentive-Level Information

The EnergizeCT website provides basic information about the EPBB and PBI incentives. The website is missing information regarding the full calculation of incentives for the EPBB and PBI, previous incentive levels (it shows only the current incentive levels), and how incentive levels are determined. The RSIP incentives page and installer training materials outline a simplified version of the EPBB incentive calculation, which omits inverter efficiency and system design factors. It is unclear whether installers and homeowners know exactly what their rebate would be until after their PV system information is entered in PowerClerk. Information on recommended and approved incentive levels for each step is documented in the meeting minutes of CEFIA's Board of Directors and posted on the CEFIA website, though there was not a complete summary of historical incentive levels available online until Cadmus completed an earlier RSIP Progress Report, which was posted on the CEFIA website with CEFIA board meeting materials for January 17, 2014.[25]

Stakeholder Communication

This section summarizes CEFIA's communication strategy for several relevant stakeholder groups.

Connecticut Residents

While CEFIA provides ample program resources to all stakeholders through the various avenues discussed above, CEFIA has historically relied mostly upon the more customer-facing installer community to deliver the program to consumers. CEFIA communicates news or announcements about the program to its group of registered eligible contractors primarily via e-mail, and then relies on those parties to inform interested residential customers of program changes or updates. CEFIA does promote solar PV through earned media stories, to generate interest in the technology.

Installers

CEFIA has communicated clearly and regularly with installers, contractors, and third-party system owners starting prior to the launch of RSIP. From January 2012 through June 2013, CEFIA sent 36 e-mail blasts to its registered eligible contractors, providing updates on incentive levels and dates that incentive changes can be expected, changes in the requirements for eligible contractors, how to request

[25] http://ctcleanenergy.com/AboutCEFIA/CEFIABoardMeetings/tabid/604/Default.aspx, 1/17/14 meeting, or http://ctcleanenergy.com/Portals/0/board-materials/CEFIA_RSIP_Evaluation_Progress_Report_Finalv5.pdf

incentive payments, how to use PowerClerk, and more. The correspondence is clear and thorough and, in addition to a wealth of resources CEFIA distributes through e-mail, it also encourages contractors to reach out to CEFIA staff with questions about the RSIP. In addition to receiving updates via e-mail, installers can monitor the Market Watch Reports and Board of Directors meeting minutes from the CEFIA website to track when these changes in incentive levels may be happening.

Each new eligible contractor participates in a one-hour training to become familiar with the RSIP. The training covers the two incentive structures, and walks through PowerClerk and the necessary application paperwork, as well as the various financial tools available to eligible contractors, such as the CT Solar Lease, CT Solar Loan, and Smart-E Loan programs.

List of Program Collateral

CEFIA has provided the following program collateral:

- Sent 36 e-mail blasts pertaining to RSIP to installers from January 2012 through June 2013
- Provided one-hour trainings for all new eligible contractors
- Held periodic check-ins and updates for eligible contractors
- Provided weekly Market Watch Report
- Provided CEFIA Board of Directors meeting minutes and meeting materials
- Provided periodic press releases.

Review of CEFIA Installation Quality Assurance Program

Description

CEFIA conducts post-installation, third-party field inspections throughout the state. Using a team of qualified contracted professionals from the solar PV industry and the municipal inspector community, CEFIA inspects approximately 70% of RSIP-funded PV systems. CEFIA spot inspects the remaining 30% of projects completed by installers who are permitted to self-inspect some of their installations. For these 30% that are spot-inspected, CEFIA reviews field verification forms submitted by the contractor to verify the site details against what is in the application, and any workmanship aspects that photo documentation can demonstrate. The privilege to self-inspect can be revoked at any time.

CEFIA's third-party inspections are conducted shortly after the installation is complete and include:

- Verification of equipment and quantity installed
- Verification of claimed design factor, including shading, tilt, and azimuth
- Compliance with NEC and installation best practices, including required labeling and grounding
- Safety issues that may have been overlooked at a municipal or utility inspection, such as loose array conductors, open conduit ends, or overhanging panels
- Verification that system performance monitoring is operational
- System performance assessment of actual production versus anticipated production
- Assessment of any potential warranty issues such as inadequate wind load conditions, unauthorized apparatuses (such as squirrel guards) being fastened to panels, or improper placement of inverters (e.g., at an unshaded south-facing exterior wall or with inadequate horizontal or vertical clearance)
- Verification of proper racking and fastening material, where site access permits
- Assessment of any structural shading, such as chimneys or roof peaks above an array.

After completing an inspection, the inspector submits a written report to the contractor and CEFIA. For minor inspection deficiencies, CEFIA will work directly with the contractor to resolve any matters via corrective photo documentation. For more significant issues, CEFIA requires that the contractor work directly with the inspector via correspondence. In rare cases, CEFIA may request a re-inspection. Installers are not paid outstanding incentive payments without a passing inspection. Where there is a discrepancy between application parameters and field conditions (e.g., fewer panels, more shading), CEFIA will reduce the incentive accordingly. In the case of a PBI, CEFIA may notify the third-party owner that production could be less than anticipated.

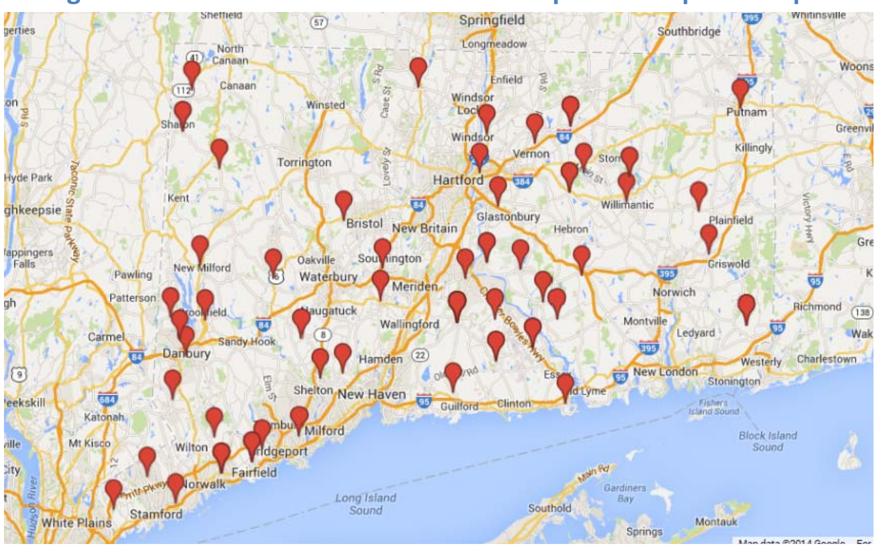
Methodology

We examined a sample of 70 inspection reports to analyze trends in inspection results and to verify PowerClerk data on equipment and system characteristics. These reports were selected at random from the population of RSIP projects approved or completed during the study period (n=1,419 projects) and we requested copies of the relevant inspection reports from CEFIA. We analyzed the inspection results to answer several key questions:

- What types of inspection failures were most common?
- Does PowerClerk reflect accurate design factors for the inspected projects?
- Does PowerClerk accurately reflect installed capacity and equipment?
- What are the most common PV module and inverter manufacturers providing equipment for RSIP-funded projects?

Figure 1 is a map of Connecticut with the locations of the sites in the sample marked by red symbols. For each inspection report, Cadmus assigned a PV technical expert to review the findings and summarize the results in a spreadsheet format for analysis.

Figure 1. Locations of Sites Included in Inspection Report Sample



Findings

- **RSIP resulted in more installed capacity than indicated in PowerClerk.** We obtained the relevant inspection reports from CEFIA and compared the field-evaluated system capacities against the PowerClerk records for those same systems. We found that field-verified system capacity was 3% higher than capacity values indicated in PowerClerk. Put simply, RSIP systems have resulted in more installed capacity than previously indicated in the program tracking database.

  Though a finding of higher-than-expected installed capacity is a generally positive result, this finding also includes room for improvement in two areas. First, only 40 of the 70 (57%) inspection reports contained enough information to determine the installed nameplate capacity. During CEFIA inspections, inspectors are not required to access rooftops, where residential PV arrays are most commonly located, so equipment verification relied on what the

inspector could observe from ground level in most cases. This is due to inspection program budget constraints in addition to safety concerns involved with inspectors gaining roof access. Furthermore, during this evaluation period, some inspectors had a different format or checklist for reports (though all reports had elements in common), which makes comparison between inspection reports challenging. In December 2013, this problem was rectified at an inspectors' meeting: the checklist was standardized. According to CEFIA, all inspectors currently use the same version of the inspection report template. On the reports themselves, it was sometimes not clear whether a missing field indicated that the inspector did not look for that item, if the item had been checked and required no remedial action, or if that field did not apply to the installation being inspected.

The second area for improvement that this finding underscores is that inspection findings are not necessarily resulting in changes to the PowerClerk database. If inspectors find deviations in equipment or capacity during inspections, PowerClerk could potentially be updated to reflect these verified conditions and, as a result, provide CEFIA with more accurate information for program tracking and reporting purposes. CEFIA does update PowerClerk in the event of inspection findings that reduce the incentive amount (e.g., fewer panels, more shading), but not in the event of findings that would increase (or leave unchanged) the incentive, in accordance with RSIP rules.

- **Inspections identified a mix of minor and serious installation issues.** The inspection reports for the sample showed that nearly half of projects had inspection failures, but that most failures were due to relatively minor issues such as missing or incomplete system labeling or documentation as shown in Figure 2. Nevertheless, 11% of inspections reviewed resulted in multiple failures. Some failures, such as improperly sized overcurrent protection devices and inadequate grounding (included in the "Other Observations" category in Figure 2), can present safety or operational concerns that should be addressed during the post-inspection process.

Figure 2. Frequency of RSIP QA Inspection Findings by Category

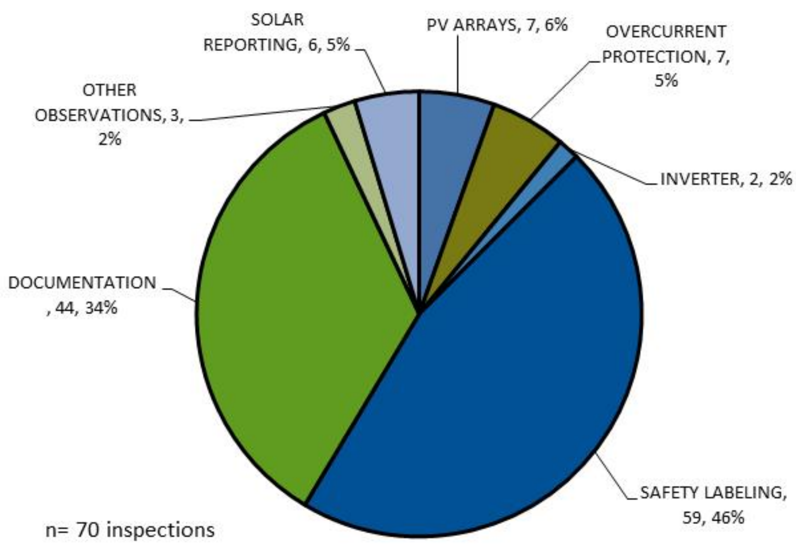


Table 7. Frequency of RSIP QA Inspection Findings by Category

Area	Failures Noted	Examples
PV Array	7	Unprotected/unsupported cables
Overcurrent Protection	7	DC voltage/current marking
Inverter	2	Appropriate overcurrent protection device
Safety Labelling	59	Warning labels, date of installation
Documentation	44	"As-built" diagrams, homeowner's manuals
Other Observations	3	Missing grounding electrode conductor, improper grounding
Solar Reporting	6	Customer unable to access data

- **Equipment and design factor information in PowerClerk was generally accurate.** The equipment identified in the inspection reports matches PowerClerk in most cases. Of the 41 inspection reports that contained module verification information, three had manufacturers that differed from the information in PowerClerk, and one had the same manufacturer but a different model module. Of those reports with sufficient data, 90% of systems had the correct PV module indicated in PowerClerk. More than 40% of inspections did not provide sufficient data to confirm that the PV module indicated in PowerClerk was actually installed. Based on discussions with CEFIA, this is likely because inspectors, for safety and budgetary reasons, are not required to access customer roofs.

  Of the 61 inspection reports that reported inverter manufacturer/model information, seven had manufacturers that differed from what was in PowerClerk and two had the same manufacturer

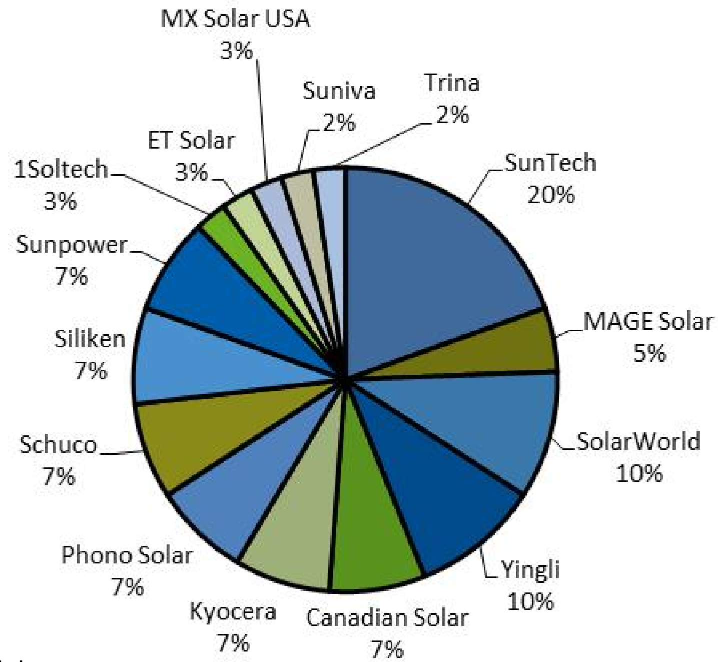
but a different model inverter. Therefore, 85% of installations with valid equipment verification data included in the inspection report had accurate inverter manufacturer and model information in PowerClerk. Though inspectors were more consistent in reporting inverter manufacturer and model information than with PV modules, 15% of inspection reports examined did not provide enough information to determine whether the inverter installed matched PowerClerk records.

Thirty-three of the 70 inspection reports reported raw shading results (i.e., obstruction angles by direction) but none of the reports examined included a calculation of design factor or commentary regarding the accuracy of program records. The design factors would later be updated by CEFIA staff in PowerClerk based on the inspectors' findings, but only in instances where the rebate would be reduced.

- **RSIP-funded installations use a wide variety of PV modules and inverters.** The PV module manufacturers varied, but SunTech (China), Solar World (U.S.) and Yingli (China) led the others as shown in Figure 3. Of systems surveyed, 47% installed panels manufactured by China-based companies (SunTech, Yingli, Phono Solar, ET Solar, and Trina), and 25% of systems used panels from U.S.-based manufacturers (Solar World, SunPower, 1SolTech, MX Solar USA, Suniva). Recent and ongoing trade negotiations between the U.S. and Chinese governments are likely to increase the price of Chinese modules by 14%, on average[26]. As a weighted average, this will have only a small impact on program-wide cost-effectiveness, though it may change the cost/benefit analysis that installers use when specifying modules.

[26] Source: GreenTech Media article, 'New Tariffs on Chinese Solar Modules will Raise US Price by 14%", accessed 9/29/2014 at: http://www.greentechmedia.com/articles/read/New-Tariffs-on-Chinese-Solar-Modules-Will-Raise-US-Price-by-14

Figure 3. Frequency of PV Module Manufacturers

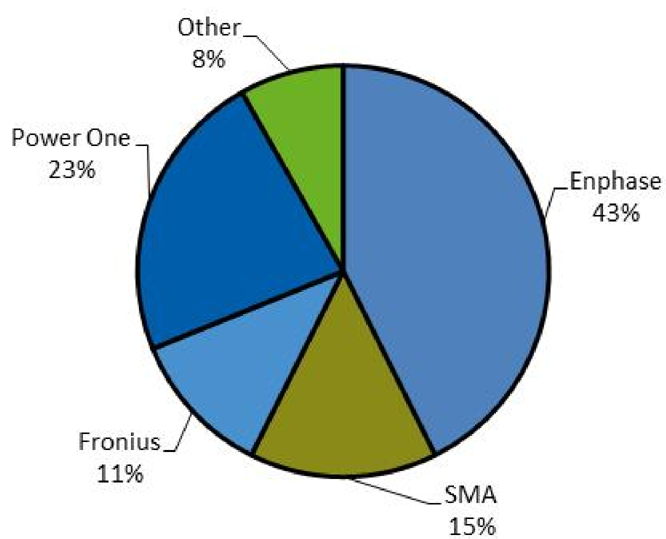


n= 70

29 reports: module manufacturer not recorded

As with the modules, the manufacturers of the inverters varied, but with less diversity. Figure 4 shows that Enphase, installed in 43% of inspected projects, is by far the single most popular inverter used in the sample, and indicates a high penetration of micro-inverters being used in the residential market.

Figure 4. Frequency of Inverter Manufacturers Represented in Inspection Reports



n= 70

9 reports: inverter manufacturer not included

Conclusions and Recommendations

Standardize QA Inspection Process

Although CEFIA inspects approximately 70% of all RSIP-funded PV systems, CEFIA has several opportunities to improve the effectiveness of the QA process. Specific recommendations are outlined below.

- **Require inspectors to access roof-mounted PV arrays.** Though a ground-level inspection can be completed more quickly, the PV array represents a substantial portion of the system, and a close visual or hands-on inspection is necessary to ensure safety and longevity, and to verify installed capacity, which is directly tied to a statutory goal of the RSIP. Though not every roof will be accessible due to weather or other safety-related concerns, many of the issues commonly found on rooftop arrays will not be readily apparent from a ground-level inspection or in the first few months of operation. Common issues such as missing or inadequate flashing, improperly supported array conductors, and PV modules improperly secured to racking can all substantially impact safety and system economics. We recommend that CEFIA consider broadening the scope of the current inspection process to include the full breadth of the PV system. Due to inspection program budget constraints and the safety concerns involved with inspectors gaining roof access, this may not be feasible for the RSIP.
- **Ensure that inspection results are used to update PowerClerk.** As CEFIA uses PowerClerk extensively for program tracking and reporting, we recommend that inspection results, where applicable, be used to update PowerClerk information, such as equipment manufacturer, model number, system capacity, and design factor. In incentive programs in other states, this is usually handled by a change order process, completed retroactively after the inspection results are submitted, so that the installer must update the values and/or upload relevant revised customer agreements reflecting any equipment or design changes. For the RSIP program, change orders are generally submitted by contractors before the inspection process, but this may not be happening in all cases. PowerClerk is only updated with inspection findings that result in a rebate reduction. In cases where a rebate could potentially increase, CEFIA would not update PowerClerk figures, as it is a rule of RSIP that rebates cannot increase as result of inspection.

RSIP Energy Generation

Description

To measure the amount of electricity generated by RSIP-funded PV systems, the program requires that all participants monitor and report electricity generation data through an automated data acquisition system (DAS). Each RSIP-funded PV system is required to include a revenue-grade meter from a program-approved Performance Data Provider (PDP) that can transmit data either directly to the LOCUS platform or through an Application-Programming Interface (API). CEFIA has an agreement with each contractor giving CEFIA access to all the generation data for the useful life of each PV system. The LOCUS platform is formally called the LOCUS SolarOS™ online portal.[27] This portal allows CEFIA staff to monitor the performance of RSIP-funded PV systems across Connecticut and supports a variety of analytical and reporting features. Performance data are also available to contractors and customers.

Methodology

CEFIA provided Cadmus with project-level electricity generation data from the LOCUS system. We received monthly total generation values, by system, from February 2012 through November 2013.[28]

Cadmus reviewed these data to:

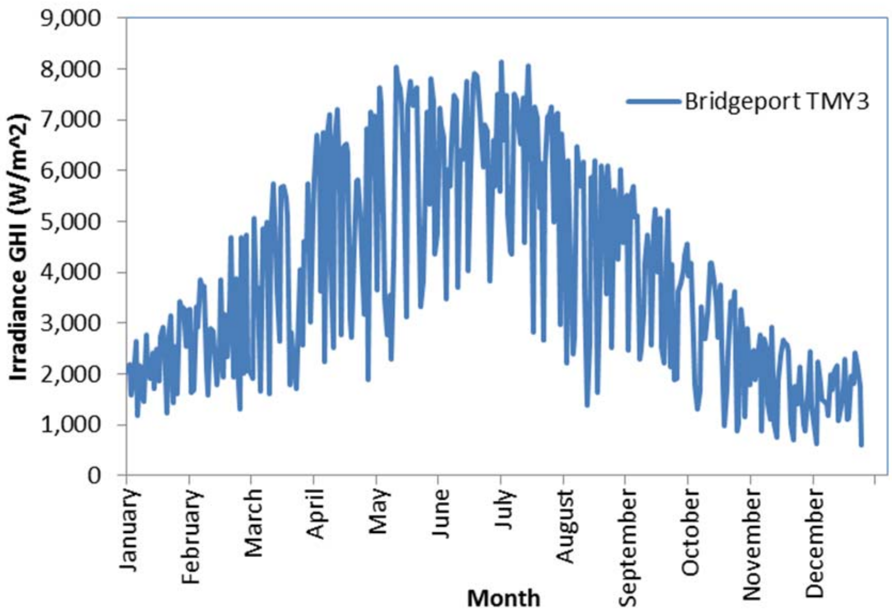
- Remove suspect data points, such as sites with missing months or non-positive generation values
- Select a sample of projects with at least six months of operational data
- Remove data that conflicted with PowerClerk such as nameplate capacity
- Eliminate non-fixed PV arrays.

Using the data from the sample sites, we normalized the LOCUS data to historical solar irradiance data from regional weather stations. We calculated the normalized production and applied the calibrated model results to typical meteorological year (TMY3)[29] data to calculate an evaluated gross energy savings for the sample and, using a realization rate, for the program as a whole. A realization rate greater than one indicates more energy savings than originally estimated by PowerClerk and, as a result, a shorter payback period.

[27] For more information on LOCUS, access www.locusenergy.com
[28] Note that Cadmus did not conduct field metering or verification activities. This analysis is based solely on the data provided and does not include an assessment of the accuracy of the provided data, beyond the data cleaning and quality control described in this report.
[29] http://rredc.nrel.gov/solar/old_data/nsrdb/1991-2005/tmy3/ TMY3 are based on more recent and accurate data and are thus used in place of earlier TMY data versions.

The solar resource varies over time due to clouds, long-term weather patterns, solar activity, and other factors, as shown in Figure 5. To study the weather-normalized electricity generation, we must obtain measurements of the weather during the period of metering.

Figure 5. Graph of Daily Average Irradiance at Bridgeport TMY3 Data Station



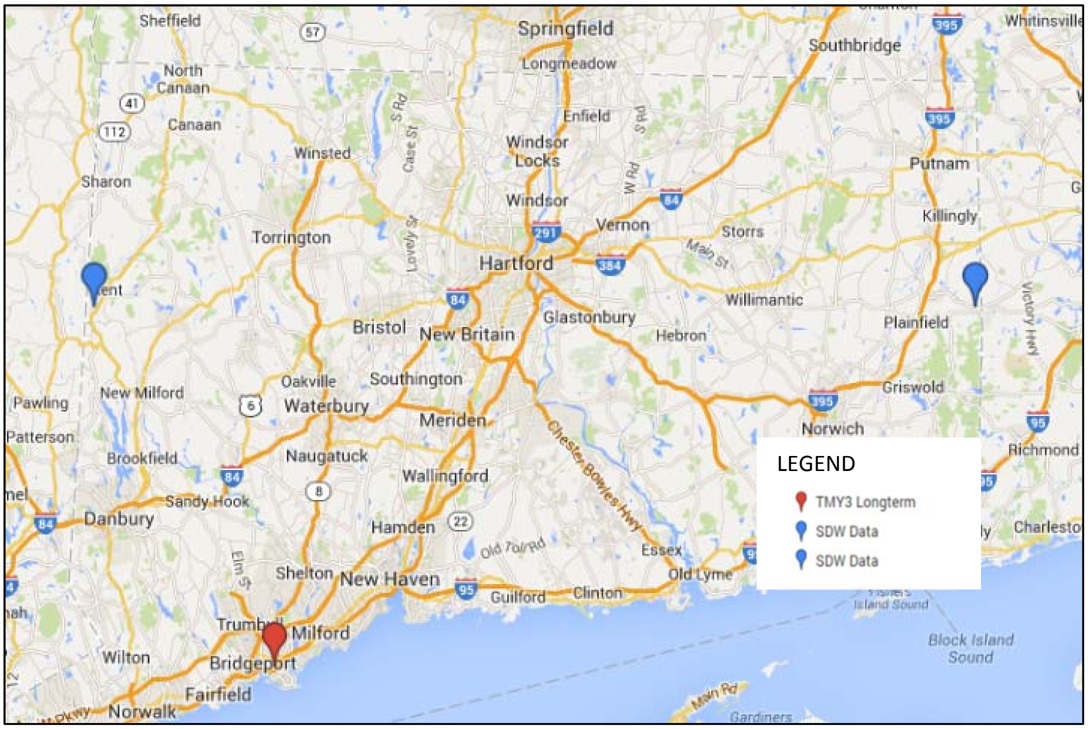
To calibrate each site's PV generation to actual weather data, Cadmus acquired total horizontal solar radiation data. We used measured global horizontal irradiance (GHI)[30] data from two applicable weather stations, purchased from the Solar Data Warehouse (SDW)[31]. We then compared this historical GHI data to long-term GHI data obtained from TMY3 data files.

Cadmus used TMY3 weather files from the National Solar Radiation Database (NSRDB[32]). These files contain compiled long-term average weather conditions for numerous sites around the country and are widely used in building and renewable energy system modeling. Most importantly, TMY data is regularly applied to predict PV system energy output, used in tools such as PVWatts, or in commonly available shading assessment tools. Cadmus used the metered data and PowerClerk PV system data as inputs to the National Renewable Energy Laboratory's (NREL's) System Advisor Model (SAM)[33]. SAM was developed by NREL; it provides a variety of economic and performance calculations for solar PV, small wind, and other renewable-energy technologies. Cadmus imported the local TMY3 data into the SAM

[30] Global Horizontal Irradiance is the total of all diffuse and direct irradiance on a horizontal plane
[31] Solar Data Warehouse: http://www.solardatawarehouse.com/
[32] Information about the TMY3 weather file format and the NSRDB can be accessed at: http://rredc.nrel.gov/solar/old_data/nsrdb/1991-2005/tmy3/
[33] Accessible online at: https://sam.nrel.gov/.

model, and combined with system characteristics such as tilt, orientation, and shading, SAM generated an 8,760-hour annual profile of generation. Figure 6 indicates the location of the weather data stations used in the analysis. The red marker indicates the TMY3 long-term data station location at Bridgeport, and the blue markers show the SDW data locations at the western and eastern ends of Connecticut.

Figure 6. Locations of Weather Stations Used for Energy Generation Analysis



Using the relevant weather station data, we completed the following steps for each site:

- Developed a scripted model, using SAM, to predict the annual electricity production (AEP) for each site in the sample, based on site specific tilt, orientation, and shading inputs from program data.
- Calculated the total global horizontal irradiance (GHI) over each PV system's operational period.
- Compared the actual GHI over the operating period to the TMY3 GHI over the same period, which resulted in a solar resource ratio that indicated how the solar resource during the PV system's operation compares with the long-term average solar resource used in initial performance predictions.
- Applied the solar resource ratio to Cadmus' predicted energy generation, resulting in a weather-adjusted prediction of how much electricity the PV system should generate over its operational period.

- Adjusted the modeled energy output by normalizing to the meter reading value, creating a modeling adjustment factor to account for real-world effects not included in the SAM analysis, as shown in Equation 0-1.

This process essentially uses the measured production to calibrate a theoretical model that is comparable to the TMY-based pre-installation estimates.

We used the weather and modeling factor (R_{model})-adjusted AEP estimates to obtain the evaluated *ex post* AEP for the site, provided by Equation 0-2.

Equation 0-1. Calculation of Modeling and Weather Bias in SAM Predictions

$$R_{model} = \frac{E_{actual}}{PEP_{SAM}\left(\frac{I_{act}}{I_{TMY3}}\right)}$$

Where:

E_{actual}	=	Cumulative electricity production meter reading, taken during on-site visit at least nine months after system commissioning date
PEP_{SAM}	=	Period Electricity Production, determined using SAM
I_{act}	=	Total global horizontal radiation (W/m^2) for the period beginning on the PV system commissioning date and ending on the date of the meter reading for E_{actual}
I_{TMY3}	=	Total global horizontal radiation (W/m^2) taken from the relevant TMY3 data file, covering the same period as I_{act}

Equation 0-2, Gross Generation Determination

$$\boldsymbol{AEP_{ex\ post} = AEP_{SAM} * R_{model}}$$

Where:

AEP_{SAM}	=	Predicted annual electricity production as calculated using SAM
R_{model}	=	Adjustment factor accounting for weather and performance variability between observed system performance and model predictions

Calculating Program Energy Generation and Capacity Factor

Based on the application of a statistical sample, Cadmus used the *ex ante* and *ex post* energy generation from each site to calculate a realization rate for the sample. This realization rate is simply the ratio between the *ex post* and *ex ante* energy generation for the sample, as shown in

Equation **0-3**.

Equation 0-3. Realization Rate

$$RR = \frac{Sample\ ex\ post\ energy\ generation\ (kWh)}{Sample\ ex\ ante\ energy\ generation\ (kWh)}$$

Once this is calculated, the realization rate can be applied to the *ex ante* energy generation for the whole population to estimate total program energy generation.

We also calculated the capacity factor for the population. The capacity factor is a measure of system energy output, as compared to a theoretical system that can produce electricity at full nameplate capacity for every hour of the year, as described in Equation 0-4.

Equation 0-4. Calculation of Capacity Factor

$$CF = \frac{AEP_{ex\ post}}{kW * 8{,}760 \frac{hrs}{yr}}$$

Where:

$AEP_{ex\ post}$ = Estimated annual electricity generation in kilowatt hours (kWh)

kW = Nameplate DC capacity of the PV system in kilowatts (kW)

Findings

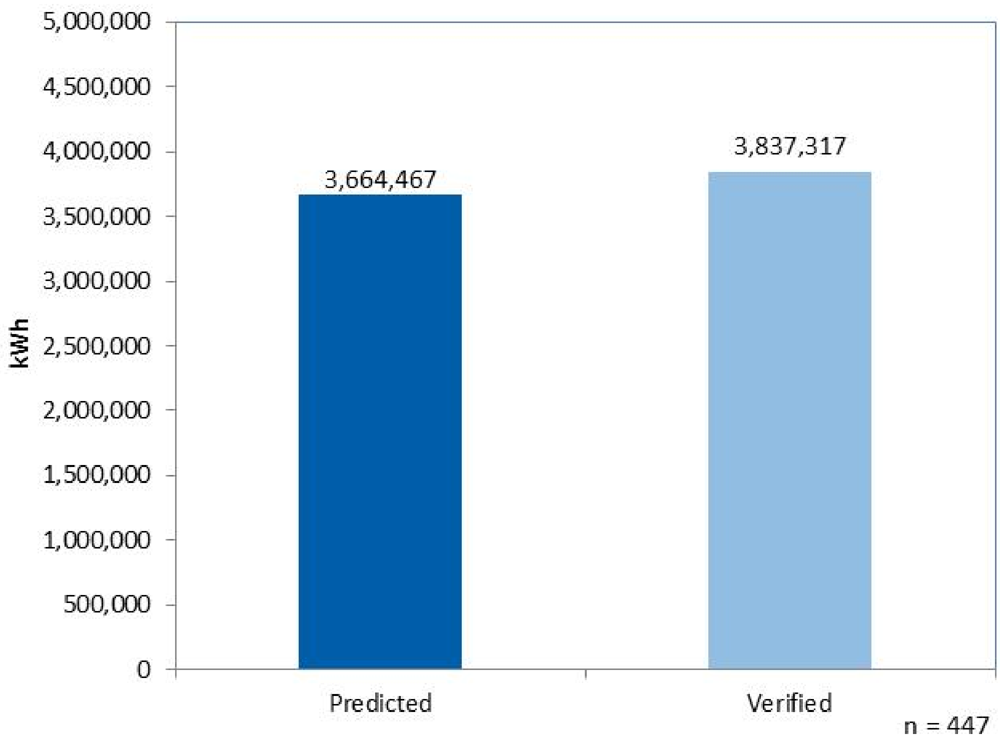
Solar PV Results

This study has produced several key findings, including:

- The evaluated gross sample is generating electricity with a capacity factor of 13.8%.
- Evaluated PV systems are generating more electricity than originally estimated by PowerClerk, with a realization rate of 105% compared with pre-installation AEP estimates.
- Actual production numbers are based on Locus monitoring data representing 3179kW installed capacity, or 447 projects, with data normalized for irradiance based on a TMY3 (typical meteorological year)
- Irradiance over 639 day period (March 1, 2012 – November 30, 2013), 99.7% typical, based on Bridgeport TMY3 data and average of two Solar Data Warehouse weather stations

Figure 7 shows the actual generation compared with the PowerClerk estimated generation rates. The *Verified* bar is the total of the weather normalized *ex post* estimates.

Figure 7. Typical Year RSIP Energy Generation for Data Sample



Conclusions and Recommendations

The LOCUS meter readings present a potentially valuable source of information for tracking program performance, reporting program benefits, and evaluating cost-effectiveness. As noted in this section, actual generation appears to exceed PowerClerk estimates. Despite this, the PowerClerk method of estimating AEP produces reasonably accurate, albeit conservative, estimates of electricity generation. We do not recommend changing these methods based on the findings of this report.

Customer Feedback

Survey Methodology

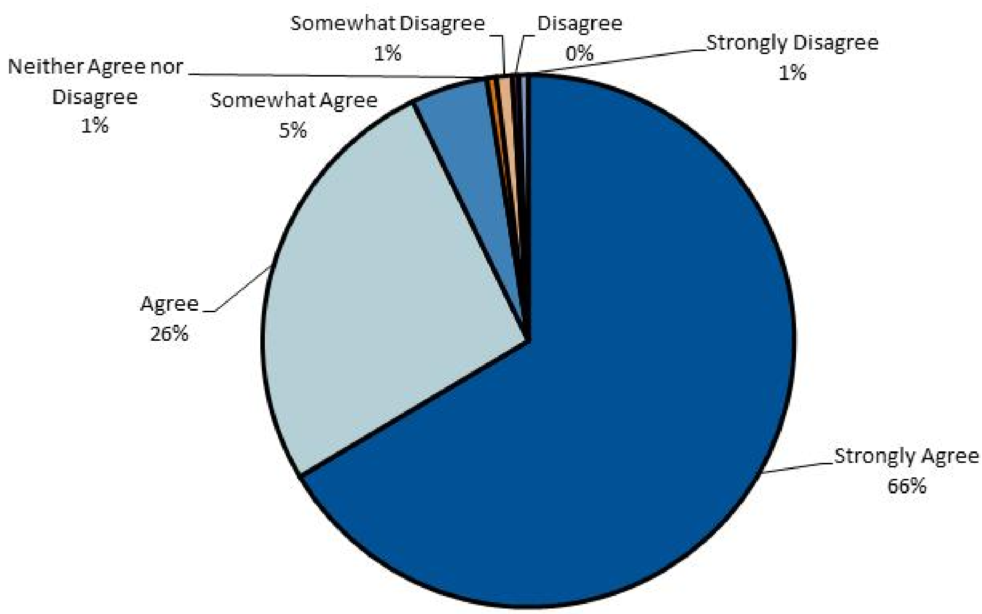
Cadmus created two online surveys for PBI and EPBB program participants using the Qualtrics® research suite. The survey instruments underwent several rounds of edits with the CEFIA team. We sent the surveys to all customers that participated in the program (420 PBI participants and 999 EPBB participants). The PBI survey received 143 responses (a 34% response rate); the EPBB survey received 407 responses (a 41% response rate). Cadmus sent respondents a personalized survey link via e-mail and sent a single reminder e-mail approximately one week after initial contact. In this section, we present key results of the survey. We indicate response quantities separately for each question discussed, because some responders may have skipped or omitted some questions.

Results

Satisfaction

Most respondents (66%) were strongly satisfied with their PV system, and there was no statistically significant difference[34] in satisfaction levels between the PBI and EPBB programs (see Figure 8). Of those who were dissatisfied, the most common remark was that the system did not provide the savings they had expected (n=6).

Figure 8. Overall Satisfaction with PV System

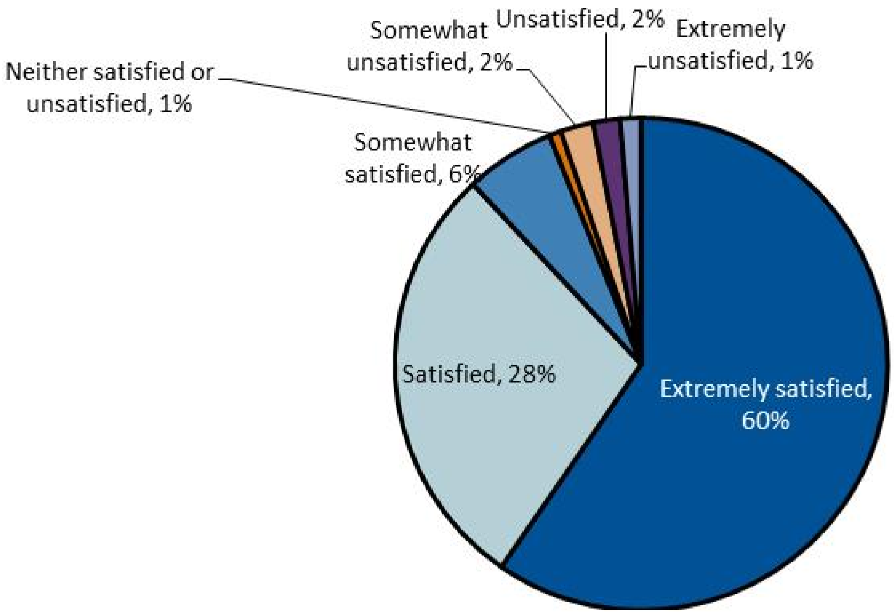


Q7. CEFIA Participant Survey. "Indicate to what extent you agree with the statement 'Overall, I am satisfied with my solar PV system'" (n=516).

[34] As measured using the statistical 2-tailed t-test, with a required p-value of 0.1 to determine significance

Respondents reported being extremely satisfied (60%) or satisfied (28%) most of the time with their PV installer (Figure 9). There was no statistically significant difference in satisfaction ratings between PBI and EPBB participants.

Figure 9. Satisfaction with PV Installer

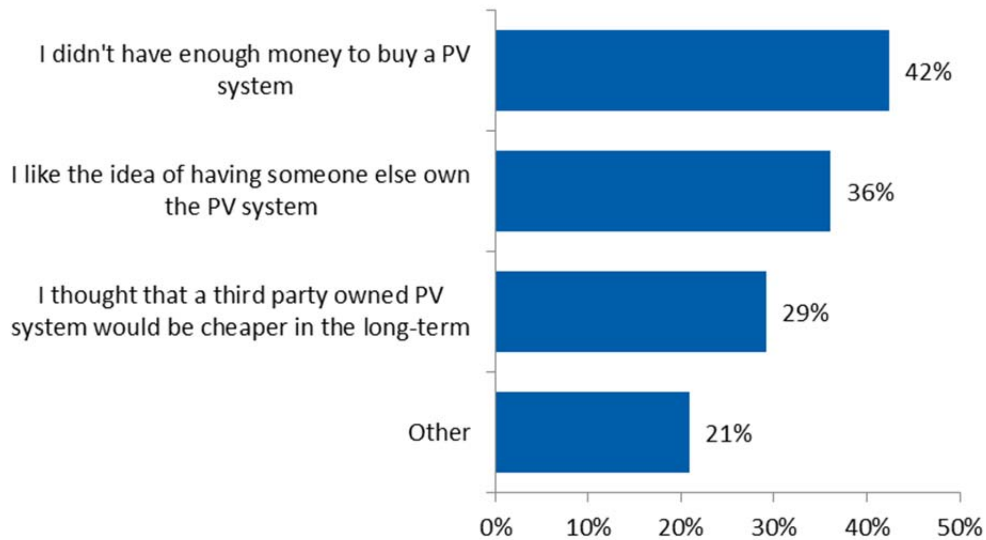


Q15. CEFIA Participant Survey. "What is your overall satisfaction with your Solar PV Installer?" (n=510).

Reasons for Choosing PBI vs EPBB

We asked customers who used the PBI incentive about their major motivations for choosing that incentive over the EPBB incentive, and thus a different ownership model. Customers were allowed to select multiple reasons. The most frequent response was that customers did not have sufficient funds for the large up-front cost of the system (42%), followed by people preferring someone else actually owning the system (36%), and the impression that a third-party-owned system would be cheaper in the long term (29%).

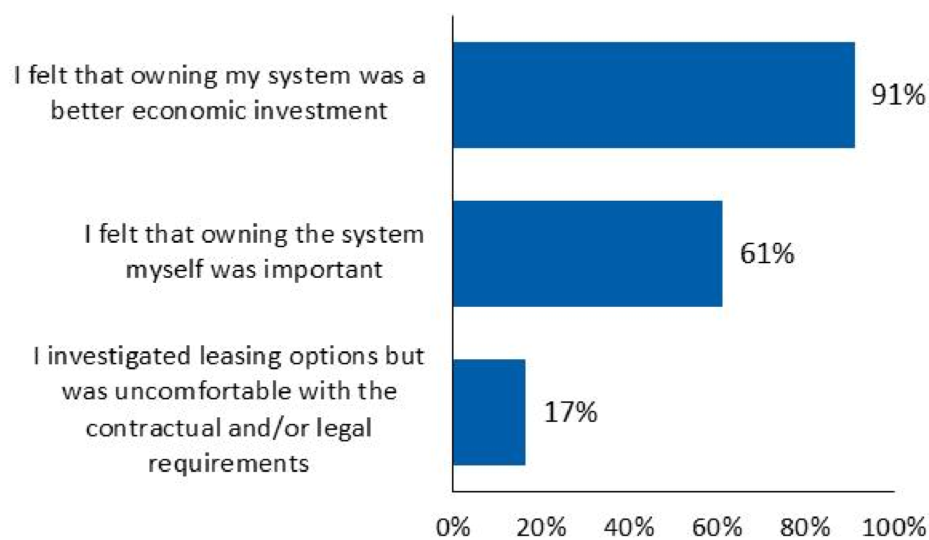
Figure 10. Reasons for Choosing the PBI Incentive



Q114. "Why did you choose to adopt a third-party-owned system through a lease or power purchase agreement (PPA) instead of purchasing your PV system?" (multiple responses allowed)

Similarly, the EPBB customers were asked why they participated in that program over the PBI program. Figure 11 shows the top three reasons for choosing the EPBB program using the top two mentions from a ranking system. Nearly all of the customers that responded to this question said that owning their own system as a better economic investment was the first or second highest reason for participating in EPBB. This is closely related to customers stating that owning the system was simply important. The third top mention includes customers' unease with leasing options.

Figure 11. Top Reasons for Choosing the EPBB Program



Q82. CEFIA Participant Survey. "Please rank your reasons for choosing to purchase your PV system rather than leasing it from most important to least important, 1 being most important" (n=90, multiple responses).

PBI Leasing and PPAs

For PBI respondents, 67% noted that they were using either a power purchase agreement (PPA) or a monthly lease for the PV system. The average reported term of the loan was 20 years, and the average monthly lease payment was $78 per month. For PPAs, respondents reported paying an average of 9.9 cents per kWh with an average term of 19.6 years - most responses were 20 years, with some 10 year terms reported (per the verification of actual contracts, described below, there were actually no 10 year terms). The remaining 33% of customers also had leases but reported having pre-paid their lease up front, with most describing it as a one-time, up-front payment for a 20-year lease. One respondent clarified his response, stating: “I prepaid the PPA so that my per-kWh price of energy generated by system is 0.” Another stated: "I am renting it for 20 years, but paid up front--no charge for me from here on."

Upon review of survey results, we recognized that some survey participants may have misreported the terms of their lease or PPA. To reconcile the discrepancy, we examined contracts of survey participants through PowerClerk. The following results attempt to clarify incorrect survey data and shed light on customers’ understanding (or recollection) of their PPA and lease terms.

- Of 142 PPA or lease customers, 91 replied to the question of whether their PPA or lease rate was fixed or escalating. Seven of the 91 answered incorrectly based on the contract stored in PowerClerk. In these seven cases, customers said that their lease or PPA rate was fixed when it is actually an escalating rate.
- Of 130, 12 incorrectly answered whether they had made a down payment or a prepayment, saying they had not made one when they had. Five of these 12 indicated in an answer to a different question that they had made a down payment or prepayment; thus, it was only seven out of 130 who reported their down payment status incorrectly.
- Of 75 respondents who gave a numerical estimate of how much their down or pre-payment was, 25 got it exactly right. Of the remaining 50, 41 underestimated what they had paid as a down/pre-payment by an average amount of $2,287. Nine overestimated by an average of $830.
- Only 25 of 142 respondents provided a per-kWh PPA or lease rate, most of which matched or were very close to actual contract rates. Contract rates were used in the analysis in order to provide a larger dataset to draw from for the analysis. Only 11 respondents provided an escalation rate and these answers were about 0.5% lower than the actual rates shown in the contracts.
- Of the contracts reviewed from PowerClerk, no 10-year terms were indicated; all contracts with a term indicated were for 20 years.

Based on this analysis, there are some differences between customer-reported contract terms and terms specified in the actual contracts stored in PowerClerk. While most responders understood their contracts, the most common cause of apparent customer confusion were related to escalation rates and pre-payment amounts. Based on these data, it is not clear exactly what is causing the differences observed between contract terms and customer reports. Possible causes may include:

- Customers incorrectly recall the terms of their contract. (We do not expect that most customers responded to the online survey with their contracts in front of them but we did not collect data on this.)
- Customers misunderstood the terms of their contracts.
- PowerClerk does not contain a final/current copy of the contract for all customers (CEFIA indicated that this is not likely as CEFIA requires the final version of the contract).

We have summarized the results of both the customer survey and the contract review in Table 8, below. Further details of escalating and fixed PPA or lease results are included in the Program Participant Economics section of this report.

Table 8. Customer-Reported and Contract Review PBI Contract Terms

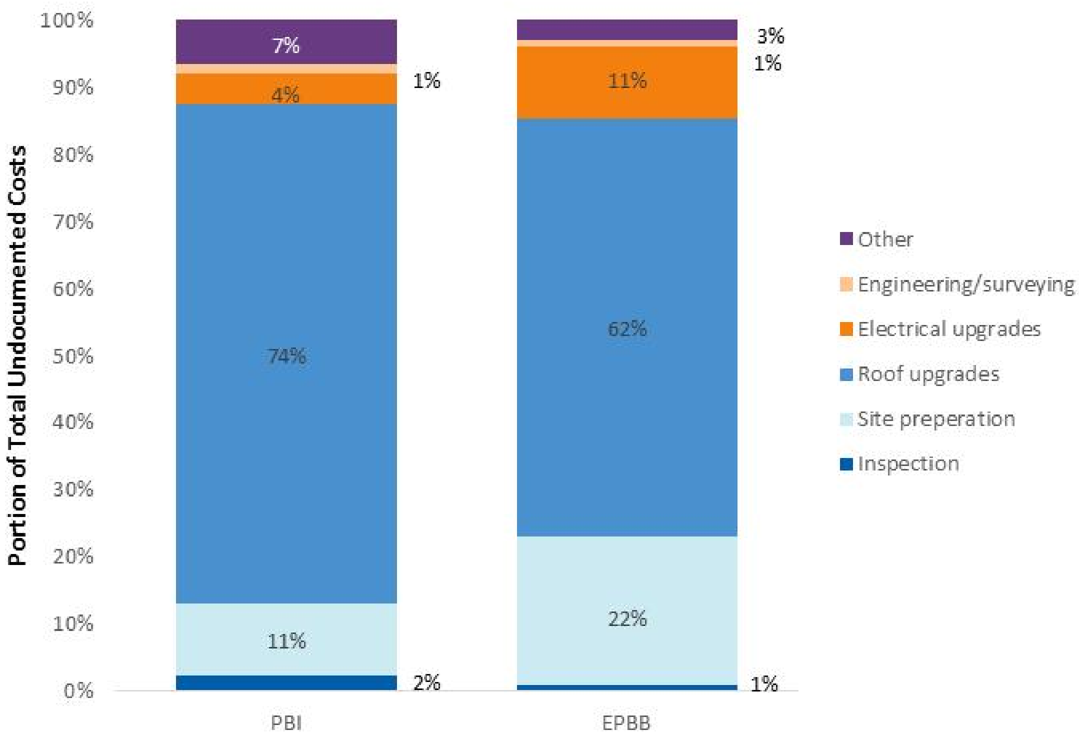
Parameter	Average Reported from Customer Survey	Average From Review of Actual Contracts
PPA Rate	$0.099	$0.107
PPA Term	19.6 years	20 years
PPA Escalation	2.5%	2.79%
Lease Rate	$78.00	$78.00
Lease Term	20.3 years	20 years
Lease Escalation	2.4%	3%

Non-Installer Costs for PV Installations

Respondents identified a number of costs associated with the installation of their PV systems, beyond the amount paid directly to installers. Table 9 shows what composed the additional costs for the PBI and EPBB participants. The most expensive non-installer costs were generally related to roof upgrades/replacement and site preparation (tree clearing, landscaping, and similar activities). As shown in , the most frequent of the reported undocumented expenses were for roof upgrades, site preparation, inspections, and electrical upgrades. The PBI group spent an average of $3,322 on these additional expenses, while the EPBB group spent an average of $4,028. Though the per-participant cost was similar between EPBB and PBI, EPBB customers were more likely to report extra costs for their system (38% of EPBB responders reported at least some extra cost, compared with 22% for PBI). The higher proportion of EPBB customers reporting additional costs could be due to the site selection criteria used by PBI installers, building extra costs into long-term lease or PPA contracts, or some other cause. Taken as an average across all program participants, these undocumented costs added $743 per system to the total cost of PV systems receiving a PBI incentive and $1,544 per system receiving an EPBB incentive, roughly equivalent to a 2% to 4% higher cost of ownership than was indicated by considering the installer costs alone.

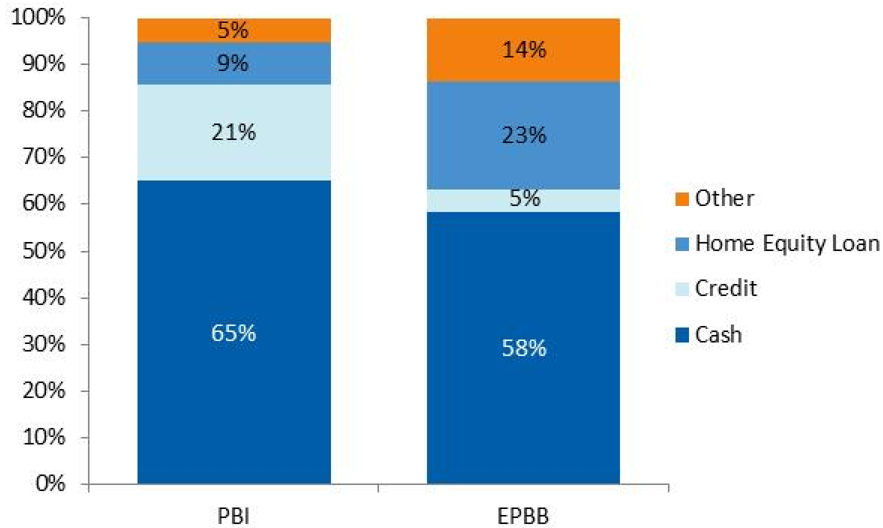
The respondents covered out-of-pocket costs of their systems by using cash, credit, or home equity loans, as detailed in Figure 13. The majority of customers in both PBI and EPBB paid for their out of pocket costs with cash or credit cards. Home equity loans were far more common among EPBB participants.

Figure 12. Undocumented Project Costs by Category



Q33. CEFIA Participant Survey. "We understand that the cost you paid to your installer may / may not fully reflect the costs of installing your PV system. Please indicate any additional costs you paid for your solar PV installation…"

Figure 13. How Respondents Covered Out-of-Pocket Costs



Q34. CEFIA Participant Survey. "Please indicate how you paid the out of pocket cost for your PV system (including a down payment, pre-payment, or other additional costs)." (PBI n=130, EPBB n=362).

Table 9. Comparison of Average Additional Costs for the PBI and EPBB Groups

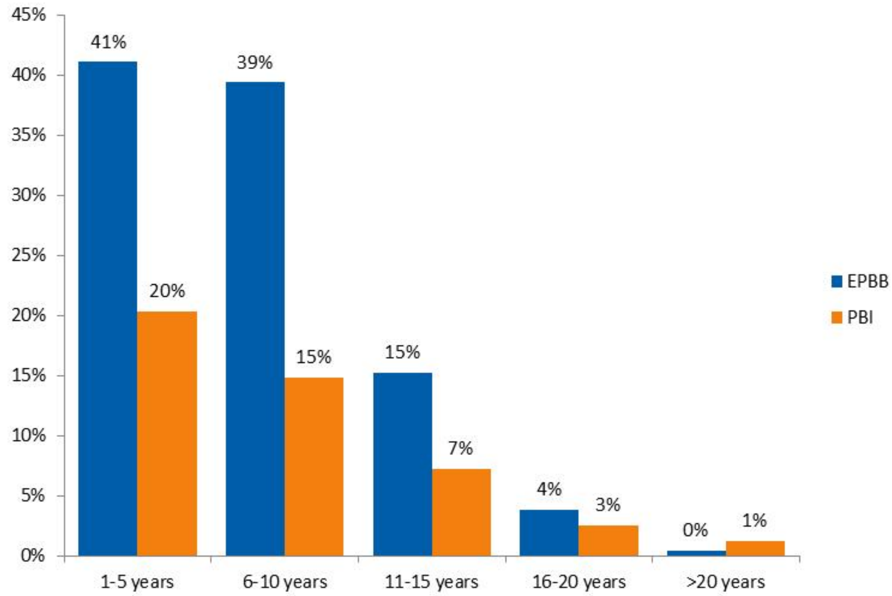
Category	PBI	EPBB
Inspection	$309.38	$243.13
Site preparation	$1,614.29	$2,031.72
Roof upgrades	$8,794.44	$5,736.54
Electrical upgrades	$791.67	$1,737.56
Engineering/surveying	$750.00	$646.60
Other	$1,017.86	$1,552.33

Q33. CEFIA Participant Survey. "Please indicate any additional costs you paid for your solar PV installation?" (PBI n=32, EPBB n=157).

Roof Replacement or Repairs

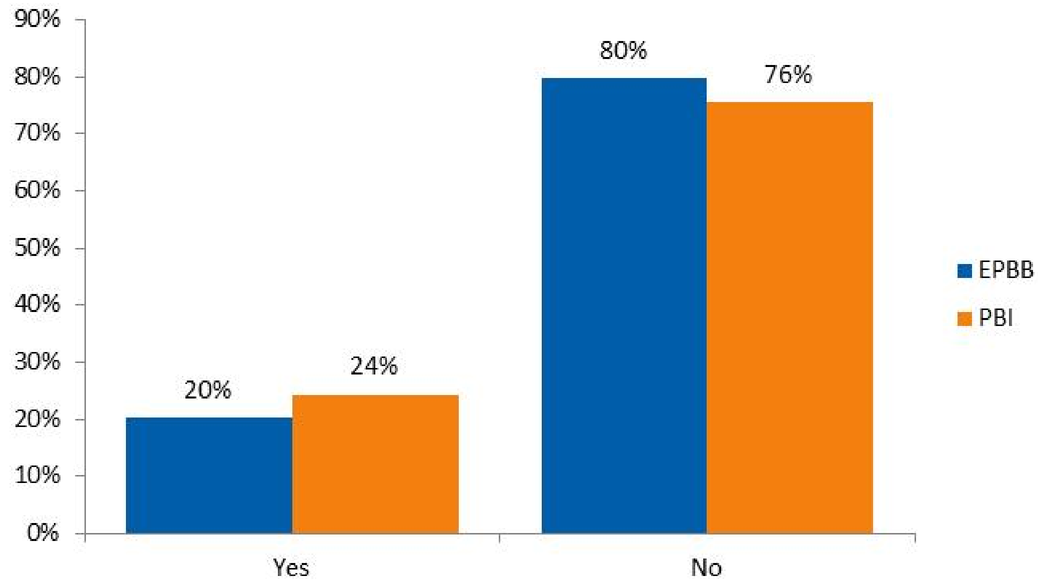
As shown in Figure 14, 19% of EPBB and 24% of PBI respondents appear to have roofs that are more than 10 years old at the time of installing their PV systems, which likely indicates that the roof will need to be replaced within the 25-year expected life of the PV system. Some customers chose to reinforce their roofs prior to installing PV, as shown in Figure 15. Assuming that the roof reinforcement undertaken was sufficient to extend the life of the roof to match that of the PV system, there are still many PBI customers who have roofs that are more than 10 years old and who did not take any steps to reinforce their roofs prior to installing PV. Of the 26 PBI responders with roofs over 10 years old, 85% did not reinforce them. Similarly, of the 46 EPBB responders with roofs over 10 years old, 83% did not reinforce them. Overall, for approximately 28% of PBI customers and 20% of EPBB customers, a roof replacement will likely be required before the 25-year expected life of their PV system has elapsed. This roof replacement will generally require uninstalling and re-installing the PV array and increase the overall cost of ownership for the PV system.

Figure 14. Age of the Roof When PV System was Installed



Q48. CEFIA Participant Survey. "How old was your roof when you installed your PV system?" (n=110 for PBI, n=244 for EPBB)

Figure 15. Roof Reinforcement for PV System



Q49. CEFIA Participant Survey. "Was your roof structure updated/reinforced to strengthen it for the PV system?" (n=126 for PBI, n=323 for EPBB)

Participant Income

Overall, 83% of participants' gross annual household income was more than $75,000. When comparing groups, the EPBB group had significantly more respondents reporting a gross household income of $125,000 or more, while the PBI group had significantly more respondents reporting between $75,000 and $125,000 gross household incomes (see Figure 16). Since EPBB respondents were purchasing their PV systems, it is not surprising that their reported income was higher, though both programs are well-represented in the lower income brackets. Though not a focus of the survey, it is interesting to note that the majority of customers reporting incomes lower than $50,000 per year also reported at least one resident 55 years of age, or older.

Figure 16. Income Level by Group

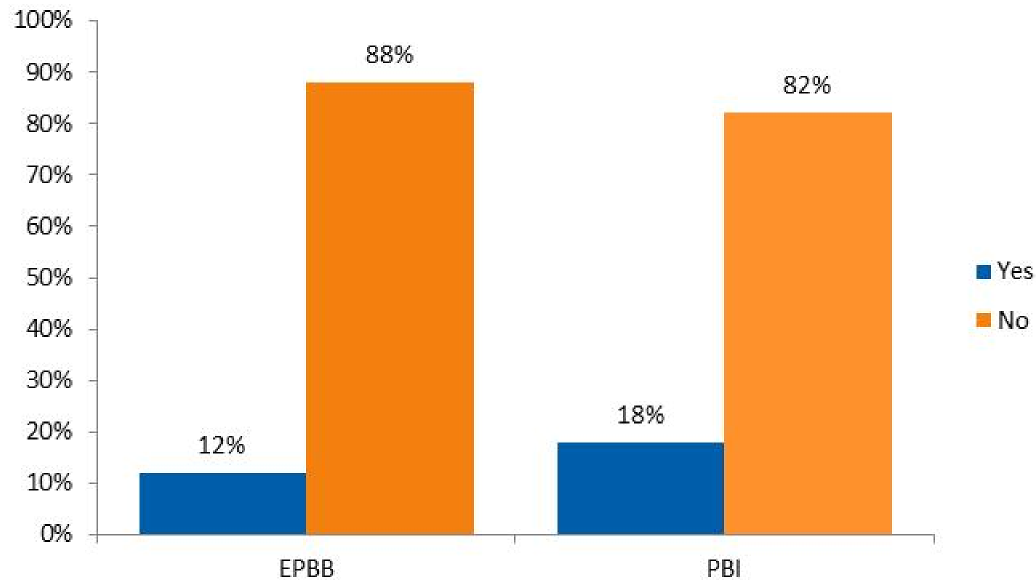
Q49. CEFIA Participant Survey. What is your annual household income level? (n=120 for PBI, n=298 for EPBB)

Program Attribution

We did not assess net-to-gross ratios for this program, but the customer survey did include some questions that touch on topics of attribution.

Figure 17 shows that the majority of customers would not have installed a PV system without a program incentive.

Figure 17. Would Have Installed Without an Incentive

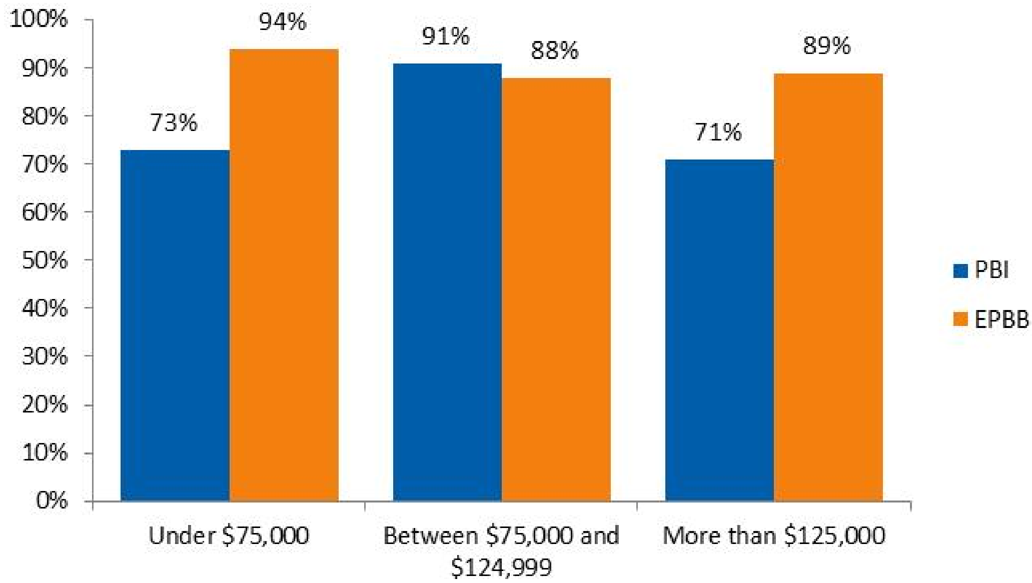


Q20. CEFIA Participant Survey: Would you have installed the PV system without CEFIA's incentive? (n=56 for PBI, n=375 for EPBB)

Figure 18 indicates that CEFIA's incentive appears to have played a larger role for the middle-income bracket of PBI participants, with 91% of these participants reporting they would not have installed the system without the CEFIA incentive, as compared to 73% of those earning under $75,000 or 71% of those earning more than $125,000. For EPBB participants, 94% of those earning under $75,000 reported that they would not have installed a PV system without CEFIA's incentive, with slightly lower percentages for those with incomes over $75,000.

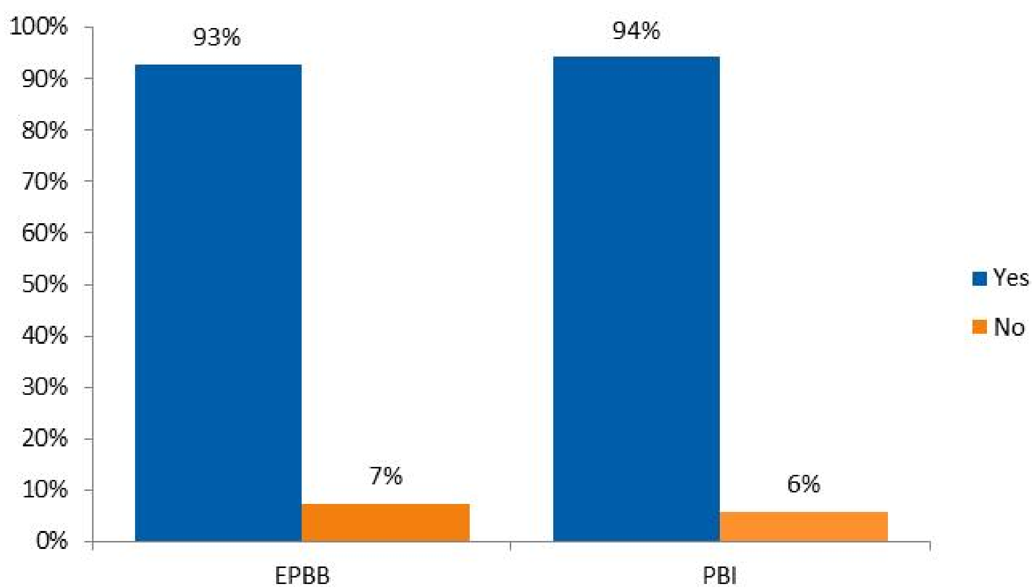
Figure 19 shows that the majority of customers were able to install their systems sooner with help from the program.

Figure 18. Would you have installed the PV system without CEFIA's incentive? "No" Responses Shown.



Q20. CEFIA Participant Survey. Would you have installed the PV system without CEFIA's incentive? (n=56 for PBI, n=375 for EPBB)

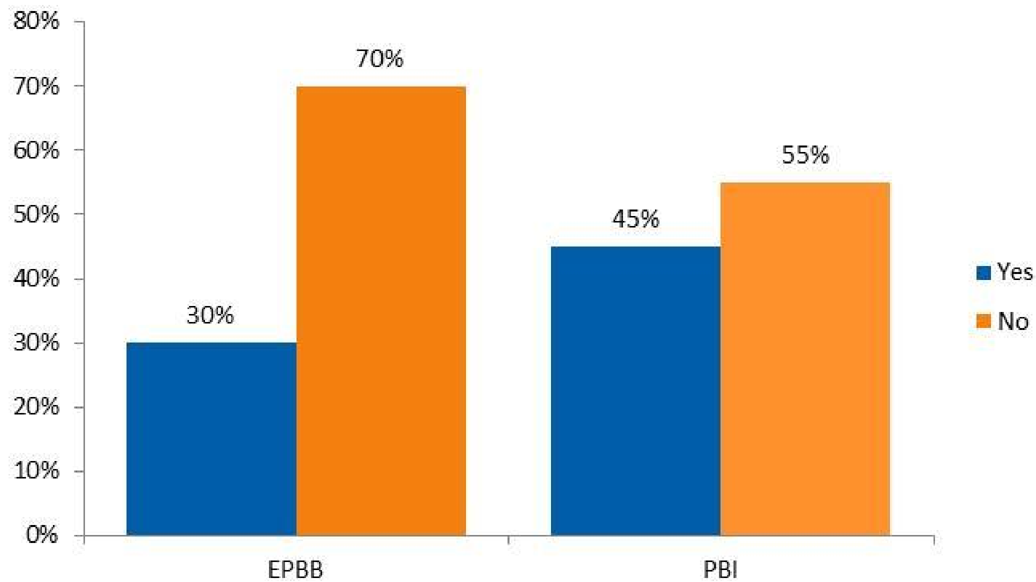
Figure 19. Installed System Sooner Because of the Program



Q21. CEFIA Participant Survey: Did the CEFIA incentive program allow you to install your PV system sooner than you otherwise would have? (n=56 for PBI, n=375 for EPBB)

In addition to the direct electricity generation benefits of the RSIP, many program participants also take additional energy efficiency or conservation measures as a result of their participation in the RSIP. Figure 20 shows that 30% of EPBB and 45% of PBI customers did, in fact, undertake additional home improvements that will result in energy savings after participation in the PV installation. Of respondents reporting an improvement after PV installation, 24% of all respondents reported upgrades to HVAC systems, 19% reported insulation upgrades, 18% reported upgrading to LEDs, 16% reported window or door upgrades, 9% reported water heater upgrades, and 15% reported other unspecified changes.

Figure 20. Energy Efficiency Improvements as a Result of PV Installation



Q88 (PBI), Q85 (EBBB). CEFIA Participant Survey. "Since the installation of your PV system, have you made any additional energy efficiency home improvements?" (n=128 for PBI, n=354 for EPBB).

Conclusions and Recommendations

Customers from both programs are generally very pleased with their PV systems and their installers. The top reason for choosing the PBI program was insufficient money to make an up-front purchase, and the main reason customers preferred the EPBB program was perception of a better economic value. Interestingly, though, 33% of PBI customers chose to fully pre-pay their leases. EPBB customers more frequently (38%) reported incurring extra costs for their PV system beyond those paid to their installer, compared with PBI customers (22%). The average costs in addition to the actual installation were similar between PBI and EPBB ($3,322 to $4,028 per customer who reported extra costs), and was primarily driven by roof upgrade and site preparation costs. However, more than 20% of the customer population had roofs that were over 10 years old and the majority of that group did not complete upgrades, signaling a potential need for repairs prior to the end of life of the PV system. Overall, more than one in five RSIP participants will likely require a roof replacement during the operating life of their PV system, which will have an impact on overall life cycle cost of ownership. The majority of customers had incomes over $75,000 annually, but 21% of PBI and 16% of EPBB customers had incomes lower than that, indicating that the programs are allowing lower-income-bracket families to participate in solar. Finally, customers indicated that the programs allowed them to install systems that they otherwise would not have been able to on their own and that they were able to do so sooner.

Customers reported additional costs to be 2% to 4% beyond the contractual installation costs. These costs include site preparation, electrical upgrades, and roof repair, and should be eligible for financing as part of the overall installation costs. Customers currently pay for the majority of these additional costs using cash and it is not explicitly stated in the documentation for current loan offerings, such as the Smart-E Loan or Sungage's Solar Loan, whether these costs are eligible to be included in financing. We recommend that CEFIA work to revise the instructions for these, and future, financing programs to clarify the eligibility of these relevant non-installation costs.

Installer Feedback

Survey Methodology

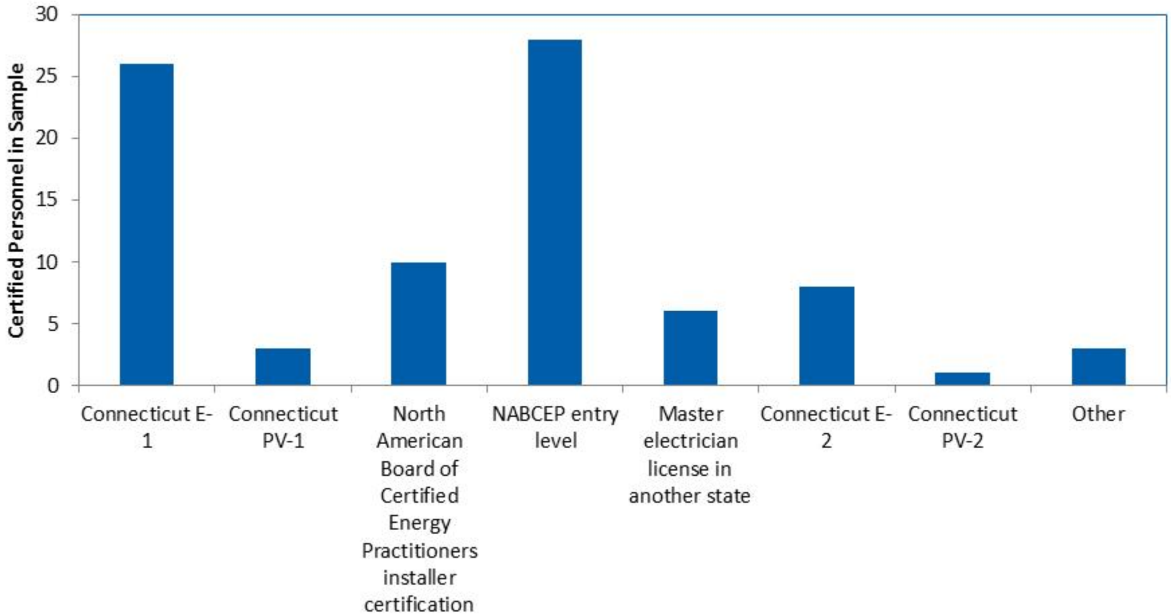
Cadmus also created a web survey targeting PV installers using the Qualtrics® research suite. We sent the surveys to all installers that participated in the program during the study period. Of the 89 installer organizations, we collected 20 responses (a 22% response rate) from installers employing 1 to 25 personnel in Connecticut, and those installers represented 27% of the study sample projects. Cadmus sent respondents a personalized link to the survey via e-mail and a single reminder e-mail approximately one week after initial contact, and CEFIA sent several communications to increase participation.

Results

PV Installer Characteristics

The majority of installers responding to the survey were from local, rather than national, installation firms employing 1 to 25 people in Connecticut. On average, the firms responding said they conducted 76% of their installations within Connecticut, with the remainder mostly devoted to New York, Massachusetts, and New Jersey. One installer said that they also work in Oregon and one other installer said that their work was nationwide and that Connecticut represented 5% of their installations. In terms of company size, installers reported between one and 25 full-time equivalent (FTE) employees at their company working on solar PV in Connecticut during the period March 2012 through June 2013. Of the licensing options available, a Connecticut E-1 or a NABCEP entry-level certification were the most commonly reported licenses held by installer employees. Installers were evenly split as to whether they hired additional employees to work on solar PV projects from March 2012 through June 2013, with nine of 18 installers reporting that they had hired additional staff, and the same number reporting that they had not hired anyone additional. For those installers indicating how many full-time and part-time staff members were hired during the study period, the average was 2.6 full-time and three part-time staff per firm. Installers reported using subcontractors frequently, with 68% of installers reporting they used subcontractors during that period. (n=19). Subcontractors were most often used for electrical work (12 of 22 installers, 55%), followed by engineering work (seven of 22 installers).

Figure 21. Number of Employees Having Licenses and Certifications

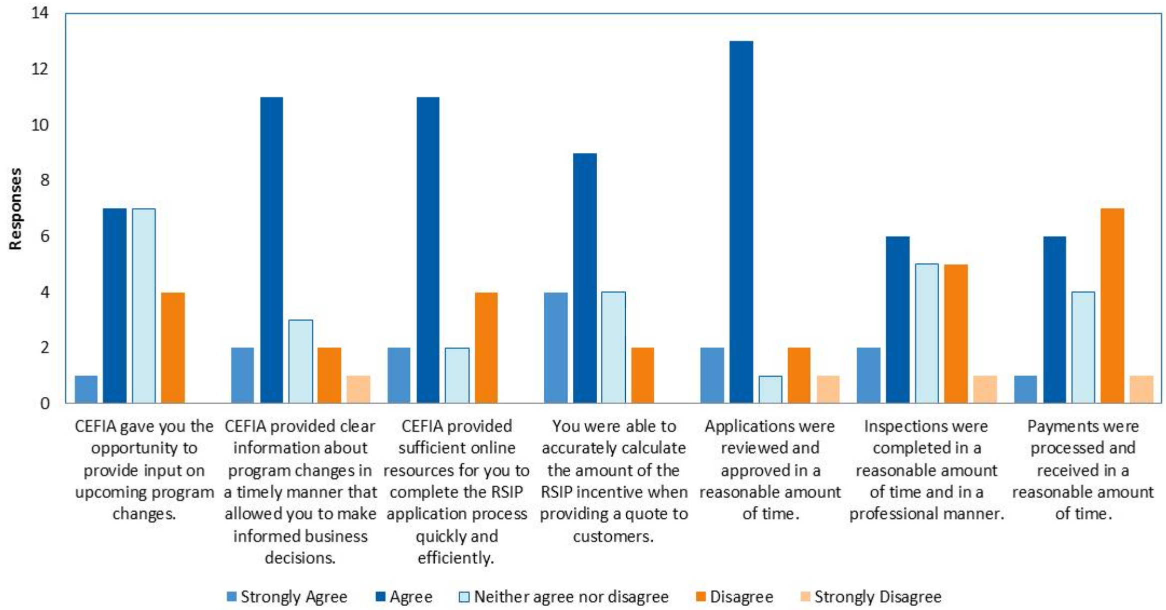


Q4. CEFIA RSIP Installer Survey. "How many employees working in Connecticut had the following licenses or certifications?" (n=20; multiple responses permitted).

Satisfaction

Installers said CEFIA provided clear information about the program changes in a timely manner and that CEFIA provided sufficient online resources for completing the RSIP application process. Most installers agreed that they were able to accurately calculate the amount of the RSIP incentive when providing an estimate. Installers said applications were reviewed and approved in a reasonable amount of time. There was less agreement that inspections were completed in a reasonable amount of time and in a professional manner, and installers expressed some disagreement with the statement: "Payments were processed and received in a reasonable amount of time." Overall, installers expressed high levels of agreement with positive statements about CEFIA and the program.

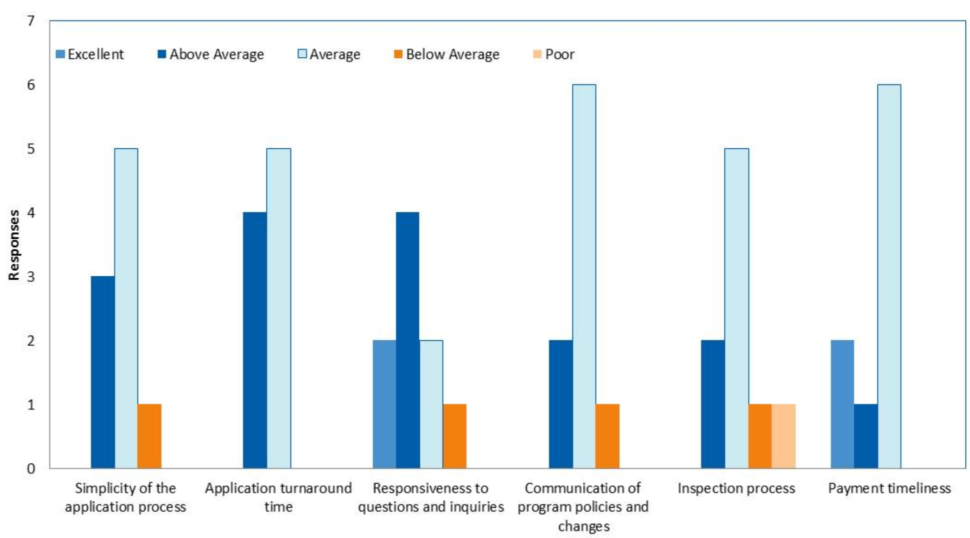
Figure 22. Installer Satisfaction



Q10. CEFIA RSIP Installer Survey, "When considering the RSIP (EPBB and PBI programs only, excluding applications for CEFIA's financing products), how strongly would you agree or disagree that…" (n=20)

When asked to rate various aspects of the program as compared to incentive programs in other states the installer worked in, installers overall rated most aspects as being average. Respondents rated application turnaround time as above average, and notably, a majority rated program responsiveness to questions as above average.

Figure 23. Installer Satisfaction Compared to Other State Programs



Q13. CEFIA RSIP Installer Survey. "Compared with the incentive programs in other states you worked in, how would you rate the RSIP found in Connecticut?" (n=20)

When asked for suggestions on how to improve the program, PV installers suggested a faster inspection process and a clear timeline for payments. One installer said, "CEFIA should not inspect each and every system and not require HES[35] audits in order to go solar. Connecticut is the only market in the country where each and every project has a minimum of four different inspections: CEFIA requires one for the HES audit, one from the AHJ[36], one from the utility, and one from CEFIA's own inspectors." Another installer expressed concern that the program should consider local companies, stating: "Please try to help the organic home-grown Connecticut companies. It seems that your focus is heavily weighted toward increasing installed capacity, which is fine, but programs like Solarize seem to be a natural fit for the larger, mostly out-of-state-headquartered companies." Another commented: "Get more funding so it will last beyond 2014. This present level of funding offsets approximately 25% to 30% of the cost for a homeowner. It usually is a deal-maker."

PV Installer Interactions with Customers

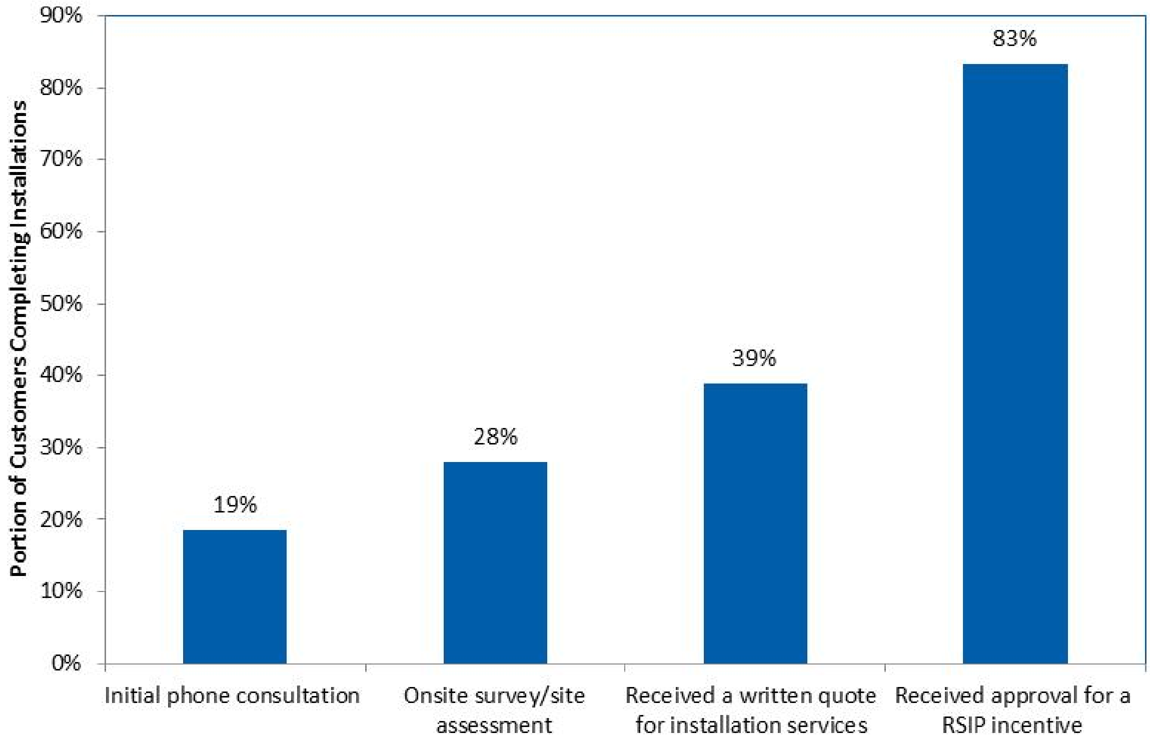
PV installers reported spending the majority of their customer acquisition time giving installation quotes and doing site visits. When asked to provide an estimate of acquisition cost for each customer on a per-watt basis, from identifying the customer through providing an installation quote, costs ranged from $0.25 per watt to $0.50 per watt, amounting to approximately 4% to 10% of (pre-incentive) installed cost. Installers were also asked to rank items in a question, "What would best support your customer acquisition efforts?" Installers overwhelmingly cited financing products to help as most important. Installers mentioned offering specific financing options such as CT Solar loans, and Smart-E loans to their customers. One installer noted that the Sungage CT Solar Loan and the CT Solar Lease offers give him the opportunity to compete with larger companies. He commented that "Sungage and lease offer much better return to customers. If we get the opp(ortunity) to propose, we typically beat the larger companies."

We collected installer input on the customer retention rate through different stages of the pre-installation process, beginning with the initial phone conversation through site surveys and approval of the RSIP incentive. Overall, installers reported that 19% of customers receiving a preliminary phone consultation ultimately followed through with the installation. In other words, for every phone consultation that results in an installation, there are four that do not. The rate of retention for each stage is shown in Figure 24 below. From this, it appears that the majority of customers are lost after receiving a written quote but before being approved for an incentive under the RSIP.

[35] The majority of energy efficiency audits are conducted through the Home Energy Solutions (HES) Program by HES-eligible contractors.

[36] AHJ refers to the authority having jurisdiction or the municipality from which an installer must obtain a permit to install a solar PV system.

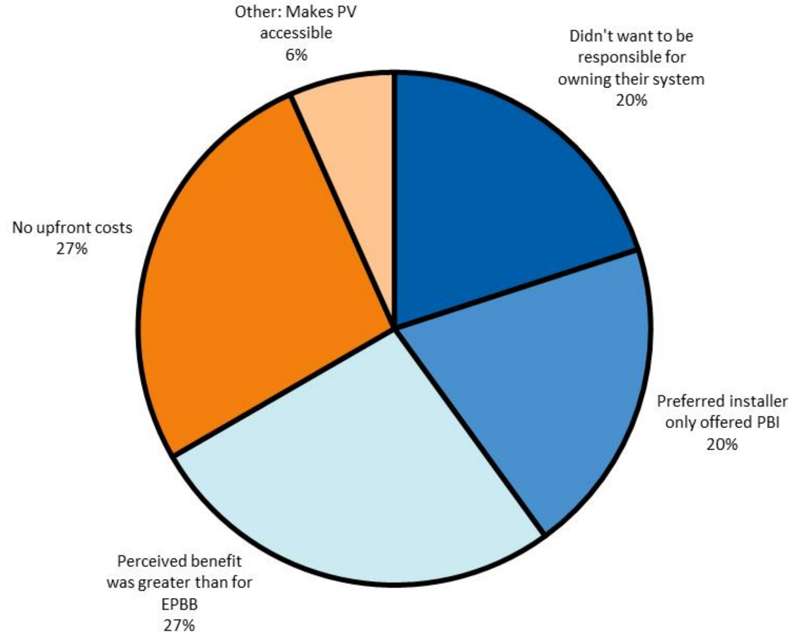
Figure 24. Customer Retention Rate at Various Stages of the Acquisition Process



Of the reasons cited for customers not proceeding with an installation, installers said that the system being more expensive than the customer expected was the most common (22%), followed by cost of roof updates or tree removal (18%). Inability to maintain the necessary permits was the least common (3%), along with the customer or installer not being eligible for incentives or tax credits. Of the "other" category, the most interesting response was "no Wi-Fi on site" which one installer said caused 50% of his customers to not proceed with an installation.

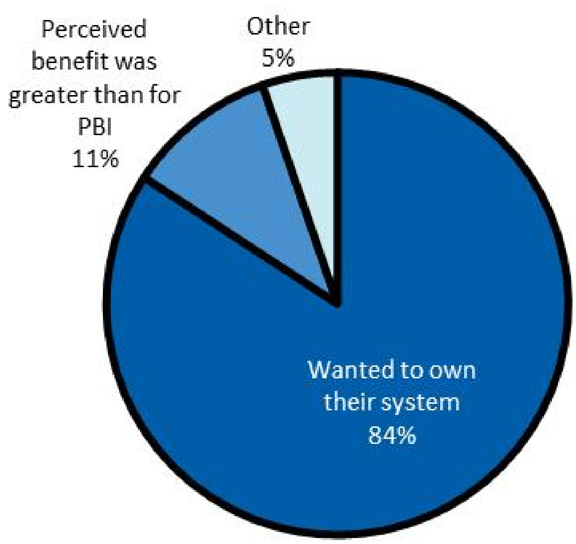
When asked why they thought customers chose the EPBB, the majority of installers thought customers wanted to own their system. Customer preference for PBI was harder to pinpoint, with some installers believing that the customer may not have wanted the responsibility of owning the system, and others believing that the customer's preferred installer only offered PBI. Some said that the perceived benefit may have been greater for PBI than for EPBB. The majority of respondents gave "Other" responses. Of those responses, seven installers cited a cost issue, guessing that "no up-front cost" or "could not take advantage financially of EPBB" may have been the reason the customer preferred PBI.

Figure 25. Perception of Customer Preference for PBI



Q29. CEFIA RSIP Installer Survey. "Why do you think customers chose PBI?" (n=20)

Figure 26. Perception of Customer Preference for EPBB

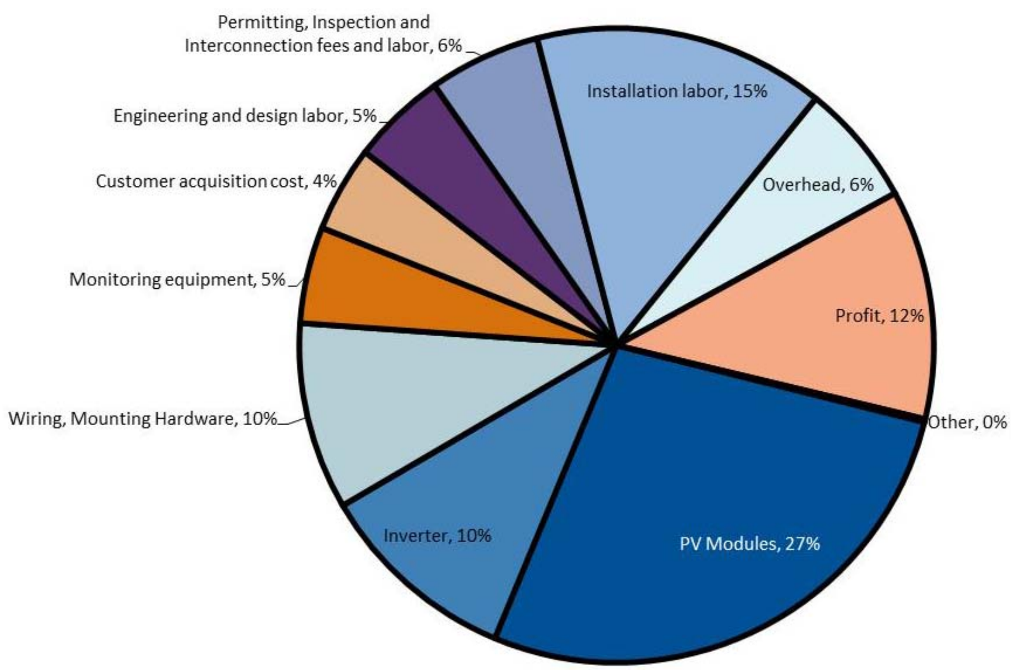


Q29. CEFIA RSIP Installer Survey. "Why do you think customers chose EPBB?" (n=20)

Costs

The survey asked installers to estimate their cost component percentages for a typical RSIP project installed during the study period. Installers cited PV modules at 27%, composing the highest cost percentage for a typical RSIP project, followed by installation labor at 15%. Hardware cost components including PV modules, inverter, wiring, mounting hardware, and monitoring equipment together composed 52% of costs, while non-hardware or soft costs totaled 48%. These percentages are comparable to those computed for the Connecticut Rooftop Solar Challenge Final Project Report[37] based on installation cost component data input by installers into PowerClerk. PowerClerk data also reflects hardware cost contribution of about 52%.

Figure 27. Project Average Cost Percentage by Component



Q33 CEFIA RSIP Installer Survey. "Please estimate your cost percentages for a typical RSIP project installed in this time period." (n=13)

Operations and Maintenance

Installers gave a range of answers to the question "How many residential PV systems has your company conducted repair or services on in a typical year?" Answers ranged from none to 30 systems, with the majority of installers saying they repair between four and 10 systems per year. One commented that "routine maintenance/review is part of the original contract." A follow-up question asked what percentage of those repairs were conducted on systems not installed by your own company, to which responses varied, with most reporting 10% to 25%. One installer commented that none of his installs

[37] The CT Rooftop Solar Challenge Final Project Report, prepared as part of a project funded by the U.S. Department of Energy SunShot Initiative, can be downloaded at www.energizect.com/sunrisene.

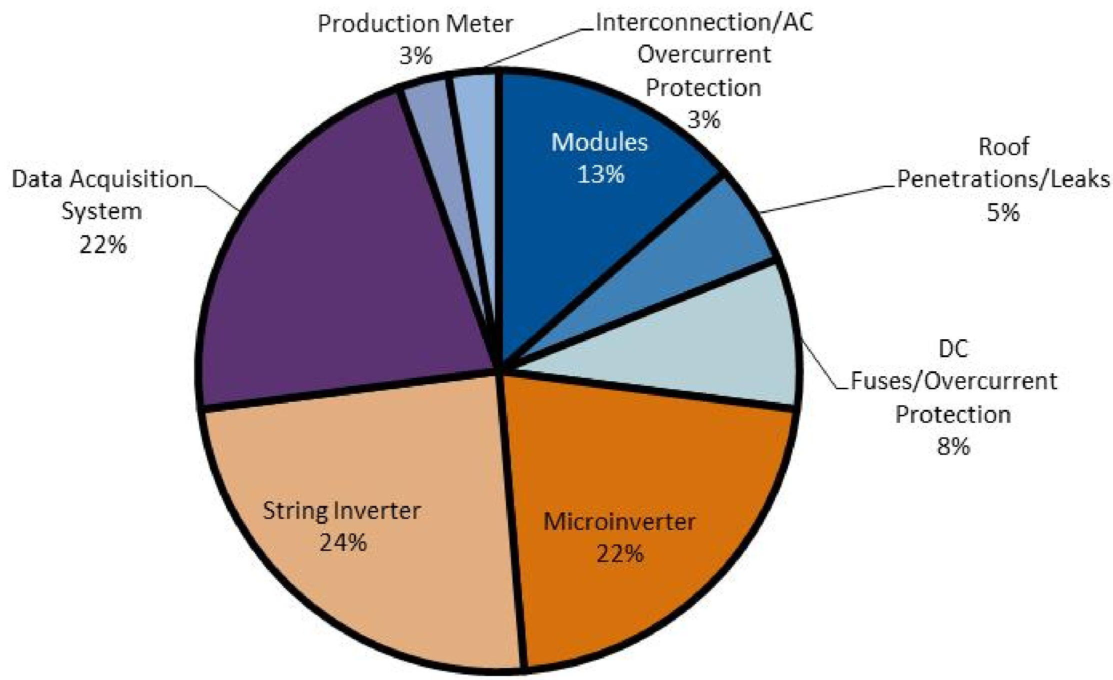
needed repair, but he had done seven repair jobs on systems installed by others. Of the repair jobs on PV system components between March 2012 and June 2013, string inverters were the most commonly repaired (24%), followed by microinverters (22%) and data acquisition systems (22%). Production meters, and interconnection/AC overcurrent protection repairs were among the least common, and no disconnects and racking or structural support repairs were reported.

Though a detailed analysis of inverter replacement trends and reliability is beyond the scope of this study, the survey responses provided some insights on string inverter and microinverter replacement. Though string inverter replacements/repairs were listed as more common than microinverter replacements/repairs, the average component age for string inverters repaired was 2.8 years, compared with an average replacement age of less than one year for microinverters. Removing string inverter outliers for nine- to ten-year-old replacements (that were originally installed well before the study period), string inverters were replaced at an average age of 1.5 years. In both cases, the majority of repairs and replacements were conducted under warranty, which makes an accurate comparison of replacement costs difficult.

Regarding extended service plans[38], beyond the five year parts and labor warranty required by CEFIA, less than half of installers (45%) indicated that the most common extra warranty period offered was an additional five years for a total of 10 years parts and labor coverage. The longest warranty offered by any installer responding to the survey was 15 years parts and labor. One installer offered a 20 year production guarantee. Overall, the service packages offered by responders are notably less standardized than service plans included in standardized PPA or lease arrangements, suggesting that another possible impetus (or an underlying reason) for customers to choose solar lease or PPA arrangements is to have more comprehensive O&M coverage.

[38] Responses related to service plans generally refer to EPBB, though some responders did indicate participation in both PBI and EPBB incentive types

Figure 28. PV Component Repair Jobs, March 2012-June 2013



Q63 CEFIA RSIP Installer Survey. "Which of the following PV system components have you repaired between March 2012 and June 2013?" (n=13)

Data Acquisition Systems

Data acquisition systems (DAS) were among the most frequently cited repairs by installers. Eight of the 13 installers who said they do repair jobs cited DAS repairs as a component they have repaired in the past year. However, much of that work falls under warranty. Five of the eight installers reported that 100% of their DAS repairs were under warranty. Two said that zero of the repairs were under warranty, and one installer said half of the repairs were under warranty. Installers described the typical age of the system requiring a DAS repair as between zero years and two years old. The median age of the DAS system repaired was one year. Estimated average repair cost was $175, with estimated costs ranging from zero to $500. One installer noted that, "Data acquisition system is generally just an internet connectivity issue -- nothing malfunctioning with the monitor."

Another installer responded that of the 20 to 30 residential PV system repairs he makes in a year, that "90% of these issues are related to DAS/Locus failures," and called it a "huge burden on our company." The same installer later suggested that "Once Locus installed, installer should not be responsible for any outages or Locus failures. Locus should have their own support team."

Conclusions and Recommendations

Installers are generally satisfied with the two RSIP incentives' delivery and structure, while reporting the common areas for improvement around incentive payment timing and a faster inspection process. PV installers reported spending the majority of their customer acquisition time giving installation quotes and performing site visits. They reported that their costs ranged from $0.25 per watt to $0.50 per watt, amounting to approximately 4% to 10% of installed cost. Installers were in agreement that customers chose the EPBB program because they wanted to own their system, while PBI customers seemed to be motivated by the absence of capital requirements. When asked to break down the overall job cost in percentages, PV modules were followed by installation costs as the two highest cost components. The majority of installers do between four and 10 repair jobs per year, with string inverter replacements, microinverter replacements, and DAS repairs being the most common. Customers may be choosing solar lease or PPA arrangements so that they can have more comprehensive O&M coverage, as the service packages offered by responders are less standardized than service plans included in standardized PPA or lease arrangements.

Program Participant Economics

Methodology

Using data from PowerClerk, the Market Watch reports, results from the customer survey, and data from Locus on system performance, Cadmus compiled typical system characteristics for each incentive step for both EPBB and PBI. We used these typical system characteristics, combined with the relevant assumptions listed in the tables below, to calculate a variety of customer-focused financial metrics, including:

- ***Simple Payback:*** Number of years of operation for the owner to recover the undiscounted, invested capital (i.e., break-even point). Simple payback is calculated only for EPBB projects, since initial capital expenditures by the customer are not required for PBI projects.
- **Internal Rate of Return (IRR):** A discount rate that, when applied to a project, yields a net present value of zero. It is meant to show the expected growth rate of a particular investment. The IRR also shows what the equivalent interest rate would be, if the customer decided to spend the same amount of money as they spent on the PV system in another way (e.g., savings bond, mutual fund). An IRR higher than the interest rate on another investment shows that the PV system generates more income than the alternative investment for the customer.
- **Net Present Value (NPV):** The difference between the present value of cash inflows and cash outflows. The present value is the discounting of future cash: a dollar today is worth more than a dollar tomorrow. A positive NPV indicates that the income (e.g., avoided energy costs) exceeds the costs (e.g., maintenance) over the life of the system.
- ***Levelized Cost of Energy (LCOE):*** The sum of the present value of future cash outflows and the initial investment, divided by the kWh produced over the life of a project. This analysis allows for comparison of renewable energy projects (with no fuel costs) to traditional electricity generation. Projects with a LCOE lower than the rate the customer would otherwise pay will generate a positive value to the customer.

Equation 0-5. Calculation of Levelized Cost of Energy

$$LCOE = TLCC \div \left(\sum_{n=1}^{N} (Q_n \div (1 + d^n)) \right)$$

Where:

LCOE = levelized cost of energy

TLCC = total life-cycle cost

Q_n = energy output in year n

d = discount rate

N = number of years in analysis period

Table 10 summarizes the typical system characteristics and key assumptions used in the analysis of EPBB-funded projects.

Table 10. Typical System Characteristics and Key Assumptions for EPBB Projects [39]

	EPBB			
	Step 1	Step 2	Step 3	Escalation
Nameplate Rating (kW)	6.54	7.17	7.13	
CEC PTC Rating (kW)	5.91	6.47	6.50	
CSI Rating (kW)	5.23	5.52	5.56	
Design Factor	91.9%	88.8%	89.6%	
Modified Design Factor[40]	N/A	N/A	93.9%	
Nameplate Installed Cost ($/W)	$5.30	$4.38	$4.48	
Cost/Watt-PTC Pre-Incentive ($/W)	$5.94	$4.81	$4.85	
Cost/Watt-PTC Post-Incentive ($/W)	$3.59	$2.69	$3.28	
Average Incentive ($/W-PTC)	$2.35	$2.12	$1.57	
Estimated Production (kWh/yr)	7,952	8,389	8,449	
Estimated Production (kWh/kW)	1,216	1,170	1,185	
Degradation (%/yr)	0.50%	0.50%	0.50%	
Federal ITC (% project cost)	30%	30%	30%	
Useful Life of System (years)	25	25	25	
RSIP Avoided Cost to Customer ($/kWh)[41]	$0.152	$0.157	$0.151	2.99%
O&M Costs per kW per Year	$20	$20	$20	2.00%

Each project has an expected annual energy generation (production) that takes into account the inverter efficiency and the project's design factor, which reflects the azimuth, tilt, orientation and shading of the system.

An important distinction between EPBB projects and PBI projects is their tax treatment. EPBB projects receive an up-front incentive payment, which decreases the Federal Investment Tax Credit (ITC) for these projects. While a typical Step 3 EPBB project has an ITC basis of $3.28/W ($4.85/W cost minus a $1.57/W incentive), a Step 2 PBI project has an ITC basis of $5.26/W, or a $0.59/W higher potential ITC.

A summary of the key assumptions used for PBI projects is included in Table 11.

[39] The EPBB economic analysis assumes that customers paid their out of pocket cost with cash, though some customers used loans that add an additional cost due to interest. EPBB customer survey data shows that 60% of customers used cash, while 40% used a home equity loan, personal loan, credit card or other means.

[40] In EPBB Step 3, CEFIA began treating design factors greater than 87% as 100% for purposes of calculating incentives. This has the effect of increasing the overall average design factor.

[41] EIA Avoided Cost Rate, less $0.02/kWh, which reflects an approximate utility monthly service charge for a typical residential customer.

Table 11. Typical System Characteristics and Key Assumptions for PBI Projects[42]

	PBI Fixed Rate			PBI with Escalator			
	Steps 1 & 2	Step 3	Escalation	Steps 1 & 2	Step 3	Step 1 & 2 Escalation	Step 3 Escalation
Nameplate Rating (kW)	7.14	6.58		7.14	6.58		
CEC PTC Rating (kW)	6.49	5.96		6.49	5.96		
CSI Rating (kW)	4.87	4.66		4.87	4.66		
Design Factor	79.2%	82.2%		79.2%	82.2%		
Modified Design Factor	N/A	N/A		N/A	N/A		
Nameplate Installed Cost ($/W)	$4.83	$5.04	-	$4.83	$5.04		-
Cost/Watt-PTC Pre-Incentive ($/W)	$5.26	$5.53		$5.26	$5.53		
Average Incentive ($/W-PTC)	$1.83	$1.41		$1.83	$1.41		
Cost/ Watt-PTC Post-Incentive ($/W)	$3.43	$4.12		$3.43	$4.12		
Estimated Production (kWh/yr)	7,393	7,076		7,393	7,076		
Estimated Production (kWh/kW)	1,036	1,075		1,036	1,075		
Degradation (%/yr)	0.50%	0.50%		0.50%	0.50%		
Federal ITC (% project cost)	30%	30%		30%	30%		
Project Year	1	1		1	1		
Year Operational	2012	2012		2012	2012		
Month Operational	5	4		5	4		
Down/ Pre-payment	$5,898	$3,843		$0	$0		
PPA/Lease Rate ($/kWh)	$0.094	$0.11	0.00%	$0.13	$0.13	2.72%	3.03%
RSIP Avoided Cost to Customer ($/kWh)	$0.152	$0.154	2.99%	$0.15	$0.15	2.99%	2.99%
O&M Costs per kW per Year	$20	$20	2.00%	$20	$20	2.00%	2.00%

Results

As shown in Table 10 and Table 11, there are key differences in calculating the financial costs and benefits of the EPBB and PBI portions of the RSIP. PBI projects, for example, do not generally have an up-front payment from the customer, so we did not calculate simple payback; it is effectively immediate, assuming no initial payment is required and as long as the PPA or lease rate is less than the customer's utility rate (and assuming any extra utility fees have been integrated into the utility rate). The exception to that is if the customer chooses to pre-pay on a lease, or make a down payment. We found that customers who made a payment up front had a lower starting $/kWh rate when compared to those PBI customers who did not make a down payment and did not have an annual escalator. The average down payment for Steps 1 and 2 was $5,898 and for Step 3 $3,843. Table 12 presents the LCOE for EPBB and PBI participants, along with other key economic metrics such as simple payback (EPBB only), IRR, and NPV. Where applicable, we have shown a range of discount rates from 2% to 8% and the impact these discount rates have on economic indicators.

Table 12 shows the typical customer's financial results. We have updated the table since the Progress Report dated January 16, 2014, to reflect the effects of CEFIA's analysis of survey participant contracts, to ensure that contract terms were reported accurately. Resulting from CEFIA's analysis of actual contracts, we learned that PBI customers had significantly higher PPA rates (than reported by survey respondents), in some cases with an annual escalator. Additionally, down payments and prepayments made by PBI customers led to lower PPA rates when compared to PBI customers who did not make a down payment, and involved no annual escalation. Following the deeper review of customer contracts, CEFIA determined that the price per kWh for PBI customers was lower than originally estimated in the Progress Report dated January 16, 2014, and some PBI customers had no annual escalation in their rate if a down payment was made. For those who did have an annual escalator in their contract, we found that the escalation rate was close to the 2.99% that had been estimated in the Progress Report, with an average escalation rate for Steps 1 and 2 of 2.718% and an average Step 3 escalation rate of 3.025%.

As the results from Table 12 indicate, EPBB systems and PBI systems with fixed rates generally have a higher NPV than PBI systems with annual escalators, particularly at lower discount rates. Related to this, EPBB systems and PBI systems with fixed rates also have lower LCOE, at lower discount rates, when compared to PBI systems with an annual escalator.

Table 12. RSIP Customer Financial Results[43]

Metric	Discount Rate	EPBB			PBI Fixed Rate		PBI with Escalator	
		Step 1	Step 2	Step 3	Steps 1&2	Step 3	Steps 1&2	Step 3
Simple Payback (year)		12	11	13	N/A	N/A	N/A	N/A
IRR and NPV								
IRR		8.6%	10.8%	8.4%	N/A	N/A	N/A	N/A
NPV @	2%	$13,597	$17,460	$14,214	$16,289	$13,865	$4,450	$3,752
NPV @	4%	$7,760	$10,988	$7,984	$12,422	$10,492	$3,424	$2,936
NPV @	6%	$3,660	$6,428	$3,609	$9,699	$8,129	$2,698	$2,353
NPV @	8%	$733	$3,163	$487	$7,744	$6,439	$2,174	$1,926
LCOE								
Total kWh produced		187,325	197,607	200,041	174,156	166,694	174,156	166,694
LCOE ($/kWh) @	2%	$0.14	$0.12	$0.14	$0.15	$0.16	$0.20	$0.20
LCOE ($/kWh) @	4%	$0.13	$0.12	$0.13	$0.13	$0.10	$0.16	$0.16
LCOE ($/kWh) @	6%	$0.13	$0.11	$0.13	$0.11	$0.08	$0.13	$0.13
LCOE ($/kWh) @	8%	$0.12	$0.11	$0.13	$0.10	$0.07	$0.10	$0.10

[43] Table 11 was updated from the Progress Report, dated January 16, 2014 to reflect corrected program participant data such as contract escalation rates and down payments made.

Solarize Connecticut Performance

Select communities were chosen to participate in Solarize Connecticut at various times through the RSIP. Under Solarize, homeowners interested in installing solar PV are able to procure solar as a group, but install it on their individual homes. Through the group procurement, homeowners gain economies of scale with a single installer, driving down the price of the technology using a defined “tiered pricing scheme.” With the same PowerClerk dataset as used in the analyses previously presented, we identified the Solarize program’s performance under the RSIP program to date. The tables below present the characteristics of the average Solarize PV system under the various steps and incentive types of the RSIP.

Table 13. Typical System Characteristics and Key Assumptions for Solarize CT EPBB Projects[44] [45]

	EPBB			
	Step 1	Step 2	Step 3	Escalation
Nameplate Rating (kW)	N/A	7.56	6.79	
CEC PTC Rating (kW)	N/A	6.54	5.90	
CSI Rating (kW)	N/A	5.77	5.30	
Design Factor	N/A	88.0%	89.5%	
Modified Design Factor[46]	N/A	92%	93.0%	
Nameplate Installed Cost ($/W)	N/A	$3.78	$3.91	-
Cost/ Watt-PTC Pre-Incentive ($/W)	N/A	$4.37	$4.50	
Cost/Watt-PTC Post-Incentive ($/W)	N/A	$2.56	$3.14	
Average Incentive ($/W-PTC)	N/A	$1.76	$1.31	
Estimated Production (kWh/yr)	N/A	8,774	8,055	
Estimated Production (kWh/kW)	N/A	1,161	1,187	
Degradation (%/yr)	0.5%	0.5%	0.5%	
Federal ITC (% project cost)	30%	30%	30%	
Project Year	1	1	1	
Year Operational	N/A	2013	2013	
RSIP Avoided Cost to Customer ($/kWh)	$0.152	$0.157	$0.151	2.99%
O&M Costs per kW per Year	$20	$20	$20	2.00%

[44] The EPBB economic analysis assumes that customers paid their out-of-pocket cost with cash, though some customers used loans that add an additional cost due to interest. EPBB customer survey data shows that 60% of customers used cash, while 40% used a home equity loan, personal loan, credit card or other means.

[45] In EPBB Step 3, CEFIA began treating design factors greater than 87% as 100% for purposes of calculating incentives. This has the effect of increasing the overall average design factor.

[46] EIA Avoided Cost Rate, less $0.02/kWh, which reflects an approximate utility monthly service charge for a typical residential customer.

Table 14. Typical System Characteristics and Key Assumptions for Solarize CT PBI Projects

	PBI Flat Rate			PBI with Escalator			
	Steps 1 & 2	Step 3	Escalation	Steps 1 & 2	Step 3	Step 1 & 2 Escalation	Step 3 Escalation
Nameplate Rating (kW)	8.27	N/A		8.27	N/A		
CEC PTC Rating (kW)	7.12	N/A		7.12	N/A		
CSI Rating (kW)	5.46	N/A		5.46	N/A		
Design Factor	76.6%	N/A		76.6%	N/A		
Modified Design Factor	78%	N/A		78%	N/A		
Nameplate Installed Cost ($/W)	$3.86	N/A	-	$3.86	N/A		-
Cost/Watt-PTC Pre-Incentive ($/W)	$4.49	N/A		$4.49	N/A		
Average Incentive ($/W-PTC)	$2.07	N/A		$2.07	N/A		
Cost/ Watt-PTC Post-Incentive ($/W)	$2.42	N/A		$2.42	N/A		
Estimated Production (kWh/yr)	8,294	N/A		8,294	N/A		
Estimated Production (kWh/kW)	1,003	N/A		1,003	N/A		
Degradation (%/yr)	0.50%	0.50%		0.50%	0.50%		
Federal ITC (% project cost)	30%	30%		30%	30%		
Project Year	1	1		1	1		
Year Operational	2012	2012		2012	2012		
Month Operational	5	4		5	4		
Down/ Pre-payment	$5,898	$3,843		$0	$0		
PPA/Lease Rate ($/kWh)	$0.094	$0.11	0.00%	$0.13	$0.13	2.72%	3.03%
RSIP Avoided Cost to Customer ($/kWh)	$0.152	$0.154	2.99%	$0.15	$0.15	2.99%	2.99%
O&M Costs per kW per Year	$20	$20	2.00%	$20	$20	2.00%	2.00%

Table 15. RSIP Solarize CT Customer Financial Results

Metric	Discount Rate	EPBB			PBI Fixed Rate		PBI with Escalator	
		Step 1	Step 2	Step 3	Steps 1&2	Step 3	Steps 1&2	Step 3
Simple Payback (year)		N/A	9	11	N/A	N/A	N/A	N/A
IRR and NPV								
IRR			13.9%	10.3%	N/A		N/A	
NPV @	2%		$20,969	$15,520	$18,273		$4,992	
NPV @	4%	N/A	$14,116	$9,607	$13,935	N/A	$3,841	N/A
NPV @	6%		$9,275	$5,444	$10,880		$3,026	
NPV @	8%		$5,796	$2,464	$8,688		$2,439	
LCOE								
Total kWh produced			145,214	133,321	137,270		137,270	
LCOE ($/kWh) @	2%		$0.10	$0.12	$0.15		$0.20	
LCOE ($/kWh) @	4%	N/A	$0.10	$0.12	$0.13	N/A	$0.16	N/A
LCOE ($/kWh) @	6%		$0.09	$0.11	$0.11		$0.13	
LCOE ($/kWh) @	8%		$0.09	$0.11	$0.10		$0.10	

As of June 2013, 327 solar PV systems receiving a RSIP incentive were installed under the Solarize Connecticut (Solarize) program. Of these, 296 systems were installed under the EPBB of the RSIP, while 31 were installed using the PBI. Based on the data reported in PowerClerk, EPBB systems under the Solarize programs have a faster simple payback period than their non-Solarize counterparts by approximately two years and an installed cost 25% to 30% lower than similar non-Solarize systems. Both EPBB and PBI systems are also generally larger than installed systems not participating in Solarize; however, Solarize systems are also comparatively less productive on an annual kWh/kW basis. It should be noted that this is a relatively small sample size and that there were no Solarize participants in EPBB Step 1 or PBI Step 3 at the time of this analysis. Solarize appears to be effective in reducing the costs to customers and providing a better-than-average simple payback period.

Conclusions and Recommendations

Upon completion of the customer survey and a more in-depth analysis of customer's contract terms with third-party system owners, we found that EPBB participants, and PBI participants who made an up-front payment and did not have an annual escalation rate, had similar 20-year NPVs and LCOE, while PBI customers who did not make a down payment and had an escalating PPA rate had comparatively less advantageous NPV and a higher LCOE. Following our results from the customer survey, the simple payback period showed a fluctuation between Steps 1 and 3, with Step 2 yielding the shortest payback period. Although the payback period is slightly higher than in CEFIA's defined near-terms goals, the rapid deployment of solar PV installations throughout the state indicates that the payback period is reasonable.

An interesting trend shown in Table 12 is in the relative economic benefit of customer and third-party ownership models. We found that EPBB participants as well as PBI participants who made an up-front payment and did not have an annual escalation rate had similar 20-year NPVs and LCOE, while PBI customers who did not make a down payment and had an escalating PPA rate had a comparatively less advantageous NPV and a higher LCOE. It is to be expected that PBI-escalator participants would have a lower NPV because they are not required to risk any capital up front. It is interesting to note that when applying a discount rate greater than 2%, PBI-fixed rate participants begin to see a widening gap of greater economic benefits when compared to EPBB participants. Under a 4% discount rate, one commonly applied to consumer investing decisions, a customer purchasing a typical (i.e., 7kW) PV system and receiving a Step 3 EPBB incentive would have a LCOE of $0.13/kWh, which is below the competing utility rates, while a customer entering a PPA with the Step 3 PBI-Fixed Rate incentive would have a LCOE of $0.10/kWh. While both cases present a positive outcome, the third-party model with no escalation provides slightly better value to the customer, although the NPV for each system are comparable. However, this analysis is sensitive to the assumption regarding discount rate. Because PPA and lease arrangements assign costs (relatively) evenly over time, an increased discount rate has a greater impact on the LCOE results for these ownership scenarios, as compared with EPBB, where most of the costs are incurred up front.

Ultimately, depending on the RSIP incentive step and the discount rate chosen, either the EPBB or PBI-Fixed Rate could have a more favorable financial outcome. The similarity in the NPV and LCOE of these two scenarios indicates that CEFIA has met its goal of providing an equal value proposition for each ownership model.

Program Cost-Effectiveness

Methodology

Cadmus analyzed program costs and benefits from CEFIA's perspective, and therefore used the **Utility Cost Test (UCT),** also known as the **Program Administrator Cost Test (PACT)**. Benefits are in the form of reduced energy costs, while costs include any incurred administrative or direct incentive costs. There are several reasons the PACT is preferable over the Total Resource Cost (TRC) test for this program; the primary reason is that the benefits and costs are most closely aligned and quantifiable. Though the TRC may represent the broadest range of overall costs and benefits, there remain many benefits that are not easily or successfully quantifiable, such as non-energy benefits. The PACT uses inputs that are known and are directly quantifiable by the program administrator and evaluator, thereby reducing overall program evaluation cost and increasing certainty in the results.

Cadmus' results are presented in multiple ways, including:

- ***Benefit to Cost (B/C) Ratio:*** The ratio of program benefits to program costs. Benefits and costs are calculated over the life of the program, and discounted to reflect the time value of money. A B/C ratio greater than 1.0 indicates program benefits exceeded costs.
- ***Net Present Value (NPV):*** The difference between discounted program benefits and costs. An NPV greater than zero indicates program benefits exceed costs.

Table 16 and Table 17 summarize the assumptions underlying this analysis. Table 16 shows the discount rates used for the benefit-cost test.

Table 16. Discount Rates

Benefit-Cost Test	Discount Rate
PACT	2, 4, 6, 8%

Cadmus examined the results for discount rates of 2%, 4%, and 6%, all of which were similar to 8%. The discount rate of 8% presented in this analysis gives the most conservative results.[47]

Table 17 shows the avoided costs and avoided cost escalator used in this analysis. We calculated avoided costs through 2037, the last year of calculated benefits.

Table 17. Avoided Costs

2012 Avoided Cost ($/kWh)	Yearly Escalator
$0.152	2.99%

Table 18 and Table 19 show the incentive and administrative cost totals, broken out by incentive structure (PBI or EPBB) and year. Incentive costs for EPBB occur at the time of installation, while for PBI

[47] The 8% discount rate ends up discounting the benefits more than the costs, as the costs are assumed to be expended over six years, thus providing the most conservative results in terms of the benefit to cost ratio.

they occur over a six-year period to reflect how the payments are made. For administrative costs, Cadmus broke out totals between incentive structures based on the ratios of the total incentive costs. For EPBB, all administrative costs are assumed to occur in the first 12 months. For PBI, all inspection costs and 80% of other administrative costs occur in the first 12 months, while the remaining 20% occur over the next six years.

Table 18.Nominal Incentive Costs

Year	2012	2013	2014	2015	2016	2017	2018	Total
PBI	$533,673	$853,877	$853,877	$853,877	$853,877	$853,877	$320,204	**$5,123,263**
EPBB	$6,585,250	$3,951,150	$0	$0	$0	$0	$0	**$10,536,400**
Total	$7,118,923	$4,805,027	$853,877	$853,877	$853,877	$853,877	$320,204	**$15,659,663**

Table 19. Nominal Administrative Costs[48]

Year	2012	2013	2014	2015	2016	2017	2018	Total[49]
PBI	$157,148	$33,753	$5,133	$5,133	$5,133	$5,133	$5,133	**$216,566**
EPBB	$434,838	$80,284	$0	$0	$0	$0	$0	**$515,122**
Total	$591,986	$114,037	$5,133	$5,133	$5,133	$5,133	$5,133	**$731,687**

Table 20 shows the assumptions for the expected useful system life, installations by year and annual kWh savings.

Table 20. Expected Useful Life, Number of Installations and Savings by Incentive Structure

Incentive Structure	System Life (Years)	2012 Installations	2013 Installations	Total Installations	Annual kWh Savings per Installation	Total Annual kWh Savings
PBI	25	262	158	420	7,971	3,347,990
EPBB	25	624	375	999	9,077	9,068,403
Total				**1,419**		**12,416,393**

Results

PBI

PACT cost-effectiveness analysis results with and without the 10% non-energy benefits (NEBs)[50] adder are shown in Table 21. The PBI incentive structure passes under both scenarios.

[48] Administrative costs are CEFIA employee related costs, expenditures for PowerClerk software, and expenditures for system inspections done by third party inspectors.
[49] Note that some totals will not match due to independent rounding of values shown in table.

Table 21. PBI PACT Results

	PACT with NEBs	PACT
Present Value Benefits	$8,468,955	$7,699,050
Present Value Costs	$4,352,118	$4,352,118
Net Present Value Benefits	$4,116,837	$3,346,932
Benefit/Cost Ratio	1.95	1.77

EPBB

Table 22 shows PACT cost-effectiveness analysis results with and without the 10% Non-Energy Benefits adder. The EPBB incentive structure passes under both scenarios.

Table 22. EPBB PACT Results

	PACT with NEBs	PACT
Present Value Benefits	$22,261,102	$20,853,737
Present Value Costs	$10,752,897	$10,752,897
Net Present Value Benefits	$11,508,205	$10,100,839
Benefit/Cost Ratio	2.07	1.94

Conclusions and Recommendations

Both incentive structures pass the PACT test with and without non-energy benefits, with the EPBB incentive structure passing by a greater margin. The PACT scores achieved by the RSIP compare favorably with similar tests run on energy efficiency programs, such as the MassSAVE program by National Grid, with a PACT score of 1.72[51] (compared with RSIP scores ranging from 1.77-2.07), though energy efficiency and solar PV are different technologies, so comparisons should be made carefully. The important finding is that the program benefits substantially exceed costs for both incentive structures, indicating that the RSIP is a cost-effective program for CEFIA. Further analysis of the RSIP could account for load shapes and seasonal variations in the calculation of avoided costs, as well as capacity savings and capacity costs, to give further refined savings figures. Examining other cost-effectiveness tests, such as the Total Resource Cost Test, the Participant Cost Test, and the Rate-Payers Impact Test, would provide additional perspectives on the benefits and costs of the program to all the parties involved.

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[50] Quantifying NEBs if often difficult and costly, so an industry standard assumed NEBs value of a 10% adder is typically used. These benefits include environmental benefits such as water and carbon savings, increased air quality, and associated medial health benefits.

[51] http://www.epa.gov/cleanenergy/documents/suca/cost-effectiveness.pdf

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Appendix A: Key Assumptions for Financial Analysis

Nameplate system size	Typical system STC or nameplate size installed since beginning of program through June 2013. System sizes determined by calculating the average nameplate sizes of projects for each incentive level (EPBB Step 1, EPBB Step 2, EPBB Step 3, PBI Step 1, PBI Step 2, PBI Step 3). This information was drawn from PowerClerk.
PTC[52] system size	Typical system PTC size installed since beginning of program through June 2013. System sizes determined in two steps: 1) dividing the PowerClerk-generated PTC system size by the inverter efficiency for each project, then 2) calculating the average PTC size of projects for each incentive (EPBB Step 1, EPBB Step 2, EPBB Step 3, PBI Step 1, PBI Step 2, PBI Step 3). This PTC and inverter efficiency information was drawn from PowerClerk.
Design Factor	Typical system design factor since beginning of program through June 2013, drawn from PowerClerk. Design factor determined by calculating the average design factor of projects for incentive levels (EPBB Step 1, EPBB Step 2, EPBB Step 3, PBI Step 1, PBI Step 2, and PBI Step 3). The design factor was applied to these incentive levels.[53] The design factor reflects the azimuth, orientation, tilt and shading of the system.

[52] PTC is an alternative PV module rating scheme that differs from Standard Test Conditions (STC) used for module "nameplate" values. The PTC rating, which is generally lower than the STC rating, is recognized to be a more realistic measure of PV output because the test conditions better reflect real-world conditions. The PTC rating is used by programs in California, Connecticut, and elsewhere as the basis of incentive calculations. PTC refers to PVUSA Test Conditions, which were developed to test and compare PV systems as part of the PVUSA or Photovoltaics for Utility Systems Applications (formerly Photovoltaics for Utility Scale Applications) project. PTC are defined as 1,000 watts per square meter solar irradiance, 20 degrees Celsius *air* temperature, and wind speed of 1 meter per second at 10 meters above ground level. STC are based on 25 degrees Celsius *cell* temperature. The PTC rating differs in that its test conditions of ambient temperature and wind speed will result in a PV cell temperature of about 50 degrees Celsius, instead of the 25 degrees Celsius assumed for STC. Consequently, for crystalline silicon PV systems with a power degradation due to temperature of -0.5% per degree Celsius, the PV module PTC power rating is generally about 88% of the PV module STC or nameplate rating.

[53] Per 12/17/2013 conversation with Dale Hedman.

Modified Design Factor	Typical system modified design factor since beginning of program through June 2013. The modified design factor is determined in two steps: 1) each project with a design factor greater than 87% was rounded up to 100%-- all other projects remained at their starting design factor, and 2) by calculating the average modified design factor of projects. Note that this modified number, not the design factor, is used in the calculation for Step 3 EPBB and Step 3 PBI. The design factor information was drawn from PowerClerk, and the method for calculating the modified design factor was provided in communications from CEFIA.
Nameplate Installed Cost/W-STC	Typical cost to install a PV system since beginning of program through June 2013. Divided total nameplate project cost by watts (STC) installed for each project, and then calculated average cost to install for each incentive level (EPBB Step 1, EPBB Step 2, EPBB Step 3, PBI Step 1, PBI Step 2, and PBI Step 3). Total project cost and watts installed are from PowerClerk.
Cost/Watt-PTC Pre-Incentive	Typical system cost to install (on a PTC basis) since beginning of program through June 2013. Divided total nameplate project cost by corrected PTC Watts installed for each project, and then calculated average cost to install for each incentive level (EPBB Step 1, EPBB Step 2, EPBB Step 3, PBI Step 1, PBI Step 2, PBI Step 3).Total project costs are from PowerClerk, corrected PTC Watts calculated based on inverter efficiency information from PowerClerk.
Estimated Production (actual)	Typical system production. Individual production per project used as basis to calculate average per kW since beginning of program through June 2013. Calculated individually for each incentive level (EPBB Step 1, EPBB Step 2, EPBB Step 3, PBI Step 1, PBI Step 2, and PBI Step 3). This information was drawn from PowerClerk.
Degradation	0.50% per year. Number agreed to with CEFIA, based on CEFIA and Cadmus experience, and as typically used by solar PV analysts.
ITC	Homeowner (for EPBB incentives) and system owner (for PBI incentives) have the ability to fully monetize ITC in the first year of operation.
Depreciation	100% at 5 year Modified Accelerated Cost Recovery System (MACRS). Homeowner has no ability to use depreciation. System owner can fully use depreciation in year accrued.
EPBB Tax Impact	EPBB incentive decreases the ITC eligible basis of a project.

PBI Tax Impact	PBI incentive decreases the ITC and depreciation eligible basis of a project.
EPBB Limitation	For Step 3 only, the maximum incentive is 35% of the PTC cost of a project. Per 12/17/2013 conversation with Dale Hedman.
Loan	It is assumed that the system owner pays for the photovoltaic system outright, without using a loan
Avoided Cost of Electricity	Values obtained from the U.S. Department of Energy (DOE) Energy Information Administration (EIA) for residential electricity rates in Connecticut, using data from the months closest to the start of each RSIP Step. As the Connecticut utilities charge a fixed customer fee of approximately $16 per month, the EIA rates have been reduced by $0.02/kWh to account for the fact that this customer charge is billed regardless of net electricity consumption, so generation from the PV system does not offset the full residential rate.
Net metering	System output is less than on-site consumption on an annual basis
O&M	$20 per kW per year, consistent with NREL analysis , escalating at 2% http://www.nrel.gov/analysis/tech_cost_om_dg.html
PBI Incentive, Amount Paid	Total incentive paid to PBI project owners by CEFIA from beginning of program through June 2013. Information provided to Cadmus by CEFIA.
Incentives, PBI	Term of PBI incentive is six years. Step 1 and 2 are $0.30/kWh and Step 3 is $0.0225/kWh. The source for the $0.30/kWh incentive level information is "Rebate Level Changes by Program.xls" provided by CEFIA. The source for the Step 3 $0.0255/kWh incentive level is http://www.energizect.com/residents/programs/residential-solar-investment-program.

Incentives, EPBB	All incentives are divided into two groups: up to 5kW installed and above 5kW up to 10 kW installed. Up to 5kW receives a higher incentive that steps down for the next 5kW, and to zero above 10kW. The incentives for Step 1 are $2.45 up to 5 kW and $1.25 per watt greater than 5 kW, and up to 10 kW. The incentives for Step 2 are $2.275 up to 5 kW and $1.10 per watt greater than 5 kW, and up to 10 kW. The incentives for Step 3 are $1.75 up to 5 kW and $0.55 per watt greater than 5 kW, and up to 10 kW. The source for the incentive levels are “Rebate Level Changes by Program.xls” and an e-mail from Ed Kranich on 12/4/2013.
Discount Rate	Applied discount rates of 2%, 4%, 6%, and 8% to calculations of NPV and LCOE.
Useful Life of System	25 years
Calendar Year and Project Year	For the sake of simplicity, the typical project begins operation on January 1, 2013.
Salvage Value	Equal to system removal value (no economic salvage value)
Accrual	Incentive payments, net metering proceeds, and costs are expensed when accrued
Law	No change in law or market structure