NYSERDA Renewable Portfolio Standard Customer-Sited Tier Impact Evaluation Report: Solar PV and On-Site Wind Programs

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Prepared for

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EVALUATION OBJECTIVES AND RESEARCH APPROACH

The Cadmus Group, Inc., under contract to the New York State Energy Research and Development Authority (NYSERDA) has completed an impact evaluation of some of NYSERDA's Renewable Portfolio Standard Customer-Sited Tier (RPS-CST) programs, focusing on standard offer[1] solar photovoltaic (PV) and On-Site Wind-energy projects at homes and businesses in New York State. Other components of the RPS-CST program, namely fuel cells, anaerobic digesters and the competitive PV program (formerly known as the geographic balance program) component were not part of the scope of this evaluation effort.[2]

In order to track the electricity generated through the RPS funded PV and On-Site Wind projects, NYSERDA uses two methods:

- For PV projects NYSERDA currently employs a static capacity factor of 13.4%. Capacity factor is commonly used for PV, and other electricity generating technologies, to provide a measure of energy generation, normalized to total rated system capacity.
- For On-Site Wind projects, NYSERDA compiles semi-annual meter readings from customers and installers. These readings are taken from dedicated energy meters measuring the wind system's grid-connected electrical output.

For this evaluation, Cadmus:

1. Reviewed data for 2,909 PV systems and 79 On-Site Wind systems installed between January 1, 2008 and December 31, 2011,
2. Performed on-site measurement and verification for a sample of PV installations and
3. Conducted surveys of PV system owners to determine the attribution of observed generation to the program

This evaluation attempts to answer five key questions:

1. **Is NYSERDA accurately reporting PV generation using the current approach?** Cadmus analyzed measured data collected from site visits to evaluate the achieved energy generation for a statistical sample of completed PV projects. We compared these evaluated results to:
    a. Pre-installation estimates made by PV system installers
    b. The estimated generation reported by NYSERDA using an assumed capacity factor of 13.4%, as shown in Equation ES-1

[1] NYSERDA's standard offer PV programs provide incentives on a first come-first served, noncompetitive basis. NYSERDA's competitive PV program was not included in this evaluation.

[2] NYSERDA and Department of Public Service (DPS) staff agreed that it was not necessary or timely to evaluate the other technologies/areas of the RPS program. NYSERDA has funded the installation of 16 anaerobic digester (ADG) projects with RPS funds. Each funded ADG project includes online performance data tracking through NYSERDA's CHP website and these data are already used for reporting program impacts to the DPS. NYSERDA has funded only one continuous operation fuel cell with RPS funds and, like the digester projects, this fuel cell has online performance data tracking. Evaluating the Geographic Balance program component would be premature at this time given the program start date and progress thus far.

Equation ES-1. Calculation Used in Current NYSERDA PV Program Reporting

$$kWh_{reported} = kW_{capacity}\left(8760\ \frac{hrs}{yr}\right)CF$$

Where:

kWh_{reported}	=	Reported annual electricity generation in kilowatt hours (kWh)
kWcapacity	=	Nameplate DC capacity of the PV system in kilowatts (kW)
CF	=	13.4% NYSERDA assumed capacity factor

2. **Are meter readings supplied by the customer and installer an accurate way to track electricity generation for NYSERDA's RPS-CST PV programs?** NYSERDA collects readings of PV system generation meters from customers and installers every six months. Cadmus reviewed these self-reported generation data and compared these against the evaluated generation results. The results of this comparison are useful in helping NYSERDA determine the value of collecting these data and the applicability of these data for future program tracking and reporting needs.
3. **Do PV systems installed four or five years ago demonstrate any performance degradation that should be included in long-term energy generation projections?** In order to identify any system performance issues related to the age of the PV system, Cadmus conducted supplemental site visits of systems installed in 2008 to evaluate the persistence of energy generation from these older projects. This included looking for factors such as equipment failure rates that could indicate a change in performance as the system ages. These findings determine whether it is necessary to adjust long-term energy generation projections to account for performance degradation.
4. **How influential are NYSERDA's programs on customers' decisions to install PV systems?** Cadmus conducted a survey of program participants to determine the impact of the programs on their decisions to purchase and install their PV systems. We used the survey results to determine program freeridership and spillover rates and adjust the gross evaluated energy generation based on these factors. These results help NYSERDA understand the energy generation attributable to its RPS-CST PV programs and identify opportunities to claim additional energy benefits from its RPS-CST PV programs.
5. **Are On-Site Wind project installers accurately predicting electricity generation in incentive applications to NYSERDA?** Cadmus reviewed self-reported meter reading data for NYSERDA's RPS-CST wind projects and compared the results of that analysis with pre-installation performance predictions in NYSERDA's records to determine how well actual electricity generation compared to estimates made prior to installing the wind projects.

Table ES-1 summarizes the evaluation activities Cadmus conducted for this impact evaluation.

Table ES-1 Summary of Evaluation Activities Completed

Sector Stratum	Site Visit*	Freeridership Survey**	Spillover Survey**	Meter Reading Analysis	Persistence Site Visit*
Residential	23 (21)	46	50	Included as part of site visit and associated analysis	29 (27)
Non-Residential	48 (39)	34	39		7 (6)
0-15kW	6 (6)	8	9		6 (5)
15-30kW	15 (9)	6	8		1 (1)
>30kW	27 (24)	20	22		0 (0)
Self-Reported Generation	N/A	N/A	N/A	883-PV 53-Wind	N/A
Total	**71 (60)**	**80**	**89**	**883**	**36 (33)**

*Note that figures in parentheses are valid records resulting from the relevant activities. Factors such as incomplete surveys or unsuitable weather conditions for completing site visits may result in some activities not resulting in valid data points for analysis.

**Freeridership and spillover were both included in a single survey but completed results are reported seperately here, for clarity.

KEY FINDINGS

The results of this impact evaluation confirm that NYSERDA's current reporting methods accurately reflect actual program electricity generation. In particular:

For PV:

- NYSERDA is accurately reporting PV generation using the current assumed capacity factor of 13.4%. Through site visits and engineering analysis, we verified this figure and found that the 2,909 PV projects included in this evaluation are generating 37,611 MWh annually.
- RPS-CST funded PV systems are generally exceeding pre-installation performance predictions, achieving realization rates of 112% and 110% for the residential and nonresidential sectors, respectively.
- Customer-supplied PV meter readings demonstrate an overall capacity factor of 13.7%, which agrees very closely with the 13.4% currently used by NYSERDA and verified through this evaluation.
- PV systems installed in 2008 show no signs of performance degradation and achieved a similar, but slightly higher, capacity factor of 14.4% as compared with the overall population. While the data available is not conclusive, this may be due to a higher average tilt angle, which slightly increases annual generation and reduces losses due to snow cover.

NYSERDA's RPS-CST PV program is critical to driving the installation of PV systems on New York State homes and businesses. We found an overall freeridership rate for RPS residential and non-residential PV systems of 4.3%, which indicates that nearly all of the electricity generated by RPS-CST funded PV projects is directly attributable to NYSERDA's program. Some customers also indicated that their participation in the RPS-CST PV program prompted further energy-saving activity (e.g., installing more energy-efficient appliances), resulting in an additional 1% energy savings that can be attributed to NYSERDA's RPS-CST PV programs. Net to Gross (NTG) is a measure of the program's influence on equipment adoption, including a quantification of what would have happened naturally outside of the program (freeridership) and additional energy efficiency upgrades undertaken by customers due to participation in the program (spillover). The overall NTG is 96.6%.

We have summarized the PV evaluation gross generation results in Table ES-2, below. There is very close agreement among the three methods for calculating population-wide electricity generation.

The Net to Gross is calculated from the Freeridership and the Spillover using Equation ES-2.

Equation ES-2: Net to Gross Ratio Calculation Method

$$NTG = 100\% - Freeridership\ \% + Spillover\ \%$$

Table ES-2 Summary of RPS-CST PV Gross Electricity Generation Results

Basis	Capacity Factor	Population Installed Capacity (kW)	Population Annual Gross Energy Generation (MWh)	Sampling Precision (90% Confidence)
Current Reporting Method Employed by NYSERDA	13.4%	32,041	37,611	N/A
Evaluated Gross Generation Result	13.4%		37,611	4.3%
Self-Reported Meter Readings*	13.7%		38,453	2% **

*There were 883 sites out of 2,909 with more than a year of meter readings

**The sampling precision shown compares a census of sites with sufficient self-reported meter reading data for analysis with the overall population of 2,909 projects.

The ratio of net to gross generation (NTG ratio) is 0.966, indicating that nearly all of the gross generation indicated in Table ES-3 is attributable to the RPS-CST PV program. Based on the evaluated gross generation, 36,332 MWh per year is attributable to NYSERDA's programs.

Table ES-3. RPS-CST PV Program Net Electricity Generation Results

	Gross Generation (MWh)	Freeridership	Spillover	NTG Ratio	Net Generation (MWh)
RPS-CST PV Program	37,611	4.3%	0.9%	0.966	36,332

For On-Site Wind:

- Installers of On-Site Wind projects are successfully predicting electricity generation, despite the challenges of siting and the limited availability of wind resource data. The evaluated electricity generation was nearly identical to pre-installation predictions included in NYSERDA's records, after accounting for relevant trends in local weather. The 79 On-Site Wind projects included in this evaluation are generating 838 MWh per year.

The On-Site Wind program achieved a realization rate of 1.00 and a gross annual generation of 838 MWh.

CONCLUSIONS AND RECOMMENDATIONS

Overall, NYSERDA's RPS-CST PV and On-Site Wind programs are performing as expected and the current reporting method appears to be reasonable. Based on this, and the other findings of this evaluation, we recommend that NYSERDA:

For PV:

1. **Continue reporting PV generation based on a single capacity factor value.** This metric is both simple to track and compares well with evaluated results.
2. **Continue requiring self-reported meter readings.** The values from these readings, which are obtained at almost no cost to NYSERDA, appear to be an accurate representation of actual achieved energy generation for the program. While there is no reason to discontinue the current practice of reporting total generation using a single capacity factor, these meter readings provide NYSERDA with a cost-effective means of updating the assumed overall capacity factor to reflect changes in technology and installation practices.
3. **Quantify the benefits of energy-saving behaviors influenced by the programs.** This study shows that there is spillover benefit attributable to NYSERDA's RPS-CST PV programs. While we were able to quantify the energy savings from direct equipment installation and retrofit activities in this study, information on behavior changes (such as adjusting thermostat settings) was not available. Such research may identify additional benefits attributable to the programs.

For On-Site Wind:

1. **Continue requiring self-reported wind site meter readings.** The values from these readings, which are obtained at almost no cost to NYSERDA, appear to be an accurate representation of actual achieved energy generation for the program.

Section 1:

INTRODUCTION

1.1 PROGRAM DESCRIPTION AND PARTICIPATION

This impact evaluation includes solar photovoltaic (PV) and wind projects funded, using Renewable Portfolio Standard (RPS) funds, through several Program Opportunity Notices (PONs). This evaluation only applies to NYSERDA's Customer Sited Tier (CST) projects, installed on the load side of customer utility meters at residential, commercial, institutional, and industrial sites across New York State. NYSERDA's main tier programs, which support larger generation facilities, were not included in this study. This section provides a brief overview of the PONs with projects included in the study.

RPS-CST incentives were provided for the installation of solar electric or PV systems under three Program Opportunity Notices (PONs)—716, 1050, and 2112. These projects must be seven kW or less for residential and 50 kW or less for non-residential sites. New York State RPS funds are allocated for the Solar Electric Incentive Program on a first-come, first-served basis, for applications received through December 31, 2015.

RPS-CST incentives have been provided for on-site wind projects since 2003 under PONs 792, 1098, and 2097. Wind incentives are available for residential, commercial, institutional, and government-owned facilities 2 MW or smaller (prior to 2011, the cap was 600 kW).

We have summarized relevant information about the PONs with projects included in this study in Table 1-1. Note that this study includes RPS-CST funded projects installed prior to December 31, 2011.

Table 1-1. NYSERDA's RPS-Funded Activities Included in Evaluation

Technology	PON	Application Acceptance Dates
Solar PV	716*	10/28/2002-3/14/2008
	1050	3/14/2008-6/30/2010
	2112	7/1/2010-12/31/2015
On-site Wind	792*	5/12/2003-3/30/2007
	1098	4/16/2007-6/30/2010
	2097	10/4/2010-12/31/2011

Note: Several other technologies are included in the RPS-CST programs but only Solar PV and On-Site Wind are in the scope of this evaluation

*Largely funded with System Benefits Charge (SBC) funds, included some RPS-CST funded projects.

1.2 EVALUATION GOALS AND METHODOLOGY

The goals of this evaluation are to:

For PV:

- Calculate the energy generation (MWh) and installed capacity (MW) of the RPS-CST projects installed through the end of 2011. Sampling precision will be at least 10% at the 90% confidence interval[3].
- Assess the accuracy of estimates of energy generation using actual production data for RPS-CST PV projects.
- Calculate the capacity factor for RPS-CST solar PV projects within the sample and assess the accuracy of the pre-installation electricity generation estimates. Document the sources of any discrepancies and, if warranted, recommend measures to improve accuracy.
- Compare the capacity factor for electricity generation of both the self-reporting population and one derived from a statistical sampling method, as described in Section 2.2. Note any possible bias or other relevant patterns in the data for self-reported electricity generation.
- Conduct field inspections for a sample of RPS-CST PV projects in order to collect meter readings, analyze the reasons actual energy production deviates from expected, and administer an attribution survey.
- Assess the persistence of RPS-CST PV systems' generation over time by analyzing a separate persistence sample of RPS-CST PV projects installed in 2008.

For On-Site Wind:

- Calculate the energy generation (MWh) and installed capacity (MW) of the RPS-CST funded On-Site Wind projects installed through the end of 2011. Sampling precision will be at least 10% at the 90% confidence interval for wind.
- Assess the accuracy of estimates of energy generation using actual production data On-Site Wind projects.

In order to accomplish these goals, Cadmus evaluated RPS-CST PV and On-Site wind projects separately, using the data available for analysis and the metrics and methods most appropriate to the individual technology. The specific methods we employed for each technology are summarized in the following sections.

1.3 REPORTING METHODS CURRENTLY EMPLOYED

NYSERDA presently reports PV energy generation attributable to its RPS-CST funded programs to the Department of Public Service (DPS) by multiplying the total installed capacity (kW_{DC}) by an assumed capacity factor of 13.4% as shown in Equation 1-1. The source of the NYSERDA capacity factor was not available for review during this study. For this evaluation, Cadmus determined an evaluated capacity factor and compared that value with the 13.4% value NYSERDA is currently using.

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[3] This metric, often expressed as 90/10 indicates a 90% confidence that the overall population results will be within 10% of those found for the statistical sample

Equation 1-1. Calculation of PV System Generation to DPS

$$kWh_{reported} = kW_{capacity}\left(8760\ \frac{hrs}{yr}\right)CF$$

Where:

$kWh_{reported}$	=	Reported annual electricity generation in kilowatt hours (kWh)
kWcapacity	=	Nameplate DC capacity of the PV system in kilowatts (kW)
CF	=	13.4% NYSERDA assumed capacity factor

For On-Site Wind projects, NYSERDA reports annual generation using customer-reported meter readings. Sites that do not have a customer-reported meter reading are reported using the pre-installation estimate of annual generation.

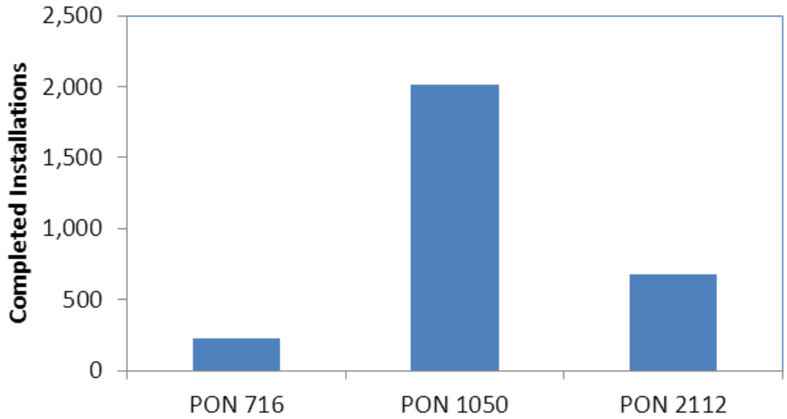
Section 2:

SOLAR PHOTOVOLTAIC EVALUATION

2.1 APPROACH OVERVIEW

During the 2008-2011 study period, NYSERDA's RPS-CST funded PV programs, through PONs 716, 1050, and 2112, supported the installation of 2,909 PV projects. We have summarized the breakdown of projects funded by each PON in Figure 2-1**.** For all RPS-CST funded PV projects, NYSERDA reports electricity generation to the New York State Department of Public Service (DPS), on an annual basis, using an assumed capacity factor of 13.4%.

Figure 2-1: Population Breakdown by PON



Our evaluation of NYSERDA's RPS-CST funded PV programs has four key components:

- **Evaluated Gross Generation:** Cadmus analyzed data from site visits to evaluate the achieved energy generation for a statistical sample of completed PV projects. Using the resulting energy generation and realization rate, as described in Section 2.2, we determined population-wide annual energy generation and compared them to pre-installation estimates made by PV system installers and generation reported by NYSERDA using an assumed capacity factor of 13.4%.
- **Self-Reported Gross Generation:** NYSERDA has been collecting readings of PV system generation meters from customers and installers every six months for several years. Cadmus reviewed these self-reported data and compared these against the evaluated gross generation results of the site visits. The results of this comparison may be useful in helping NYSERDA determine the value of collecting these data and the applicability of these data for future program tracking and reporting needs.
- **Persistence of Generation:** In order to identify any system performance issues related to the age of the PV system, Cadmus conducted supplemental site visits, in addition to those included in the evaluated gross generation sample for systems installed in 2008. These findings may be useful,

should it be necessary to adjust long-term energy generation projections to account for performance degradation.

- **Net Generation:** Using results from analyses of survey data, Cadmus adjusted the evaluated gross generation to account for factors such as freeridership and spillover[4]. These results may help NYSERDA identify opportunities to claim additional energy savings benefits from its RPS-CST PV programs.

To achieve the goals of this evaluation, Cadmus conducted these main activities: site visits, paper surveys, and an analysis of self-reported meter readings.

<u>Site Visits</u>

Cadmus' field inspectors, who have technical backgrounds in renewable energy, visited each site in the samples to investigate the following factors:

- Inventory of equipment installed
- Physical system characteristics (tilt, orientation, etc.)
- Factors affecting system performance (shading, equipment failure, etc.)
- System operational history and downtime, if applicable

Field inspectors conducted informal interviews with system owners to gather background data. Field inspectors generally assessed system characteristics visually. Other characteristics—such as system tilt, orientation, and shading—were measured at the site. Shading was measured with the Solmetric SunEye and Solar Pathfinder™ tools. For each completed site visit, Cadmus calculated the annual reduction in expected energy output due to shading, tilt, and orientation factors.

One of the most important tasks of the field inspection was to verify reasonable system operation. The inspectors established the operational period energy output from the on-site meter reading and confirmed the system interconnection date. They then compared the energy output reading with a weather-adjusted estimate derived from the System Advisor Model (SAM)[5]. Cadmus then adjusted the SAM, which relies on assumptions for system losses and component efficiencies, to match real-world conditions for the location, application, and operational period of evaluated projects.

Inspectors recorded all of the site visit data in real-time using a proprietary online field data collection system on hand-held tablet computers. They verified, and uploaded these data to a central database for review by project analysts, who in turn verified the data quality and identified any missing or incomplete data. Where necessary, field inspectors followed up with on-site representatives and other key stakeholders to obtain complete records for each site visit. Descriptions of the systems in each sample, including the county each is located and general specifications, can be found in the Appendix A.

<u>Survey</u>

Cadmus provided each site visit customer either an electronic or, if requested, paper survey. The purpose of the survey was to determine program attribution, focusing on such subjects as the influence of the program on the customer's decision to install a solar PV system, and any additional activities taken to

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[4] Freeridership indicates how many participants would have installed PV projects without the program and spillover indicates extra energy savings attributable to the programs through activities such as installing energy efficiency measures

[5] Information about SAM can be found online at: https://sam.nrel.gov/

reduce or increase energy consumption. The survey was reviewed and collected during the site visit by the field inspector in most cases.

<u>Meter Reading Analysis</u>

NYSERDA's solar PV incentive programs require that PV system generation be tracked by recording the readings from an onsite meter. The meter readings must be conducted by the installer or customer at least every six months. Power production data is submitted directly into PowerClerk two times per year for three years for each installed system. Cadmus analyzed these self-reported generation readings to establish the system-installed capacity and operational period. Cadmus then determined the annualized electricity output of the reporting systems and the overall capacity factor.

All of Cadmus' solar PV-related activities are summarized in Table 2-1, below.

Table 2-1. Summary of Activities: RPS-CST Solar PV Evaluation

Sector Stratum	Site Visit	Survey	Meter Reading Analysis	Persistence Site Visit
Residential	23 (21)	46	Included as part of site visit and associated analysis	27
Non-Residential	48 (39)	34		6
0-15kW	6 (6)	8		5
15-30kW	15 (9)	6		1
>30kW	27 (24)	20		0
Self-Reported Generation	N/A	N/A	883	N/A
Total	**71 (60)**	**80**	**883**	**33**

*Note that figures in parentheses are the number of valid records resulting from the relevant activities.

Note that not all surveys and site visits resulted in valid data points for analysis. For example, out of 47 nonresidential site visits conducted, 39 valid records were obtained. Some causes for a site visit to result in unusable data were:

- Inability to gather all necessary data while on site due to access restrictions, adverse weather conditions, or other factors.
- Inability to obtain valid generation meter reading due to metering equipment malfunction or meter turnover.
- Inconsistent system startup date due to conflicting information in NYSERDA program records, customer records, or field observations.

Some surveys also did not result in usable data points. This was primarily due to customers not properly completing all survey questions. Although field technicians attempted to review surveys with customers prior to leaving the site, this was not always possible because:

- Site visit representatives were not always the same as the person who had prepared the survey.
- Some customers chose to mail or e-mail surveys, rather than deliver them during site visits.
- Time constraints prevented the customer and technician from reviewing the survey during the site visit.

If the survey or site visits resulted in unusable data, Cadmus attempted to clarify information in a follow-up phone call or e-mail whenever possible.

The following sections are organized to follow the main four components of our evaluation of NYSERDA's RPS-CST PV programs, with subsections devoted to evaluated gross generation, self-reported gross generation, persistence findings, and net generation respectively. Each section includes more details on the relevant calculations and methods outlined in this section, as well as results and findings. Overall results and recommendations for NYSERDA's RPS-CST PV programs are in Section 2.6.

2.2 EVALUATED GROSS ENERGY GENERATION

The following subsection describes the gross energy generation determined using the site visit data and associated engineering analysis, as described below. Gross energy generation for self-reported and persistence samples are discussed in subsequent sections.

2.2.1 Calculations and Secondary Data

This section summarizes Cadmus' calculations and secondary data sources for calculating gross energy generation for the RPS-CST PV program.

2.2.1.1 Population and Sampling

Cadmus began this study by obtaining from NYSERDA a MS Excel® file that contained relevant solar PV project information such as installation date, funding program, system capacity, *ex ante* electrical generation, and other details. To establish the population and select a sample relevant to this study, Cadmus completed several steps:

- Removed any projects installed after December 31, 2011.
- Sorted data set by sector and, for the nonresidential sector, by installed capacity.
- Established an assumed coefficient of variation (CV), based on Cadmus' experience evaluating solar PV programs.
- Developed sample sizes that met NYSERDA's requirement for 90% confidence and 10% precision, as well as qualitative requirements for representation of a range of system capacities in both the residential and nonresidential sectors.

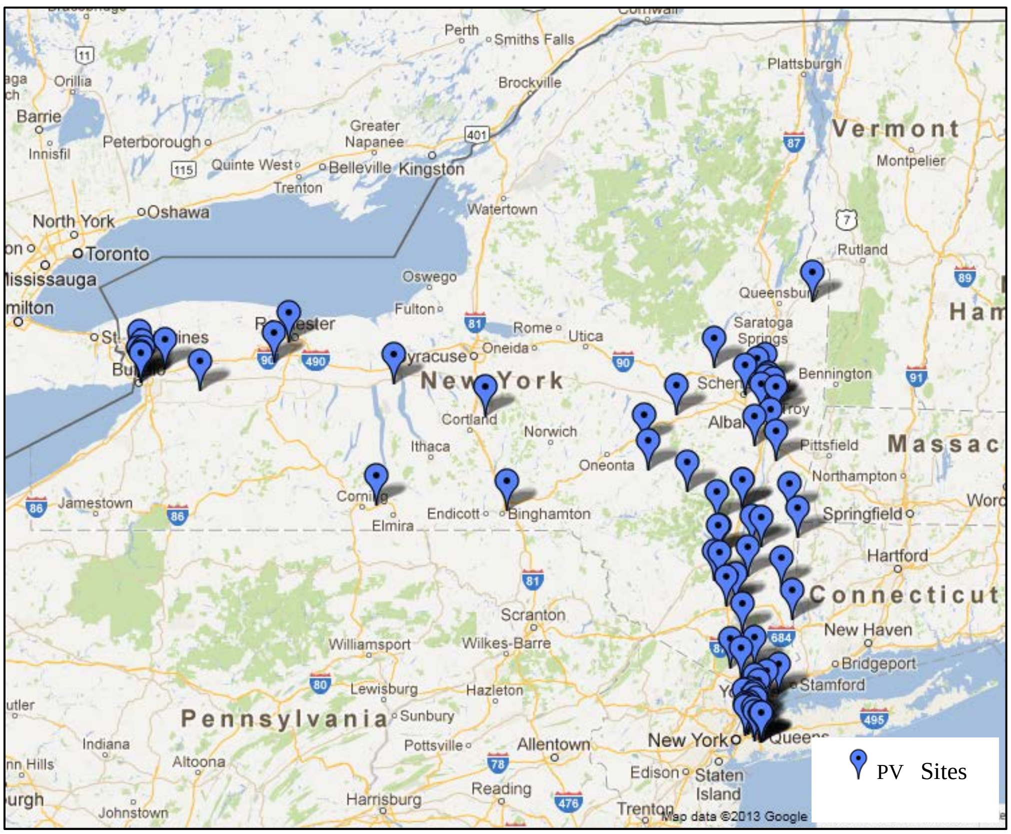
These steps resulted in the sampling plan presented in Table 2-2. Note that the assumed CV for residential PV is higher than that assumed for nonresidential. This accounts for a higher expected variability in shading conditions among residential installations, which often contain complex sloped roofs and significant tree cover. Nonresidential PV systems, however, are more frequently installed on large, flat roofs with minimal shading.

Table 2-2. RPS-CST PV Site Visit Sampling Plan

Sector Stratum	Population (Projects Completed) 2008-2011)	Installed Capacity (kWdc)	Site Visits	Assumed CV	Expected Precision
Residential	**2,126**	**11,518**	**23**	**0.45**	**15%**
Non-Residential	**783**	**20,523**	**47**	**0.30**	**7%**
0-15kW	269	2,102	5		
15-30kW	279	6,443	15		
>30kW	235	11,978	27		
Total	**2,909**	**32,041**	**70**	**0.35**	**10%**

Figure 2-2 displays the location of solar PV site visits selected for the evaluation sample.

Figure 2-2. Site Visit Locations in RPS-CST Solar PV Evaluated Gross Generation Sample



2.2.1.2 Calculating Annual Energy Production

Cadmus calculated the annual energy production (AEP) at each site using NREL's SAM software. SAM uses typical meteorological year (TMY3) data files, along with relevant information such as system capacity, losses, shading, tilt, location, and orientation to estimate, among other things, the AEP of PV systems. This tool is widely accepted and used in the solar industry.

Using SAM requires several user-entered inputs, most of which were derived during site visits. We employed several additional assumptions, based on Cadmus' solar industry experience and other sources, as listed in Table 2-3**.**

Table 2-3. AEP Modeling Assumptions

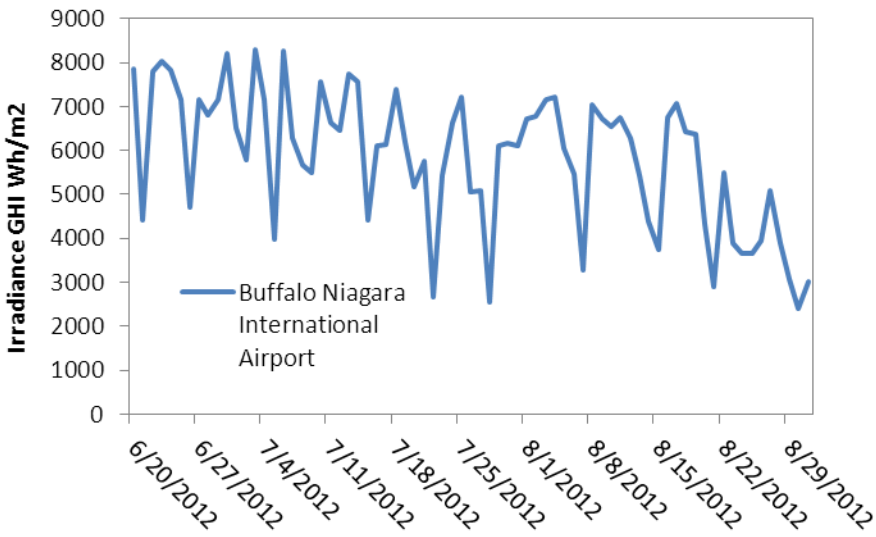
Assumption	Value	Reference/Source
System Installed Capacity (kW_{DC})	Varies	Site visit results/NYSERDA program records
System Location	Varies	Site visit results
Tilt/Orientation	Varies	Site visit results
AC/DC Derate Factor*	0.77	SAM default value
Shading	Varies	Site visit results

* This derate factor accounts for losses due to wiring, AC/DC electrical conversion, and other PV system inefficiencies

2.2.1.3 Normalization of Energy Production Using Long-Term Weather Station Data

Analyzing meter readings from PV systems without considering the available solar resource during the system's operational period is analogous to measuring the fuel economy of a car without knowing how much gas was consumed for a given distance. The solar resource varies over time due to clouds, long-term weather patterns, solar activity, and other factors, as shown in Figure 2-3**.**

Figure 2-3: Graph of Daily Average Irradiance at Buffalo Niagara International Airport



To calibrate each site's PV generation performance to actual weather data, the Cadmus team obtained total horizontal solar radiation data. We used measured global horizontal irradiance data from 8 applicable weather stations, purchased from the Solar Data Warehouse (SDW) [6]. We selected the appropriate actual weather data for each site based on the nearest linear distance between the site and the weather station.

Cadmus also used TMY3 weather files from the National Solar Radiation Database (NSRDB[7]). These files are 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 consistently applied to predict PV system energy output, using tools such as PVWatts or commonly available shading assessment tools. As with the historical solar radiation data, Cadmus selected the nearest TMY3 weather station based on proximity to each PV system. (A list of the TMY3 and SDW data station locations is provided in Appendix B.)

Figure 2-4. Map of Weather Station Locations Used

[6] Solar Data Warehouse: http://www.solardatawarehouse.com/.

[7] 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/

Once each site visit was paired with the relevant weather station, we completed the following steps for each site:

- Calculated the total global horizontal irradiance (GHI) over the PV system 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 2-1.
- Used the weather and modeling factor (R_{model})-adjusted AEP estimates to obtain the evaluated *ex post* AEP for the site

Equation 2-1. 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}	=	Estimated operational period electricity generation, 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 2-2 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

2.2.1.4 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 2-3.

Equation 2-3. 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 **2-4**.

Equation 2-4. 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)

2.2.2 Solar PV Results

This study has produced several key findings, including:

- The evaluated gross sample is generating electricity with a capacity factor of 13.4%.
- Evaluated PV systems are generating more electricity than expected, with a realization rate of 110% compared with pre-installation AEP estimates.
- The evaluated sample has an overall precision of 4.3% at 90% confidence.

Overall evaluated gross generation results are listed in Table 2-4. While there is a range of resulting realization rates, the programs are, overall, producing more electricity than indicated by pre-installation estimates provided by PV installers in incentive applications.

Table 2-4. Evaluated Sample Gross Generation Results

	Site Visit	Capacity (kW)	*Ex Post* Generation (kWh)	*Ex Ante* Generation (kWh)	Realization Rate	Capacity Factor
Residential	21	111	140,649	125,159	1.12	0.145
Non-Residential	39	1,397	1,635,507	1,493,519	1.10	0.134
0-15kW	6	35	34,712	35,401	0.98	0.113
15-30kW	9	199	229,974	197,780	1.16	0.132
>30kW	24	1,163	1,370,821	1,260,338	1.09	0.135
TOTAL	60	1,508	1,776,156	1,618,678	1.10	0.134

The reported energy generation uses the existing capacity factor of 13.4%. Cadmus' evaluated sample verified this result, with an overall evaluated capacity factor of 13.4%. Residential sites obtained a slightly higher capacity factor than nonresidential sites but this had only a small effect on the overall capacity-weighted result due to the generally larger capacity of the nonresidential sites. The higher capacity factor of the residential sites is likely caused by a generally steeper tilt angle, which both increases energy capture and reduces loss due to snow buildup.

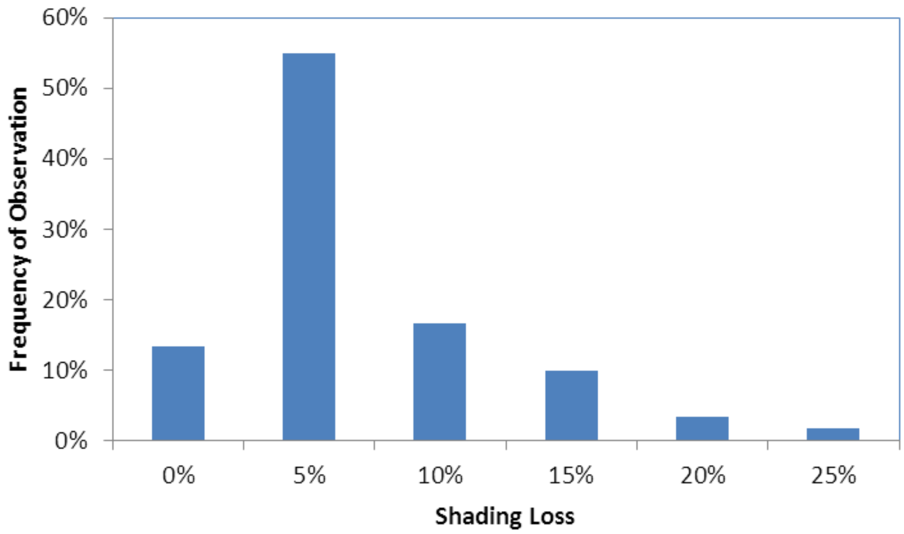
When the evaluated capacity factor of 13.4% is applied to an installed capacity of 32,041 kW (for the population of 2,909 installations included in this study), the result is 37,611 MWh annual energy generation.

2.2.2.1 Shading Related Findings

In addition to the evaluated generation and capacity factor, we also found several interesting trends related to the PV installations completed under the RPS-CST programs, including:

- Average losses due to shading are 6.2% and 4.2% for residential and nonresidential projects, respectively. The overall average was 4.9%.
- Shading losses appear to be decreasing over time (i.e., less for more recent projects as compared to older projects), likely reflecting the fact that installers are gaining more experience in the program and with solar site assessment in general.
- The majority of sites had shading losses of 0% to 5%, with a range of 0% to 24% shading losses observed in the evaluation sample. The distribution of shading losses observed in the sample is shown in Figure 2-5.

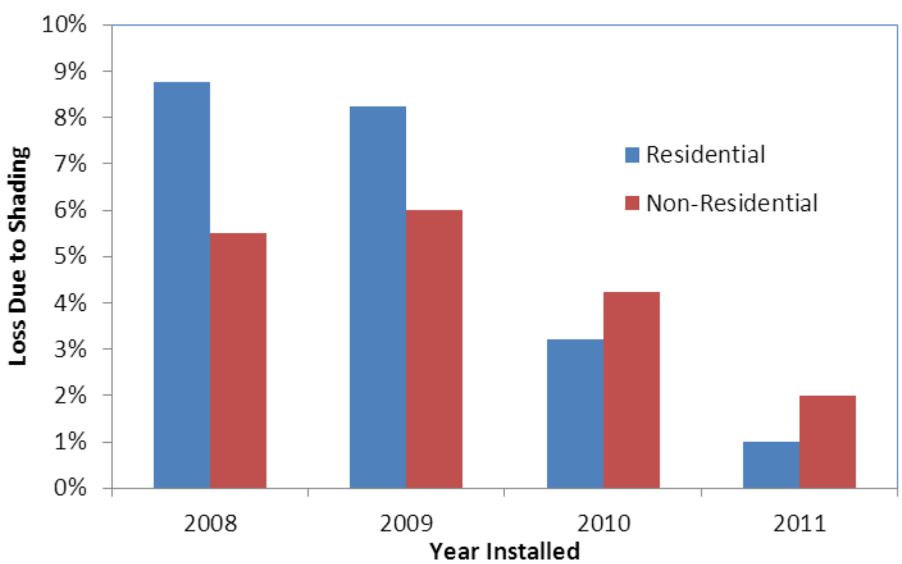
Figure 2-5. Distribution of Shading Losses Observed



Shading losses, measured during site visits, showed an interesting trend. Based on the year installed, we found that average losses due to shading, as a percentage of total system energy output, are decreasing over time.

In 2008, shading losses in residential PV systems were approximately 9%, on average. In 2011, however, those losses were closer to 1%. We found a similar trend for nonresidential PV systems, as shown in Figure 2-6.

Figure 2-6. Trends in PV System Shading Losses by Year Installed



2.2.2.2 Trends in Equipment Installed

The breakdown of equipment used in RPS-CST funded projects is led by SunPower, Inc., Kyocera Solar, Inc., and Sharp® for PV modules and SunPower, Inc., SMA America LLC, and Satcon® for inverters, as shown in Figure 2-7 and Figure 2-8. The PV marketplace has undergone significant changes in recent years, however, so these breakdowns likely do not reflect projects installed in 2012 and 2013.

Figure 2-7. Breakdown of Installed PV Modules in Evaluated Sample

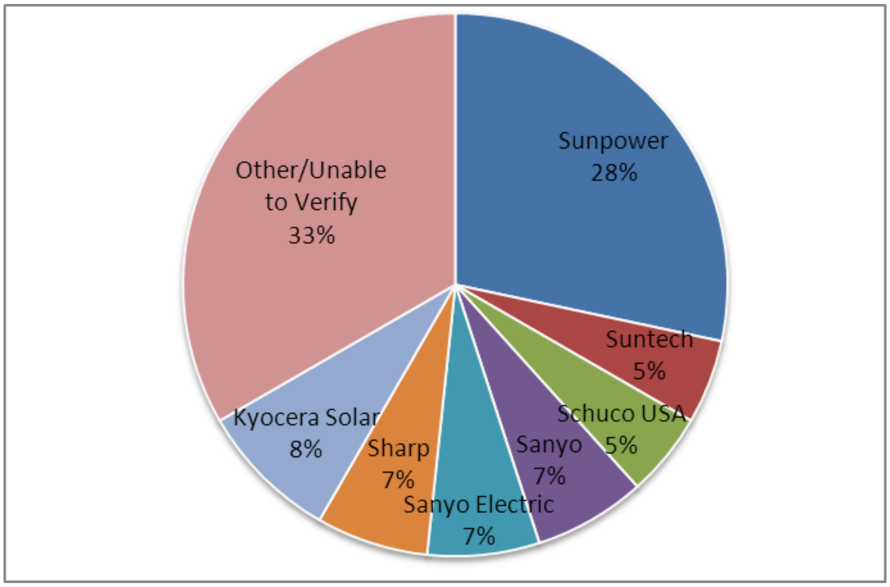
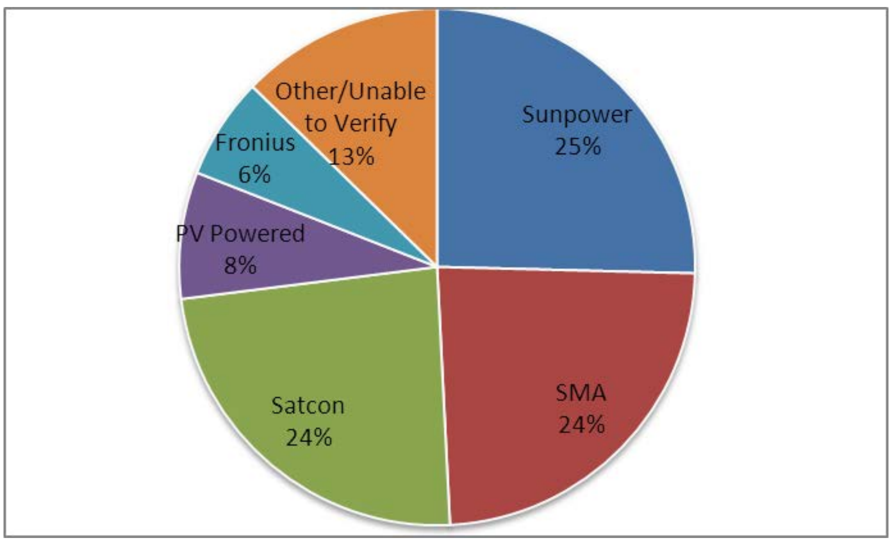


Figure 2-8. Breakdown of Inverter Manufacturer in Evaluated Sample



During site visits, Cadmus checked the equipment against NYSERDA program records and verified that 99% match program records, with only one project found with a module installed that did not match program records.

2.3 SELF-REPORTED GROSS GENERATION

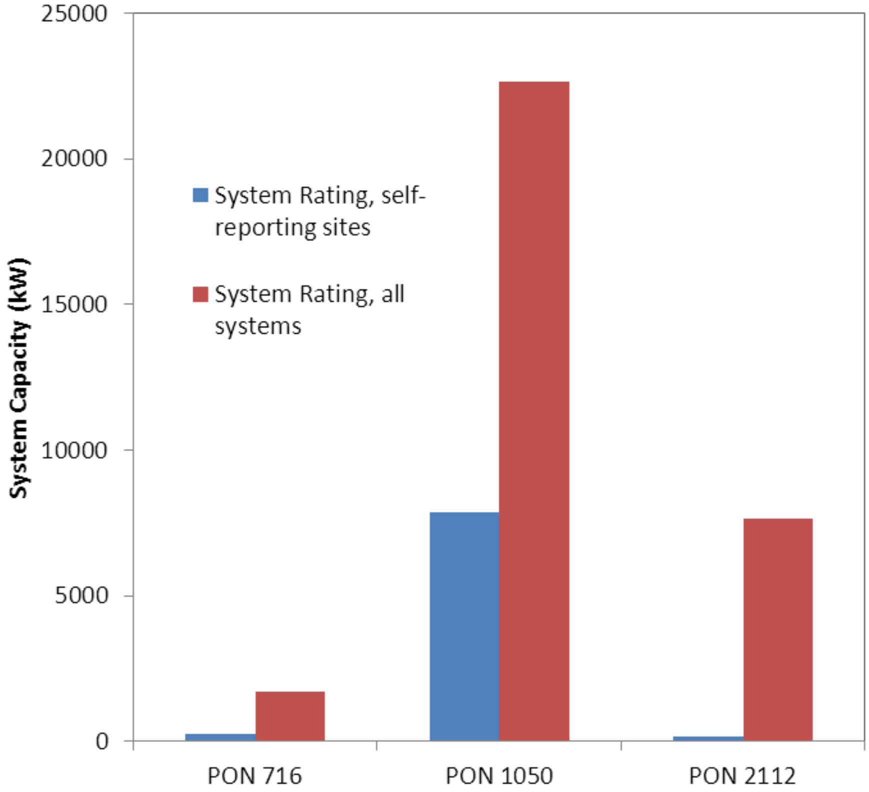
As a requirement of NYSERDA's solar PV incentive programs, customers or installers submit regular readings taken from dedicated electricity production meters. The meter readings must be conducted by the installer or customer at least every six months. Power production data is submitted directly into PowerClerk two times per year for three years for each installed system. The meters, installed as a program requirement, monitor the alternating current (AC) output of the solar PV system, net of any standby electricity consumption of the balance of system components (e.g., inverter).

These meter readings present a potentially valuable source of information for tracking program performance, reporting program benefits, and evaluating cost-effectiveness. At this point in time, 883 out of 2,909 systems are reporting one year, or more, of electricity generation, the majority of which come from PON 1050, as shown in Figure 2-9. Unlike projects in PON 2112, projects completed under PON 1050 have had several years to provide the required reporting and it is likely that the reporting rate for PON 2112 will likewise increase over time. Furthermore, the sample size already obtained through NYSERDA's customer-reported meter readings is far in excess of the sample size required to obtain the 90/10 confidence and precision required by Commission's April 2, 2010 Order[8].

While 883 reporting sites is a substantial sample size for evaluation, it is not necessarily a random sample and there is potential for bias. For example, some installers support their customers by compiling and sending meter readings to NYSERDA and regularly comparing system performance to expectations. These installers may tend to be better represented in the self-reported sample than installers that provide minimal support and follow-up in the post-installation phase.

[8] DPS Case Number 03-E-0188, which can be accessed at: http://documents.dps.ny.gov/public/Common/ViewDoc.aspx?DocRefId=%7BC05CD0D6-8EA5-4CB9-A9FA-6ADD3AECB739%7D

Figure 2-9: Self Reporting Sites Capacity and Number of Sites



To evaluate this bias, Cadmus has analyzed the self-reported meter readings to calculate an overall capacity factor for the self-reporting sample of 883 projects, as described in the next section. Following that analysis, Cadmus compared this result with the overall capacity factor calculated from a random sample, as described in Section 2.2.2.

2.3.1 Calculations

From the customer self-reported data for the PV sites in PONs 716, 1050, and 2112 installed from 2008 through the end of 2011, 883 have reported meter readings for one, or more, years of operation. Production data were obtained via monthly energy production meter readings. The capacity factor was determined by Equation 2-5**.**

Equation 2-5. Calculation of capacity factor of each system

$$CF = \frac{kWh_{actual}}{kW_{System} * P_{operational} * \left(\frac{8760\ hours}{year}\right)}$$

Where:

kWh_{actual} = Cumulative electricity production meter reading for an operational period longer than one year

kW_{System} = System rating –DC (kW).

$P_{operational}$ = Operational period that the meter reading covers and that is longer than one year, expressed as a decimal number of years

Normalizing a large set of meter readings to applicable weather patterns, as outlined in Section 2.2.1, would be a time-consuming and difficult process that would likely not be feasible for NYSERDA to complete on a regular basis. Therefore, Cadmus has foregone weather normalization of these results and, instead, simulated a hypothetical reporting process on these self-reported data.

2.3.2 Results

Cadmus calculates the average capacity factor for the 883 sites is 13.7%, as shown in Table 2-5. This result is very close to the value of 13.4% currently in use in NYSERDA's reporting process (and confirmed through this evaluation) and suggests that the assumed capacity factor currently used is a reasonable value.

Based on the achieved CV from the evaluated PV sample (0.20), the results from the meter readings have a precision of 2% at 90% confidence. The calculated capacity factor based on the self-reporting sample is approximately 2% higher than that found in the evaluated gross generation sample. Given that no weather normalization was applied to these meter readings, this value appears to be consistent with both the evaluated gross generation result and the value that NYSERDA is currently using to report energy generation to DPS.

Table 2-5. Summary of Results for Self-Reporting Sample

Number of Sites	System Rating, kW_{Dc}	Operational Period, Years	Meter Readings Total kWh	Average of Capacity Factors
883	8,270	2008-2011	16,818,516	13.7%

2.4 PERSISTENCE

In order to investigate the persistence of solar PV generation over time, Cadmus conducted site visits to a sample of 36 projects (of a total of 258) that were installed in 2008. The goal was to determine if any adjustment should be made to long-term generation estimates due to performance degradation or other issues found during the audits of these sites.

2.4.1 Methods and Calculations

This phase of the evaluation used the same calculation process as in the evaluated gross generation sample. The results, however, were calculated separately from the overall evaluation sample to facilitate comparison.

We based our comparison of the persistence and evaluated samples on three factors:

- Incidence of equipment failure
- Calculated capacity factor
- Calculated realization rate

Variations in these areas between the persistence and evaluated sample might indicate the need for an adjustment to assumed long-term generation.

2.4.1 Results

We completed site visits at 36 PV systems that were installed using RPS-CST funds in 2008. Of these, 33 provided valid records useful for further analysis. Three records, as discussed previously, were omitted due to factors such as metering equipment malfunction or inability to confirm an accurate system startup date.

Evaluation of the sample records produced generally positive results. These were:

- Observed capacity factors for both the residential and nonresidential sectors were equal to, or higher than, those of the evaluated gross sample.
- Realization rates were similar for both samples; the residential realization rate was slightly higher for the evaluated sample, while the nonresidential realization rate was higher for the persistence sample.
- Shading losses were generally higher in the persistence sample than in the evaluated sample, with an average shading loss of 6% in the persistence sample, compared with 4.9% for the evaluated sample.
- We found no instances of significant equipment downtime or degradation in the persistence sample to indicate a substantive difference in performance or reliability between newly installed systems and those that are four to five years old.
- For the 258 projects installed in 2008, the persistence sample results are reported with a precision of 4.6% at 90% confidence.

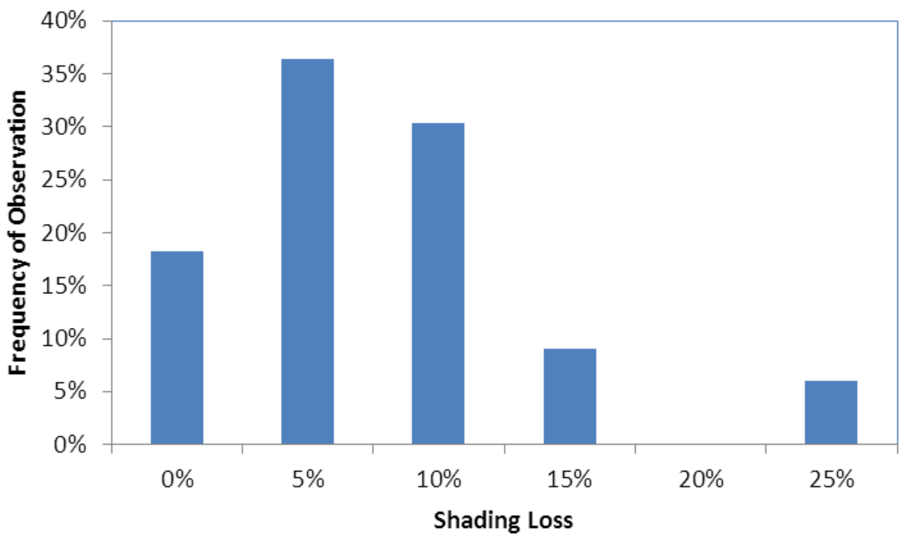
We have listed the key numerical results in Table 2-6.

Table 2-6. Summary of Results for Persistence Sample Site Visits

Sector Stratum	Site Visit	kW	*ex post*	*ex ante*	Realization Rate	Capacity Factor
Residential	27	163.7	202,951	184,425	1.10	0.142
Non-Residential	6	59.9	78,107	66,719	1.17	0.149
0-15kW	5	39.2	52,213	42,843	1.22	0.152
15-30kW	1	20.7	25,894	23,876	1.08	0.143
>30kW	0					
Total	33	223.6	281,058	251,144	1.12	0.143

As noted above, shading losses were generally more significant than those in the evaluated sample but still had a generally modest impact on energy generation. These results could also include factors such as additional tree growth or new buildings, which would increase the shading losses on projects in the persistence sample more than projects in the evaluated gross generation sample. Figure 2-10 displays a histogram of shading losses observed during our site visits. Unlike the evaluated sample, there are proportionally more occurrences of sites with 10% to 25% shading loss. This may indicate that some installers are new to the program and unfamiliar with NYSERDA's methods for evaluating shading losses.

Figure 2-10. Distribution of Shading Loss Findings in Persistence Sample



2.5 NET GENERATION

The net-to-gross (NTG) ratio is calculated for energy efficiency or renewable energy programs to determine what portion of the customer's activities are attributable to the program. Two parameters are analyzed—freeridership and spillover—to determine the behavior of participants in the absence of the program and what further actions they have taken because of their participation.

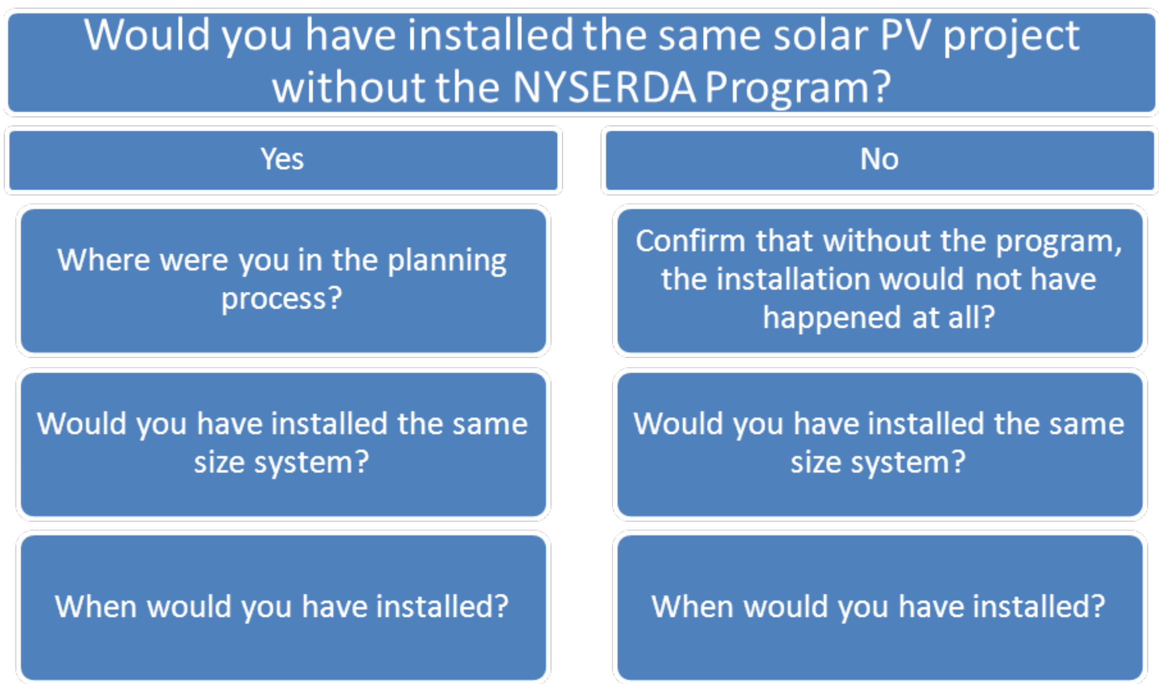
Because the programs serviced many different building types, Cadmus performed the NTG analysis on residential and nonresidential populations separately.

2.5.1 Freeridership

Freeridership, or the percent of energy generation that would have occurred in the absence of the program, was calculated using survey data collected during site visits performed by Cadmus staff in late 2012. We used a multiple-question battery such that an initial positive or negative indication of freeridership was verified with secondary questions (the questionnaires can be found in Appendix C).

These secondary questions were also used to determine partial freeridership. Partial freeridership is assigned to participants who claim they would have installed the equipment regardless of their participation, but that the program allowed installation of a larger PV system or an earlier installation than might otherwise have been possible. Figure 2-12 shows abbreviated questions that form the freeridership algorithm. A "yes" or "no" answer to the first question leads the respondent down one of two sets of secondary questions, that are tailored to determine partial or no freeridership. For brevity, skip patterns and response options are omitted, but the full battery is shown in Appendix D.

Figure 2-11. Freeridership Algorithm Tree



There are several response combinations that determine no freeridership. For example, if the respondent answers "no" to the first question and then "yes" to the confirmation question, the respondent is considered a 0% freerider and skips the last two questions. If a respondent answers "yes" to the first question and answers affirmatively of freeridership to the three secondary questions, the respondent is assigned 100% freeridership. Each combination of responses result in a cascading level of freeridership such that partial freeridership can be assigned for partial affirmative responses**.** Table 2-7 shows the detailed scoring algorithm for responses linked to the freeridership questions. Blank cells indicate section is skipped, or answer is irrelevant to the algorithm.

Table 2-7. Freeridership Scoring Algorithm

F1	F2	F3	F4	F5	F6	F7	NONRES	RES
Same	Plan	Size	When	Confirm	Size	When	FR %	FR %
b				a			0%	0%
b				b	c		0%	0%
b				b		c	0%	0%
b				b	a	a	75%	75%
b				b	a	b	50%	0%
b				b	b	a	25%	25%
b				b	b	b	10%	0%
a		c					0%	0%
a			c				0%	0%
a	a	a	a				75%	75%
a	b	a	a				80%	80%
a	c	a	a				85%	85%
a	d	a	a				100%	100%
a	a	a	b				50%	50%
a	b	a	b				55%	55%
a	c	a	b				60%	60%
a	d	a	b				75%	75%
a	a	b	a				25%	25%
a	b	b	a				30%	30%
a	c	b	a				35%	35%
a	d	b	a				50%	50%
a	a	b	b				10%	0%
a	b	b	b				15%	0%
a	c	b	b				20%	0%
a	d	b	b				35%	0%

Cadmus completed a total of 89 surveys for the site visits, of which 80 yielded complete freeridership battery responses. Nine survey results were discarded due to incomplete or inconsistent responses.

We analyzed each respondent's answers to derive a separate freeridership score expressed as a percentage. The higher the percentage, the more likely that the respondent would have taken the specified action without the program. A low score indicated that the program was responsible for all, or most, of the energy generation achieved by participants.

These scores were weighted by the capacity of the PV system incented. For example, a participant who installed a 100 kW system would have proportionally more weight than someone who installed only a1 kW system when calculating the weighted average for the sector.

Table 2-8. Freeridership Results

Sector	Number of Completed Surveys	Capacity Weighted Freeridership %
Residential	46	7.4%
Nonresidential	34	3.6%
Combined	80	4.3%

We found that the result was not unexpected: the RPS-CST PV program freeridership is a modest 4.3% overall. Because of the high installation cost of PV systems, program incentives often help make purchasing this technology possible, as is evident here. As expected, the nonresidential freeridership was also less than residential due to the prevalence of early adopters in the residential sector and the fact that nonresidential institutions and businesses often have strict budgets and would likely not have undertaken the installation without financial assistance.

2.5.2 Spillover

Spillover, defined as the additional clean energy generation or energy savings caused by the program but not otherwise captured by program records, was also determined through surveys with participating customers. This study only examined inside participant spillover. It did not assess outside, or non-participant spillover.[9] Cadmus examined three kinds of inside spillover: other renewable technologies, energy-efficient equipment and energy-saving behavior changes.

Through the survey, we asked participating customers if they installed any additional renewable or energy-efficient equipment after participating in the NYSERDA program. A single participant may have installed one or many additional measures, all of which we took into consideration when calculating spillover.

Each spillover measure was counted only if it passed two qualifications for attribution to the program: 1) we asked respondents who answered affirmatively to each measure if they had received any funding for the measure from another source, and then 2) we asked them if participation in the program influenced them to make the additional energy-efficiency improvements. We removed from the spillover attribution any measures that had been rebated by another source. We assigned full savings to those measures stated to have been “very influenced” by the program, gave 50% savings credit to those “somewhat influenced” by the program, and did not count anything with lower influence.

Table 2-9 shows the savings allocation for each influence rating given.

[9] A possible future study would be to analyze the spillover effects of the PON 2112 clipboard audits.

Table 2-9. Program Influence Attribution on Spillover Savings Allocation

Influence Rating	Savings Allocation
Very Influential	100%
Somewhat Influential	50%
Not Very Influential	0%
Not At All Influential	0%

2.5.2.1 Renewable Energy Spillover

Thirteen of 50 residential respondents claimed new renewable measures including PV, solar thermal hot water, and geothermal systems. All residential measures received some form of financial incentive and therefore do not qualify for spillover in this study. These incentives included other NYSERDA rebates to the customer or installer and federal and state tax credits and grants.

Nearly all respondents stated that the NYSERDA program was somewhat or very influential in their decision to install the additional equipment.

Of 39 nonresidential respondents, five claimed they had already or were soon going to install additional renewable measures, all of which were additional PV. Nearly all cited that the NYSERDA program was very influential in their decision, but the respondents indicated that they had received financial assistance for the additional renewable measures.

Because no renewable measures met both qualifying criteria, the spillover for this section is 0% for both residential and nonresidential sectors.

2.5.2.2 Energy Efficiency Spillover

Residential

The 50 residential participants we surveyed claimed to have installed 83 energy-efficiency measures of various types. Forty-five of the participants gave ratings of somewhat or very influenced by the NYSERDA program (refer to Table 2-9 for scoring). Fourteen of these remaining measures received other incentives.

Table 2-10 provides the details on the qualifying spillover measure counts and savings per unit.

Table 2-10. Residential Energy-Efficiency Spillover Measures

Efficient Equipment Retrofit Type	Somewhat Influenced by Program	Very Influenced by Program	Annual Unit Savings (kWh)*
Windows	1	2	63[1]
Clothes Washer	4	1	162[1]
Clothes Dryer	4	0	73
Stove	3	0	3[3]
CFLs	0	2	37.6
Refrigerator	4	2	176.8
Freezer	0	1	136[2]
Dishwasher	2	1	107
Window Air Conditioner	1	0	57[4]
Tankless Water Heater	1	0	0 (assumed gas)
Heat Pump	1	0	549
Power Strips	1	0	75[2]
Pool Pump	1	0	400[2]
LEDs	1	0	47.6

*Savings values obtained from NY Technical Resource Manual (TRM) unless otherwise noted.

[1]NYSERDA Residential Analysis (www.nyserda.ny.gov/~/media/Files/EDPPP/Energy Prices/Current Outlook/Presentations/appendix_a_residential.pdf)

[2]MA TRM
[3]6th Power Plan

[4]NYSERDA's Electricity and Peak Demand Savings Reviews of the New York Energy Smart Programs, Appendix B (http://www.nyserda.ny.gov/Program-Evaluation/NYE$-Evaluation-and-Status-Reports/NYE$-Initial-3-Year-Report.aspx)

This sample of spillover measures is representative of the total residential population of program participants. By extrapolating to the population, the total amount of energy-efficient equipment spillover for the program is 110.1 MWh, which is 0.8% of the residential verified gross generation.

Nonresidential

The 39 nonresidential participants we surveyed claimed to have installed 32 energy-efficiency measures of various types.

For 18 of the 32 measures, participants rated their decision to install as somewhat or very influenced by the NYSERDA program. Ten of the remaining measures received other incentives, and three saved energy other than electricity. The five measures that qualified as spillover were installed by just three participants. These measures included lighting, building signs and lighting controls. Savings calculations were analyzed from the NY TRM assuming values for a small retail establishment.

These spillover measures are representative of the total nonresidential population of program participants. By extrapolating to the population, the total energy-efficient equipment spillover for the program is 232.8 MWh, which is 1.0% of the nonresidential verified gross generation.

2.5.2.3 Behavior Change

Energy-Saving Behavior Changes

The survey included questions about eight energy-saving behaviors. Respondents were asked to rate on a scale of 1 to 4, where 1 was not at all influenced and 4 was very influenced, if any of the following behaviors were influenced by program participation:

- Increase thermostat setting in the summer
- Decrease thermostat settings in winter
- Decrease temperature setting on water heater
- Decrease hot water use
- Turn off the lights more
- Reduce the amount of electrical equipment plugged in
- Install motion sensors for lighting
- Turn off office equipment when not in use (only for nonresidential customers)

The following two figures show the results of questions about energy-saving behaviors for residential and nonresidential participants (Figure 2-12 and Figure 2-13, respectively). For each action, the blue bar is the percentage of participants claiming to have performed the action in total and the pale bar is the percentage of responses for "somewhat" or "very" influenced by the program.

Figure 2-12. Residential Energy Saving Behavior

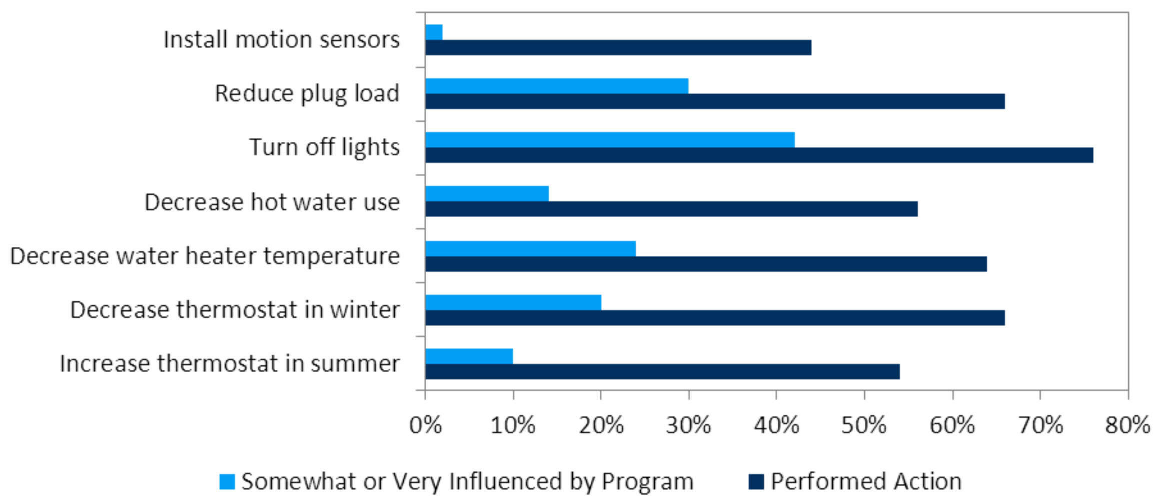
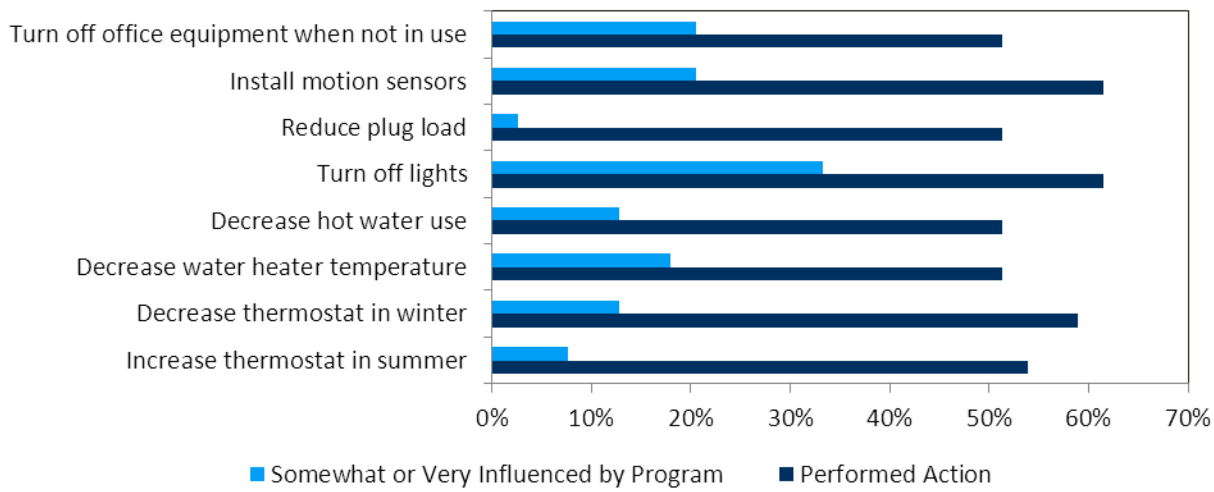


Figure 2-13. Nonresidential Energy Saving Behavior



On average, we found that approximately 60% of residential and 55% of nonresidential respondents undertook these energy saving behaviors and approximately 20% of residential and 15% of nonresidential respondents attributed these behaviors to participation in NYSERDA's RPS-CST PV programs.

Due to the highly variable nature of claimed behavior changes, and a lack of useful information available from a literature review, we were not able to report a spillover value for behavior change.

Takeback Behavior Changes

The survey included questions about behaviors that resulted in an increase in energy use, also known as takeback.

- Decrease thermostat setting in the summer
- Increase thermostat settings in winter
- Increase temperature setting on water heater
- Increase hot water use
- Keep the lights on more
- Increase the amount of electrical equipment plugged in
- Install additional large equipment

The residential population responded with only 18 total behaviors (out of a possible 7 behaviors by 50 participants), all of which related to decreasing thermostat settings in the summer, increasing hot water use, installing large electrical equipment, and increasing the number of pieces of electrical equipment plugged in at the same time.

The nonresidential respondents listed only six total actions (out of a possible 7 behaviors by 39 participants); these mainly related to installing extra equipment and hot water use.

Cadmus noted that several participants stated they had installed the PV system in part to run the air conditioner more frequently, use more hot water, or to operate larger pieces of electrical equipment such as geothermal heat pumps, freezers, and hot water heaters.

2.5.2.4 Total Program Spillover

The three spillover components—renewable, energy efficiency, and behavior change—are combined for a total program-level spillover value, as shown in Table 2-11**.**

Table 2-11. Total Spillover Percentage by Sector

Sector	Renewable Spillover	Energy Efficiency Spillover	Behavior Change	Total Spillover
Residential	0%	0.8%	N/A	0.8%
Nonresidential	0%	1.0%	N/A	1.0%

2.5.3 Net-To-Gross

Table 2-12 shows the freeridership and spillover percentages and the resulting NTG percentage for NYSERDA's RPS-CST PV programs. We calculated the NTG percentage by subtracting freeridership from 100% and adding spillover, as shown in Equation 2-6.

Equation 2-6: Net to Gross Ratio Calculation

$$NTG = 100\% - Freeridership\,\% + Spillover\,\%$$

Table 2-12. Calculated NTG for NYSERDA RPS-CST PV Programs by Sector

Sector	Freeridership	Spillover	NTG
Residential	7.4%	0.8%	93.4%
Nonresidential	3.6%	1.0%	97.4%

The high NTG percentages indicate that the solar RPS-CST PV program is doing well and is still necessary to encourage customers to adopt this technology.

2.6 CONCLUSIONS AND RECOMMENDATIONS FOR SOLAR RPS-CST PV PROGRAM

In evaluating NYSERDA's RPS-CST PV programs, Cadmus concluded:

- The capacity factor of 13.4% calculated from the sample in this evaluation verifies NYSERDA's current method of reporting generation that uses a capacity factor of 13.4%, . Therefore, NYSERDA should continue using this value for reporting purposes.
- PV systems, on average, have been saving 10% to 12% more energy than predicted by system installers.
- Self-reported meter readings from 883 completed projects resulted in a measured capacity factor of 13.7%, which is very close to, but slightly higher than, the value Cadmus calculated from the sample in this evaluation (13.4%) and the value currently used by NYSERDA to report electricity generation to NY DPS (13.4%). NYSERDA should continue to collect these meter readings and

use them to periodically review, and update if necessary, the capacity factor value used for reporting

- PV systems that were installed four to five years ago continue to generate electricity at the expected rate, with no significant difference in downtime or any indications of system degradation. While this is not an old enough sample to fully characterize persistence, this result is encouraging and indicates that PV system generation remains reliable over at least a 4-5 year period.
- Average losses due to shading are in the 4% to 6% range for both the evaluated and persistence samples (with slightly higher shading losses observed in the persistence sample).
- The program achieved a high NTG ratio, which indicates the program fills a necessary role in promoting the development of PV projects and also influences other energy-saving activities and behaviors.

The capacity, gross energy generation, and precision level for solar PV systems funded by the RPS-CST program and installed prior to December 31, 2011 are shown in Table 2-13.

Table 2-13. Gross Energy Generation and Average Capacity Factor for PV Systems Installed 2008-2011

	Capacity Factor	Population Installed Capacity (kW)	Population Annual Gross Energy Generation (MWh)	Precision Achieved (90% Confidence)
Existing Method	13.4%	32,041	37,611	N/A
Evaluation Sample	13.4%		37,611	4.2%
Persistence Sample	14.3%		40,137	4.6%
Self-Reported	13.7%		38,453	2%

The evaluated net generation for the program is 36,332 MWh per year, including freeridership and spillover effects, as shown in Table 2-14.

Table 2-14. RPS-CST PV Program Net Generation Results for PV Systems Installed 2008-2011

	Gross Generation (MWh)	Freeridership	Spillover	NTG Ratio	Net Generation (MWh)
RPS-CST PV Program	37,611	4.3%	0.9%	0.966	36,332

Cadmus recommends that NYSERDA consider the following activities:

- Continue requiring self-reported meter readings. The values from these readings, which are obtained at almost no cost to NYSERDA, appear to be an accurate representation of actual achieved energy savings for the program.

- Continue reporting based on a single capacity factor value. This metric is both simple to track and compares well with evaluated results. In order to remain up to date with trends in installations and technology, NYSERDA may wish to use the self-reported meter readings to re-evaluate this capacity factor value periodically.
- Quantify the benefits of energy-saving behaviors. This study shows that there is significant spillover benefit attributable to NYSERDA's PV programs. While we were able to quantify the energy savings from direct equipment installation and retrofit activities in this study, information on behavior changes (such as adjusting thermostat settings) was not available; such savings likely would further increase attributable program energy savings.

Section 3:

ON-SITE WIND EVALUATION

3.1 APPROACH OVERVIEW

During the 2008-2011 study period, NYSERDA supported the installation of 79 small wind energy projects under PONs 792, 1098, and 2097. Similar to the solar PV program, the small wind program requires that customers or installers regularly submit to NYSERDA electricity generation data collected from dedicated production meters.

Cadmus evaluated the performance of 53 small wind systems that were funded under PONs 792, PON 1098, and PON 2097 and installed between June 26, 2008, and August 15, 2011. These 53 projects represent approximately 65% of the systems that received incentives.

We calculated the following metrics:

- Long-term adjusted annual energy production (AEP) estimates
- System-level realization rate
- Program-level realization rate (based on pre-installation AEP estimates provided by installers)

The 53 small wind systems included in the sample are located in the northern regions of New York State, as shown on the map in Figure 3-1. Descriptions of all of the systems, including the county each is located and general specifications, can be found in the Appendix E

Figure 3-1. On-Site Wind Turbine Sites Included in Evaluation Sample

Cadmus compared the pre-installation estimates of energy production provided by system installers to actual energy production values for each system's 12-month monitoring period. We normalized energy production by scaling the 12-month figures to the long-term average using local weather station data. (A list of the weather stations and their locations are provided in Appendix F.)

We then calculated the realization rate for the fleet of small wind systems by taking the ratio of the normalized production figures to the pre-installation estimates of energy production. We also calculated individual realization rates for each project in the sample, in order to identify trends such as chronic over-predictions by installer or region. The following section provides a more detailed description of the relevant calculations and results are reported in Section 3.2.2.

3.2 SELF-REPORTED GROSS GENERATION

3.2.1 Calculations and Data Sources

Cadmus first evaluated the data available for small wind projects by screening for:

- Valid meter reading data
- 12 months, or more, of meter readings
- Valid site location data
- Valid pre-installation AEP estimate value

Cadmus adjusted the self-reported meter readings to account for variability in the available wind resource during each system's 12-month monitoring period. The method is described in the following five steps.

Step 1: Normalize AEP to Long-Term Weather Data

We normalized the measured annual mean wind speed to the nearest long-term weather station data available.

First, we calculated the ratio between the annual mean of the weather station data for the most recent year that matched the measurement period and the long-term (10-year) mean of the weather station data:

Equation 3-1. Wind Speed Ratio

$$R_{ws} = \frac{U_{LT}}{U}$$

Where:

R_{ws} = the ratio of the weather station annual mean wind speed for the measurement period and the weather station long-term mean wind speed;

U = the weather station annual wind speed for the measurement period (m/s); and

U_{LT} = the long-term (i.e., 10-year) weather station mean wind speed (m/s).

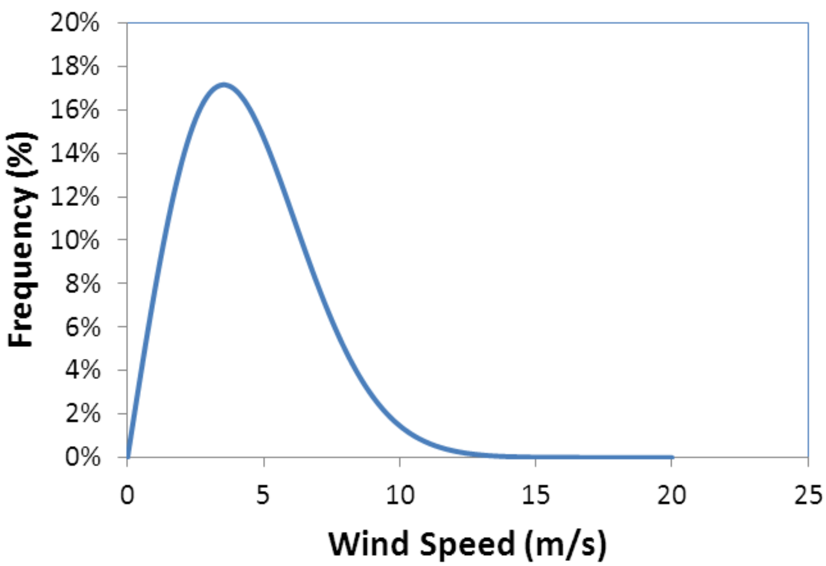
Step 2: Wind CAD Weibull Correction Calculation

We used WindCAD[10], a Microsoft Excel®-based calculator, developed by NREL and Bergey WindPower Co., to establish a relationship between relative wind speed changes and AEP. WindCAD uses a statistical Weibull distribution to model the frequency at which different wind speeds occur during the year. This model has been widely used throughout the wind energy industry and is generally accepted as an

[10] The WindCAD model can be accessed online at: http://bergey.com/technical

approximation of wind speed distributions in many locations. We have provided an example of a typical Weibull distribution, such as we used in this analysis, in Figure 3-2. We have provided the general form of the Weibull distribution in Equation 3-2.

Figure 3-2: Example of a Typical Weibull Distribution



Equation 3-2: General Form of the Weibull Distribution

$$P(u) = k\Gamma(1+\frac{1}{k})\left[\frac{u}{U}\Gamma(1+\frac{1}{k})\right]^{k-1} e^{-\left[\frac{u}{U}\Gamma(1+\frac{1}{k})\right]^{k}}$$

Where:

P(u)	=	Probability that the wind will be moving at a wind speed, u
U	=	Mean wind speed
k	=	Shape factor, assumed to be 2
Γ	=	Gamma function

The Weibull wind speed distribution is driven by two assumed factors: mean annual wind speed and the shape factor of the distribution. Empirical data for the northeastern United States shows that a shape factor of 2.0 is reasonable for many areas; therefore we used the 2.0 value in this analysis.

We chose 5 meters per second (m/s), as this is a typical hub height wind speed for small wind turbine applications throughout New York. This value was only used to establish relative changes in AEP with corresponding changes in wind speed.

Table 3-1 shows the impacts of relative changes in wind speed on the modeled AEP, along with the resulting Weibull correction used in our analysis of the meter readings data. The non-linear form of the Weibull distribution produces substantial differences in AEP for large increases or decreases in wind speed, relative to the mean value. For example, an increase in the wind speed of 20% results in more than a 60% gain in AEP.

The Weibull correction values in Table 3-1 were used to adjust the observed AEP for differences in wind speeds between the turbine's operational period and the typical long-term average wind speed.

Table 3-1. Impacts of Wind Speed on AEP Based on Weibull Distribution for a 10kW Wind System

Wind Speed (m/s)	Normalized Wind Speed (5m/s base)*	AEP (kWh)	Weibull Correction
4	0.8	7,014	0.51
4.1	0.82	7,574	0.56
4.2	0.84	8,158	0.60
4.3	0.86	8,765	0.64
4.4	0.88	9,396	0.69
4.5	0.9	10,049	0.74
4.6	0.92	10,724	0.79
4.7	0.94	11,421	0.84
4.8	0.96	12,138	0.89
4.9	0.98	12,876	0.94
5	1	13,633	1.00
5.1	1.02	14,407	1.06
5.2	1.04	15,199	1.11
5.3	1.06	16,007	1.17
5.4	1.08	16,830	1.23
5.5	1.1	17,667	1.30
5.6	1.12	18,517	1.36
5.7	1.14	19,377	1.42
5.8	1.16	20,248	1.49
5.9	1.18	21,128	1.55
6	1.2	22,016	1.61

This table is useful for finding the Weibull Correction for each wind speed.

* Wind speed has been normalized using a shape factor of 2.0 and a mean wind speed of 5 m/s for a 10 kW system.

Step 3: Multiply Actual Production by the Weibull Correction

To normalize AEP, we multiplied the actual AEP from each wind project (obtained from customer meter readings) by the Weibull correction for R_{xi} (the ratio of the mean wind speed during the monitoring period for the weather station nearest each site and the long-term mean wind speed), as shown in Equation 3-3.

Equation 3-3. Normalizing AEP for Relative Wind Speed and Weibull AEP Impact

$$AEP_{normalized} = AEP_{actual} * WC_{x,i}$$

Where:

$AEP_{normalized,I}$	=	Annual energy production for system *i*, normalized to the long-term mean wind speed (kWh/yr)
$AEP_{actual,i}$	=	Actual annual energy production for system *i* during monitoring period (kWh/yr)
$WC_{x,i}$	=	Weibull Correction for the ratio, R_{xi} , of the annual mean wind speed for the measurement period and long-term mean wind speed for weather station *x* during the monitoring period for system *i*

Step 4: Calculate Individual Realization Rates

We calculated the realization rates for each wind system by dividing the actual production of each by the long-term adjusted AEP estimates found in Step 2. This calculation is shown in Equation 3-4**.**

Equation 3-4. Realization Rate for On-Site Wind Project AEP

$$RR_i = \frac{AEP_{normalized,i}}{AEP_{estimated,i}}$$

Where:

RR_i	=	the realization rate of system *i* for 12-month monitoring period.
$AEP_{normalized,i}$	=	the estimated energy production for system *i* (kWh/yr);

Step 5: Calculate Realization Rate of Fleet

Next, we calculated the realization rate for the entire fleet by summing the normalized annual productions for each system and dividing this total by the sum of the annual energy-production estimates:

Equation 3-5. On-Site Wind Fleetwide Realization Rate

$$RR_{fleet} = \frac{\sum AEP_{normalized,i}}{\sum AEP_{estimated,i}}$$

Where:

RR_{fleet}	=	the realization rate of the fleet

3.2.2 Results

The key results from Cadmus' evaluation of a sample population of 53 small wind projects, including the realization rate for each system and the fleet-wide realization rate, are presented in Table 3-2.

Table 3-2. Key Results for Sample Population of Wind Projects

Number of Systems in Sample	Total Capacity of Sample (kW)	Estimated Sample AEP (kWh/yr)	Actual Sample AEP (kWh/yr)	Normalized AEP (kWh/yr)	Sample Realization Rate
53	575.9	488,250	423,207	487,323	1.00

In order to calculate the population annual energy generation, we applied the realization rate from Table 3-2 to the *ex ante* energy generation for the population. The overall population of 79 projects in the study population had a combined *ex ante* energy generation of 838 MWh per year. Based on the weather-adjusted realization rate from Table 3-2, the On-Site Wind Program had an evaluated gross energy generation of 838 MWh per year.

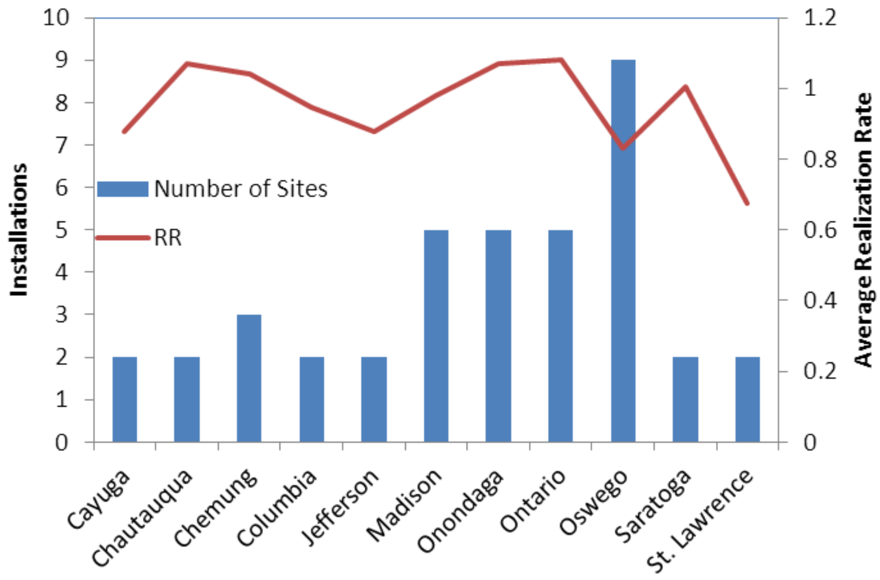
We did not assess attribution or NTG as part of this study.

3.2.2.1 Trends in Wind Resource

If we do not adjust for the variation in annual mean wind speed, the fleet-wide realization rate is 86.7%. This suggests that many of the projects in the 12-month sample of 53 projects have been operating during a relatively low-wind period, compared to long-term average conditions.

We also observed some geographic variability in realization rates. In this sample, Oswego County had 9 installations, more than any other county. (Figure 3-3 shows all of the counties with two or more wind turbines.) Oswego County's weather normalized realization rate was 0.83, slightly lower than the fleet-wide weather-normalized realization rate of 1.00. Realization rates were also below the fleet average in Saratoga and St. Lawrence counties. These low realization rates suggest that the wind maps used to make performance predictions in those areas should be reviewed for accuracy or specific regional effects, as this could be driving optimistic AEP projections by installers in those areas.

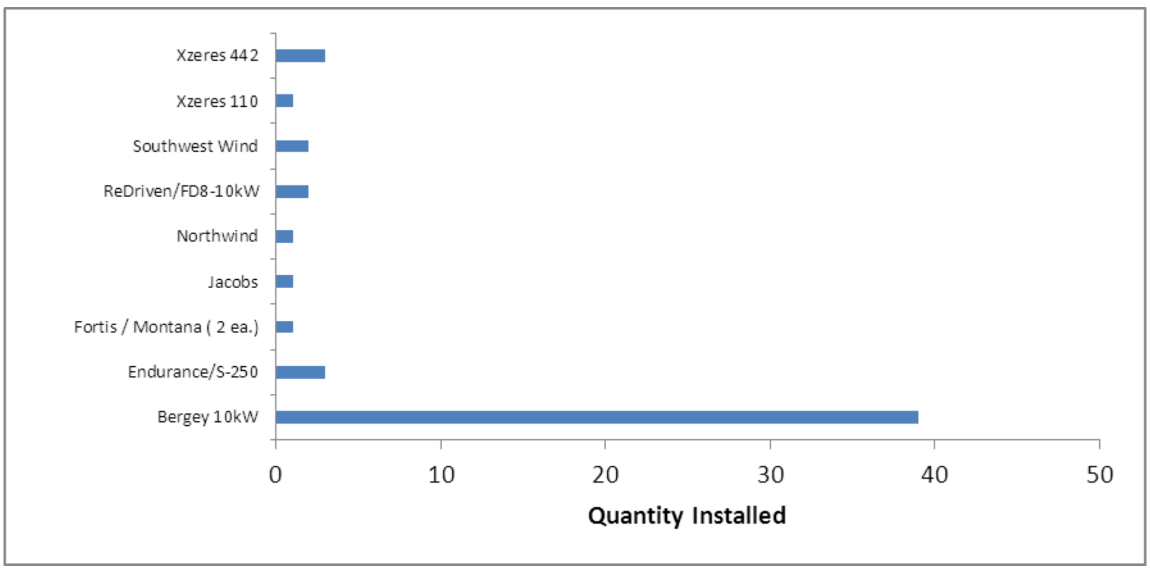
Figure 3-3. Realization Rate in Counties with Two or More Sites



3.2.2.2 Equipment and Installation Trends

Figure 3-4 shows all turbine manufactures in the sample and how many of each model was used. Bergey Windpower's 10 kW turbines far exceeded the other types of turbines with 39 installations.

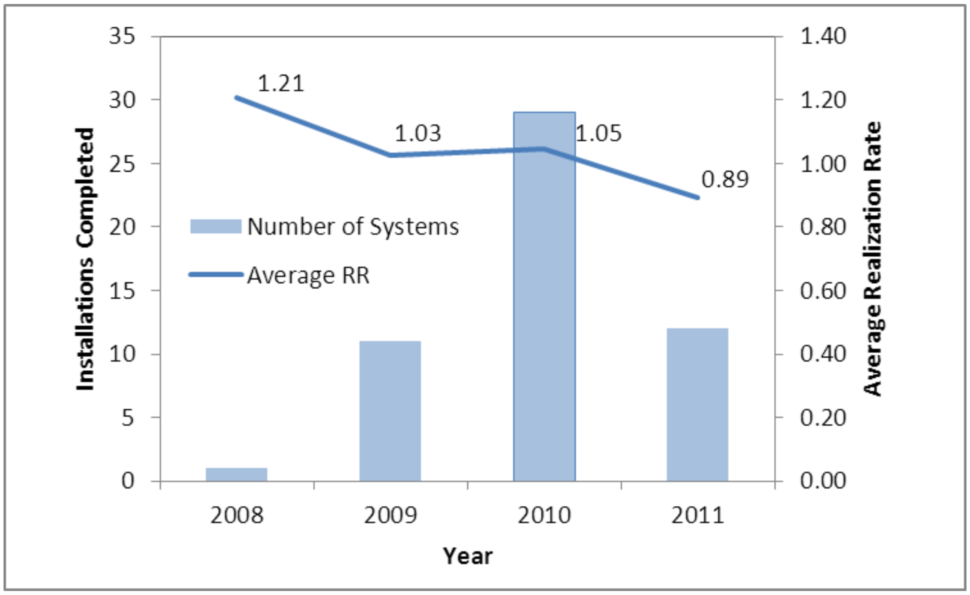
Figure 3-4. Wind Turbine Manufacturers in Study Population



The RPS-CST program is ongoing and the realization rate has varied each year since the program has been operating. The chart in Figure 3-5 shows the number of systems installed each year and the average realization rate for each year.

The sample population contains only one site that started in 2008; this site shows a 1.21 realization rate. In subsequent years realization rates ranged from 0.89 to 1.05 as more wind systems were installed (the majority were installed in 2010). Cadmus notes that a four-month gap between PON 1098 and PON 2097 in late 2010 likely contributed to a lower number of installations in 2011, but there is no clear cause for the lower realization rates in 2011. One possible explanation, based on discussion with NYSERDA staff, is that NYSERDA implemented a new online performance prediction tool for the On-Site Wind program in 2011, which was not widely in use in previous years.

Figure 3-5. Realization Rate and Number of Systems by Year



The wind systems in the sample were installed by 23 installers. The majority of installers had only one or two projects included in the sample, with only two installers having five, or more, systems included.

3.3 On-Site Wind Related Conclusions and Recommendations

Most sites performed near the estimated AEP with just a few sites having low realization rates. The fleet-wide realization rate is 100%, after weather normalization was factored into the calculations and the 79 projects included in this evaluation are generating 838 MWh per year. This realization rate indicates that the program appears to be doing an excellent job of accurately projecting energy generation.

Cadmus makes the following recommendations for NYSERDA's On-Site Wind Program:

- Continue collecting meter readings from participants.
- Continue technical oversight and other activities related to pre-installation AEP estimates, as these efforts appear to be successful in ensuring that pre-installation predictions are realistic.
- Review AEP predictions and underlying wind resource data for counties with lower realization rates, such as Oswego and Saratoga counties

Section 4:

PROGRAM CONCLUSIONS AND RECOMMENDATIONS

4.1 OVERALL PROGRAM GENERATION FINDINGS

Based on the results of this evaluation study, NYSERDA's RPS-CST-funded Solar PV Program is saving approximately 37,051 MWh of electricity per year. All aspects of the study met, or exceeded 90% confidence and 10% precision, as shown in Table 4-1**.** The evaluated gross sample also found a realization rate of 110%, indicating that PV systems are generating more electricity than expected.

Table 4-1. Summary of PV Gross Generation Results

	Capacity Factor	Population Installed Capacity (kW)	Population Annual Gross Energy Generation (MWh)	Precision Achieved (90% Confidence)
Existing Method	13.4%	32,041	37,611	N/A
Evaluation Sample	13.4%		37,611	4.3%
Persistence Sample	14.4%		40,291	4.6%
Self-Reported	13.7%		38,453	2%

Adjusting for NTG, the program has a net generation of 36,332 MWh per year, after accounting for a low freeridership and significant spillover effects, as shown in Table 4-2.

Table 4-2. Summary of PV Net Generation

	Gross Generation (MWh)	Freeridership	Spillover	Net Generation (MWh)
PV Program	37,611	4.3%	0.9%	36,332

Based on our sample of 53 On-Site Wind projects, NYSERDA's On-Site Wind program achieved a realization rate of 100% for a total annual population generation of 838 MWh per year.

Collectively, the RPS-CST PV and On-Site Wind projects included in this evaluation, installed from January 1, 2008 through December 31, 2011, are saving a net 37,170 MWh per year. The vast majority (98%) of the total generation are attributable to the RPS-CST PV program.

4.2 OVERALL PROGRAM CONCLUSIONS AND RECOMMENDATIONS

The current reporting methods employed by NYSERDA appear to be accurate and reasonable for both the Solar PV and the On-Site Wind programs. Furthermore, we found no evidence to indicate that systems installed four to five years ago, in 2008, have experienced any significant degradation in energy output.

Based on the results of this study, we recommend that NYSERDA generally continue with its present reporting and tracking methods and consider the following activities:

- Continue requiring self-reported meter readings: These values, obtained at almost no cost to NYSERDA, appear to be an accurate representation of actual achieved energy generation for the program.
- Continue reporting PV annual energy generation to DPS using a single capacity factor value: This metric is both simple to track and compares well with evaluated results. In order to remain up to date with trends in installations and technology, NYSERDA may wish to use the self-reported meter readings to re-evaluate this capacity factor value periodically.
- Quantify the benefits of energy-saving behaviors: This study shows that there is significant spillover benefit attributable to NYSERDA’s solar RPS-CST PV programs. While we were able to quantify the energy savings from direct equipment installation and retrofit activities in this study, information about behavior changes (such as adjusting thermostat settings) was not available; such savings likely further would increase attributable program energy generation.

We do not recommend, at this time, that NYSERDA make any adjustments to reported energy generation to account for the age of PV projects.

APPENDIX A: NYSERDA RPS CST SOLAR PV SAMPLES SITE DESCRIPTIONS

Table 1. Evaluation Sample PV System Information

Application Number	County	Sector	Nameplate (kW)	AEP estimate (kWh)	Panels Manufacturer
02015-024	Bronx	Non-Residential	49.5	57400	Schuco
4170-20057	Westchester	Residential	3.6	2891	SunPower
4170-151	Westchester	Non-Residential	41.4	45065	Suntech Power
4170-137	Westchester	Residential	3.6	4244	SunPower
4056-029	Rockland	Residential	4	4663	Sanyo Electric
4120-20034	Queens	Non-Residential	64.064	79484	Solyndra
4008-001	Westchester	Residential	9.45	10867	Suntech Power
4095-007-1	Queens	Non-Residential	51.24	58310	SunPower
4609-19856	Queens	Non-Residential	24.3	23534	Schuco USA
4609-19855	Queens	Non-Residential	30.375	28432	Schuco USA
4609-19218	Queens	Non-Residential	31.725	29969	Schuco
4061-095	Putnam	Non-Residential	24.84	27179	SunPower
4030-21356	Orange	Residential	5.55	6630	Schuco USA
4030-051	Dutchess	Residential	5.4	6059	SunPower
4030-111	Dutchess	Residential	5.4	6265	SunPower
4056-033	Rockland	Residential	8.36	9310	Suntech Power
4030-017	Dutchess	Non-Residential	20.16	22952	SunPower
4170-059	Queens	Non-Residential	50.4	55531	Suntech Power
4170-050	Queens	Residential	3.15	3726	SunPower
4095-006	Queens	Non-Residential	32.76	36658	Suntech Power

Application Number	County	Sector	Nameplate (kW)	AEP estimate (kWh)	Panels Manufacturer
4095-008	New York	Non-Residential	49.68	60974	SunPower
4120-20033	Queens	Non-Residential	17.64	20718	Schuco USA
4170-014	Queens	Non-Residential	49.104	53523	United Solar Ovonic
4095-005	Queens	Non-Residential	49.105	56128	SunPower
4170-053	Bronx	Non-Residential	24.4	29228	SunPower
4170-086	Bronx	Non-Residential	50.02	57487	SunPower
4170-007-1	Westchester	Non-Residential	49.68	57566	SunPower
4030-078	Ulster	Residential	5.16	6198	SunPower
4061-020	Ulster	Non-Residential	46.94	27448	Mitsubishi Electric
4061-075	Columbia	Residential	6.3	6995	SunPower
4375-19650	Schenectady	Non-Residential	44.1	49101	Kyocera Solar
4375-20953	Albany	Non-Residential	56.7	54217	Kyocera Solar
4375-20954	Albany	Non-Residential	56.7	55057	Kyocera Solar
4139-014	Albany	Non-Residential	2.07	2278	SunPower
4056-020	Orange	Non-Residential	8.55	9955	Sanyo Electric
4333-19883	Orange	Non-Residential	22	26134	Lumos
4040-002	Dutchess	Non-Residential	9.36	9851	Sanyo Electric
4003-004	Albany	Residential	5.52	5116	SunPower
4158-20462	Schenectady	Residential	5.805	6662	SunPower
4375-21006	Albany	Non-Residential	56.7	69346	Kyocera Solar
4003-042	Rensselaer	Residential	6.21	7295	SunPower
4375-21005	Montgomery	Non-Residential	57.12	55480	Kyocera Solar
4158-038	Schoharie	Residential	5.52	6451	SunPower

Application Number	County	Sector	Nameplate (kW)	AEP estimate (kWh)	Panels Manufacturer
4148-19655	Greene	Residential	8.6	10052	Sanyo Electric
4040-018	Ulster	Residential	4.6	4561	Sharp
4158-121	Ulster	Non-Residential	77.22	100903	Suntech Power
4042-21074	Ulster	Non-Residential	2.3	2371	Trina Solar
4135-040	Albany	Residential	5.04	4848	Suntech Power
4147-011	Ulster	Residential	3	3563	Sanyo Electric
4147-019	Ulster	Non-Residential	49.14	57086	Sanyo Electric
4015-004	Rensselaer	Non-Residential	50.4	55042	GE Energy
4375-19474	Saratoga	Non-Residential	80.64	86157	Kyocera Solar
02158-010	Washington	Residential	5.04	5727	SunPower
02158-015	Delaware	residential	3.36	3819	SunPower
4147-020	Ulster	Non-Residential	49.14	57086	Sanyo Electric
4054-19812	Broome	Non-Residential	5.04	5219	Kyocera Solar
4116-112	Wyoming	Non-Residential	15.12	10006	SunPower
4116-015	Erie	Non-Residential	31.5	30975	Suntech Power
4116-127	Erie	Non-Residential	25.38	21228	Sharp
4116-054	Erie	Non-Residential	30.55	30070	Sharp
4116-145	Erie	Non-Residential	25.08	15891	Sharp
4116-138	Erie	Non-Residential	25.38	21339	Sharp
4054-20168	Erie	Non-Residential	30.24	31917	Kyocera Solar
4116-034	Erie	Non-Residential	49	47182	Schott Solar
4211-21027	Otsego	Non-Residential	7.44	5727	Sharp
4124-020	Monroe	Residential	5.52	6027	SunPower

Application Number	County	Sector	Nameplate (kW)	AEP estimate (kWh)	Panels Manufacturer
4116-19668	Monroe	Non-Residential	48.8	50375	SunPower
4124-19239	Seneca	Non-Residential	15.18	10916	SolarWorld
4188-006	Chemung	Residential	4.8	5391	Sanyo Electric
4011-003	Cortland	Non-Residential	27.6	30316	SunPower
4158-20028	Columbia	Non-Residential	49.28	52606	-
4158-138	Sullivan	Non-Residential	23.76	26959	-

Table 2. Persistence Sample PV System Information

Application Number	County	Sector	Nameplate (kW)	AEP estimate (kWh)	Panels Manufacturer
02030-140	Ulster	Residential	5.88	7055	SunPower
02170-010	Westchester	Residential	5.04	6026	SunPower
4056-005	Rockland	Non-Residential	4.8	5825	Sanyo Electric
4061-007	Ulster	Residential	5.04	5813	SunPower
4148-001	Ulster	Residential	4.68	5232	Sanyo Electric
4108-001	Ulster	Residential	10	11815	Sanyo Electric
4042-001	Ulster	Residential	9.6	11231	Sanyo Electric
4030-005	Dutchess	Residential	10.08	11566	SunPower
4181-002	Washington	Non-Residential	10.32	10964	SunPower
4173-001	Warren	Residential	4.56	4834	Evergreen Solar
02174-005-1	Orange	Residential	6	7459	Sanyo
02061-078	Ulster	Residential	10.5	12599	SunPower
02030-157	Dutchess	Residential	7.2	8576	SunPower

Application Number	County	Sector	Nameplate (kW)	AEP estimate (kWh)	Panels Manufacturer
02061-089	Dutchess	Residential	4.5	4845	SunPower
02147-002	Ulster	Non-Residential	3	2591	Sanyo
4030-010	Dutchess	Non-Residential	20.7	23876	SunPower
4003-010	Columbia	Residential	5.52	6133	SunPower
4030-006	Columbia	Non-Residential	11.25	12856	SunPower
02061-091	Dutchess	Residential	9	10720	SunPower
02003-084	Washington	Non-Residential	10.08	11526	SunPower
02030-148	Ulster	Residential	6.75	6214	SunPower
4086-001	Rensselaer	Residential	3.6	3842	Evergreen Solar
02061-077	Ulster	Non-Residential	4.5	4906	SunPower
02061-092	Ulster	Residential	3.6	4709	SunPower
02061-088	Ulster	Residential	4.5	5404	Sunpower
02086-022	Washington	Residential	3.6	4021	Evergreen
02001-050	Herkimer	Residential	4.305	5304	SunPower
02030-146	Columbia	Residential	6.15	7133	SunPower
02181-002	Schoharie	Residential	5.76	5950	Evergreen
4077-007	Erie	Residential	4.07	4111	Mitsubishi Electric
4077-002	Monroe	Residential	2.22	2295	Mitsubishi Electric
4077-009	Ontario	Residential	5.52	6027	SunPower
4006-001	Cayuga	Residential	9.984	10655	Sharp
4086-008	Oneida	Residential	5.04	5351	Evergreen Solar
4025-001-1	Monroe	Residential	4.56	4214	Evergreen Solar
02061-086	Orange	Residential	5.4	6441	-

APPENDIX B: NYSERDA RPS CST TMY3 AND SDW STATION LOCATIONS

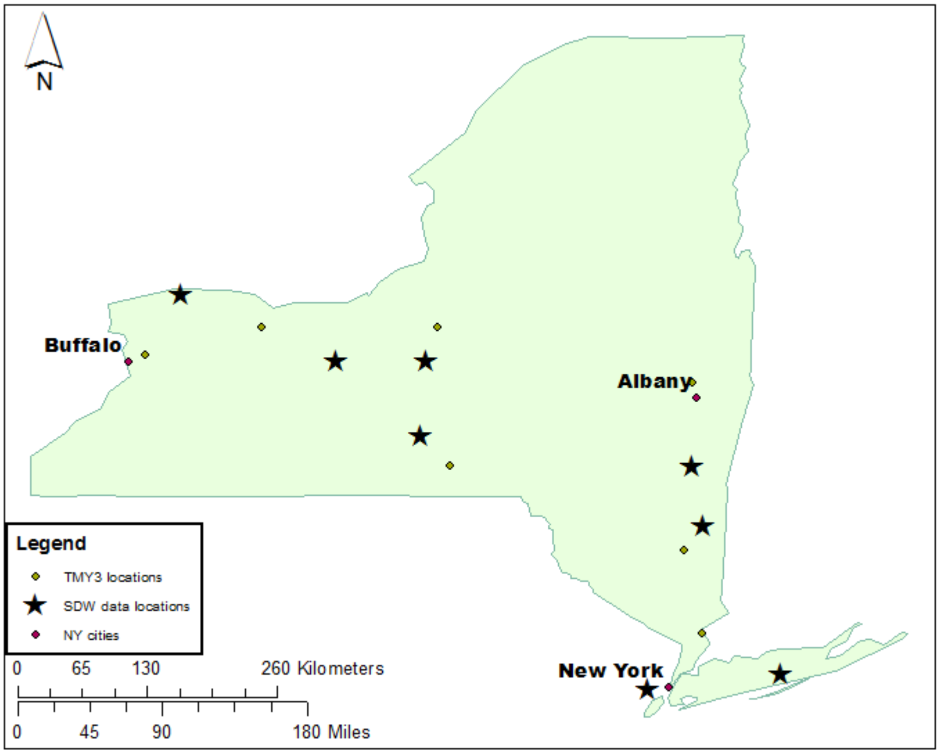
Table 1. NREL/TMY3 Data Station Locations

NREL/TMY3 Station	Latitude	Longitude
ALBANY COUNTY AP	42.75	-73.8
BINGHAMTON EDWIN A LINK FIELD	42.2	-75.983
BUFFALO NIAGARA INTL AP	42.933	-78.733
POUGHKEEPSIE DUTCHESS CO AP	41.633	-73.883
ROCHESTER GREATER ROCHESTER I	43.117	-77.683
SYRACUSE HANCOCK INT'L ARPT	43.117	-76.1
WHITE PLAINS WESTCHESTER CO A	41.067	-73.717

Table 2. Solar Data Warehouse Data Station Locations

SDW Data Station	Latitude	Longitude
NY021-1	42.2	-73.8
NY023-1	42.4	-76.25
NY027-2	41.8	-73.7
NY067-1	42.9	-76.2
NY069-2	42.9	-77
NY103-2	40.8	-73
NJ017-1	40.7	-74.2
NY073-1	43.33	-78.4

Figure 1. Map of TMY3 Weather and Solar Data Stations



APPENDIX C: NYSERDA RPS CST SOLAR PV PROGRAM SURVEYS

Figure 1. NYSERDA RPS CST Solar PV Program Residential Survey

CST Solar PV Program Residential Survey 1

NYSERDA Renewable Portfolio Standard-Funded Customer-Sited Tier (CST) Solar PV Program Residential Survey

Thank you for participating in this study. *Your experience is important.* Your feedback, together with the feedback of others, will help NYSERDA improve future programs. Your responses will be kept private to the extent permitted by law. NYSERDA's analysis only uses summary-level data and does not identify individuals.

- Please print this form and have it completed by the person most knowledgeable about solar photovoltaic (PV) equipment installed at your home.
- Have the completed form ready for the PV engineer during the on-site inspection.
- Should you have any questions about this study, contact Rebecca Reed from NYSERDA at 866-697-3732, ext. 3559, or by e-mail at rlr@nyserda.org.

Respondent Name: ________________________________ **Phone Number:** __________________

Address of PV System: ____

Home Square Footage: _________ **Number of Occupants:** _____

Water Heating: __ Natural Gas __Electricity __Other_______ **Air Conditioning**: __Yes __No

Home Heating: __Natural Gas __Fuel Oil __Propane __Electricity __Other_______

System Information

Array Capacity: ___________ DC kW

Circle the letter of the choice that applies to your household.

1. Do you have a service contract with your installer to provide maintenance of your system?

a. Yes, I currently have one in place.

b. My service plan has expired, and I have not renewed it with my installer.

c. No, I have never had a service plan.

d. Other: ____

2. To your knowledge, has your system had any operational issues or downtime since its installation?

a. No.

b. Yes. (***Please fill in table below. The first row of the table below provides an example.***)

Issue	Approximate Date	Length of Downtime
Example: Inverter failure, damaged module, etc.	*March 2011*	*3 days, etc.*

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3. How do you track your system's energy output? If possible, please provide relevant production data for review by our inspector.

a. I don't keep track.

b. Spreadsheet

c. Data logger/monitoring system

d. Written log

4. Can you tell when your system is working and when it is not?

a. No.

b. Yes. How can you tell? ____
____

Decision Making

F1. Would you have installed the **same** Solar PV project without the NYSERDA program?

a. Yes. Please complete questions F2 through F4

b. No. Please complete questions F5 through F7

F2. ***[If yes to F1]*** From this list, select the statement that best describes where you were in the planning of your installation when you learned of NYSERDA's program.

a. We had no formal plans for the project. We had discussed it but had not contacted a PV installer.

b. We had already spoken to PV installers but had not received any quotes.

c. We had already spoken to PV installers and had received a quote.

d. We had received a quote and had decided upon the PV system we wanted to install.

F3. ***[If yes to F1]*** Without the NYSERDA program, what would you have installed?

a. The same size system

b. A smaller system

c. No new system at all ***(Skip to next section, "Other Purchases and Behaviors," question S1.)***

F4. ***[If yes to F1]*** Without the NYSERDA program, when would you have installed the Solar PV project?

a. Within the same year?

b. Within one to two years?

c. Within three to five years?

Please skip to next section, "Other Purchases and Behaviors," question S1.

F5. ***[If no to F1]*** To confirm, when you indicate you **would not have installed** the same Solar PV project, do you mean that in the absence of the NYSERDA program you would not have installed the Solar PV project **at all?**

a. Yes ***(Skip to next section, "Other Purchases and Behaviors," question S1.)***

b. No

F6. ***[If no to F1]*** Without the NYSERDA program, what would you have installed?

a. The same size system

b. A smaller system

c. No new system at all ***(Skip to next section, "Other Purchases and Behaviors," question S1.)***

F7. ***[If no to F1]*** Without the NYSERDA program, when would you have installed the Solar PV project?

a. Within the same year?

b. Within one to two years?

c. Within three to five years?

Other Purchases and Behaviors

S1. Since installing your PV system, have you installed additional renewable equipment at this location or others in New York State?

a. No. Why not? ____
(Skip to question S4 on the following page.)

b. Yes. ***(Provide details on the lines below.)***

Technology Type**:** ____

If wind or PV, how many kW of additional capacity were provided: ______________DC kW

If biomass, solar thermal, solar wall, solar water heater, or other, how much energy usage do you offset with your new system? _________ kWh or therms or BTUs
(Write the amount and circle the appropriate energy measure.)

S2. Would you say that your involvement with NYSERDA's incentive program for your PV system influenced your decision to install the additional renewable equipment? Was the program:

a. Not at all influential.

b. Somewhat influential.

c. Very influential.

d. Extremely influential.

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S3. Did you receive rebates, grants, or tax credits for installation of your additional renewable equipment?

a. No.

b. Yes. Please specify ____

S4. Since installing your RPS-CST PV system, have you installed any energy-efficient or ENERGY STAR-qualified equipment? If yes, please fill out the following three questions in the table:

List any energy-efficient or ENERGY STAR-rated equipment you installed after your RPS-CST PV system. (Examples include appliances, insulation, and HVAC equipment.)	For each piece of equipment, rate the program's influence on your decisions to make additional purchases: 1 = not at all influential; 2 = not very influential; 3 = somewhat influential; 4 = very influential.	For each piece of equipment, did you receive any rebates or other financial assistance? If so, please list the funding type you received.
#1	1 2 3 4	
#2	1 2 3 4	
#3	1 2 3 4	
#4	1 2 3 4	
#5	1 2 3 4	

S5. For equipment listed in S4, please tell us a little more about the equipment cited. What fuel does this upgrade help you save on? What type and how old was the previous equipment?

Equipment #1: ____

____

Equipment #2: ____

____

Equipment #3: ____

____

Equipment #4: ____

____

Equipment #5: ____

____

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S6. Since installing your RPS-CST PV system, have you undertaken any of the following behaviors? For each new behavior, circle the letter preceding the sentence and then circle the Influence Rating number to show the program's influence on your decision to make this purchase: 1 = not at all influential; 2 = not very influential; 3 = somewhat influential; 4 = very influential.

a. Increase thermostat settings in the summer.	*Influence Rating:*	1	2	3	4
b. Decrease thermostat settings in winter.	*Influence Rating:*	1	2	3	4
c. Decrease temperature setting on water heater.	*Influence Rating:*	1	2	3	4
d. Decrease hot water use.	*Influence Rating:*	1	2	3	4
e. Turn the lights off more.	*Influence Rating:*	1	2	3	4
f. Reduce the number of electrical equipment plugged in.	*Influence Rating:*	1	2	3	4
g. Installed motion sensors for lighting.	*Influence Rating:*	1	2	3	4

S7. Since installing your RPS-CST PV system, have you undertaken any of the following behaviors? Please circle all that apply.

a. Decrease thermostat settings in the summer.
b. Increase thermostat settings in winter.
c. Increase temperature setting on water heater.
d. Increase hot water use.
e. Keep the lights on more.
f. Increased the amount of electrical equipment plugged in.
g. Installed additional large electrical equipment.

S8. Do you have any comments or questions?

____
____
____
____
____

Thank you for taking the time to answer these questions. Your information helps improve the program.

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Figure 2 NYSERDA CST Solar PV Program Non-Residential Survey

NYSERDA Renewable Portfolio Standard-Funded Customer-Sited Tier (CST) Solar PV Program Commercial Survey

Thank you for participating in this study. *Your experience is important.* Your feedback, together with the feedback of others, will help NYSERDA improve future programs. Your responses will be kept private to the extent permitted by law. NYSERDA's analysis only uses summary-level data and does not identify individuals.

- Please print this form and have it completed by the person most knowledgeable about solar photovoltaic (PV) equipment installed at your facility.
- Have the completed form ready for the PV engineer during the on-site inspection.
- Should you have any questions about this study, contact Rebecca Reed from NYSERDA at 866-697-3732, ext. 3559, or by e-mail at rlr@nyserda.org.

Respondent Name: ________________________________ **Phone Number:** __________________

Address of PV System: ____

Building Square Footage: _________ **Number of Employees:** _____

Water Heating: __ Natural Gas __Electricity __Other_______ **Air Conditioning**: __Yes __No

Building Heating: __Natural Gas __Fuel Oil __Propane __Electricity __Other_______

System Information

Array Capacity: ___________ DC kW

Circle the letter of the choice that applies to your organization.

1. Do you have a service contract with your installer to provide maintenance of your system?

a. Yes, I currently have one in place.

b. My service plan has expired, and I have not renewed it with my installer.

c. No, I have never had a service plan.

d. Other: ____

2. To your knowledge, has your system had any operational issues or downtime since its installation?

a. No.

b. Yes. (***Please fill in table below. The first row of the table below provides an example.***)

Issue	Approximate Date	Length of Downtime
Example: Inverter failure, damaged module, etc.	*March 2011*	*3 days, etc.*

3. How do you track your system's energy output? If possible, please provide relevant production data for review by our inspector.

a. I don't keep track.

b. Spreadsheet

c. Data logger/monitoring system

d. Written log

4. Can you tell when your system is working and when it is not?

a. No.

b. Yes. How can you tell? ____

____

Decision Making

F1. Would you have installed the **same** Solar PV project without the NYSERDA program?

a. Yes. Please complete questions F2 through F4

b. No. Please complete questions F5 through F7

F2. ***[If yes to F1]*** From this list, select the statement that best describes where you were in the planning of your installation when you learned of NYSERDA's program.

a. We had no formal plans for the project. We had discussed it but had not contacted a PV installer.

b. We had already spoken to PV installers but had not received any quotes.

c. We had already spoken to PV installers and had received a quote.

d. We had received a quote and had decided upon the PV system we wanted to install.

F3. ***[If yes to F1]*** Without the NYSERDA program, what would you have installed?

a. The same size system

b. A smaller system

c. No new system at all ***(Skip to next section, "Other Purchases and Behaviors," question S1.)***

F4. ***[If yes to F1]*** Without the NYSERDA program, when would you have installed the Solar PV project?

a. Within the same year?

b. Within one to two years?

c. Within three to five years?

Please skip to next section, "Other Purchases and Behaviors," question S1.

F5. ***[If no to F1]*** To confirm, when you indicate you **would not have installed** the same Solar PV project, do you mean that in the absence of the NYSERDA program you would not have installed the Solar PV project **at all?**

a. Yes ***(Skip to next section, "Other Purchases and Behaviors," question S1.)***

b. No

F6. ***[If no to F1]*** Without the NYSERDA program, what would you have installed?

a. The same size system

b. A smaller system

c. No new system at all ***(Skip to next section, "Other Purchases and Behaviors," question S1.)***

F7. ***[If no to F1]*** Without the NYSERDA program, when would you have installed the Solar PV project?

a. Within the same year?

b. Within one to two years?

c. Within three to five years?

Other Purchases and Behaviors

S1. Since installing your PV system, have you installed additional renewable equipment at this location or others in New York State?

a. No. Why not? ____
(Skip to question S4 on the following page.)

b. Yes. ***(Provide details on the lines below.)***

Technology Type**:** ____

If wind or PV, how many kW of additional capacity were provided: _____________DC kW

If biomass, solar thermal, solar wall, solar water heater, or other, how much energy usage do you offset with your new system? _________ kWh or therms or BTUs
(Write the amount and circle the appropriate energy measure.)

S2. Would you say that your involvement with NYSERDA's incentive program for your PV system influenced your decision to install the additional renewable equipment? Was the program:

a. Not at all influential.

b. Somewhat influential.

c. Very influential.

d. Extremely influential.

S3. Did you receive rebates, grants, or tax credits for installation of your additional renewable equipment?

a. No.

b. Yes. Please specify ____

S4. Since installing your RPS-CST PV system, have you installed any energy-efficient or ENERGY STAR-qualified equipment? If yes, please fill out the following three questions in the table:

List any energy-efficient or ENERGY STAR-rated equipment you installed after your RPS-CST PV system. (Examples include appliances, insulation, and HVAC equipment.)	For each piece of equipment, rate the program's influence on your decisions to make additional purchases: 1 = not at all influential; 2 = not very influential; 3 = somewhat influential; 4 = very influential.	For each piece of equipment, did you receive any rebates or other financial assistance? If so, please list the funding type you received.
#1	1 2 3 4	
#2	1 2 3 4	
#3	1 2 3 4	
#4	1 2 3 4	
#5	1 2 3 4	

S5. For equipment listed in S4, please tell us a little more about the equipment cited. What fuel does this upgrade help you save on? What type and how old was the previous equipment?

Equipment #1: ____

____

Equipment #2: ____

____

Equipment #3: ____

____

Equipment #4: ____

____

Equipment #5: ____

____

S6. Since installing your RPS-CST PV system, have you undertaken any of the following behaviors? For each new behavior, circle the letter preceding the sentence and then circle the Influence Rating number to show the program's influence on your decision to make this purchase: 1 = not at all influential; 2 = not very influential; 3 = somewhat influential; 4 = very influential.

a. Increase thermostat settings in the summer.	*Influence Rating:*	1	2	3	4
b. Decrease thermostat settings in winter.	*Influence Rating:*	1	2	3	4
c. Decrease temperature setting on water heater.	*Influence Rating:*	1	2	3	4
d. Decrease hot water use.	*Influence Rating:*	1	2	3	4
e. Turn the lights off more.	*Influence Rating:*	1	2	3	4
f. Reduce the number of electrical equipment plugged in.	*Influence Rating:*	1	2	3	4
g. Installed motion sensors for lighting.	*Influence Rating:*	1	2	3	4
h. Turn off office equipment when not in use.	*Influence Rating:*	1	2	3	4

S7. Since installing your RPS-CST PV system, have you undertaken any of the following behaviors? Please circle all that apply.

a. Decrease thermostat settings in the summer.
b. Increase thermostat settings in winter.
c. Increase temperature setting on water heater.
d. Increase hot water use.
e. Keep the lights on more.
f. Increased the amount of electrical equipment plugged in.
g. Installed additional large electrical equipment.

S8. Do you have any comments or questions?

____
____
____
____
____

Thank you for taking the time to answer these questions. Your information helps improve the program.

APPENDIX D: NYSERDA RPS CST SOLAR PV PROGRAM SURVEY RESPONSES

1.1 Introduction

Surveys were administered by Cadmus to 2008 through 2011 NYSERDA CST Solar PV Program participants during the site visits completed in Q4 of 2012. Table 1 shows how many residential and non-residential program participants were surveyed.

Table 1. Surveys Administered by Participant Class

Participant Class	Number Surveyed
Residential	50
Non-residential	39
TOTAL	89

Survey data was used to calculate program freeridership and spillover as discussed in the body of the report. This additional analysis aims to:

- Highlight interesting anecdotal information,
- Identify reasons for installing or not installing additional renewable energy equipment, and
- Discuss relationships between these and other survey data.

1.2 Anecdotal Information from Participant Comments

1.2.1 Residential Participants

Of the 50 residential participants surveyed, 29 provided additional comments. Many respondents (9) expressed their general appreciation for the program and/or for the energy cost savings they now enjoy; some (4) expressed interest in increased levels of funding and/or funding for other, similar programs; others (2) went further to explain how their investment in renewable energy equipment only occurred – or occurred sooner rather than later – because of the incentives offered through NYSERDA.

Multiple respondents (7) noted the “green” or environmental benefits of their own investments and/or of the program’s impact more generally. One of these seven respondents noted that, although she was happy with pursuing the installation of renewable energy equipment for environmental reasons, she laments not investing first in building envelope and other energy efficiency measures due to their being more cost-effective.

One respondent regretted not installing a larger system, and furthermore would have preferred to connect his system directly to the grid.

One respondent expressed frustration with his grid connection agreement. Two others expressed frustration with their installed equipment; one felt that although the implementation contractor was very professional, his installed solar panels were “deplorable,” and the other felt that his installed solar panels did not match what was depicted in the “post cards.”

1.2.2 Non-residential Participants

Of the 39 non-residential participants surveyed, 14 provided additional comments. Two respondents explicitly expressed their appreciation for the program. Others (3) were also appreciative of the program, noting that their renewable energy installations were financially out of reach prior to program participation. Additionally, one respondent expressed gratitude for NYSERDA and the CST Solar PV program because solar energy production prevents carbon from entering the atmosphere.

Three non-residential respondents shared plans for implementing additional renewable energy equipment. One shared plans to install additional solar PV panels within the next five years; one explained how cost savings on her solar project resulted in budgetary flexibility for planning a separate 1.2 MW solar array; and one expressed interest in pursuing geothermal and wind installations.

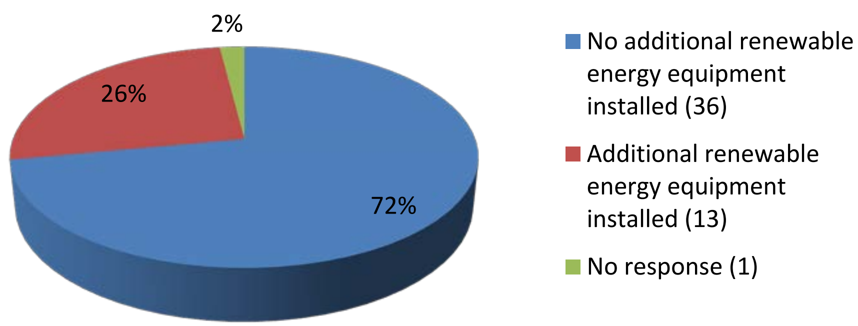
Finally, one non-residential respondent expressed frustration about the capacity limits for array installations; another respondent expressed similar frustration, noting specifically that energy costs have not decreased as much as expected.

1.3 Installation of Additional Renewable Energy Equipment

1.3.1 Residential Participants

Of the 50 residential program participants surveyed, 36 indicated that they had not installed additional renewable energy equipment at any locations within New York State; 13 indicated that they had installed additional equipment; and one did not respond to the question. Figure 1 illustrates the breakdown in residential participant responses.

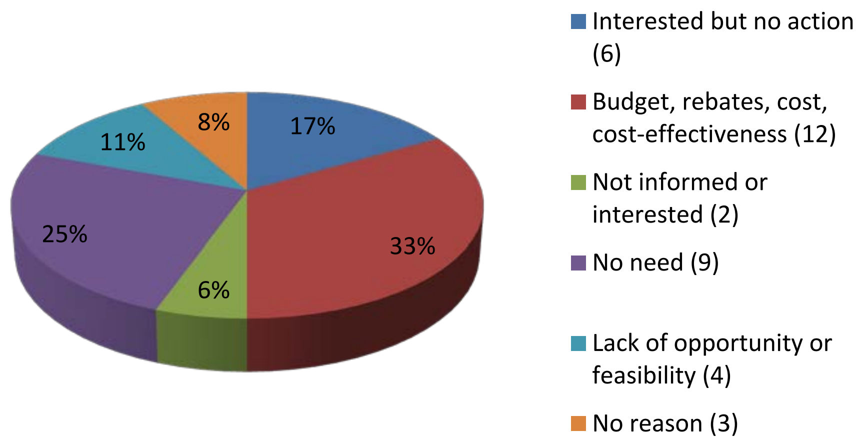
Figure 1. Residential Installation of Additional Renewable Energy Equipment



Of the 36 residential respondents who indicated they had not installed additional renewable energy equipment, six indicated interest in pursuing additional installations in the near future. Five of these respondents simply expressed an interest in pursuing additional installations, either in general or a specific type; the sixth shared concrete plans for future solar panel installations.

The other 30 residential respondents who indicated they had not installed additional renewable energy equipment gave various reasons for not doing so and, furthermore, for not planning to do so. Twelve respondents cited a limited budget, lack of rebates (for additional solar panels), project cost, or project cost-effectiveness as the primary reason for not installing additional renewable energy equipment. Nine respondents noted that they didn't see any additional need for more renewable energy equipment. Four respondents expressed a lack of opportunity or feasibility. Two respondents indicated that they were lacking information about additional possibilities or simply not interested in additional projects. Finally, three respondents did not give a reason for not pursuing additional renewable energy equipment. Figure 2 illustrates the different reasons given by residential respondents for not installing additional renewable energy equipment.

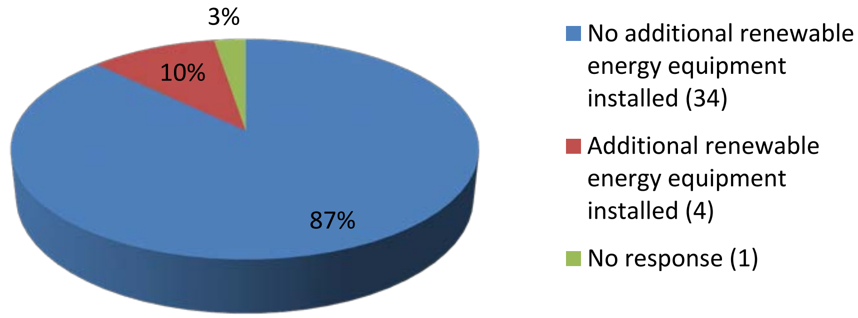
Figure 2. Reasons for Not Installing Additional Renewable Energy Equipment (Residential)



1.3.2 Non-residential Participants

Of the 39 non-residential program participants surveyed, 34 indicated that they have not installed additional renewable energy equipment at any sites within New York State; four indicated that they have installed additional equipment; and one did not respond to the question. Figure 3 illustrates the breakdown in non-residential participant responses.

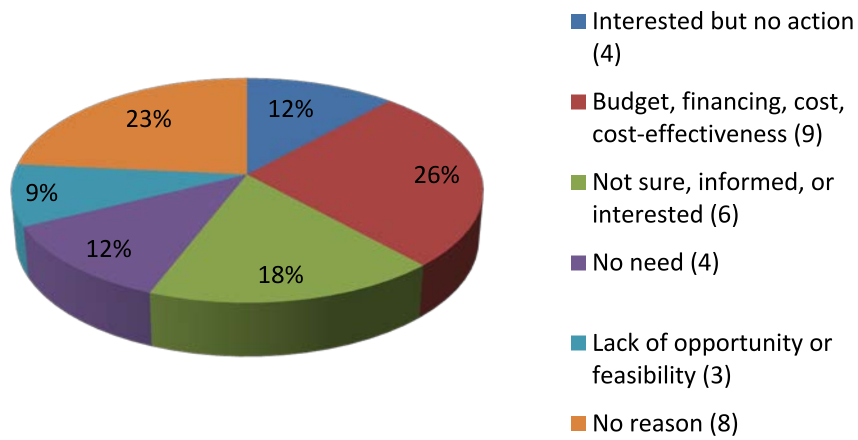
Figure 3. Non-residential Installation of Additional Renewable Energy Equipment



Of the 34 non-residential respondents who indicated they had not installed additional renewable energy equipment, four indicated interest in pursuing additional installations in the near future. Three of these respondents shared concrete plans for future installations and/or third party energy evaluations that would inform future projects; the fourth simply expressed an interest in pursuing additional installations within the next five years.

The other 30 non-residential respondents who indicated they had not installed additional renewable energy equipment gave various reasons for not doing so and, furthermore, for not planning to do so. Nine respondents cited a limited budget, lack of financing, project cost, or project cost-effectiveness as the primary reason for not pursuing additional installations. Six respondents indicated that they were not sure what to pursue, not informed about additional possibilities, or simply not interested in additional renewable energy projects. Four respondents noted that they didn't see any additional need for more renewable energy installations. Three respondents expressed a lack of opportunity or feasibility. Finally, eight respondents did not give a reason for not pursuing additional renewable energy equipment. Figure 4 illustrates the different reasons given by non-residential respondents for not installing additional renewable energy equipment.

Figure 4. Reasons for Not Installing Additional Renewable Energy Equipment (Non-residential)



1.4 Relationships with Other Survey Data

1.4.1 Service Contracts and Additional Renewable Energy Equipment

Among both residential and non-residential participants, no one with a current service contract has plans to install additional renewable energy equipment. Within this group, all residential participants expressed a lack of need for additional renewable equipment; there was no similar trend among non-residential participants with service contracts.

1.4.2 Operational Issues and Additional Renewable Energy Equipment

Of the program participants surveyed, 14 residential and 11 non-residential respondents have experienced some operational issues with their installed solar equipment. None of the non-residential respondents expressed intentions to install additional renewable equipment. No similar trend was apparent among residential respondents, however, as five of the 14 have plans for installing additional renewable equipment.

1.4.3 Program Influence and Additional Renewable Energy Equipment

Of the program participants surveyed, ten residential and 13 non-residential respondents noted that the NYSERDA incentive program was “extremely influential” in making the decision to install renewable energy equipment.

Seven of these ten residential respondents have since installed additional renewable energy equipment. Meanwhile, only six of the 40 residential respondents who were less influenced by the NYSERDA incentive program – or not influenced at all – have since installed additional renewable energy equipment.

Conversely, only three of these 13 non-residential respondents have since completed additional installations; however, three more shared plans to complete additional installations in the future. Only one of the 26 non-residential respondents who were less influenced by the NYSERDA incentive program – or not influenced at all – has since installed additional renewable energy equipment.

APPENDIX E: NYSERDA RPS CST ON-SITE WIND SAMPLE SITE DESCRIPTIONS

Table 1. On-Site Wind System Information

Application Number	County	Type	Turbine Make/Model	Nameplate Capacity kW	Estimated AEP kWh
3002-07	Chautauqua	Residential	Bergey Excel-S	10	4,250
3002-08	Wyoming	Agricultural	Bergey Excel-S	10	11,508
3003-01	Onondaga	Residential	Bergey Excel-S	10	9,623
3004-10	Ontario	Residential	Bergey Excel-S	10	8,035
3004-11	Ontario	Residential	Bergey Excel 10	10	14,746
3012-03	Cortland	Educational	Endurance/S-250	4.25	6,500
3012-04	Allegany	Residential	Bergey Excel-S	10	8,600
3016-06	Chemung	Residential	Bergey Excel 10	10	7,400
3016-07	Chemung	Residential	Bergey Excel 10	10	8,130
3017-01	Ontario	Residential	Bergey Excel-S	10	6,665
3017-02	Ontario	Agricultural	Bergey Excel-S	10	8,332
3017-04	Cayuga	Commercial	Bergey Excel-S	10	6,514
3023-01	Clinton	Residential	Bergey Excel-S	10	9,209
3031-01	Wayne	Agricultural	Endurance/S-250	4.25	5,300
3132-10	Yates	Agricultural	Southwest Wind	2.1	2,800
3132-12	Onondaga	Residential	Jacobs	17	4,700
3136-01	Chautauqua	Residential	Bergey Excel 10	10	19,700
3140-01	Madison	Residential	Bergey Excel-S	10	10,200
3140-02	Dutchess	Agricultural	Bergey Excel-S	10	11,175
3140-04	Oswego	Municipal	Northwind	77.7	71,373
3141-01	Tioga	Agricultural	Bergey Excel-S	10	5,222
3142-01	Cayuga	Residential	Bergey Excel 10	10	6,646
3143-01	Wayne	Agricultural	Southwest Wind	2.1	1,980
3144-02	Oswego	Residential	Bergey Excel-S	10	3,850
3144-03	Oswego	Agricultural	Bergey Excel-S	10	8,293
3144-04	Oswego	Residential	Bergey Excel-S	10	9,000
3144-05	Onondaga	Residential	Bergey Excel-S	10	14,000
3144-06	Oswego	Residential	Bergey Excel-S	10	11,463

3144-07	Jefferson	Agricultural	Bergey Excel 10	10	8,055
3144-08	Sullivan	Agricultural	Bergey Excel 10	10	7,000
3144-09	Oswego	Residential	Bergey Excel 10	10	8,000
3144-10	Oswego	Residential	Bergey Excel 10	10	5,787
3144-11	Onondaga	Residential	Bergey Excel 10	10	11,453
3144-12	Madison	Commercial	Bergey Excel 10	10	7,000
3144-13	Columbia	Agricultural	Bergey Excel 10	8.9	6,599
3144-15	Columbia	Agricultural	Bergey Excel 10	8.9	8,846
3144-17	Jefferson	Agricultural	Bergey Excel 10	8.9	9,922
3145-01	St. Lawrence	Residential	Endurance/S-250	4.25	5,047
3148-01	Albany	Agricultural	Bergey Excel-S	10	10,000
3149-03	Oswego	Agricultural	Xzeres 442	10	9,885
3149-06	Montgomery	Residential	ReDriven/FD8-10kW	10	3,000
3149-09	Oswego	Agricultural	Xzeres 442	9.2	9,031
3149-10	St. Lawrence	Residential	ReDriven/FD8-10kW	10	2,000
3149-19	Livingston	Agricultural	Xzeres 442	9.17	12,554
3152-01	Saratoga	Residential	Bergey Excel-S	10	5,200
3156-01	Chemung	Residential	Bergey Excel-S	10	6,850
3156-02	Steuben	Residential	Bergey Excel 10	10	8,104
3158-01	Onondaga	Residential	Bergey Excel-S	10	11,825
3158-02	Madison	Residential	Bergey Excel-S	10	11,243
3158-03	Madison	Residential	Bergey Excel 10	10	10,515
3158-04	Madison	Residential	Bergey Excel 10	10	11,000
3165-01	Saratoga	School	Fortis / Montana (2 ea.)	11.6	2,520
3170-1	Ontario	Residential	Xzeres 110	2.50	1,600

APPENDIX F: NYSERDA RPS CST ON-SITE WIND WEATHER DATA STATION LOCATIONS

Table 1. NOAA/NCDC Weather Station Locations: Wind Data

NOAA/NCDC **Weather Station**	**Latitude**	**Longitude**
Albany International Airport	42.748	-73.803
Binghamton: Greater Binghamton/E A Link Field AP	42.208	-75.981
Dunkirk Airport	42.492	-79.275
Massena International Airport-Richards Field	44.934	-74.846
Rochester: Greater Rochester International Airport	43.117	-77.677
Syracuse: Syracuse Hancock International Airport	43.109	-76.103
Watertown: Watertown International Airport	43.992	-76.022

Figure 1. NOAA/NCDC Weather Station Locations: Wind Data