## Title
Tracking the Sun VII: An Historical Summary of the Installed Price of Photovoltaics in the United States from 1998 to 2013



## Authors
Barbose, Galen
Weaver, Samantha
Darghouth, Naim

## Publication Date
2014-09-15

# Tracking the Sun VII

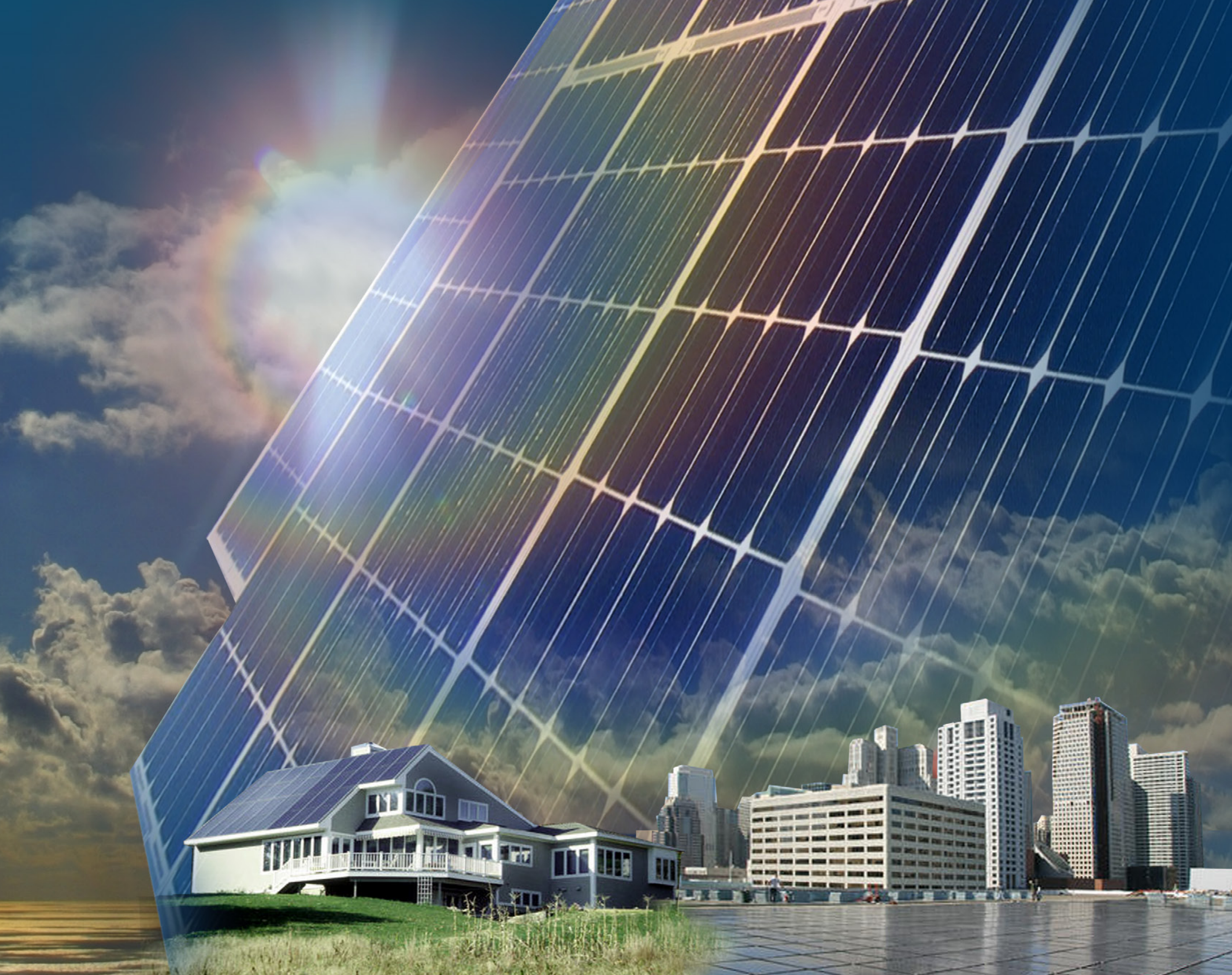
## An Historical Summary of the Installed Price of Photovoltaics in the United States from 1998 to 2013

Galen Barbose, Samantha Weaver, Naïm Darghouth

September 2014

BERKELEY LAB

Lawrence Berkeley
National Laboratory



# Tracking the Sun VII

## An Historical Summary of the Installed Price of Photovoltaics in the United States from 1998 to 2013

**Primary Authors: Galen Barbose, Samantha Weaver, Naïm Darghouth**

Environmental Energy Technologies Division, Lawrence Berkeley National Laboratory

## Contents

Executive Summary ........................................................ 1

1. Introduction ........................................................ 5

2. Data Summary ........................................................ 8
   - Data Sources ........................................................ 8
   - Data Standardization and Cleaning ........................................................ 8
   - Sample Description ........................................................ 9

3. Installed Price Trends: Residential and Commercial PV........................................................ 13
   - Installed Prices Continued Their Precipitous Decline in 2013 and 2014 ........................................................ 13
   - Installed Price Reductions Have Persisted, Even as Module Prices Flattened ........................................................ 15
   - Installed Price Declines Have Occurred in Concert with Falling State/Utility Incentives ........................................................ 16
   - Installed Prices in the United States Are Higher than in Many Other Major International PV Markets ........................................................ 19
   - Installed Prices Vary Widely Across Individual Projects ........................................................ 20
   - Installed Prices Exhibit Clear Economies of Scale ........................................................ 22
   - Installed Prices Differ Significantly Among States ........................................................ 22
   - Installed Prices for Third Party Owned Systems Retained in the Data Sample Are Similar to Those for Host Customer Owned Systems ........................................................ 25
   - Microinverters Are Associated with Higher Installed Prices for Small Systems but Lower Installed Prices for Medium-Sized System ........................................................ 28
   - Installed Prices Are Higher for Systems with High Efficiency Modules ........................................................ 29
   - Installed Prices for Systems with Chinese-Brand Modules Have Generally Been Slightly Lower than for Other Systems with Comparable Module Efficiency ........................................................ 31
   - Installed Prices Are Higher for Tax-Exempt Customers than for Other Customer Segments ........................................................ 32
   - Residential New Construction Offers Significant Installed Price Advantages Compared to Retrofit Applications ........................................................ 34
   - Within the Residential New Construction Market, BIPV Systems Have Shown Substantially Higher Installed Prices than Rack-Mounted Systems ........................................................ 35
   - The Relative Installed Price of Ground-Mounted to Roof-Mounted Systems Depends on System Size ........................................................ 36
   - Residential and Commercial Systems with Tracking Have Higher Installed Prices than Fixed-Tilt Systems ........................................................ 37

4. Installed Price Trends: Utility-Scale PV ........................................................ 39
   - The Installed Price of Utility-Scale PV Has Declined over Time, Though Considerable Variation Exists across Projects ........................................................ 40
   - Installed Price Trends Differ Across System Configurations ........................................................ 41
   - Larger Utility-Scale PV Projects Tend to Exhibit More-Uniform Pricing ........................................................ 42

5. Conclusions and Policy Implications ........................................................ 43

Appendix A: Data Cleaning, Coding, and Standardization ........................................................ 46

Appendix B: Residential and Commercial PV Data Sample Summaries ........................................................ 49

# Executive Summary

As the deployment of grid-connected solar photovoltaic (PV) systems has increased, so too has the desire to track the cost and price of these systems. This report helps to fill this need by summarizing trends in the *installed price* of grid-connected PV systems in the United States from 1998 through 2013, with partial data for the first half of 2014. The analysis is based on project-level data for more than 300,000 individual residential, commercial, and utility-scale PV systems installed across 33 states and representing 80% of all grid-connected PV capacity installed in the United States through 2013.

**It is essential to note at the outset what the data presented within this report represent.** First, the data consist of prices paid to project developers or installers (prior to receipt of any incentives), and for a variety of reasons, those prices may differ from the underlying costs borne by project developers/installers. Second, the data are historical, focusing primarily on projects installed through the end of 2013, and therefore do not reflect the price of projects installed more recently (with the exception of the limited set of results presented for systems installed in the first half of 2014); nor are the data indicative of prices currently being quoted for prospective projects to be installed at a later date. For these reasons and others (see Text Box 1, within the main body), the results presented in this report may differ from current PV price or cost benchmarks. Third, by focusing on the up-front price paid by the PV system owner prior, the report does not capture trends associated with PV performance or other factors that impact the levelized cost of electricity for PV. Finally, the underlying data collected for this report include third party owned (TPO) projects where either the system is leased to the site-host or the generation output is sold to the site-host under a power purchase agreement. For a subset of TPO systems, the installed price data represent *appraised values* rather than transaction prices, and those projects were removed from the data sample in order to eliminate any associated bias (see Section 2 and Appendix A for further details).

The report presents one set of installed price trends for residential and commercial PV systems, and another set for utility-scale PV. In all cases, installed prices are identified in terms of real 2013 dollars per installed watt (DC-STC), prior to receipt of any direct financial incentives or tax credits.

**Key findings for residential and commercial PV[1] are as follows:**

- Installed prices continued their precipitous decline in 2013, falling year-over-year by \$0.7/W, or 12-15% depending on system size range. Among projects installed in 2013, median installed prices were \$4.7/W for systems ≤10 kW, \$4.3/W for systems 10-100 kW, and \$3.9/W for systems >100 kW.
- Data for the first six months of 2014 indicate that installed prices have continued to fall, with the median installed price of systems in a number of the larger state markets declining by an additional \$0.2/W to \$0.5/W (5-12%) depending on system size, relative to the price of systems installed throughout all of 2013.
- The decline in installed system prices since 2008 is largely attributable to module price reductions, which fell by \$2.7/W from 2008 through 2013 and represented 67% of the total drop in installed prices for ≤10 kW systems over that period. That said, module prices remained relatively flat from 2012 to 2013, yet installed price reductions continued. This

[1] For the purpose of this report, residential and commercial PV are defined to consist of roof-mounted systems of any size and ground-mounted systems up to 5 $MW_{AC}$ in size.

may signify the lagged effect of module price reductions from the preceding year, but is also consistent with reductions in non-module costs.

- Over the long-term, non-module costs –including such items as inverters, mounting hardware, labor, permitting and fees, customer acquisition, overhead, taxes, and installer profit – have fallen substantially. For ≤10 kW systems, non-module costs declined by approximately $3.0/W from 1998 to 2013, constituting 42% of the reduction in total installed system prices over that period.
- Cash incentives provided through state and utility PV incentive programs (i.e., rebates and performance based incentives) have fallen by 85% to 95% since their peak a decade ago, offsetting much of the installed price reductions from the perspective of customer-economics. From 2012 to 2013, the median pre-tax value of cash incentives provided through the PV incentive programs in the data sample declined by an amount equivalent to 40% to 50% of the corresponding drop in installed prices, depending on system size.
- International experience suggests that greater near-term price reductions in the United States are possible, as the median installed price of residential PV installations in 2013 (excluding sales/value-added tax) was just $2.1/W in Germany, $2.7/W in the United Kingdom, $2.9/W in Italy, and $4.0/W in France, compared to $4.4/W in the United States.
- The distribution of installed prices across projects has narrowed somewhat over time, but has remained relatively stable in recent years, and significant pricing variability persists. For example, among ≤10 kW systems installed in 2013, roughly 20% had an installed price less than $3.9/W, while a similar percentage was priced above $5.6/W. Such variability likely reflects differences in project and installer characteristics, as well as regional and local market and regulatory conditions.
- Installed prices exhibit significant economies of scale, with a median installed price of $4.8/W for systems ≤2 kW completed in 2013, compared to $3.1/W for commercial systems >1,000 kW. The installed price of utility-scale systems is even lower, as discussed further below.
- Installed prices vary widely across states. Among ≤10 kW systems completed in 2013, median installed prices ranged from a low of $3.3/W in Florida to a high of $5.3/W in North Carolina. California, which constitutes a large fraction of the data sample and therefore heavily impacts the aggregate price trends, is a relatively high-priced state, with a median price of $4.9/W for ≤10 kW systems in 2013.
- Installed prices for TPO systems retained in the data sample, which represent sales prices paid to installation contractors, have generally been similar to or slightly less than prices reported for customer-owned systems. The growing prominence of TPO thus does not appear to have had a significant direct impact on the overall price trends presented within this report (given that appraised value systems have been removed from the data sample).
- Small PV systems with microinverters have generally had slightly higher installed prices than those with standard inverters, though that differential shrank in 2013 to just $0.1/W (2%). The increasing penetration of microinverters has thus modestly dampened the installed price decline for small systems. In contrast, among larger systems sizes, systems with microinverters have generally had lower installed prices, with a difference in median installed price equal to $0.4/W (10%) for 10-100 kW systems installed in 2013.

- Installed prices have been significantly higher for systems with high-efficiency modules than for those with standard efficiency modules. Among systems installed in 2013, the median installed price of systems with module efficiencies >18% was $0.5/W to $1.0/W higher than for those with module efficiencies of 14-16%, depending on system size.
- Systems with Chinese-brand modules generally have had slightly lower installed prices than those with Non-Chinese brand modules, when comparing within a given module efficiency class. Among systems installed in 2013 with module efficiencies ranging from 14-16%, systems with Chinese-brand modules had a median installed price $0.1/W to $0.3/W less than those with non-Chinese modules, depending on system size.
- Installed prices for systems installed at tax-exempt customer sites are typically higher than for similarly sized systems at residential and for-profit commercial customer sites. The differential was greatest among systems >100 kW in 2013, for which the median price of tax-exempt systems was $0.9/W higher than for similarly sized commercial systems, potentially reflecting greater incidence of prevailing wage requirements, carport or parking structures, and other factors.
- The residential new construction market appears to offer significant price advantages relative to residential retrofits. Among 1-4 kW systems (the size range typical of PV in residential new construction) installed in California in 2013, the median installed price of rack-mounted systems in new construction was $0.9/W lower than for comparably sized retrofit systems.
- Within the new construction market, BIPV systems exhibit significantly higher prices than rack-mounted systems, with a $2.1/W difference in median installed prices for systems installed in 2013. That comparison, however, does not account for any avoided roofing materials cost associated with BIPV.
- Ground-mounted systems are generally higher priced than roof-mounted systems for small system sizes, but lower priced for larger systems. In 2013 for example, the median installed price of ground-mounted systems was $0.7/W higher than roof-mounted systems among ≤10 kW systems but $0.7/W lower for >1,000 kW commercial systems.
- The installed price of residential and commercial systems with tracking is, not surprisingly, higher than for fixed-tilt, ground-mounted systems, though the differential appears to have diminished considerably over time. Among systems installed in 2013, the premium for systems with tracking ranged from $0.2/W to $0.8/W (4% to 20%), depending on system size.

This report separately summarizes installed price data for utility-scale PV projects, drawing upon data also presented in LBNL's companion report, *Utility Scale Solar 2013: An Empirical Analysis of Project Cost, Performance, and Pricing Trends in the United States*. For our purposes, utility-scale PV is defined to consist of ground-mounted projects larger than 5 MW. The sample of installed price data includes 100 projects with commercial operation dates spanning the period 2007-2013. Several important features of the utility-scale data are worth noting, in addition to those noted earlier for the dataset as a whole. First, the sample includes only fully operational projects for which all individual phases are in operation and treats all phases as a single project with a commercial operation date based on the final phase. Second, installed prices reported for utility-scale projects often reflect transactions that occurred several years before project completion; the prices reported for some of these projects may not fully capture recent reductions in module costs or other changes in market conditions, and thus may exhibit a relatively large "temporal lag".

With those considerations in mind, **key findings for utility-scale PV are as follows**:

- Over the full timeframe of the utility-scale data sample, capacity-weighted average installed prices fell by 40%, from $5.0/W for the 5 systems installed during the 2007-2009 period to $3.0/W for the 25 systems completed in 2013. Year-over-year, however, capacity-weighted average prices in 2013 remained virtually unchanged from 2012, though that apparent flattening may be partly an artifact of a preponderance of large (>100 MW) projects completed in 2013, some with tracking and/or premium efficiency modules, and that may have been contracted 3-4 years earlier.
- Installed prices have fallen much more substantially over time for systems with crystalline silicon (c-Si) modules than for those with thin-film modules. For example, among c-Si systems with tracking, average installed prices fell by $3.4/W (52%) between the 2007-2009 period and 2013. By comparison, the average price of thin-film projects remained virtually unchanged over that span, leading to a marked convergence in pricing between the two technology classes.
- Installed prices vary considerably across individual utility-scale PV projects, ranging from $1.9/W to $4.9/W across the 25 projects completed in 2013, with most projects ranging from $2.6/W to $3.5/W (the 20$^{th}$ and 80$^{th}$ percentiles, respectively), and similar or greater levels of variability in prior years. This variation partly reflects differences in project configuration and size, though other factors are also clearly important.
- Among utility-scale projects completed in 2013, the capacity-weighted average installed price was $3.1/W for systems with c-Si modules and tracking, $3.0/W for fixed-tilt, c-Si systems, and $2.7/W for fixed-tilt, thin-film systems. Aside from differences in underlying technology costs (i.e., the incremental cost of tracking equipment and the relative cost of c-Si vs. thin-film modules), differences in pricing among these technology classes may also indirectly reflect project characteristics associated with particular configurations (e.g., higher DC/AC ratios in c-Si, fixed-tilt applications and larger project sizes for systems with tracking or thin-film modules).
- Economies of scale are not readily apparent within the utility-scale dataset, presumably because they are obscured by other confounding factors; however, larger utility-scale projects do tend to exhibit more-uniform pricing. For example, among projects completed in 2012 and 2013, systems >50 MW are clustered within a relatively narrow band from $2.6/W to $3.2/W, while the price distribution for projects <50 MW has a longer tail and a number of projects priced well above $4.0/W.

# 1. Introduction

Installations of solar photovoltaic (PV) systems have been growing at a rapid pace in recent years. In 2013, approximately 38,000 megawatts (MW) of PV were installed globally, up from 30,000 MW installed in both 2012 and 2011 and 17,000 MW in 2010.[2,3] With roughly 4,800 MW of grid-connected PV capacity added in 2013, the United States was the world's third-largest PV market in that year, behind China and Japan.[4] Solar energy (most of which being solar PV) was the second-largest source of new electric generation capacity added in the United States in 2013, representing 26% of all new capacity added in that year. Despite this significant growth, however, the share of global and U.S. electricity supply met with PV still remains relatively small.

The market for PV in the United States is, to a significant extent, driven by national, state, and local government incentives, including up-front cash rebates, production-based incentives, renewables portfolio standards, and federal and state tax benefits. These programs are, in part, motivated by the popular appeal of solar energy, and by the positive attributes of PV – modest environmental impacts, mitigation of fuel price risks, coincidence with peak electrical demand, and the ability to deploy PV at the point of use. Given the relatively high historical cost of PV, a key goal of these policies is to encourage cost reductions over time. Complementing those deployment-focused incentive policies are various research and development efforts, including the U.S. Department of Energy (DOE)'s SunShot Initiative, which aims to reduce the cost of PV-generated electricity by 75% between 2010 and 2020. As these various policies and initiatives have become more prevalent, and as PV deployment has accelerated, an increasing need has emerged for comprehensive and reliable data on the cost and price of PV systems. Such data may serve to track progress towards cost reduction targets and identify opportunities for further cost reductions, as well as to better understand pricing dynamics with the PV markets and identify opportunities for improving transparency and competition.

To address these needs, Lawrence Berkeley National Laboratory (LBNL) initiated this annual report series focused on describing historical trends in the *installed price* (that is, the up-front cost borne by the system owner) of grid-connected PV systems in the United States. The present report, the seventh in the series, describes installed price trends for projects installed from 1998 through 2013, with some limited and preliminary results presented for projects installed in the first half of 2014. The analysis is based on project-level data from more than 300,000 residential, commercial, and utility-scale PV systems in the United States. The raw data sample represents 80% of all grid-connected PV capacity installed in the United States through 2013, comprising one of the most comprehensive and detailed sources of installed PV price data. Based on this dataset, the report describes historical installed price trends over time, and by location, market segment, and technology and application type. The report also briefly compares recent PV installed prices in the United States to those in other major international markets, and describes trends in customer incentives for PV installations.

**It is essential to note at the outset what the data presented within this report represent.** First, the data consist of prices paid to project developers or installers (prior to receipt of any incentives), and for a variety of reasons, those prices may differ from the underlying costs borne by project developers/installers. Second, the data are historical, focusing primarily on projects

[2] Throughout this report, all capacity numbers represent rated direct current (DC) module power output.
[3] Data source: EPIA (2014).
[4] Data sources: SEIA/GTM Research (2014a) and REN21 (2014).

installed through the end of 2013, and therefore do not reflect the price of projects installed more recently (with the exception of the limited set of results presented for systems installed in the first half of 2014); nor are the data indicative of prices currently being quoted for prospective projects to be installed at a later date. For these reasons and others (see Text Box 1), the results presented in this report may differ from current PV price benchmarks. Third, by focusing on the up-front price paid by the PV system owner prior, the report does not capture trends associated with PV performance or other factors that affect the levelized cost of electricity (LCOE) for PV.

Also important to note is that the data sample includes many third party owned (TPO) projects where either the system is leased to the site-host or the generation output is sold to the site-host under a power purchase agreement. For a *subset* of TPO systems – namely, those installed by *integrated* companies that both perform the installation and customer financing – the installed price data initially compiled for this analysis represents an *appraised value*. In order to avoid any bias that such data would otherwise introduce into the trends described herein (see Text Box 3 for further discussion), projects for which reported installed prices were deemed likely to represent appraised values were excluded from the analysis; all other TPO systems were retained.[5]

This report is produced in conjunction with a number of other related studies and ongoing research activities. First, the data for this report are collected in concert with the National Renewable Energy Laboratory (NREL)'s *OpenPV* project, an online data-visualization tool that includes most of the data contained within the present report as well additional data contributed by individual PV system owners and installers.[6] Second, select results from each edition of *Tracking the Sun* are incorporated into an annual briefing issued jointly by LBNL and NREL titled, *Photovoltaic System Pricing Trends: Historical, Recent, and Near-Term Projections,* which also draws upon ongoing NREL-led research activities to model PV installed prices and synthesize industry projections for component and system pricing.[7] Third, LBNL has launched a separate annual report series, *Utility-Scale Solar,* focusing exclusively on utility-scale solar projects and presenting data and trends related to not only installed prices but also operating costs, capacity factors, and power purchase agreement prices.[8] Finally, several parallel analyses have been recently completed or are underway, which analyze the underlying data within this report using more-sophisticated statistical techniques.[9]

The remainder of the report is organized as follows. Section 2 summarizes the data collection methodology and resultant data sample. Section 3 presents installed price trends for residential and commercial PV, including trends over time and by system size, state, system ownership model (host customer-owned vs. third party owned), host customer segment (residential vs. commercial vs. tax-exempt), application (new construction vs. retrofit and ground-mounted vs. roof-mounted), and technology characteristics (micro-inverter vs. central inverter, module country-of-origin and efficiency level, building-integrated vs. rack-mounted, and tracking vs. fixed-tilt). Section 3 also compares installed prices between the United States and other major international markets and

[5] TPO systems retained in the analysis are financed by *non-integrated* companies that purchase PV systems from installation contractors; installed prices reported for these systems are purchase prices paid to installation contractors.
[6] See: https://openpv.nrel.gov
[7] See Feldman et al. (2014) for the 2014 edition of the joint NREL-LBNL briefing.
[8] See Bolinger and Weaver (2014) for the 2014 edition of LBNL's *Utility-Scale Solar* report.
[9] These in-depth statistical analyses include Dong and Wiser (2013) and Burkhardt et al. (2014), both of which analyze the impact of permitting and local regulatory processes on residential PV prices and/or development times. Additional forthcoming publications in 2014 and 2015 will examine other drivers for variability in system pricing, including the impact of incentives (i.e., value-based pricing) and the degree to which incentives and reductions in hardware costs are passed through to customers.

summarizes trends in PV incentive levels over time, focusing specifically on incentives provided through state and utility programs. Section 4 then summarizes trends in the installed price of utility-scale PV systems. Brief conclusions are offered in the final section, and several appendices provide additional details on the analysis methodology and additional tabular summaries of the data.

**Text Box 1. Reasons for Deviations between Market Price Data and Current Price Benchmarks**

The installed prices presented in this report are based on data from a large number of market transactions. Various other entities publish benchmarks for the cost or price of PV systems in the United States, often based on bottom-up modeling of individual cost components and processes, and the data presented in this report may differ from those benchmarks for a number of reasons.

- *Timing*: This report focuses on systems installed through the end of 2013, with some limited data for systems installed in the first half of 2014. Installed prices for those systems generally reflect module and other component pricing at the time that installation contracts were signed, which may precede installation dates by up to a year for larger commercial projects and by as much as four years for some of the largest utility-scale projects. PV cost or price benchmarks issued near the same time as this report may instead be based on recent system price quotes or on contemporaneous component pricing, which has fallen significantly in recent years.
- *Price versus cost*: The data summarized in this report represent reported prices paid to installers or project developers. In contrast, other published benchmarks may represent the costs borne by installers or developers, which may differ (for a variety of reasons) from the ultimate sale price.
- *Inefficient pricing*: Even where benchmarks refer to system prices rather than costs, they may be based on stipulated developer/installer profit margins. The reported market price data, in contrast, are based on whatever profit margin developers are able to capture or willing to accept. In markets with relatively high incentives and/or barriers to entry, developers may be able to price projects above the theoretically “efficient” level. Conversely, in other markets, developers may be willing to accept “below-market” margins. In either case, the underlying profit margins embedded in the reported market price data may differ from the assumptions within current PV system pricing benchmarks.
- *Project size, location, and other characteristics*: The market price data summarized in this report reflect the particular characteristics of the projects in the data sample, including their size, geographical location, and component selection. Of particular note, perhaps, is that the residential and commercial sample is weighted heavily towards systems installed in California, which is a relatively expensive market, and the utility-scale systems in the sample include many systems with high-efficiency (and relatively high-cost) modules. These project characteristics may differ from the prototypical system characteristics used to construct published cost or pricing benchmarks.
- *Utility-scale PV definition and sample scope*: This report defines utility-scale PV to consist of ground-mounted systems greater than 5 MW and includes only fully operational projects for which all individual phases were in operation at the end of 2013. Other published price benchmarks for utility-scale PV may instead be based on larger, prototypical “central station” PV systems, or conversely, as in the case of SEIA/GTM (2014a), may be based on systems connected to the utility-side of the meter, which may include systems considerably smaller than 5 MW.

## 2. Data Summary

The analysis presented in this report derives from project-level data for residential, commercial, and utility-scale PV systems collected from a variety of sources (see note on terminology below for definitions of these market sectors). This section describes the data sources and the procedures used to standardize and clean the data, and then summarizes the basic characteristics of the data sample, including: the number of systems and installed capacity; the sample size relative to the total U.S. grid-connected PV market; and the distribution of PV systems in the sample by year, state, and project size.

### *Data Sources*

Data for *residential and commercial systems* were sourced primarily from state and utility PV incentive program administrators. Ultimately, project-level installed price data were provided by 60 PV incentive programs (see Table B-1 in the Appendix for a list of these programs and the associated sample sizes).[10] Data for *utility-scale systems* were collected from a diverse set of sources, including the Section 1603 Grant Program[11], FERC Form 1 filings, SEC filings, company presentations, and trade press articles; data from the same set of sources were also used for a limited number of large commercial PV systems that were not already included within the data provided by state and utility PV incentive programs.

**A Note on Terminology**

Throughout this report, ***Residential and Commercial PV*** includes rooftop systems of any size and ground-mounted systems up to 5 $MW_{AC}$ in size. ***Utility-Scale PV*** refers to ground-mounted systems larger than 5 $MW_{AC}$. These distinctions are independent of whether electricity is delivered to the customer-side or utility-side of the electrical meter. Note that prior editions of this report used 2 MW as the threshold for utility-scale PV.

### *Data Standardization and Cleaning*

To the extent possible, this report presents the data as provided directly by the aforementioned sources; however, several steps were taken to clean and standardize the raw data, as briefly summarized here and described in greater detail in Appendix A. Two key conventions used throughout this report and applicable to all systems deserve specific mention:

1. All price and incentive data are presented in real 2013 dollars (2013$), which required inflation adjustments to the nominal-dollar data provided by PV programs.
2. All capacity and dollars-per-watt ($/W) data are presented in terms of rated direct current module power output under Standard Test Conditions (DC-STC), requiring that capacity data provided by several PV incentive programs be translated to DC-STC.

[10] In addition, one utility (Xcel Energy) provided aggregate program-level summary data for its PV incentive programs in Colorado and Minnesota; those data are included in the state-level comparisons in Figure 19 through Figure 21, but otherwise are not used within this report and are not counted as part of the data sample.
[11] Section 1603 grant data were used to estimate installed prices for 1,776 MW (56%) of utility-scale PV capacity in the data sample. In these cases, installed prices were estimated based on reported Section 1603 grant amounts by assuming that the grant is equal to 30% of the installed price, subject to take-back provisions for grants issued after March 1, 2013. This is a simplified assumption and ignores that (a) some project costs may be deemed ineligible for the grant and that (b) the grant amount for some projects may be based on an appraised "fair market value" that differs from the price actually paid to the developer.

A number of additional steps were then undertaken to clean and standardize the raw data. First, projects with missing data for installed price, system size, or installation date were eliminated from the data sample. Remaining data were then cleaned by correcting text fields with obvious errors and by standardizing the spelling of module and inverter manufacturers and models. To the extent possible, each PV system was then classified as building-integrated PV or rack-mounted, the module efficiency was determined, and the system was classified as using either crystalline or thin-film modules, Chinese-made or non-Chinese made modules, and a micro-inverter or central or string inverter, based on a combination of information sources.

Aside from the removal of incomplete observations from the data sample, various categories of systems were excluded from the analysis. The most significant group of excluded systems are those for which the reported installed prices were deemed likely to represent *appraised values*, rather than purchase prices paid to installers. Those systems are a subset of TPO systems – namely, systems financed and installed by integrated companies that provide both the installation service and the customer financing – representing 38% of all TPO systems in the data sample. Further details on the number of excluded appraised-value systems are provided below, and details on the procedure used to identify those systems are described in Appendix A. Also excluded from the data analysis are a relatively small number of systems with battery-back up, self-installed systems, and systems with installed prices less than $1/W or greater than $20/W (assumed to be data entry errors).

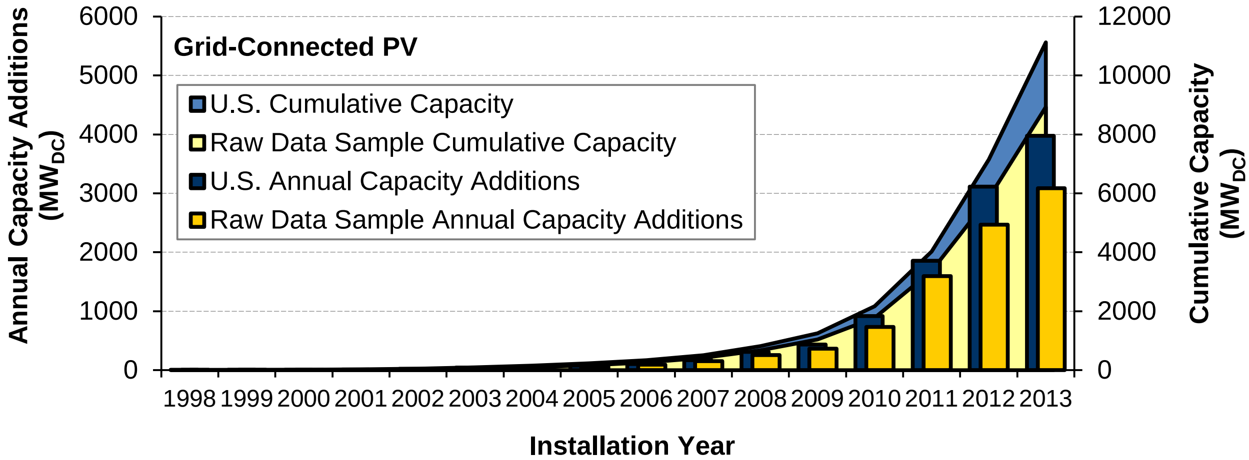
## *Sample Description*

The raw data sample, prior to removal of appraised value systems and others ultimately excluded from the analysis, consists of more than 300,000 individual systems and a combined 8,900 MW across all market segments (residential, commercial, and utility-scale), including 3,100 MW installed in 2013. This represents 80% of all grid-connected PV capacity installed in the United States through 2013 and 78% of capacity additions in 2013 (see Figure 1). Sample coverage for the utility-scale sector is relatively high, comprising 88% of all utility-scale PV capacity and 81% of 2013 capacity additions.[12] Coverage for the residential and commercial segments is somewhat lower, and has declined over time as PV incentive programs in several large state markets have phased out[13]; the raw sample includes data for 76% of all U.S. residential and commercial PV capacity and 75% of 2013 capacity additions.

Removal of appraised-value and other excluded systems reduces the residential and commercial PV sample capacity by roughly 18% overall and by 33% among systems installed in 2013. The resulting final sample used for the data analysis, summarized in Table 1, consists of roughly 260,000 residential and commercial PV systems totaling 4,700 MW, and 100 utility-scale systems totaling 3,200 MW. Unless otherwise noted, this is the sample frame used as the basis for all summary statistics presented in this report. See Tables B-1 through B-3 in the Appendix for further detail on the residential and commercial sample disaggregated by system size range and state. Note that the utility-scale PV sample consists of only *fully operational* projects for which all individual phases are in operation; separate project phases are not treated as individual projects.

[12] When comparing our sample to the total U.S. PV market, we count large multi-phase utility-scale projects as single projects (rather than counting each phase as a separate, individual project), and assign the entire project to the year in which the final phase was completed.

[13] Of particular note, incentives within the California Solar Initiative (CSI) program began to phase out in 2013. The raw data sample includes roughly 375 MW of residential and commercial PV capacity installed through the CSI program in 2013 (as well as roughly 50 MW installed through other incentive program), but does not include the roughly 200 MW of residential and commercial PV capacity installed in 2013 without any state or utility incentives.




*Data sources for U.S. total grid-connected PV capacity additions: Sherwood (2014) and SEIA/GTM (2014a). LBNL modified those values by re-assigning the capacity associated with individual phases of large, multi-phase utility-scale projects to the year in which the final project phase was (or is scheduled to be) completed.*

**Figure 1. Comparison of Raw Data Sample to Total U.S. Grid-Connected PV Capacity**

**Table 1. Final Data Sample by Installation Year and Market Segment**

| Installation Year | No. of Systems | | | Capacity (MW$_{DC}$) | | |
|---|---|---|---|---|---|---|
| | Residential & Commercial | Utility-Scale | *Total* | Residential & Commercial | Utility-Scale | *Total* |
| 1998 | 33 | 0 | *33* | 0.2 | 0 | *0.2* |
| 1999 | 162 | 0 | *162* | 0.8 | 0 | *0.8* |
| 2000 | 180 | 0 | *180* | 0.8 | 0 | *0.8* |
| 2001 | 1,302 | 0 | *1,302* | 5.8 | 0 | *5.8* |
| 2002 | 2,441 | 0 | *2,441* | 18 | 0 | *18* |
| 2003 | 3,480 | 0 | *3,480* | 31 | 0 | *31* |
| 2004 | 5,657 | 0 | *5,657* | 44 | 0 | *44* |
| 2005 | 5,797 | 0 | *5,797* | 64 | 0 | *64* |
| 2006 | 8,943 | 0 | *8,943* | 92 | 0 | *92* |
| 2007 | 12,764 | 2 | *12,766* | 132 | 22 | *154* |
| 2008 | 13,686 | 1 | *13,687* | 238 | 12 | *250* |
| 2009 | 24,319 | 2 | *24,321* | 303 | 53 | *356* |
| 2010 | 36,455 | 10 | *36,465* | 506 | 204 | *710* |
| 2011 | 42,360 | 26 | *42,386* | 981 | 482 | *1463* |
| 2012 | 51,753 | 34 | *51,787* | 1174 | 1019 | *2193* |
| 2013 | 50,614 | 25 | *50,639* | 1098 | 1441 | *2539* |
| **Total** | ***259,946*** | ***100*** | ***260,046*** | ***4,688*** | ***3,234*** | ***7,922*** |

## Residential and Commercial PV Sample

The final data sample for residential and commercial PV includes systems spanning 33 states. As is the case for the entirety of the U.S. PV market, this sample is heavily weighted towards California and New Jersey, with Arizona, Massachusetts, and North Carolina each constituting the next largest shares (see the right-most bar in Figure 2).[14] As shown though, the sample has

[14] The distribution of the residential and commercial PV data sample comports reasonably well with the overall U.S. PV market, though two relatively significant state markets (Colorado and Hawaii) are largely absent from the sample. Colorado is under-represented, because the utility administering the state's primary PV incentive program did not

diversified considerably over time, consistent with trends in the broader U.S. market. Although California has remained by far the largest individual state, its share has declined substantially over the course of the analysis period, representing 32% of 2013 capacity additions in the sample. The remaining 2013 capacity additions were spread among North Carolina (19%), Massachusetts (16%), New Jersey (16%), Arizona (9%), and all other states (9%).

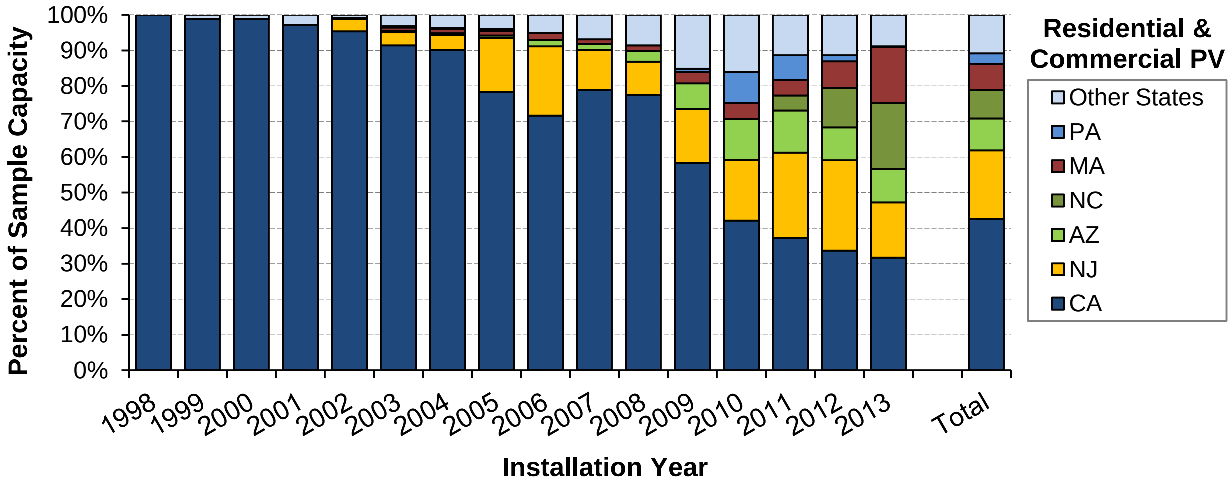



**Figure 2. Residential & Commercial PV Sample Distribution among States**

The residential and commercial PV systems in the data sample span a wide size range, from as small as 100 W to as large as 10 MW (given that this class of systems is defined to include all roof-mounted systems, regardless of size). In terms of the number of projects, the vast majority are relatively small systems, with roughly 85% consisting of systems ≤10 kW in size (see Figure 3). In terms of installed capacity, however, the sample is considerably more evenly distributed across system size ranges, split roughly into thirds among systems ≤30 kW, 30-1,000 kW, and >1,000 kW.

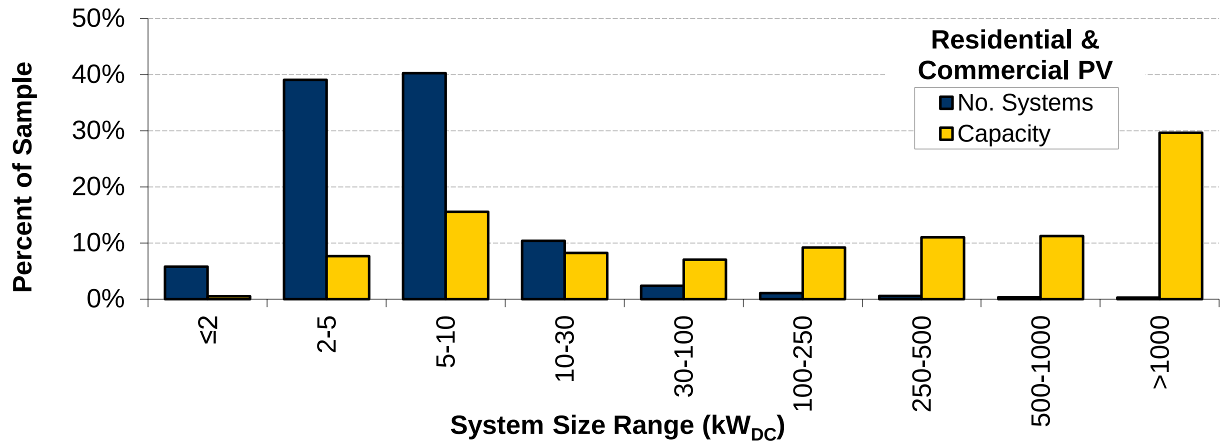



**Figure 3. Residential & Commercial PV Sample Distribution by System Size**

contribute project-level data, though it did provide aggregate summary statistics that are incorporated in the state-level comparisons in Figure 19 through Figure 21. Hawaii is under-represented, because system-level installed-price data is not collected as part of that state's incentive program.

## Utility-Scale PV Sample

The 100 utility-scale PV systems in the data sample are spread across 17 states. The vast majority of that capacity, however, is located in just three states – California, Arizona, and Nevada – with most of the remaining capacity in New Mexico, Texas, New Jersey, Colorado, and Florida (see Figure 4). This geographical distribution reflects the locus of large projects centered in and around the desert Southwest. The utility-scale PV data sample also includes projects in Maryland, New York, Illinois, North Carolina, Delaware, Ohio, Indiana, Pennsylvania, and Tennessee.

As indicated previously, *utility-scale PV* is defined for the purposes of this report to include any ground-mounted system with a nameplate capacity of 5 MW or larger. As such, the size of projects in the utility-scale PV data sample ranges widely, from 5 MW up to 320 MW. Note again that large multi-phase projects that become operational in phases are considered, for our analysis, as single projects. As indicated in Figure 5, most systems in the utility-scale PV data sample fall within the mid-size ranges of either 10-20 MW or 20-50 MW. Not surprisingly, however, the distribution in terms of capacity is quite heavily skewed towards relatively large systems, with almost half of the sample capacity consisting of projects >50 MW. These distributions have potential implications for the installed price data presented in Section 4, where we summarize certain data in terms of capacity-weighted averages.

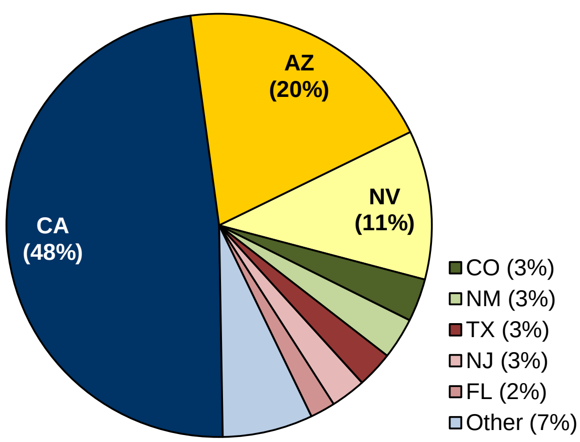



**Figure 4. Utility-Scale PV Sample Capacity Distribution among States**

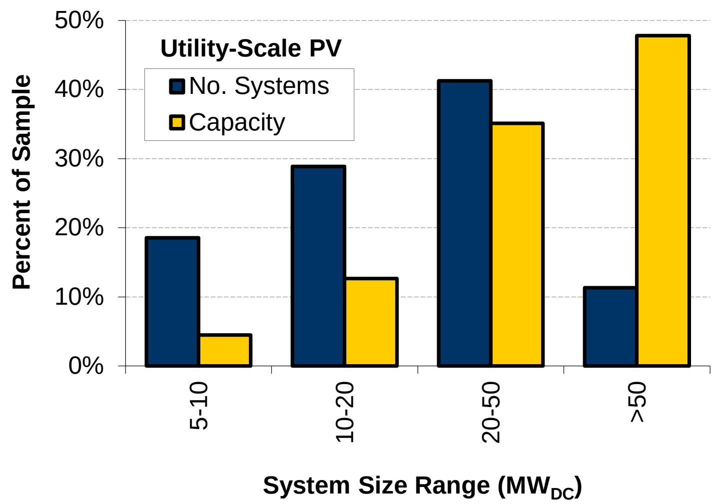



**Figure 5. Utility-Scale PV Sample Distribution by System Size**

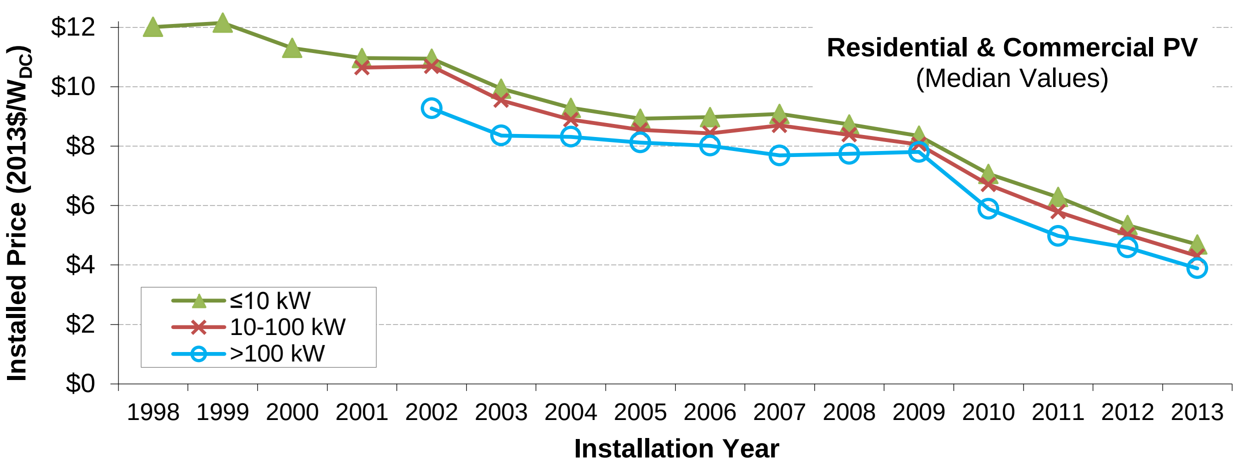
# 3. Installed Price Trends: Residential and Commercial PV

This section describes trends in the installed price of grid-connected, *residential and commercial* PV systems, based on the data sample and cleaning methods described in Section 2. The installed price data represent reported installed prices, prior to receipt of any financial incentives (e.g., rebates, tax credits, etc.). As indicated previously, the data sample excludes systems for which the reported price was deemed likely to represent an appraised value, rather than a purchase price paid to an installer (see Appendix A for further details).

The present section begins by describing trends in installed price over time, decomposing those trends into underlying module and non-module costs, and presenting temporal trends related to cash incentives provided through state and utility programs. The section then compares installed prices between the United States and other international markets. It then examines the wide variability in installed prices across projects, describing trends by system size, among individual states, between third party-owned and customer-owned systems, across host customer sectors, and between various types of applications and technologies, including: microinverters vs. central inverters, systems with varying module efficiencies, Chinese-brand vs. non-Chinese-brand modules, residential new construction vs. residential retrofit, BIPV vs. rack-mounted systems, rooftop vs. ground-mounted systems, and tracking vs. fixed-tilt systems.

## *Installed Prices Continued Their Precipitous Decline in 2013 and 2014*

Figure 6 presents the median installed price of all residential and commercial projects within the sample, segmented into three system size groupings, from 1998 through 2013. Among the roughly 50,000 residential and commercial PV systems in the sample installed in 2013, the median installed price was \$4.7/W for systems ≤10 kW, \$4.3/W for systems 10-100 kW in size, and \$3.9/W for systems >100 kW. Importantly, though, these median values represent central tendencies, and considerable spread exists among the data, as will be summarized in subsequent figures. Also of particular note is that the national price trends in Figure 6 are dominated by trends within California, which constitutes a large fraction of the total U.S. market and, as will be shown later, is relatively high-priced compared to other states.

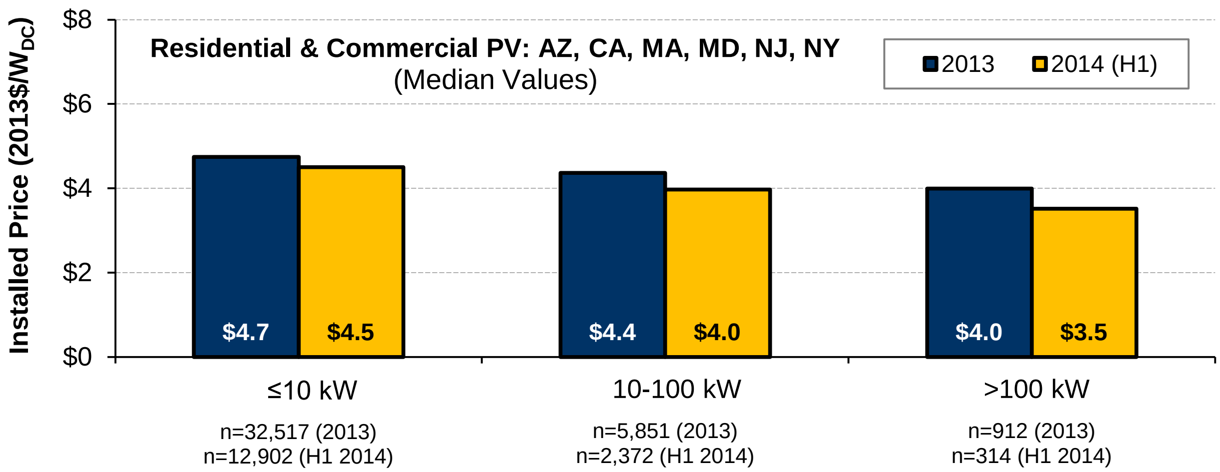



*Notes: See Table 1 and Table B-2 for residential and commercial PV sample sizes by installation year. Median installed prices are shown only if 15 or more observations are available for the individual size range.*

**Figure 6. Installed Price of Residential & Commercial PV over Time**

Over the entirety of the historical period depicted in Figure 6, installed prices have declined by about $0.5/W (6-8%) per year, on average, depending on system size range. Price declines, however, have not occurred at a steady pace over that period. In particular, installed prices declined markedly until 2005, but then stagnated through roughly 2009, while the PV supply chain struggled to keep pace with surging worldwide demand. Since 2009, installed prices have fallen precipitously as upstream cost reductions – principally PV module cost reductions – worked their way through to end consumers, and as state and utility PV incentive programs continued to ramp down their incentives. From 2012 to 2013, installed prices fell by $0.7/W (or 12-15%, depending on system size range).

Early evidence suggests that installed price declines in 2014 are keeping pace with those in recent years. As an indication of this trend, Figure 7 compares the installed price of systems in 2013 and the first half (H1) of 2014, based on data from a subset of the PV incentive programs and states covered elsewhere in this report (including most of the larger programs). Although the data should be considered provisional – both because they are drawn from a limited pool of programs and because they may be impacted by seasonal trends – they show that installed price declines have persisted into 2014. Specifically, the median installed price of systems installed in H1 2014 fell by roughly $0.2/W (5%) for systems ≤10 kW, $0.4/W (9%) for systems 10-100 kW, and $0.5/W (12%) for systems >100 kW, relative to median installed prices for systems installed in 2013 (from the same set of programs). If the same price reductions observed within these states transpire more broadly and continue on the same trajectory as in the first half of the year, then national price reductions in 2014 will be even greater than those witnessed in 2013 (at least for systems >10 kW, which have thus far witnessed the steepest price declines in 2014). As discussed further in the next section, the prospect continued installed price declines in the latter half of 2014 (and beyond) will depend, in large measure, on continued declines in non-module costs, given the flattening or slight rise in global module prices since 2012.



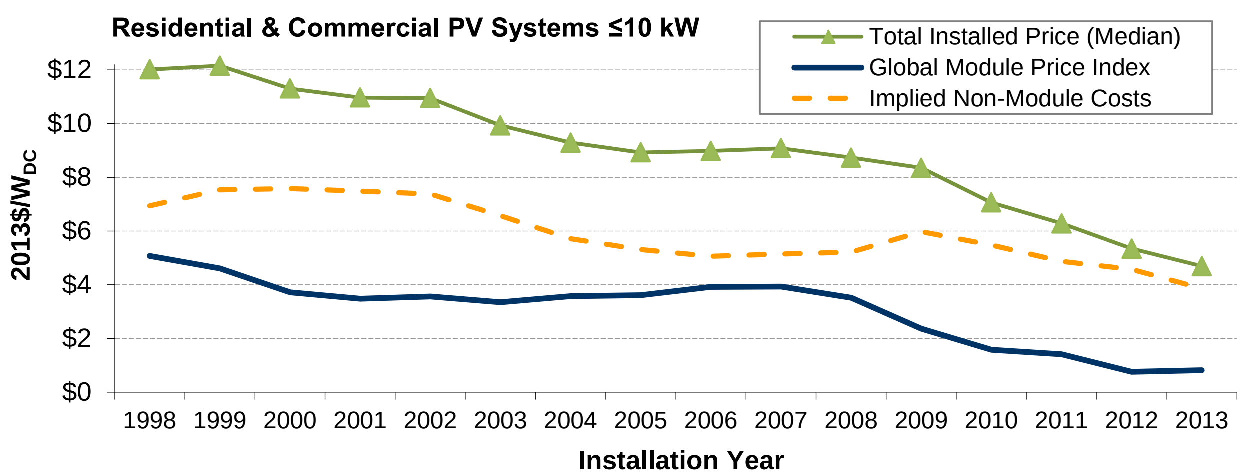

*Notes: Given the reduced sample of PV incentive programs and states represented within the figure, the 2013 median installed prices shown here differ from national median values cited elsewhere.*

**Figure 7. Installed Prices for Systems Installed in 2013 and the First Half of 2014**

## *Installed Price Reductions Have Persisted, Even as Module Prices Flattened*

Figure 8, which focuses specifically on ≤10 kW systems, illustrates the close but imperfect historical linkages between installed system prices and PV module prices. As shown, module prices began a steep descent in 2008, falling by $2.7/W in real 2013 dollars from 2008 to 2013 and constituting 67% of the total $4.0/W decline in the installed price of ≤10 kW systems over that period. Installed price declines since 2008 are thus, in large measure, the result of falling module prices.

It is evident, however, that year-by-year installed price declines have not proceeded in perfect lock-step with module prices. For example, module prices dropped by $1.1/W from 2008 to 2009, while total installed prices fell by only $0.4/W over that year. Installed prices then began their dramatic descent a year later, suggestive of a lag between movements in module prices and installed system prices.[15] Conversely, in the last year of the historical period, from 2012 to 2013, total installed prices fell by $0.7/W while module prices slightly rose (by less than $0.1/W), and as noted in the previous section have continued to decline through the first half of 2014, despite further modest increases in module pricing.[16] This continued decline in installed system prices may partly reflect some residual lagged effect of module price reductions in preceding years, though it may also be indicative of reductions in non-module costs, as discussed further below.




*Notes: The Global Module Price Index is the SPV Market Research index for large-quantity buyers (Mints 2014). "Implied Non-Module Costs" are calculated as the Total Installed Price minus the Global Module Price Index.*

**Figure 8. Installed Price, Module Price Index, and Implied Non-Module Costs over Time for Residential & Commercial PV Systems ≤10 kW**

Over the long-term, it is clear that non-module costs (which include such items as inverters, mounting hardware, labor, permitting and fees, overhead, taxes, and installer profit) have also fallen

[15] The fact that movements in the global module price index are not immediately reflected in total installed price may reflect any number of underlying dynamics, including: differences in time between when installation contracts are signed and when systems are actually installed, excess module inventory by system installers, supply and delivery constraints among installers or component manufacturers, a lack of competitive pressure in particular markets resulting in value-based rather than cost-based pricing, a divergence between global and domestic module prices, or differences between module prices paid by large-quantity buyers (the basis for this index) and installers more generally (which may face a larger distributer mark-up).

[16] The average price of poly-silicon modules sold in the United States rose by $0.09/W from its nadir at the start of 2013 through the second quarter of 2014 (SEIA/GTM 2014a and 2014b).

and have contributed significantly to the overall decline in installed system prices.[17] The "implied non-module costs" presented in Figure 8 are a residual term, calculated as the difference between the total installed price for systems ≤10 kW and the module price index in each year, and provide a rough proxy for non-module costs over time for this system size range.[18] Given the manner in which this residual term is calculated and the possible confounding influences of lags in module price reductions, it is not a particularly reliable indicator for short-term movements in non-module costs; it does, however, provide a reasonable approximation for longer term trends.[19] Specifically, over the full 16-year period shown in Figure 8, implied non-module costs fell by approximately $3.0/W (44%), from $6.9/W in 1998 to $3.9/W in 2013. This represents 42% of the decline in the total installed price for ≤10 kW systems over that period, clearly signifying a significant impact from non-module cost reductions over the long-term.

In recent years, module prices have fallen much more rapidly than non-module costs, and as a result, non-module costs have grown in terms of their relative share of total system costs. This shift in the cost structure of PV systems has heightened emphasis within the industry and among policymakers on reducing non-module costs – particularly the variety of business process or "soft" costs, including such things as marketing and customer acquisition, system design, installation labor, and costs associated with permitting and inspection processes. As shown in Figure 8, implied non-module costs fell by $0.7/W (16%) from 2012 to 2013. Although that decline may not provide an accurate estimate of the true reduction in non-module costs over that timeframe, the size of the reduction in this residual term, in combination with the continued drop in installed prices during the first half of 2014 – all while module prices have remained flat or rose – collectively suggest that recent efforts to target PV soft costs may have begun to bear fruit.

## *Installed Price Declines Have Occurred in Concert with Falling State/Utility Incentives*

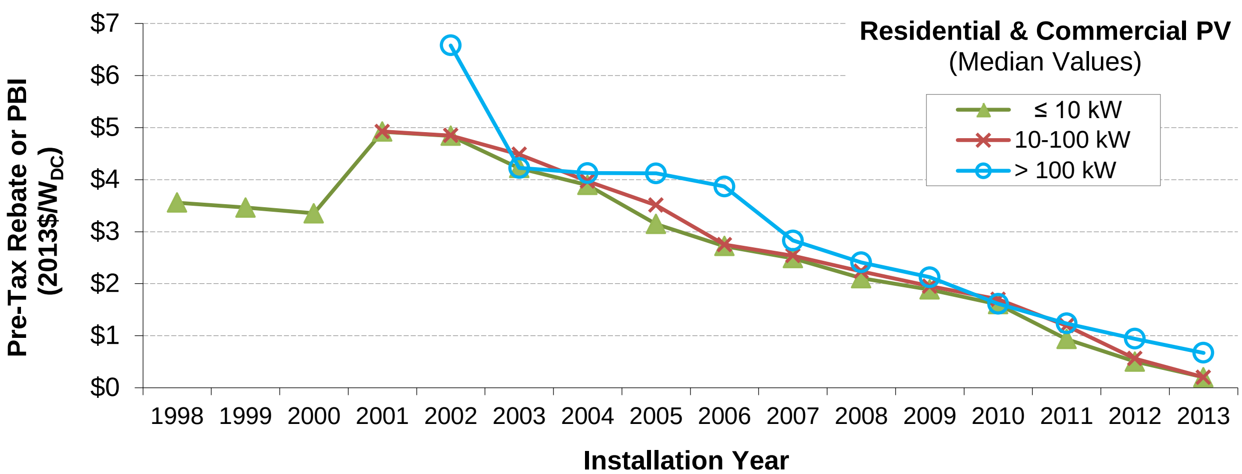
Financial incentives provided through utility, state, and federal programs have been a driving force for the PV market in the United States. For residential and commercial PV systems, those incentives have potentially included some combination of cash incentives provided through state and/or utility PV programs (rebates, grants, and performance-based incentives), the federal investment tax credit (ITC) or U.S. Treasury grant in lieu of the ITC, state ITCs, revenues from the sale of renewable energy certificates (RECs) or solar renewable energy certificates (SRECs), and accelerated depreciation of capital investments in solar energy systems.

Focusing solely on cash incentives provided through state/utility programs, Figure 9 shows the median cash incentive over time provided by those PV incentive programs within the data sample that provide either up-front rebates or performance-based incentives.[20] These data are presented on

[17] The line between module costs and non-module costs can become somewhat blurred, such as for modules with integrated racking and AC modules with micro-inverters, which also impact design and installation costs.
[18] Inverters and mounting structures represent the largest hardware costs within the residual non-module costs term, and based on data from SEIA/GTM (2014a), constituted roughly $0.50/W, on average, for residential systems in 2013. Much of the remaining residual non-module cost term therefore consists of various soft costs.
[19] In effect, the calculated implied non-module costs reflect both actual non-module costs as well as any divergence between the module price index and the module prices actually paid by installers for systems installed in any given year.
[20] Most PV incentive programs in the data sample provide an up-front cash incentive (i.e., rebate) based on system capacity, in some cases adjusted for expected performance. Several programs instead provide performance-based incentives (PBIs), paid out over time based on actual energy production; for the purpose of constructing Figure 10, PBI payments are translated into an up-front incentive of equivalent net present value (see Appendix A). SREC payments are not included in Figure 10, but their potential value is discussed within Text Box 2.

a *pre-tax* basis – that is, prior to assessment of state or federal taxes that may be levied if the incentive is treated as taxable income. Note also that the figure presents data based on the year in which systems are installed; as such, it does not necessarily provide an accurate depiction of the size of cash incentives *offered* in each year, as there is typically a lag between the time that a project reserves its incentive and its installation date.

As shown in Figure 9, cash incentives (in the form of rebates and performance-based incentives) have declined steadily and significantly over the past decade (on a per-kW basis). Among systems installed in 2013, median cash incentives ranged from $0.2/W to $0.7/W across the three system size categories shown, having fallen by roughly $3.5/W to $4.5/W (85% to 95%) from their historical peak in 2001/2002. Within just the last year of the analysis period, median cash incentives fell by $0.3/W to $0.4/W across the size ranges shown. Although the incentive levels depicted in Figure 9 are, to some extent, dominated by trends within California's programs, which comprise a large portion of the data sample, incentives within nearly all of the PV incentive programs in the sample have declined over time.




*Notes: The figure depicts the pre-tax value of rebates and PBI payments provided through state/utility PV incentive programs, among those systems that received such incentives. The high median incentive for >100 kW systems in 2002 reflects the large percentage of systems that received an incentive through LADWP's PV incentive program, which provided especially lucrative incentives in that year. Results are excluded if fewer than 15 observations are available.*

**Figure 9. State/Utility Cash Incentives for Residential & Commercial PV**

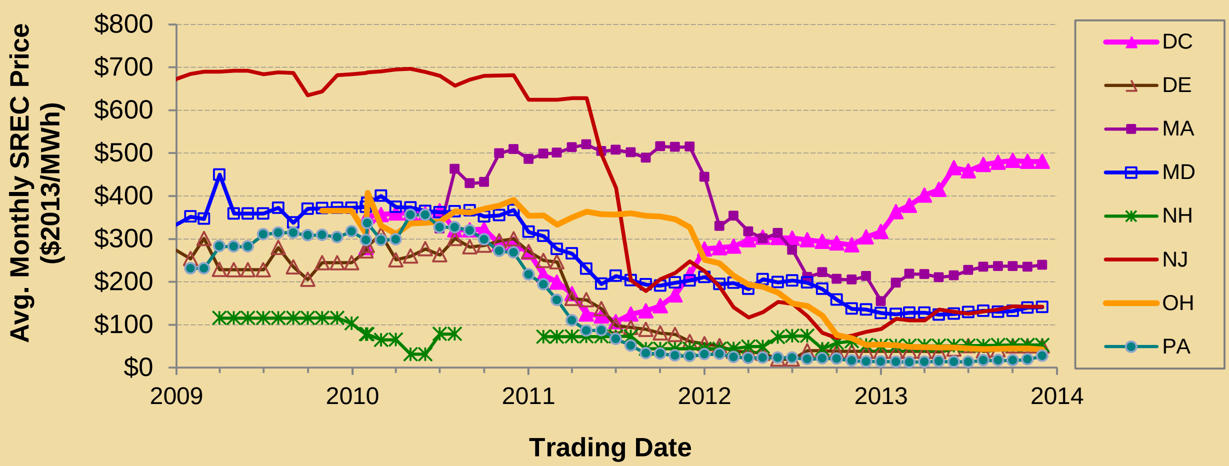
From the perspective of the customer-economics of PV, the steady decline in cash incentives has, at least partially, offset the reductions in installed prices, and thus the customer-economics of PV has not necessarily improved to the extent that might be inferred from the installed price reductions alone. Over the course of the past decade, the median pre-tax value of cash incentives provided through state and utility programs has declined by an amount equivalent to roughly 80% of the corresponding drop in installed prices. Within just the last year of the analysis period, reductions in cash incentives equaled 40% to 50% of the installed price decline, depending on system size range.

The continued ratcheting down of cash incentives provided through state and utility PV incentive programs reflects a combination of drivers. Over the long-term, program administrators have reduced these incentives as other sources of financial support for PV projects – most notably, increases in the federal ITC and the emergence of SREC markets in a number of states (see Text Box 2) – have become more widely available or lucrative. PV incentive program administrators have also reduced incentives over time both in response to installed price declines and to encourage further declines. The premise behind the latter is that regular and scheduled incentive reductions can provide a long-term signal to the industry to reduce costs and improve installation efficiencies. In addition, to the extent that value-based pricing exists – where installers are able to price their systems based on the value provided to the customer rather than on the underlying cost borne by the installer – incentive reductions may force installers to reduce installed prices, in order to maintain the targeted level of returns for system owners.

### Text Box 2. SREC Price Trends

Seventeen states plus the District of Columbia have enacted renewables portfolio standards with either a solar or distributed generation set-aside (also known as a "carve-out"), and many of those states have established solar renewable energy certificate (SREC) markets to facilitate compliance. PV system owners in these (and in some cases neighboring) states may sell SRECs generated by their systems, either in addition to or in lieu of direct cash incentives received from state/utility PV incentive programs. Many solar set-aside states have transitioned away from standard-offer based incentives, particularly for medium and large commercial systems, and towards SREC-based financing models with SREC prices that vary over time. For small residential and commercial systems, traditional rebate programs (and/or SREC payments provided on an up-front basis) may still be offered.

As illustrated in Figure 10, SREC spot-market prices in most markets declined significantly over the 2011-2012 period, falling below $150/MWh in most states, and with the exception of Washington, D.C., remained level throughout much of 2013. Long-term (multi-year) SREC contract prices have also fallen in recent years, although the availability of such contracts and visibility into their pricing is limited. In general, however, these recent declines in SREC prices reflect a surplus of available SRECs relative to solar set-aside compliance obligations, which is both a result of reductions in the installed price of PV as well as a source of continuing downward pressure on installed prices.

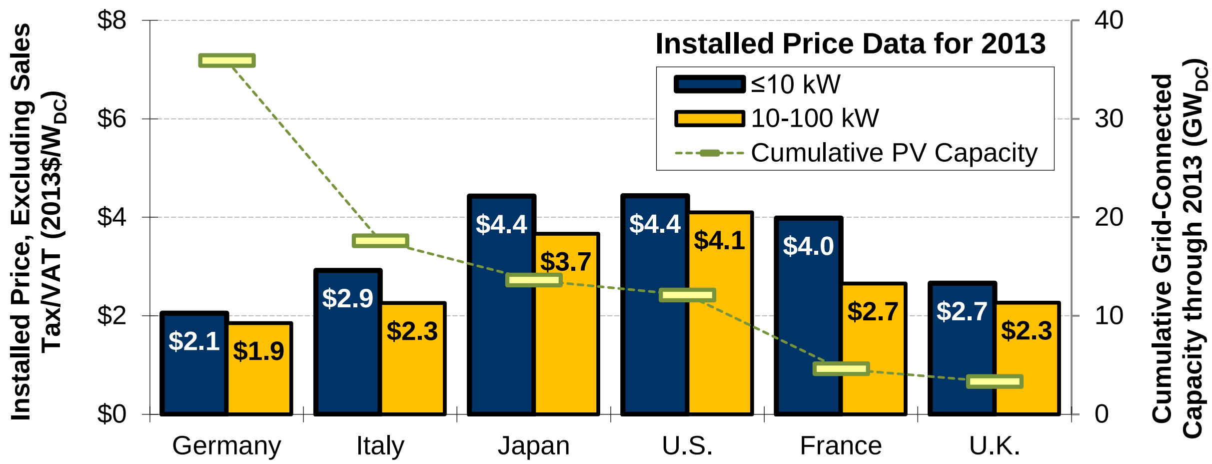



*Notes: Data sourced from Spectron, SRECTrade, and Flett Exchange (data averaged across available sources). Plotted values represent SREC prices for the current or nearest future compliance year traded in each month. Data for Ohio are for in-state SRECs.*

**Figure 10. Monthly Average SREC Prices for Current or Nearest Future Compliance Year**

## *Installed Prices in the United States Are Higher than in Many Other Major International PV Markets*

Notwithstanding the significant installed price reductions that have already occurred in the United States, international experience suggests that greater near-term reductions may be possible. Figure 11 compares 2013 installed prices, *excluding sales or value-added tax (VAT)*, across many of the major national markets for residential and commercial PV (Germany, Italy, France, Japan, the United Kingdom, and the United States). Although the data across countries may not be perfectly comparable, the figure nevertheless suggests that installed prices in the United States remain relatively high compared to most other major markets.[21] In particular, all of the other countries shown in Figure 11 except for Japan had lower prices than the United States within the ≤10 kW range, and all had lower prices for 10-100 kW systems. The pricing disparity was greatest in comparison to Germany, where median installed prices were more than 50% lower than in the United States, for both of the size ranges shown.




*Notes: Installed price data for Germany are based on price quotes issued for individual systems throughout 2013 (EuPD 2014). Installed prices for all other countries (with the exception of the U.S.) are based on data reported by individual country members to the IEA Photovoltaic Power Systems Programme (IEA-PVPS 2014). Data for cumulative grid-connected PV capacity through 2013 are from REN21 (2014).*

**Figure 11. Comparison of the Installed Price for Residential PV Systems in 2013 across Major National Markets (Pre-Sales Tax/VAT)**

Given that modules and other hardware items are effectively global commodities with only marginal price differences across countries, much of the pricing variation across countries can be attributed to differences in soft costs.[22] Those differences in soft costs may, in turn, be partly attributable to differences in the size of each market, on the theory that larger markets facilitate price reductions through learning-by-doing and economies of scale. This theory is partially borne out by Figure 11, in the case of Germany and Italy, which had amassed roughly 36 GW and 18 GW

[21] Limited information is available about the underlying sources for the price data reported to the IEA-PVPS, so the comparison to U.S. data may be imperfect. For example, several countries report installed prices as of December 2013, while the U.S. data are based on systems installed over the course of the entire year. System sizes may also not be perfectly aligned, as the installed price data from IEA-PVPS are identified as referring to “Residential – 10 kW” and “Commercial – 100 kW” systems. In addition, data for some countries, including Germany, may be based on price quotes, rather than on actual invoiced prices for installed projects.

[22] See Seel et al. (2012)

of grid-connected PV capacity through 2013, compared to roughly 12 GW in the United States. That said, the fact that the U.K. – a relatively small market in absolute terms – also had relatively low installed prices suggests that larger absolute market size, alone, does not account for the entirety of installed price differences among countries.[23]

## *Installed Prices Vary Widely Across Individual Projects*

The preceding figures have focused on median installed prices. Considerable spread exists within the data, however, as illustrated in Figure 12 through Figure 14, which present frequency distributions of installed prices for systems ≤10 kW, 10-100 kW, and >100 kW. As shown, the installed price distributions have, over time, both *shifted* to the left, reflecting the long term decline in installed prices, and also *narrowed*. This convergence of prices, with high-priced outliers becoming increasingly infrequent, is consistent with a maturing market characterized by increased competition among installers and module manufacturers and by better-informed consumers.

That said, the narrowing trend was most evident within the early years of the historical period, i.e., when comparing the distributions for 1998-2005 and 2006-2010. Since then, the spread in the installed price distributions has remained seemingly stable, with significant variability in pricing persisting across systems. For example, among ≤10 kW systems installed in 2013, which had a median installed price of $4.7/W, roughly 20% of systems had an installed price less than $3.9/W, while a similar percentage was priced above $5.6/W. The remaining 60% of systems were spread within the relatively wide range between those two prices. The installed price distributions for 10-100 kW and >100 kW systems exhibit comparable spread.

The potential underlying causes for such pricing variability are numerous. These may include project characteristics (e.g., related to system size, technology type, or configuration) as well as attributes of individual installers. Installed price variation likely also reflects differences in regional or local market and regulatory conditions. For example, markets with less competition among installers, higher incentives, and/or higher electricity rates for net metering may have higher installed prices if installers are able to "value-price" their systems (i.e., price their systems based on the value they provide to the customer, rather than based on the cost borne by the installer). Variability in prices also likely derives from differences in administrative and regulatory compliance costs (e.g., permitting and interconnection) as well as differences in labor wages and taxes. Many of these potential pricing drivers are explored throughout the remainder of this report, and as noted previously, LBNL also is engaged in a series of separate analyses, using more sophisticated statistical methods, to further explain the sources of PV pricing variability.[24] Regardless of its causes, however, the fact that such variability exists underscores the need for caution and specificity when referring to the installed price of PV, as clearly there is no single "price" that characterizes the U.S. market, or even particular market segments, as a whole.

[23] For example, installed prices may also differ among countries as a result of (among other things) differences in incentive levels; building architecture; component country-of-origin; interconnection standards; labor costs; incentive, permitting, and interconnection processes; foreign exchange rates; and average system size.

[24] In studies already completed, Dong and Wiser (2013) found that cities in California with the most-favorable permitting practices had installed prices $0.27/W to $0.77/W lower than in cities with the most-onerous practices. Examining a broader geographical footprint, Burkhardt et al. (2014) found that variations in local permitting procedures lead to differences in average residential PV prices of approximately $0.18/W across jurisdictions; when considering variations not only in permitting practices, but also in other local regulatory procedures, price differences grew to $0.64/W to $0.93/W between the most-onerous and most-favorable jurisdictions.

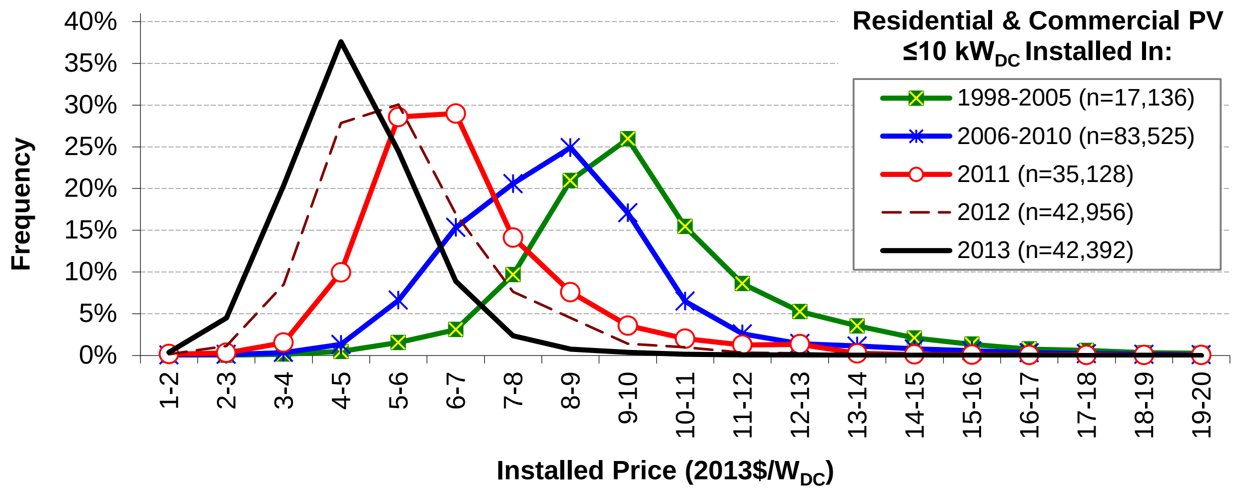



**Figure 12. Installed Price Distribution for Residential & Commercial PV (≤10 kW Systems)**

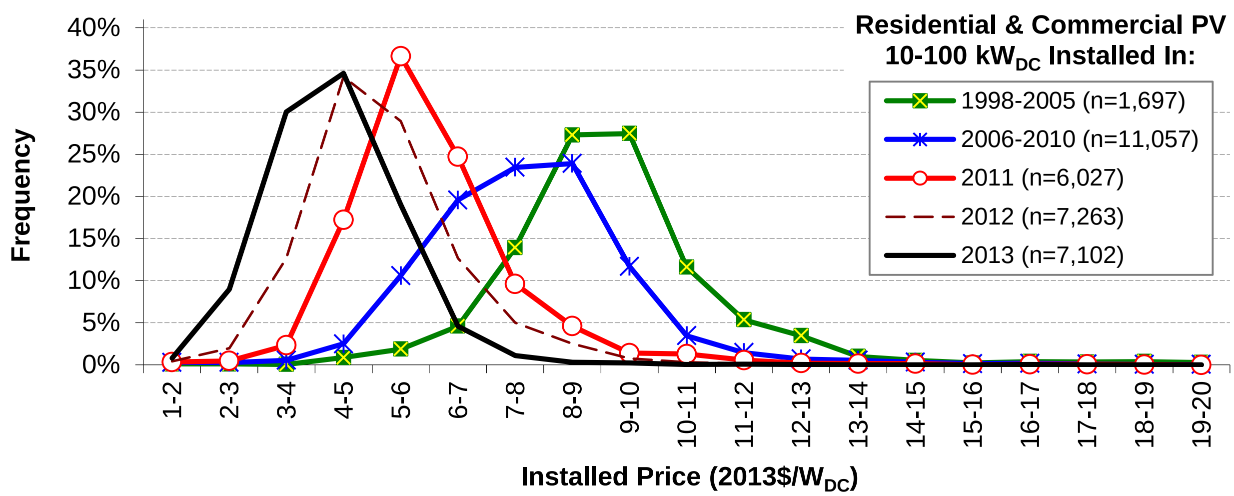



**Figure 13. Installed Price Distribution for Residential & Commercial PV (10-100 kW Systems)**

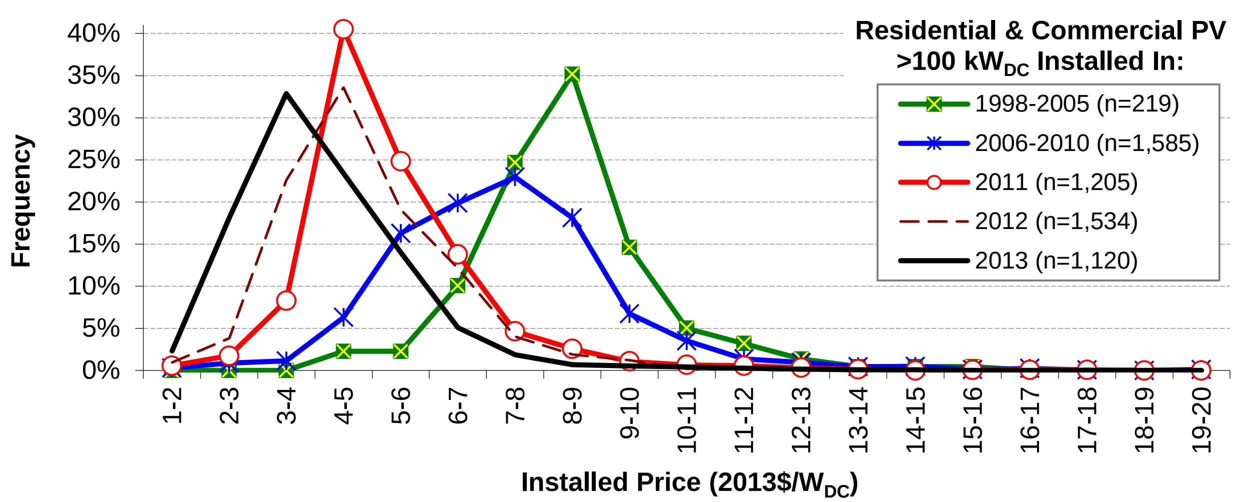



**Figure 14. Installed Price Distribution for Residential & Commercial PV (>100 kW Systems)**

## *Installed Prices Exhibit Clear Economies of Scale*

Larger PV installations benefit from economies of scale by spreading fixed project and overhead costs over a larger number of installed watts and, depending on the installer, through price reductions on volume purchases of materials. This trend was evident previously in Figure 6, which distinguished among three broad system size categories over time, and can be observed with greater precision in Figure 15, which focuses only on systems installed in 2013 and distinguishes among narrower systems size ranges. Across the two extremes (excluding utility-scale systems, which are addressed in Section 4), the median installed price for large commercial systems >1,000 kW is 35% lower than for systems ≤2 kW, and 27% below the median price of systems in the 100-250 kW range. Some portion of the installed price variation observed in Figure 12 through Figure 14 can thus be attributed to variation in system sizes within each of the three size groupings (particularly among >100 kW systems, as the group spans a particularly wide range of system sizes). That said, as the percentile bands in Figure 15 suggest, even within relatively narrow system size bins, significant pricing variability remains.

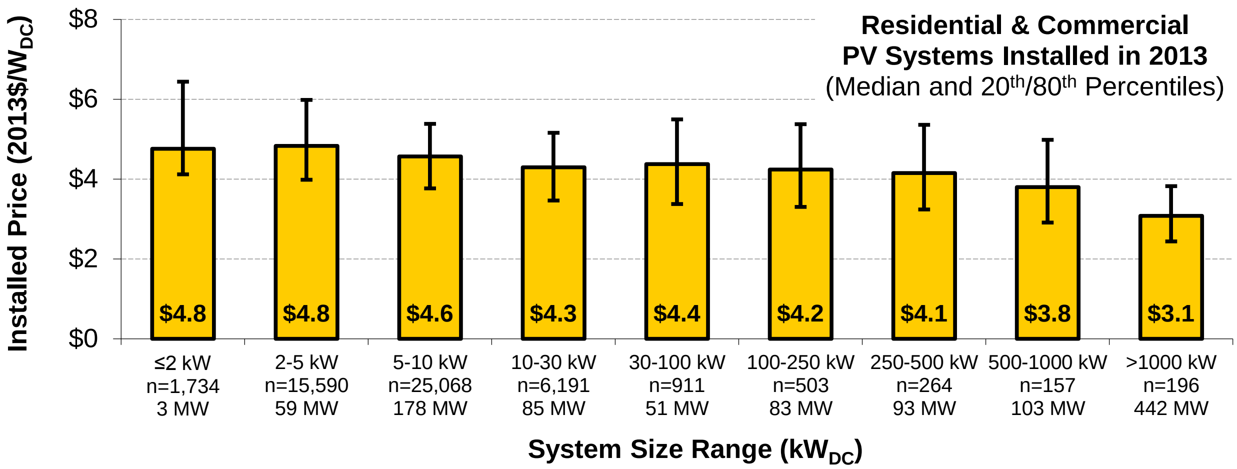



**Figure 15. Installed Price of Residential & Commercial PV According to System Size**

## *Installed Prices Differ Significantly Among States*

The U.S. PV market is fragmented into a large number of quasi-regional, state, and even local markets. Focusing specifically on the potential influence of state-level conditions, Figure 16 through Figure 18 compare median installed prices across the states represented within the data sample, focusing on systems installed in 2013 (see Table B-3 in the Appendix for time series data on median installed prices by state).[25] The figures include only those states with at least 15 systems installed in 2013 within the respective size grouping. Some caution is nevertheless warranted in generalizing from results for those states with relatively small sample sizes (as identified within the x-axis labels in the figures), as the installed price differences relative to other states may simply reflect idiosyncrasies of the particular systems or installers in the sample for those states, rather than fundamental underlying state or local conditions.

Within all three system size ranges, substantial differences in median installed prices can be observed across states. For systems ≤10 kW in size, median installed prices range from a low of

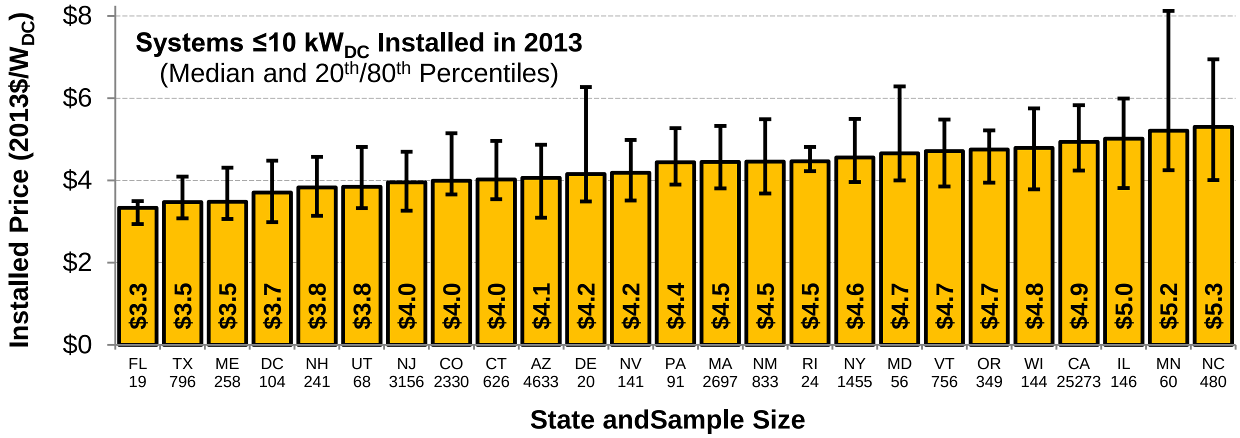
[25] Data for CO and MN are based on aggregate statistics provided by Xcel Energy for its programs in those two states; those data are included in Figure 19 through Figure 21, as well as in Table B-3 in the appendix, but are not otherwise included within this document.

$3.3/W in Florida to a high of $5.3/W in North Carolina. Within the 10-100 kW size range, median installed prices range from $3.0/W in Florida to $5.1/W in Minnesota. Finally, for systems >100 kW, median installed prices range from $2.5/W in North Carolina to $5.3/W in Arizona (though the ordering of states within this size range is arguably less meaningful, given the relatively small sample sizes for many states and the greater potential for variation in project characteristics).

Importantly, within all three size categories, California is a relatively high-cost state, thereby pulling the installed price statistics for the entire country upward by virtue of its large fractional share of the market. In general, one might anticipate that larger or more mature state markets would have lower prices as a result of greater competition and efficiency, as well as perhaps more extensive bulk purchasing and better access to low-cost products. Even beyond California, however, a strong correlation is not readily apparent between state market size and installed system prices. Among other large state markets, Massachusetts, New York, Arizona, Colorado, and New Jersey generally reside near the middle, or in several cases the upper-end, of the pricing spectrum for ≤10 kW and 10-100 kW sized systems. On their face, these results therefore suggest that other factors, beyond market size, also strongly impact PV system pricing.

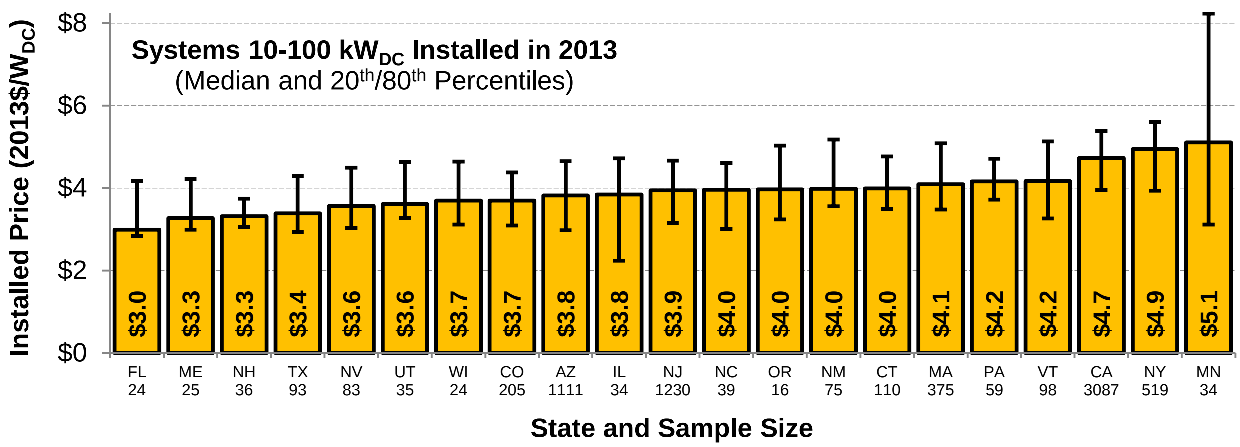
These other factors may include many of the potential drivers mentioned with respect to overall variability in system pricing across the dataset as a whole. For example, installed prices may be higher in states as a result of higher labor costs or more onerous permitting and administrative processes. States with higher incentives and/or higher electricity rates may have higher installed prices as a result of value-based pricing. State-level price variation can also arise from differences in the characteristics of systems installed in each state, such as typical system size and configuration, as well as differences in the composition of the PV customer base. For example, in both California and Arizona, a large fraction systems >100 kW were at government, school, or non-profit facilities, which tend to have high installed prices relative to systems at for-profit commercial facilities (as shown and discussed in a later section). Conversely, most of the North Carolina systems in this size range were 2-5 MW commercial, ground-mounted systems, which are relatively low-cost. Finally, differing sales tax rates and the fact that roughly half of the states shown in the figures exempt PV systems from state sales tax can lead to installed price differences of as much as $0.4/W between states with relatively high sales tax for PV systems and those that exempt PV from sales tax (or that simply do not have sales taxes).

Notwithstanding the potential significance of these cross-state differences, it is again also important to observe the substantial pricing variation *within* each state. In many states, that variability is at least as wide as cross-state differences, potentially reflecting more localized jurisdictional conditions, as well as intra-state variations in installer- and system-level price drivers.



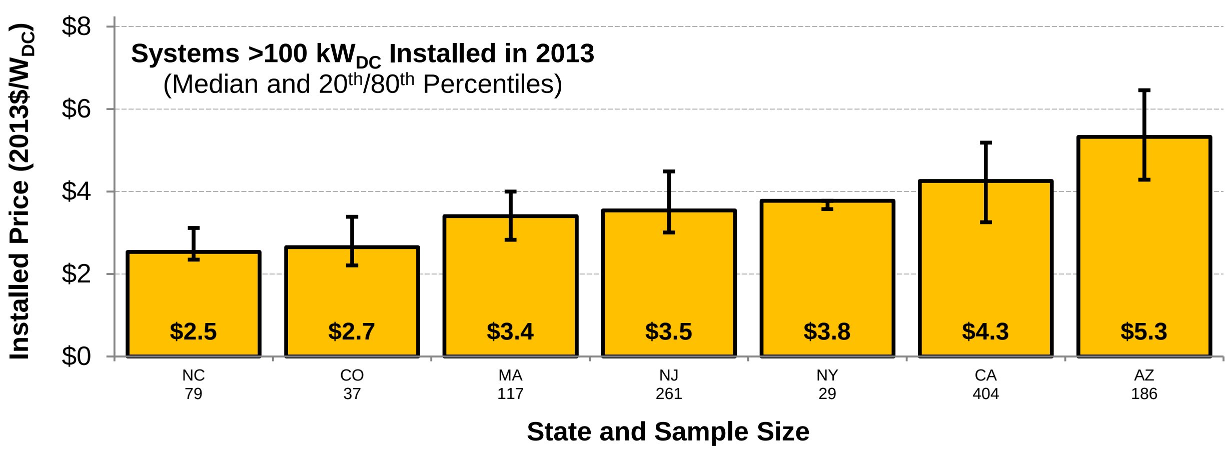

*Notes: Median installed prices are shown only if 15 or more observations were available for a given state.*

**Figure 16. Installed Price of Residential & Commercial PV Systems by State (≤10 kW Systems)**




*Notes: Median installed prices are shown only if 15 or more observations were available for a given state.*

**Figure 17. Installed Price of Residential & Commercial PV Systems by State (10-100 kW Systems)**




*Notes: Median installed prices are shown only if 15 or more observations were available for a given state.*

**Figure 18. Installed Price of Residential & Commercial PV Systems by State (>100 kW Systems)**

## *Installed Prices for Third Party Owned Systems Retained in the Data Sample Are Similar to Those for Host Customer-Owned Systems*

Third party ownership of customer-sited PV systems through power purchase agreements and leases has become increasingly common for PV systems of all sizes, representing 67% of all systems installed in 2013 within our raw data sample.[26] Under these arrangements, the owner of the PV system is an entity other than the host customer, and the cash outlay by the host customer typically consists of a series of payments over time, rather than a single up-front payment for the purchase of the PV system. As such, the installed price data reported to state and utility PV incentive programs for third-party owned (TPO) systems may represent something different than it would under a standard cash sale transaction, depending on the type of third party finance provider.

In particular, for systems financed by *non-integrated* third party providers (i.e., companies that provide customer financing but purchase the system from an engineering, procurement, and construction [EPC] contractor), the installed price data reported to PV incentive programs generally represent the actual price paid to the EPC contractor by the customer finance provider, and are roughly (though not perfectly) comparable to what the reported installed price would be under a cash sale transaction.[27] Accordingly, these systems were retained in the data sample. In contrast, for systems financed by *integrated* third party providers (i.e., companies that provide both the installation service and customer financing), the installed price data reported to PV incentive program administrators generally represents an *appraised* value, as there is no intermediate transaction to report. To the extent that systems installed by integrated third party finance providers could be identified, they were removed from the data sample and are excluded from the summary statistics presented in this report (with the exception of Text Box 3, which demonstrates the importance of having removed appraised value systems). In total, roughly 40,000 appraised value systems were removed from the data sample, including almost 20,000 systems installed in 2013 (see Appendix A for details on the screening method).

Focusing on TPO systems *retained* in the data sample, Figure 19 and Table 2 compare reported installed prices between those systems and customer-owned systems. In principle, installed prices for retained TPO systems might be either higher or lower than for similar customer-owned systems. For example, an installer selling a system to a finance provider might bear higher transaction costs associated with arranging financing, but may bear lower customer acquisition costs (either because the availability of customer financing makes for an easier sale or because the finance provider, itself, performs some portion of the customer acquisition function).

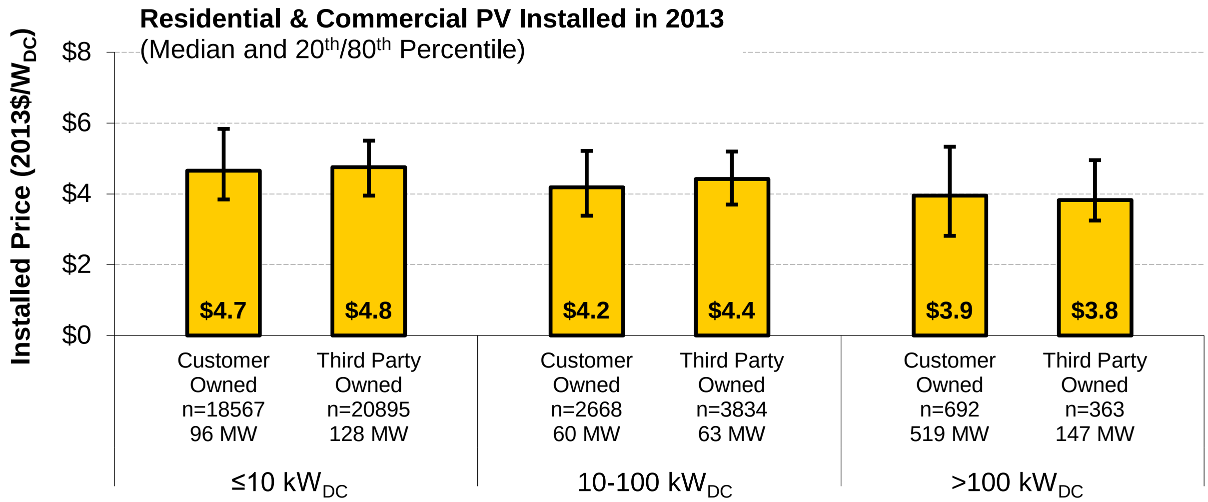
As the data show, the difference in installed prices between TPO and customer-owned systems has generally been small, though the size and direction of that gap has varied somewhat over time and across different size groups. In 2013, median prices for retained TPO systems were between \$0.2/W higher and \$0.1/W lower than for customer-owned systems, depending on the system size range. In years prior to 2013, median installed prices for retained TPO systems have generally been lower than for customer-owned systems, particularly among systems ≤10 kW, though the differences have generally been no more than \$0.5/W. The growing prominence of TPO thus does

[26] The penetration of third-party ownership varies somewhat across customer segments. Among 2013 installations in the raw data sample (i.e., prior to removing appraised-value systems), 68% of residential systems, 45% of systems hosted by tax-exempt customers, and 61% of systems hosted by for-profit commercial customers were TPO.

[27] Some non-integrated finance providers may assist the EPC contractor with lead generation and/or may be responsible for filling out incentive paperwork and other back-office functions, in which case those soft costs would not be reflected in the sale price between the EPC contractor and finance provider.

not appear to have had a significant direct impact on the overall price trends presented within this report (given that appraised value systems have been removed from the data sample), though increasing shares of TPO systems may have contributed modestly to temporal declines in median installed prices for smaller systems in some years prior to 2013.

Separate from any comparison of median values, the *distribution* of installed prices for TPO systems in 2013 was somewhat narrower than for customer-owned systems, as reflected in the percentile bands in Figure 19. The narrower distribution results from the fact that customer-finance providers often purchase bundles of systems at a standard price from EPC contractors, and thus large numbers of such systems have an identical installed price within the dataset. In addition, finance providers are relatively well-informed buyers, which would also tend to compress the distribution of installed prices for TPO systems.




*Notes: As is the case throughout the report, data from TPO systems for which reported installed prices were deemed likely to represent an appraised value were excluded from the sample. The values shown here for TPO systems are based only on systems for which the installed prices reported to state/utility PV incentive programs were deemed likely to represent an actual transaction price between an EPC contractor and a customer finance provider.*

**Figure 19. Installed Prices Reported for Host Customer-Owned vs. Third Party Owned PV Systems**

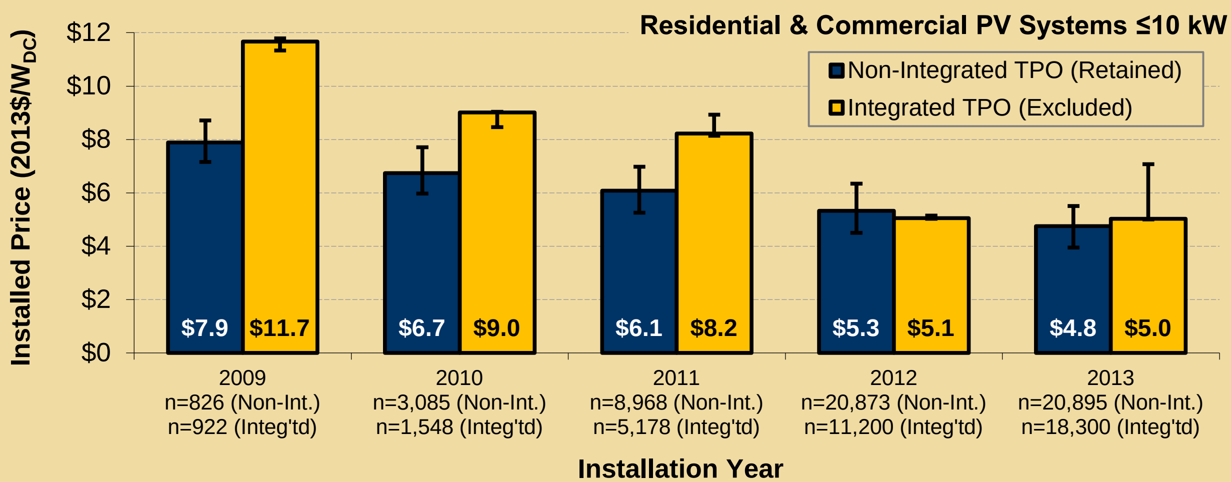
**Table 2. Median Installed Price of Customer-Owned vs. Third Party Owned PV (2013$/W)**

| Installation Year | ≤10 kW | | 10-100 kW | | >100 kW | |
|---|---|---|---|---|---|---|
| | Customer Owned | Third Party Owned | Customer Owned | Third Party Owned | Customer Owned | Third Party Owned |
| 2009 | $8.4 (n=16314) | $7.9 (n=826) | $8.0 (n=1739) | $7.9 (n=150) | $7.7 (n=129) | $7.9 (n=94) |
| 2010 | $7.2 (n=19129) | $6.7 (n=3085) | $6.8 (n=2496) | $6.6 (n=405) | $6.2 (n=291) | $5.7 (n=90) |
| 2011 | $6.5 (n=19052) | $6.1 (n=8968) | $5.9 (n=2639) | $5.7 (n=1159) | $5.1 (n=597) | $5.0 (n=347) |
| 2012 | $5.4 (n=17801) | $5.3 (n=20873) | $5.0 (n=2811) | $5.0 (n=3126) | $4.6 (n=931) | $4.7 (n=503) |
| 2013 | $4.7 (n=18567) | $4.8 (n=20895) | $4.2 (n=2668) | $4.4 (n=3834) | $3.9 (n=692) | $3.8 (n=363) |

### Text Box 3. Appraised Value Price Reporting for TPO Systems

As noted previously, for certain types of TPO systems – namely those installed by integrated TPO providers – the installed price data reported to PV incentive programs typically represent some form of appraised value. To the extent possible, those data have been eliminated from the data sample, in order to eliminate any distortion they might introduce into the historical trends presented in this report. To provide some insight into the potential significance of this distinction, Figure 20 compares reported installed prices between TPO systems that were financed by *integrated* providers and thus excluded from the data sample and TPO those systems that were financed by non-integrated providers and retained in the sample. For simplicity, the figure focuses on systems ≤10 kW, for the period from 2009 onward.

As shown, through 2011, installed prices reported for the excluded TPO systems installed by integrated finance providers were dramatically higher than for non-integrated TPO systems. For many integrated TPO systems, the appraised values used as the basis for reported installed prices were the assessed "fair market value" used by the project owner when applying for a Section 1603 Treasury Grant or federal investment tax credit. That fair market value is often based on a discounted cash flow from the project, which can be substantially higher than the price that would be paid under a cash sale transaction (such as those reported for non-integrated TPO systems).[28,29] Starting in 2012, however, at least one major integrated TPO provider changed its installed price reporting methodology for PV incentive programs, and is now reporting a standard appraised cost rather than an appraised fair market value. As a result, the disparity between installed prices reported for integrated and non-integrated TPO systems has since largely disappeared.




*Notes: The data for integrated TPO systems are included in this figure but excluded throughout all other elements of this report. The data presented here for both types of TPO systems represent installed prices reported to state and utility PV incentive programs, which may differ from those reported to other entities (e.g., to the U.S. Treasury Dept. or the IRS, for the purposes of the 1603 Grant or federal ITC).*

**Figure 20. Installed Prices Reported for Integrated and Non-Integrated TPO PV Systems**

[28] The Treasury Department's guidelines for assessing the cost basis of solar properties identifies three allowable methods for assessing fair market value: the cost approach, based on the actual cost to install the project; the market approach, based on the sale price of comparable properties; or the income approach, based on the discounted value of future cash flows generated by and appropriately allocable to the eligible property. For additional information, see: http://www.treasury.gov/initiatives/recovery/Documents/N%20Evaluating_Cost_Basis_for_Solar_PV_Properties%20final.pdf.

[29] Integrated and non-integrated TPO providers both follow similar reporting conventions when reporting fair market value for tax incentives; the difference is simply in what is reported to state/utility PV incentive program administrators, where non-integrated providers may report the intermediate transaction price with the EPC contractor.

## *Microinverters Are Associated with Higher Installed Prices for Small Systems but Lower Installed Prices for Medium-Sized Systems*

Microinverters have made significant gains in market share in recent years, owing in part to their performance advantages relative to standard central or string inverters.[30] Those performance gains, however, come at some cost, with microinverter prices in 2013 exceeding standard residential inverter prices by roughly $0.32/W and standard commercial inverter prices by $0.38/W (SEIA/GTM 2014a). Separate from the direct cost of the inverter, microinverters may also impact, either positively or negatively, certain balance of systems (BOS) or soft costs, such as installation labor and system design.

In order to understand the net effect of these underlying cost drivers, Figure 21 compares the installed price of systems with microinverters to those with standard inverters, focusing on 2013 installations, and Table 3 presents time series data for the five-year period through 2013. The figure and table focus only on systems ≤10 kW and 10-100 kW, for which sample sizes of systems with microinverter are sufficient. Again, we note that the comparison here focuses on installed price, and therefore ignores the reduction in LCOE associated with increased performance from the use of microinverters.

As shown, the differences in installed price between systems with microinverters and those with standard inverters have varied both over time and also across system size classes. Among systems ≤10 kW in size (for which microinverters are most common), installed prices for systems with microinverters have generally been higher than for those with standard inverters. That gap, however, shrank considerably over the past several years of the analysis period, with the premium for microinverter systems declining from $0.6/W (10%) in 2011 to $0.1/W (2%) in 2013. In contrast, within the 10-100 kW size range, systems with microinverters have generally had lower installed prices than those with standard inverters. In 2013, this gap was relatively large, with a difference in median installed price equal to $0.4/W (10%) between systems with microinverters and those with standard inverters. In previous years, that gap was considerably smaller, typically on the order of $0.1/W to $0.2/W, but directionally consistent.

These differences in total installed prices allow for some provisional conclusions about how aggregate non-inverter BOS and soft costs may differ with the choice of inverter technology. For ≤10 kW systems, the differential in total installed price ($0.1/W in 2013) is slightly less than the price premium for microinverters ($0.3/W), suggesting that aggregate non-inverter BOS and soft costs might be slightly less for systems with microinverters, partially offsetting the higher inverter costs. For 10-100 kW systems, however, the fact that systems with microinverters had lower total installed prices, despite higher inverters costs, suggests that microinverters in those applications may have delivered fairly significant net BOS/soft cost savings.[31]

Differences in the installed price of systems with microinverters and standard inverters also have implications for overall temporal trends in the installed price of PV systems in the dataset. As

[30] Deline et al. (2012) estimate 4-12% greater annual energy production from systems with microinverters. Such performance gains are associated primarily with the ability to control the operation of each panel independently, thereby eliminating losses that would otherwise occur on panels in a string when the output of a subset of panels is compromised (e.g., due to shading or orientation) or when mismatch exists among modules in the string.

[31] Although the data do not permit exploration of this question, it is conceivable that installers tend to choose microinverters for more-complex installations (e.g., systems on multiple roof planes), especially for small systems where space constraints are often binding. To the extent that this is the case, the differences in total installed prices shown here would suggest greater net savings on non-inverter BOS and soft costs for systems with microinverters.

indicated in Table 3, the penetration of microinverters has increased substantially in recent years, rising from 2% in 2009 to 31% in 2013 for ≤10 kW systems in the data sample, and from 2% to 22% for 10-100 kW systems over that period. Given the price differentials observed here, that growth in penetration would appear to have put some modest degree of upward pressure on the installed price of systems ≤10 kW, though any impact in 2013 would have been quite small. Conversely, for systems 10-100 kW, the relatively low price of systems with microinverters has helped to aid the overall decline in installed prices, though likely by only a modest amount.

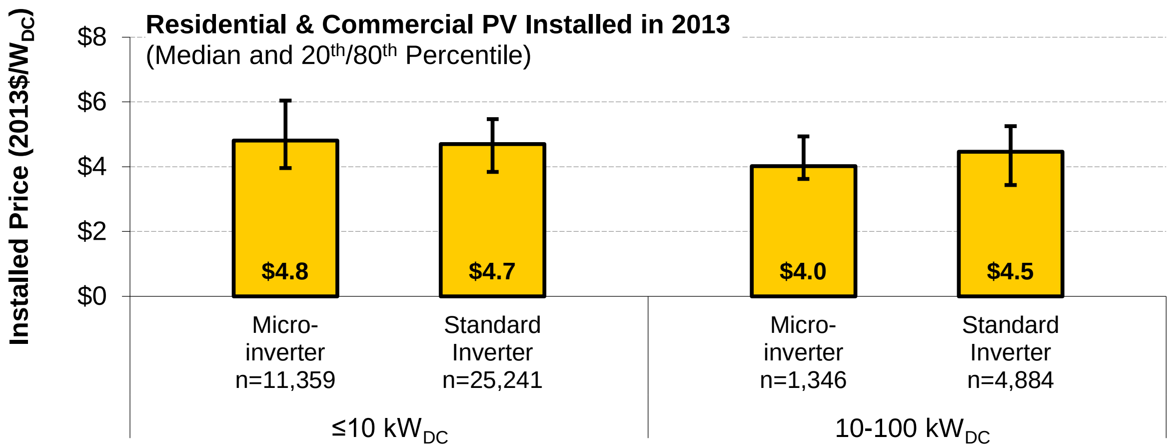



**Figure 21. Installed Price Differences between Systems with Microinverters and Standard Inverters**

**Table 3. Median Installed Price of Microinverter vs. Standard Inverter PV Systems (2013$/W)**

| Installation Year | ≤10 kW | | 10-100 kW | |
|---|---|---|---|---|
| | Microinverter | Standard Inverter | Microinverter | Standard Inverter |
| 2009 | $8.3 (n=326) | $8.3 (n=15026) | $7.5 (n=36) | $8.0 (n=1788) |
| 2010 | $7.3 (n=1022) | $7.1 (n=21199) | $6.5 (n=154) | $6.7 (n=3522) |
| 2011 | $6.8 (n=5653) | $6.2 (n=22455) | $5.7 (n=475) | $5.8 (n=4034) |
| 2012 | $5.8 (n=9140) | $5.3 (n=27645) | $4.9 (n=807) | $5.0 (n=4984) |
| 2013 | $4.8 (n=11359) | $4.7 (n=25241) | $4.0 (n=1346) | $4.5 (n=4884) |

*Notes: Results are omitted (*) if fewer than 15 observations are available.*

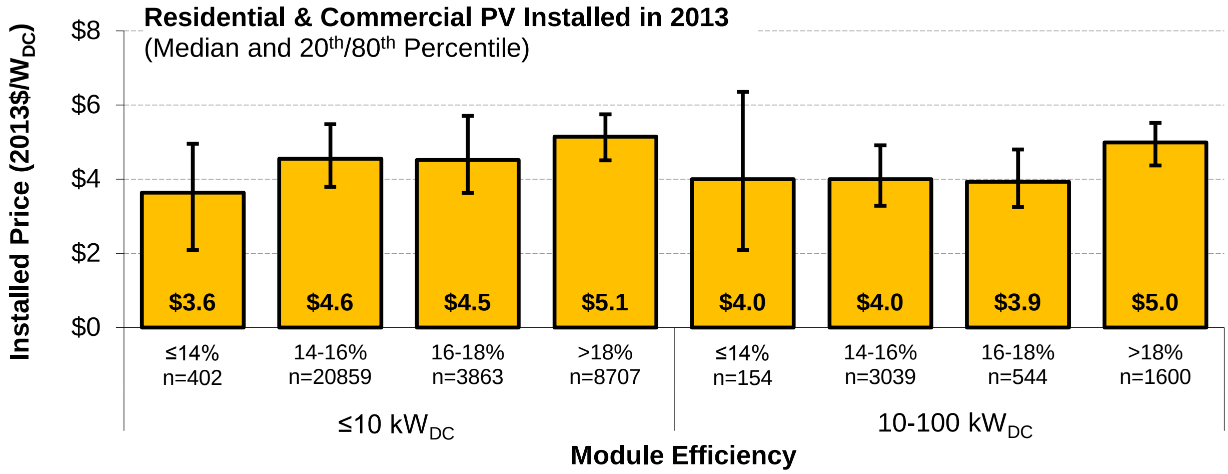
## *Installed Prices Are Higher for Systems with High Efficiency Modules*

The conversion efficiency of commercially available PV modules varies considerably, from less than 12% for amorphous silicon and certain other types of thin-film modules to greater than 20% for high-performance monocrystalline silicon modules. Within the data sample for this report, roughly half of the systems have module efficiencies of 14-16%, typical of current poly-silicon modules, though the distribution of module efficiency levels has shifted over time as efficiencies have increased across all module technologies.

Module efficiency impacts the installed price of PV systems in countervailing ways. On the one hand, increased module efficiency reduces area-related balance of systems costs, while on the other hand, high-efficiency modules are typically more expensive. To examine the net effect of these opposing cost drivers, Figure 22 compares installed prices according to module efficiency for systems installed in 2013, and Table 4 presents corresponding time series data. The figure and table focus only on systems ≤10 kW and 10-100 kW, for which the sample sizes are sufficient within each of the module efficiency ranges shown.

The figure and table indicate that systems with high-efficiency modules generally have a higher installed price than systems with lower efficiency modules. Within the ≤10 kW system size range, the price differential between systems with >18% efficiency modules and those with efficiencies in the 14-16% range was roughly $0.5/W in 2013; similar or somewhat larger differences occurred in prior years. For 10-100 kW systems, the gap was even larger, with a difference in median installed prices of roughly $1.0/W in 2013, and $0.6/W to $1.2/W in previous years.

These trends suggest that the cost premium for high-efficiency modules has, thus far at least, generally outweighed any corresponding reduction in balance of systems costs, though high-efficiency modules may entail other benefits (financial and otherwise) not reflected directly in the installed price of the system. One potential explanation for the lower installed price of systems with lower efficiency modules is that those systems disproportionately use Chinese-made modules, which are less expensive than modules made elsewhere (or alternatively, that price competition from Chinese-made models has most directly affected modules within a comparable efficiency class). These potential drivers are explored more directly in the following section.




*Notes: The figure excludes building-integrated PV (BIPV) systems, in order to avoid any bias associated with a higher incidence of BIPV systems with particular module efficiency levels.*

**Figure 22. Installed Price Variation with Module Efficiency**

**Table 4. Median Installed Price According to Module Efficiency (2013$/W)**

| Installation Year | ≤10 kW | | | | 10-100 kW | | | |
|---|---|---|---|---|---|---|---|---|
| | ≤14% | 14-16% | 16-18% | >18% | ≤14% | 14-16% | 16-18% | >18% |
| 2009 | $8.0 n=5,291 | $8.0 n=1,281 | $8.7 n=2,114 | $8.8 n=3,098 | $7.7 n=512 | $7.3 n=184 | $8.4 n=211 | $8.5 n=385 |
| 2010 | $7.0 n=7,583 | $6.6 n=7,324 | $7.6 n=2,073 | $7.8 n=2,948 | $6.6 n=1,139 | $6.4 n=1,158 | $7.4 n=256 | $7.5 n=437 |
| 2011 | $6.3 n=4,477 | $6.1 n=14,426 | $7.0 n=781 | $7.0 n=4,672 | $5.8 n=815 | $5.7 n=1,981 | $6.7 n=123 | $6.3 n=495 |
| 2012 | $5.4 n=1,148 | $5.3 n=20,925 | $5.7 n=567 | $5.8 n=8,734 | $5.1 n=369 | $4.8 n=2,566 | $5.1 n=106 | $5.4 n=1,413 |
| 2013 | $3.6 n=402 | $4.6 n=20,859 | $4.5 n=3,863 | $5.1 n=8,707 | $4.0 n=154 | $4.0 n=3,039 | $3.9 n=544 | $5.0 n=1,600 |

## *Installed Prices for Systems with Chinese-Brand Modules Have Generally Been Slightly Lower than for Other Systems with Comparable Module Efficiency*

The rapid expansion of the Chinese photovoltaic industry has transformed the global PV market and had significant impacts on installed price trends. These impacts are, in part, associated with the large over-supply of PV manufacturing capacity that has persisted in recent years, contributing to steep reductions in global module selling prices (which also reflect underlying cost reductions and scale economies). Aside from the broader impacts on the global PV module market supply-demand balance, Chinese-brand modules also tend to be lower-priced than modules manufactured in Europe, the United States, or Japan. In particular, for modules shipped in 2013, the average sales price (ASP) of Chinese-brand modules was roughly $0.50/W lower than the weighted-average ASP of modules from Europe, Japan, and the United States (Mints, 2014).[32] One might therefore suppose that some portion of the recent reduction in the installed price of PV in the United States is attributable directly to the increasing market share of Chinese modules (in addition to the *indirect* effect via downward pressure on the price of non-Chinese modules).

To examine this supposition, Figure 23 compares the installed price of systems with Chinese and Non-Chinese modules installed in 2013, and Table 5 presents the corresponding time series data. As shown, the differences in median installed prices depend critically on whether one controls for module efficiency. Across all module efficiencies, median installed prices were $0.5/W to $0.6/W lower for systems with Chinese-brand modules in 2013, depending on system size, with somewhat smaller differences in prior years (generally in the range of $0.2/W to $0.5/W). This gap in system installed prices is somewhat larger than the differential in spot market prices for Chinese and non-Chinese modules, and it largely mirrors the installed price differential noted previously between systems with standard-efficiency and premium-efficiency modules.

Focusing more narrowly on systems with module efficiencies of 14-16% – the range within which most Chinese-brand modules fall – the installed price differential between systems with Chinese and non-Chinese modules is considerably smaller (and of somewhat inconsistent direction). In 2013, for example, median installed prices differed by only $0.1/W to $0.4/W between systems with Chinese and Non-Chinese modules in the 14-16% efficiency range. In prior years, however, the installed price gap has generally remained within $0.2/W. Collectively, these results suggest that the increasing prevalence of Chinese-brand modules within the U.S. market has perhaps had some modest direct and downward effect on the long-term trajectory of installed prices in the United States (though the size of that effect depends on the extent to which Chinese-brand modules displaced high efficiency vs. standard efficiency non-Chinese brands). That proximate effect, however, is separate from the broader effect of the Chinese PV module industry on the global module market and module pricing.

---

[32] Pricing differences in the spot market are much narrower, with Bloomberg New Energy Finance reporting only a $0.05/W difference between average monthly spot market prices for Chinese-brand vs. European- and American-brand modules in 2013 (BNEF 2014).

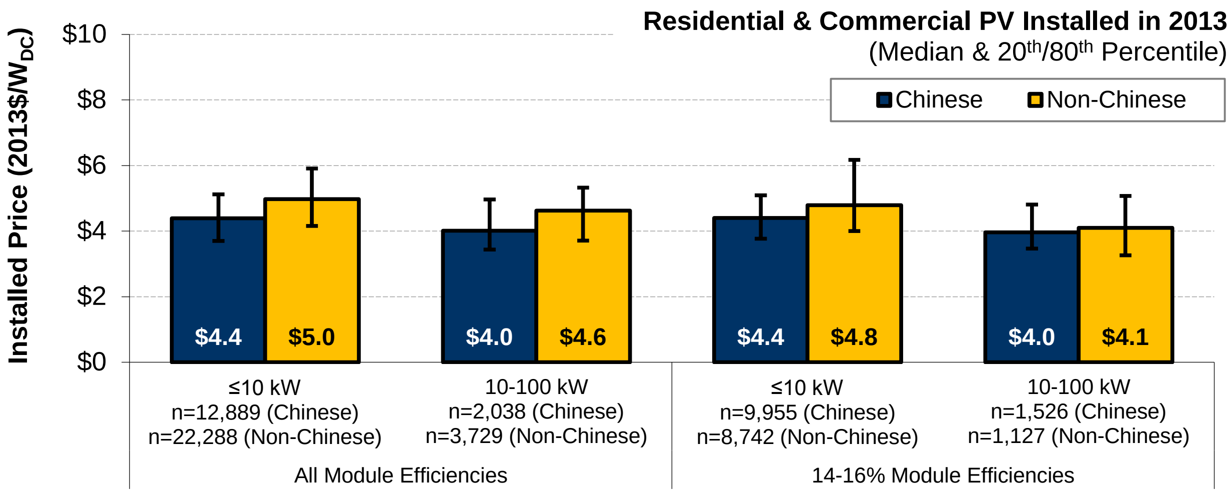



**Figure 23. Installed Price of PV Systems with Chinese vs. Non-Chinese Modules**

**Table 5. Median Installed Price of PV Systems with Chinese vs. Non-Chinese Modules (2013$/W)**

| Installation Year | All Module Efficiencies | | | | 14-16% Module Efficiencies | | | |
|---|---|---|---|---|---|---|---|---|
| | <10 kW | | 10-100 kW | | <10 kW | | 10-100 kW | |
| | Chinese | Non-Chinese | Chinese | Non-Chinese | Chinese | Non-Chinese | Chinese | Non-Chinese |
| 2009 | $7.9 (n=3491) | $8.4 (n=12795) | $7.6 (n=382) | $8.0 (n=1569) | $8.0 (n=339) | $8.1 (n=921) | $7.4 (n=70) | $7.2 (n=111) |
| 2010 | $6.7 (n=5904) | $7.1 (n=18431) | $6.4 (n=1078) | $6.8 (n=2743) | $6.5 (n=1901) | $6.7 (n=5352) | $6.2 (n=387) | $6.5 (n=759) |
| 2011 | $6.1 (n=8204) | $6.3 (n=20304) | $5.6 (n=1453) | $6.0 (n=3048) | $6.2 (n=5270) | $6.1 (n=9056) | $5.6 (n=760) | $5.8 (n=1198) |
| 2012 | $5.2 (n=9672) | $5.5 (n=24295) | $4.8 (n=1613) | $5.1 (n=3876) | $5.3 (n=7473) | $5.4 (n=10993) | $4.8 (n=1021) | $4.9 (n=1378) |
| 2013 | $4.4 (n=12889) | $5.0 (n=22288) | $4.0 (n=2038) | $4.6 (n=3729) | $4.4 (n=9955) | $4.8 (n=8742) | $4.0 (n=1526) | $4.1 (n=1127) |

## *Installed Prices Are Higher for Tax-Exempt Customers than for Other Customer Segments*

Figure 24 and Table 6 compare median installed prices across three host-customer sectors: residential, commercial (for-profit), and tax-exempt (i.e., government, schools, and non-profit). This distinction between commercial/for-profit host customers and tax-exempt host customers is made in this section only; elsewhere both are included within the general "commercial" designation.

The most consistent trend, both across system sizes and over time, is that tax-exempt systems generally have had higher installed prices than similarly sized commercial (and to a lesser extent, residential) systems. Among systems installed 2013, the median price of systems hosted by tax-exempt customers was \$0.1/W to \$0.2/W higher than residential and \$0.3/W to \$0.9/W higher than commercial systems within each size range, with the most substantial disparity in the >100 kW size class. Similarly sized installed price differences occurred in prior years as well, suggesting some continuity in this trend over time. Higher installed prices for tax-exempt customers may reflect a number of underlying drivers, including prevailing wage/union labor requirements, preferences for domestically manufactured components, a high incidence of shade and parking structure PV arrays at schools and other public buildings, additional permitting requirements for government facilities, more complex government procurement processes, and higher incentives. In addition, a relatively high proportion of 2013 systems hosted by tax-exempt customers were installed in California (53%), compared to the California-share of commercial systems (18%), and as previously noted, installed prices are generally higher in California.[33]

Comparing residential to commercial systems within each size range, the trends over time are inconsistent, and differences in median prices between the two segments are small. Among systems installed in 2013, the median installed price of commercial systems was $0.3/W lower than for residential systems in the 5-10 kW size range, and $0.1/W lower in the 10-100 kW size range. In various years prior to 2013, however, residential systems have at times exhibited slightly lower median prices.

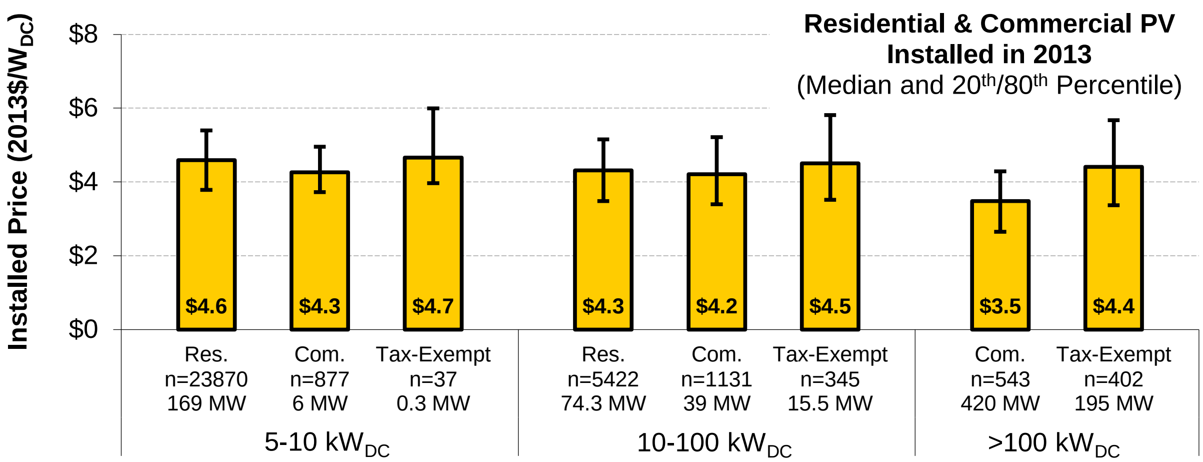



**Figure 24. Installed Price Variation across Host Customer Sectors**

**Table 6. Median Installed Price by Host Customer Sector (2013$/W)**

| Installation Year | 5-10 kW | | | 10-100 kW | | | >100 kW | |
|---|---|---|---|---|---|---|---|---|
| | Residential | Commercial | Tax-Exempt | Residential | Commercial | Tax-Exempt | Commercial | Tax-Exempt |
| 2009 | $8.0 (n=8632) | $8.6 (n=258) | $8.8 (n=51) | $7.9 (n=1535) | $8.2 (n=710) | $8.5 (n=164) | $7.6 (n=205) | $8.1 (n=105) |
| 2010 | $6.7 (n=14405) | $7.0 (n=387) | $7.5 (n=76) | $6.6 (n=3076) | $6.8 (n=1353) | $7.1 (n=406) | $5.8 (n=378) | $6.0 (n=139) |
| 2011 | $6.0 (n=16060) | $5.8 (n=532) | $6.3 (n=97) | $5.8 (n=3445) | $5.8 (n=1719) | $6.1 (n=548) | $4.8 (n=640) | $5.5 (n=330) |
| 2012 | $5.2 (n=20774) | $5.0 (n=1155) | $5.9 (n=81) | $5.0 (n=4607) | $5.0 (n=1805) | $5.3 (n=578) | $4.3 (n=773) | $5.1 (n=565) |
| 2013 | $4.6 (n=23870) | $4.3 (n=877) | $4.7 (n=37) | $4.3 (n=5422) | $4.2 (n=1131) | $4.5 (n=345) | $3.5 (n=543) | $4.4 (n=402) |

[33] The fact that the installed prices of commercial-scale systems is higher in California than elsewhere may of course partly be due to the prevalence of tax-exempt systems there; however, other state-specific conditions in California are invariably also responsible for relatively high prices across all market segments.

## *Residential New Construction Offers Significant Installed Price Advantages Compared to Retrofit Applications*

PV systems installed in residential new construction may enjoy cost advantages relative to systems installed as retrofits to existing homes, as a result of economies of scale (in the case of new housing developments with multiple PV homes) and economies of scope (where certain labor or materials costs can be shared between the PV installation and other elements of home construction). To examine the extent to which these potential cost advantages have materialized, Figure 25 compares the installed price of PV systems in residential retrofit and residential new construction applications, based on systems funded through two companion incentive programs in California: the California Solar Initiative (CSI) program and the New Solar Homes Partnership (NSHP) program, which respectively fund PV systems in residential retrofit and new construction applications. For the purpose of comparability, the figure focuses solely on 1-4 kW systems (the most typical size range for PV systems installed in residential new construction) and includes only rack-mounted systems. The next section will discuss differences in installed price between rack-mounted and building-integrated PV within residential new construction.

As evident within Figure 25, rack-mounted PV systems in residential new construction have consistently exhibited lower installed prices than comparably sized residential retrofits, though the magnitude of the price differential has varied over the five-year period shown, with a difference of $0.9/W in 2013. A certain degree of caution is warranted in interpreting these trends, both because of the small sample size of new construction systems (particularly in 2009 and 2010) and because of potential idiosyncrasies in how data are reported for PV in new construction. In particular, a temporal lag in the data for residential new construction may exist if PV modules are being held in inventory by housing developers as they slowly complete new developments and/or if PV system prices are being reported only after home sales occur. In addition, there may be some uncertainty in how installed prices are reported for PV in residential new construction in cases where the system is installed by an electrical or roofing contractor as part of a larger job.

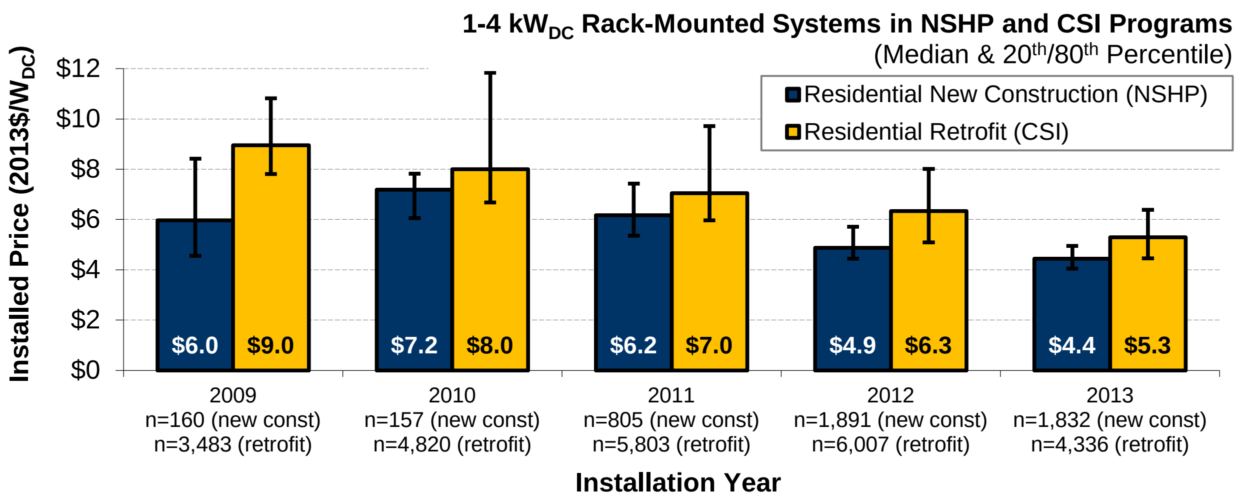



**Figure 25. Installed Price of Residential Retrofit vs. New Construction**

## *Within the Residential New Construction Market, BIPV Systems Have Shown Substantially Higher Installed Prices than Rack-Mounted Systems*

Building-integrated PV (BIPV) technologies offer the potential for more aesthetically pleasing designs, but have attained relatively modest market shares to-date. Compared to traditional rack-mounted systems, BIPV also holds the prospect of lower costs associated with reduced mounting hardware and labor costs, as well as the ability to potentially offset roofing materials (James et al. 2011). At the same time, however, BIPV products may be sold at a premium relative to rack-mounted modules due to their additional structural features and functional requirements, and BIPV panel efficiencies are generally lower than typical crystalline module efficiencies in rack-mounted applications, leading to increased area-related balance of systems costs.[34]

As a measure of the net impact of these countervailing factors, Figure 26 compares the installed price of BIPV and rack-mounted systems in residential new construction, focusing on 1-4 kW systems funded through the California NSHP program. Though based on a relatively small sample size, the figure shows that the median installed price of BIPV systems has consistently been higher than that of rack-mounted systems, with a premium of $2.1/W for systems installed in 2013. Note, though, that by focusing on installed prices, these data do not account for avoided roofing material costs, and thus do not necessarily provide a comprehensive comparison of the relative installed price of BIPV vs. rack-mounted systems, nor do they account for performance differences between BIPV and rack-mounted systems that may impact LCOE.

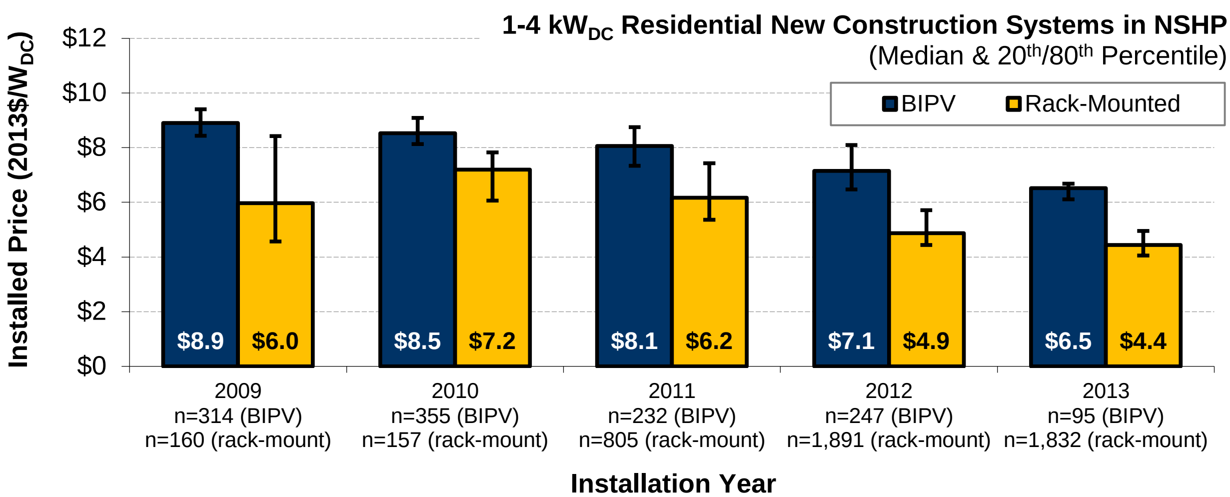



**Figure 26. Installed Price of BIPV vs. Rack-Mounted Systems in Residential New Construction**

[34] BIPV systems may also experience lower performance than rack-mounted systems as a result of higher operating temperatures and faster thermal degradation rates, most directly affecting LCOE but perhaps also putting downward pressure on installed prices.

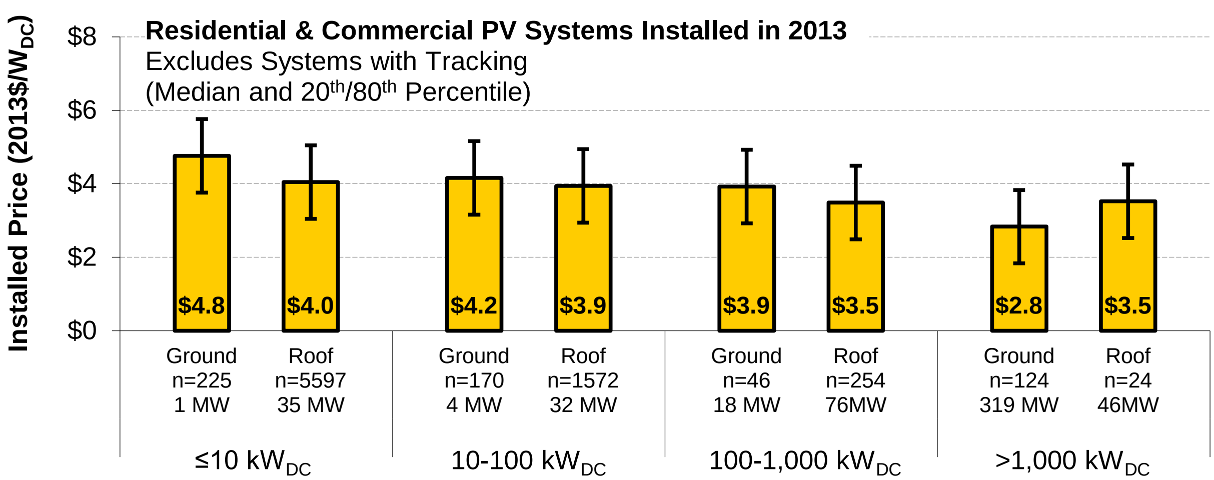
## *The Relative Installed Price of Ground-Mounted to Roof-Mounted Systems Depends on System Size*

While residential and commercial PV systems are primarily roof-mounted, ground-mounting is prevalent among the largest commercial projects in the dataset, particularly those >1,000 kW. Residential and smaller commercial systems may also be ground-mounted in specific cases, for example, where roof-space is inadequate due to size, orientation, or structural considerations, or where easy access to panels is needed for maintenance. In such cases, ground-mounting may enable improved system performance over time.

Information on whether systems in the dataset were roof- or ground-mounted was available for only a small subsample of systems (e.g., 18% of all 2013 installations, consisting primarily of systems installed in New Jersey, Massachusetts, North Carolina, and Vermont). Figure 27 and Table 7 compare installed prices among this limited set of systems, focusing only on those with fixed-tilt (i.e., excluding systems with tracking). As elsewhere, ground-mounted systems >5 MW are considered to be utility-scale and are excluded from the comparison.

At relatively small system sizes, ground-mounted systems have consistently higher installed prices than roof-mounted systems. That differential, however, tends to recede and then invert at progressively larger system sizes. In 2013, for example, the median installed price of ground-mounted systems exceeded that of roof-mounted systems by \$0.7/W for systems ≤10 kW, \$0.2/W for systems 10-100 kW, and \$0.4/W for systems 100-1,000 kW. Within the >1,000 kW size range, however, ground-mounted systems were \$0.7/W less than roof-mounted systems. The same general pattern across system size ranges is evident in earlier years as well, suggestive that economies of scale may be somewhat greater for ground-mounted systems.

The higher installed price of ground-mounted systems, at least among smaller system sizes, may reflect the additional costs associated with foundations and land preparation. In addition, some portion of the ground-mounted systems are likely installed on carports or shade structures within parking lots, and the cost of these additional structural elements may, to some degree, be included within the reported installed price. Finally, to the extent that the performance of ground-mounted systems is higher, that may itself lead to higher installed prices, where value-based pricing exists.




*Notes: The figure is derived from the relatively small subsample of systems for which data were available indicating whether the system is roof- or ground-mounted, and excludes systems with tracking or BIPV.*

**Figure 27. Installed Price of Ground- vs. Roof-Mounted Systems**

**Table 7. Median Installed Price of Ground- vs. Roof-Mounted Systems (2013$/W)**

| Installation Year | ≤10 kW | | 10-100 kW | | 100-1,000 kW | | >1,000 kW | |
|---|---|---|---|---|---|---|---|---|
| | Ground-Mounted | Roof-Mounted | Ground-Mounted | Roof-Mounted | Ground-Mounted | Roof-Mounted | Ground-Mounted | Roof-Mounted |
| 2009 | $9.1 (n=62) | $8.6 (n=1109) | $8.6 (n=34) | $8.3 (n=240) | * (n=6) | $7.7 (n=56) | * (n=4) | * (n=5) |
| 2010 | $8.0 (n=128) | $7.2 (n=2840) | $7.4 (n=75) | $6.7 (n=735) | $5.2 (n=15) | $5.5 (n=161) | * (n=6) | * (n=9) |
| 2011 | $6.5 (n=189) | $6.1 (n=5205) | $5.7 (n=197) | $5.7 (n=1332) | $5.1 (n=34) | $4.9 (n=367) | $4.2 (n=33) | $4.2 (n=47) |
| 2012 | $5.5 (n=209) | $4.8 (n=5995) | $5.2 (n=242) | $4.6 (n=1525) | $4.6 (n=81) | $4.4 (n=541) | $3.6 (n=76) | $4.4 (n=33) |
| 2013 | $4.8 (n=225) | $4.0 (n=5597) | $4.2 (n=170) | $3.9 (n=1572) | $3.9 (n=46) | $3.5 (n=254) | $2.8 (n=124) | $3.5 (n=24) |

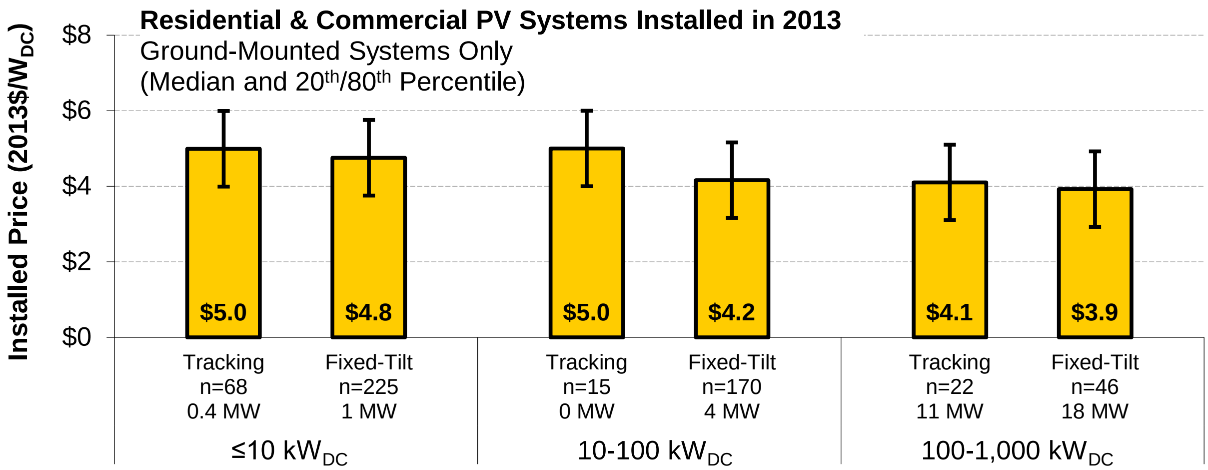
*Notes: The table is derived from the relatively small subsample of systems for which data were available indicating whether the system is roof- or ground-mounted, and excludes systems with tracking or BIPV. Results are omitted (*) if fewer than 15 data points are available.*

## *Residential and Commercial Systems with Tracking Have Higher Installed Prices than Fixed-Tilt Systems*

Although tracking equipment is most typically associated with large utility-scale PV projects, a small portion of residential and commercial PV systems within the data sample include tracking equipment. Figure 28 and Table 8 compare the installed price of residential and commercial PV systems with tracking to fixed-tilt, ground-mounted systems. Only ground-mounted systems are included in this comparison, and thus the sample sizes are again limited due to the paucity of data on whether systems are roof- or ground-mounted.

As to be expected, systems with tracking equipment exhibit consistently higher installed prices than their fixed-tilt counterparts. Among systems installed in 2013, the median installed price premium for tracking systems ranged from $0.2/W to $0.8/W (4% to 20%) higher than fixed-tilt, ground-mounted systems, across the size ranges shown. Installed price differences in previous years were generally larger, especially for smaller systems, when the median installed price of systems with tracking was typically $0.5/W to $1.5/W higher than similarly sized fixed-tilt systems, suggestive of a potential decline in the incremental cost of tracking equipment.

As mentioned previously, this report focuses solely on the up-front installed price and therefore does not consider the net impact of tracking equipment on the LCOE of PV. As a simple benchmark, however, one can compare the installed price premium for tracking equipment to the increase in annual energy yield; for example, Drury et al. (2013) estimate a 12-25% increase in annual electricity generation for single-axis tracking and a 30-45% increase for dual-axis tracking.




*Notes: The results for fixed-tilt systems are based on only those systems for which data were available indicating that the system is ground-mounted. Results for systems >1,000 kW are omitted due to insufficient sample size but are included in Table 8 for preceding years.*

**Figure 28. Installed Price of Tracking vs. Fixed-Tilt, Ground-Mounted Systems**

**Table 8. Median Installed Price of Tracking vs. Fixed-Tilt, Ground-Mounted Systems (2013$/W)**

| Installation Year | ≤10 kW | | 10-100 kW | | 100-1,000 kW | | >1,000 kW | |
|---|---|---|---|---|---|---|---|---|
| | Tracking | Fixed-Tilt | Tracking | Fixed-Tilt | Tracking | Fixed-Tilt | Tracking | Fixed-Tilt |
| 2009 | $10.4 (n=73) | $9.1 (n=62) | * (n=7) | $8.6 (n=34) | $7.9 (n=18) | * (n=6) | $7.5 (n=22) | * (n=4) |
| 2010 | $9.5 (n=87) | $8.0 (n=128) | $8.3 (n=19) | $7.4 (n=75) | * (n=13) | $5.2 (n=15) | $6.1 (n=16) | * (n=6) |
| 2011 | $8.2 (n=115) | $6.5 (n=189) | $7.2 (n=30) | $5.7 (n=197) | $5.5 (n=18) | $5.1 (n=34) | $4.7 (n=21) | $4.2 (n=33) |
| 2012 | $6.8 (n=63) | $5.5 (n=209) | $6.7 (n=33) | $5.2 (n=242) | $5.1 (n=40) | $4.6 (n=81) | $4.5 (n=33) | $3.6 (n=76) |
| 2013 | $5.0 (n=68) | $4.8 (n=225) | $5.0 (n=15) | $4.2 (n=170) | $4.1 (n=22) | $3.9 (n=46) | * (n=9) | $2.8 (n=124) |

*Notes: The results for fixed-tilt systems are based on only those systems for which data were available indicating that the system is ground-mounted. Results are omitted (*) if fewer than 15 data points are available.*

# 4. Installed Price Trends: Utility-Scale PV

This section describes trends in the installed price of utility-scale PV systems, based on the data sample described in Section 2, consisting of 100 projects installed from 2007 through 2013 and representing 88% of all utility-scale PV project capacity installed in the United States through 2013. The data presented here are a subset of the data presented within the companion LBNL annual report, *Utility Scale Solar 2013: An Empirical Analysis of Project Cost, Performance, and Pricing Trends in the United States*. In addition to installed prices, that report also describes trends in operating costs, capacity factors, and power purchase agreement prices, and covers not only utility-scale PV projects, but concentrating solar power (CSP) projects as well.

As indicated previously, utility-scale PV is defined in this report to consist of ground-mounted systems >5 MW, irrespective of whether they are interconnected on the utility-side or customer-side of the meter. In addition, the utility-scale PV project sample includes only *fully operational* projects for which all individual phases are in operation; separate project phases are not treated as individual projects, given the possibility that some costs may be shared across phases.

The section begins by describing the installed price of utility-scale projects over time, highlighting the wide range in pricing across individual projects. The section then describes installed price differences according to system configuration and project size, noting the potential contributions of these factors to the overall level of observed variation in pricing. Compared to the preceding section on residential and commercial PV, the cross-sectional comparisons for utility-scale PV are more limited, due to the relatively small underlying data sample; however, as the data sample grows over time, a broader set of comparisons may be possible.

**A few key points are worth bearing in mind with respect to the utility-scale installed price data presented in this section:**

- *Lag in component pricing and market conditions.* Installed price data for many projects may reflect transactions that occurred several or more years prior to project completion. In some cases, those transactions may have been based on component pricing at that time, or a conservative projection of component pricing, in which case the installed price may not fully capture reductions in component costs or other changes in market conditions that occurred in the intervening period. For this reason and others (see Text Box 1), the data presented here may not correspond to recent price benchmarks for utility-scale PV.
- *DC versus AC capacity ratings*. AC units may be more appropriate than DC for describing the installed price of utility-scale PV, given that other forms of utility-scale generation are also typically denoted in AC terms. However, for comparability to the residential and commercial data in the preceding section, we present installed price data for utility-scale PV in DC units as well (with the exception of Figure 29, which includes both DC and AC). LBNL's *Utility Scale Solar 2013* report provides all installed price trends in AC terms.
- *Reliability of data sources*. The installed price data for utility-scale PV projects are derived from varied sources and, in some instances, may be less reliable or consistently defined than the data presented for residential and commercial systems.
- *Focus on installed price rather than levelized cost*. It bears repeating that our focus on upfront installed price trends ignores performance-related differences and other factors influencing the levelized cost of electricity (LCOE), which is arguably the more meaningful metric for comparing the cost of utility-scale PV systems.

## *The Installed Price of Utility-Scale PV Has Declined over Time, Though Considerable Variation Exists across Projects*

Figure 29 presents the installed price of each individual project in the data sample, based on the year of commercial operation. (Note that this figure deviates from the normal convention in this report, by providing installed price data in both DC and AC units, the latter included for comparison to other forms of utility-scale generation.) Discerning a time trend in these data is challenging, given the relatively small and diverse sample of projects, and the changing composition of projects over time. Over the full duration of the timeframe shown in Figure 29, the capacity-weighted average installed price fell by 40%, from $5.0/$W_{DC}$ for the 5 projects installed during the 2007-2009 period to $3.0/$W_{DC}$ for the 25 systems completed in 2013 (or by 37% in AC terms, from $5.8/$W_{AC}$ to $3.7/$W_{AC}$). Most of that decline, however, occurred through 2012, and capacity-weighted average prices remained virtually unchanged from 2012 to 2013. To some extent, the apparent flattening of installed prices in the last year of the analysis period may be an artifact of the particular projects in the data sample – e.g., a preponderance of large (>100 MW) projects completed in 2013, some with tracking and/or premium efficiency modules, and that may have been contracted 3-4 years earlier.[35]

Importantly, capacity-weighted average prices represent only central tendencies, and installed prices for utility-scale PV systems vary substantially from project to project. Among projects completed in 2013, for example, installed prices ranged from $1.9/$W_{DC}$ to $4.9/$W_{DC}$, with most projects falling within a narrower range from $2.6/$W_{DC}$ to $3.5/$W_{DC}$ (the 20$^{th}$ and 80$^{th}$ percentiles, respectively), and similar or greater levels of variability in prior years. In part, the wide distribution in pricing reflects differences in project size and configuration, both of which are examined further in the following sections, as well as other project-specific details (e.g., whether projects are built on public vs. private land, whether land is leased or owned, design requirements associated with specific climatic conditions, etc.).

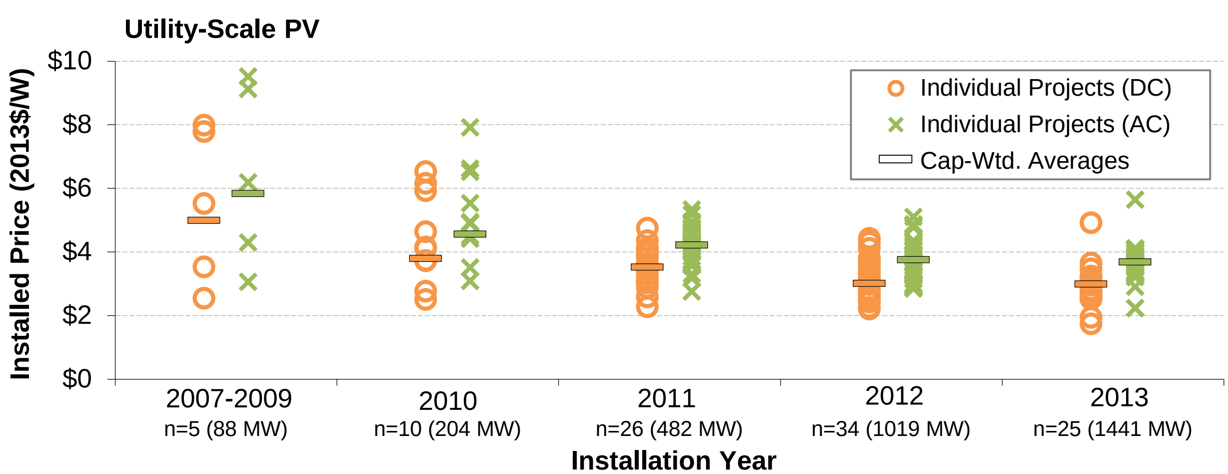



**Figure 29. Installed Price of Utility-Scale PV over Time**

[35] Some utility-scale projects currently under development have been quoted well below the average price of projects completed in 2013; for example, Public Service Company of New Mexico recently filed for regulatory approval of two projects, to be completed in 2015, each with a turnkey price of roughly $1.6/$W_{DC}$ (O'Connell 2014).

## *Installed Price Trends Differ Across System Configurations*

The utility-scale PV data sample includes projects with either crystalline silicon (c-Si), thin-film (largely Cadmium Telluride, CdTe), or concentrating photovoltaic (CPV) modules, and with either tracking equipment (typically single-axis) or fixed-tilt. As shown in Figure 30, these varying system configurations contribute, to some extent, to the overall pricing variability of the dataset as a whole, though clearly substantial variability also exists within each technology class. Among projects completed in 2013, for example, the capacity-weighted average installed price for systems with c-Si modules and tracking was \$3.1/W (with a range of \$2.5/W to \$3.0/W), compared to \$3.0/W for c-Si, fixed-tilt systems (with a \$2.6/W to \$3.7/W range, excluding an outlying project[36]), and \$2.7/W for thin-film, fixed tilt systems (with a \$1.7/W to \$3.1/W range).[37]

Differences in pricing among these groups of systems most directly reflect underlying technology costs, such as the incremental cost for tracking equipment or the relative cost of c-Si vs. thin-film modules. However, pricing differences among technology classes is also likely impacted by project characteristics indirectly associated with particular configurations, for example, higher DC/AC ratios in c-Si, fixed-tilt applications and larger project sizes for systems with tracking or thin-film modules.

Also evident in Figure 30 are the differing temporal trends for systems with c-Si vs. thin-film modules. Though sample sizes are small for early years of the sample frame, installed prices for c-Si systems clearly declined substantially over time, coinciding with the drop in c-Si module prices (though, as with residential and commercial PV, the system price and module price trajectories did not progress in lock-step). For example, among c-Si systems with tracking, average installed prices fell by \$3.4/W (52%) between the 2007-2009 period and 2013. By comparison, the average price of thin-film projects remained virtually unchanged over that span, leading to a marked convergence in pricing between the two classes.

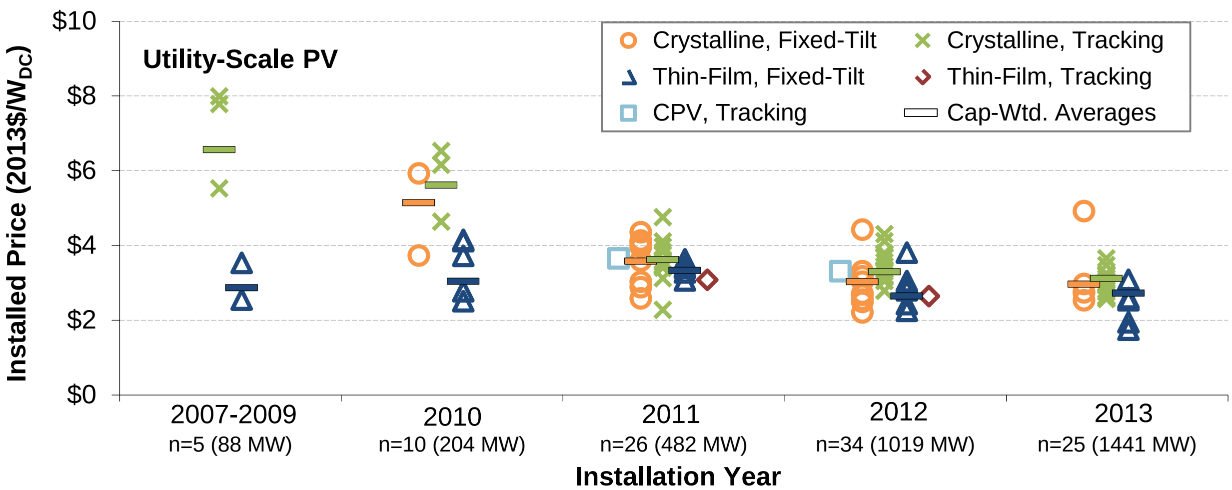



**Figure 30. Installed Price of Utility-Scale PV over Time and by System Configuration**

[36] This is Los Angeles Department of Water and Power's Pine Tree Solar project, a roughly 10 MW system contracted in 2010 and owned by the utility. Excluding this project from the sample would reduce the capacity-weighted average installed price to \$2.7/W for the four other c-Si, fixed-tilt systems installed in 2013.

[37] Several of the 2013 thin-film projects are similarly priced, and thus the markers for those projects are thus not readily distinguishable from one another in the figure.

## *Larger Utility-Scale PV Projects Tend to Exhibit More-Uniform Pricing*

Variability in pricing, both across the utility-scale sample as a whole and within each technology class, is likely also attributable, in part, to differences in project size. Scale economies are not readily discernible within the utility-scale data in Figure 31 – which includes projects completed in 2012 and 2013 – given many other unobserved drivers that introduce noise into the small sample frame. In addition, scale economies may be obscured to some extent by a longer temporal lag in the pricing data for the largest projects.

The effect of project size is perhaps most apparent in terms of the spread within the data. In particular, utility-scale projects >50 MW are clustered within a relatively narrow band, from roughly \$2.6/W to \$3.2/W (the $20^{th}$ and $80^{th}$ percentile values). In contrast, the distribution for projects <50 MW has a longer tail, with a number of projects priced well above \$4.0/W. These differences in pricing spread may reflect underlying scale economies, though other factors may also contribute, for example, if larger projects tend to be developed by more experienced and/or vertically integrated companies.

Figure 31 also serves to illustrate the relative pricing across system configurations within a given project size range (thus perhaps controlling to some extent for differing scale economies and temporal lags associated with project size). Focusing on utility-scale projects <50 MW, the capacity-weighted average price of c-Si systems with tracking was \$0.4/W higher than for fixed-tilt, c-Si systems (\$3.2/W vs. \$2.8/W). Comparing fixed-tilt thin-film and c-Si systems within that size range, average installed prices were slightly higher for thin-film than c-Si (\$2.9/W vs. \$2.8/W), suggesting perhaps a more severe narrowing of the price differential between c-Si and thin-film systems than suggested by the comparison in the preceding section across all system sizes.

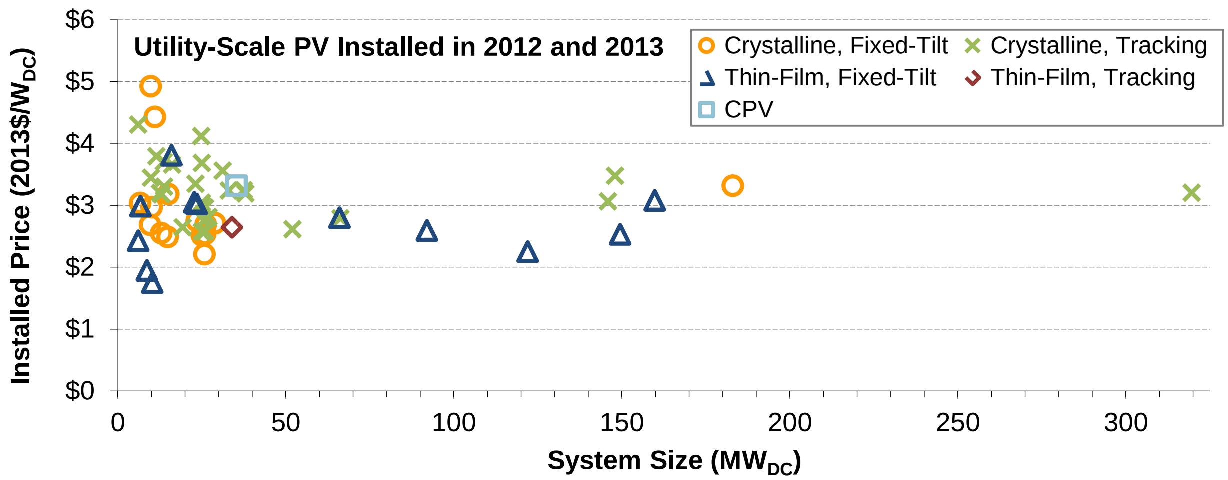



**Figure 31. Installed Price of Utility-Scale PV According to System Size and Configuration**

# 5. Conclusions and Policy Implications

The number of PV systems installed in the United States has grown at a rapid pace in recent years, driven in large measure by government incentives. Given the relatively high historical cost of PV, a key goal of these policies has been to encourage cost reductions over time through increased deployment. Key research and development efforts to drive cost reductions have also been led by the U.S. DOE's SunShot Initiative, which aims to reduce the cost of PV-generated electricity by about 75% between 2010 and 2020.

Available evidence confirms that the installed price of PV systems (i.e., the up-front cost borne by the PV system owner, prior to any incentives) has declined substantially since 1998, though both the pace and source of those cost reductions have varied over time. Following a period of relatively steady and sizeable declines, installed price reductions began to stall around 2005, as the supply-chain and delivery infrastructure struggled to keep pace with rapidly expanding global demand. Beginning in 2008, however, global module prices began a steep downward trajectory, which has been the driving force behind the roughly 50% reduction in the installed price of PV from 2008 through 2013. Those module price declines ceased in 2013, and given the limits to further reductions in module prices, continued deep reductions in installed prices will necessarily require significant reductions in non-module costs.

To date, non-module costs have yet to exhibit dramatic declines, though certainly they have fallen over the long-run and show signs of more recent reductions. Unlike module prices, which are primarily established through global markets, non-module costs consist of a variety of soft costs that may be more readily affected by local policies – including deployment programs aimed at increasing demand (and thereby increasing competition and efficiency among installers) as well as more-targeted efforts, such as training and education programs. The heightened focus on cost reductions within the solar industry and among policymakers, and recognition of the importance of soft costs for achieving further price reductions, has spurred a flurry of initiatives and activity in recent years, aimed at driving reductions in soft costs. The fact that installed prices fell substantially in 2013 and continued to fall through the first half of 2014 – despite level or slightly rising module prices – suggests that these efforts may have begun to bear fruit.

Nevertheless, lower installed prices in other major international markets suggest that deeper near-term soft cost reductions in United States are possible. Although such reductions may accompany increased market scale, it is also evident that market size alone is insufficient to fully capture potential near-term cost reductions (as suggested by the fact that many of the U.S. states with the lowest installed prices are relatively small PV markets). Achieving deep reductions in soft cost thus likely requires a broad mix of strategies, including: incentive policy designs that provide a stable and straightforward value proposition to foster efficiency and competition within the delivery infrastructure, targeted policies aimed at specific soft costs (for example, permitting and interconnection), and basic and applied research and development.

## References


BNEF. 2014. *Solar Spot Price Index*. Bloomberg New Energy Finance (BNEF).

Bolinger, M., G. Barbose, and R. Wiser. 2008. *Shaking Up the Residential PV Market: Implications of Recent Changes to the ITC*. Berkeley, CA: Lawrence Berkeley National Laboratory. LBNL-1204E.

Bolinger, M. and S. Weaver. 2014. *Utility-Scale Solar 2013: An Empirical Analysis of Project Cost, Performance, and Pricing Trends in the United States*. Berkeley, CA: Lawrence Berkeley National Laboratory (forthcoming).

Burkhardt, J., R. Wiser, N. Darghouth, C. Dong, and J. Huneycutt. 2014. *Do Local Regulations Matter? Exploring the Impact of Permitting and Local Regulatory Processes on PV Prices in the United States.* Berkeley, CA: Lawrence Berkeley National Laboratory.

Deline, C., J. Meydbray, M. Donovan, and J. Forrest. 2012. *Partial Shade Evaluation of Distributed Power Electronics for Photovoltaic Systems*. Golden, CO: National Renewable Energy Laboratory. NREL/CP-5200-54039.

Dong, C. and R. Wiser. 2013. *The Impact of City-level Permitting Processes on Residential Photovoltaic Installation Prices and Development Times: An Empirical Analysis of Solar Systems in California Cities*. Berkeley, CA: Lawrence Berkeley National Laboratory. LBNL-6140E.

Drury, E., A. Lopez, P. Denholm, and R. Margolis. 2013. Relative performance of tracking versus fixed tilt photovoltaic systems in the USA. *Progress in Photovoltaics: Research and Applications.* Early View (Online Version of Record published before inclusion in an issue).

DSIRE (Database of State Incentives for Renewables and Efficiency). 2013. "State Sales Tax Incentives for Solar Projects." Accessed June 30, 2013. http://www.dsireusa.org/documents/summarymaps/Solar_Sales_Tax_Map.pdf

EPIA (European Photovoltaic Industry Association). 2014. *Global Market Outlook for Photovoltaics 2014-2017*. Brussels, Belgium.

EuPD. 2014. Personal communication (price quotes collected by EuPD via quarterly surveys of German PV installers).

Feldman D., G. Barbose, R. Margolis, T. James, S. Weaver, N. Darghouth, R. Fu, C. Davidson, and R. Wiser. 2014. *Photovoltaic System Pricing Trends: Historical, Recent, and Near-Term Projections. 2014 Edition.* Golden, CO: National Renewable Energy Laboratory.

IEA-PVPS. 2014. PV Cost Data Collected by the IEA in January 2014 (provided via personal communication). International Energy Agency – Photovoltaic Power Systems Programme.

James, T., A. Goodrich, M. Woodhouse, R. Margolis, and S. Ong. 2011. *Building-Integrated Photovoltaics (BIPV) in the Residential Sector: An Analysis of Installed Rooftop System Prices*. Golden, CO: National Renewable Energy Laboratory. NREL/TP-6A20-53103.

Mints, P. 2014. "Photovoltaic Manufacturer Shipments: Capacity, Price & Revenues 2013/2014". SPV Market Research.

O'Connell, P. 2014. "Direct Testimony of Patrick J. O'Connell" in Case No. 14-00158-UT, *In The Matter Of Public Service Company Of New Mexico's Renewable Energy Portfolio Procurement*

*Plan For 2015 And Proposed 2015 Rider Rate Under Rate Rider No. 36*, filed before the Public Regulation Commission of New Mexico on June 2, 2014.

REN21 (2014). *Renewables 2014 Global Status Report*. Paris: REN21 Secretariat.

Seel, J., G. Barbose, and R. Wiser. 2012. *Why Are Residential PV Prices in Germany So Much Lower Than in the United States? A Scoping Analysis*. Berkeley, CA: Lawrence Berkeley National Laboratory.

SEIA/GTM Research. 2014a. *U.S. Solar Market Insight 2013 Year-in-Review*. Washington, DC: Solar Energy Industries Association/GTM Research.

SEIA/GTM Research. 2014b *U.S. Solar Market Insight Q2 2014*. Washington, DC: Solar Energy Industries Association/GTM Research.

Sherwood, L. 2014. *U.S. Solar Market Trends 2013*. Latham, NY: Interstate Renewable Energy Council, Inc.

# Appendix A: Data Cleaning, Coding, and Standardization

To the extent possible, this report presents data as provided directly by PV incentive program administrators and other data sources; however, several steps were taken to clean and standardize the data, as described below.

**Residential and Commercial PV Projects Removed from the Data Sample:** The raw data received from all PV incentive program administrators was initially cleaned to remove systems with missing data for installation date, system size, or installed price, as well as any utility-scale systems and duplicate systems participating in multiple programs. These initial cleaning steps yielded a raw data sample consisting of 304,307 residential and commercial PV systems installed through 2013. The raw sample was then further cleaned by removing projects under any of the following conditions:

- installed price less than $1.0/W (314 systems) or greater than $20/W (710 systems)
- systems with battery back-up (48 systems)
- self-installed systems (2,654 systems)
- systems for which the reported installed price was deemed likely to be an appraised value (40,635 systems).

In total, 44,361 systems from the initial sample were removed from the dataset as a result of the aforementioned screens, yielding a final data sample of 259,946 residential and commercial PV systems. Additional details on several of the cleaning steps are provided below.

<u>*Systems in Multiple PV Incentive Programs:*</u> In order to eliminate double-counting of individual systems, an effort was made to identify systems that received incentives from multiple PV incentive programs in the data sample. Where these systems could be identified (either using data fields that explicitly indicated participation in other programs or by matching addresses or other system characteristics across programs), duplicate entries were eliminated, and records associated with those programs were consolidated under a single program. Based on this process, records were consolidated for systems in both ETO's and OR DOE's programs, systems in both the Massachusetts DOER's and the MassCEC's programs, systems in both the Florida Energy & Climate Commission's program and either GRU's or OPUC's programs, and systems in both California's SGIP and either SMUD's or LADWP's programs.

<u>*Identification and Removal of Appraised Value Systems*</u>*:* Systems were removed from the data sample if the reported installed price within the raw data was deemed likely to represent an *appraised value*. As discussed further within the main body of the report, appraised-value reporting occurs for a particular type of third party owned (TPO) systems – namely, for TPO systems financed by *integrated* third party providers that provide both the installation service and customer financing. In order to eliminate any bias that such data could introduce into the summary statistics presented in this report, an effort was made to identify and remove appraised-value systems from the data sample.

Appraised-value systems were identified based on the reported *installer name* and *system ownership type* (i.e., host customer-owned vs. TPO). Both data fields were provided for 73% of all systems in the raw data sample and for 94% of systems installed in 2013, including most of the major TPO markets. For this subset of systems, all TPO systems installed by the three known integrated third-party installers (SolarCity, Sungevity, and Vivint) were deemed likely to be appraised-value systems and were removed from the data sample. Known customer-owned systems installed by those entities, however, were retained within the sample.

Where only one of the two data fields – *installer name* and *system ownership type* – was available, appraised-value systems were identified using a "price clustering" approach. The logic for the price clustering approach is founded on the observation that systems installed by integrated TPO providers are typically clustered with an identical price reported for a large group of systems (which may reflect, for example, the average per-kW assessed fair market value of a bundle of systems sold to tax equity investors).

The first step in the price clustering analysis was to identify the price clusters among the systems explicitly identified within the dataset as being TPO and installed by an integrated TPO provider. Then, among the set of systems for which either installer name or system ownership type were provided (but not both), systems were identified as appraised value if they fell within any of those price clusters and either of the following two conditions were also met: (1) the installer name identified in the raw data is an integrated TPO provider and the system is located in a state/utility service territory that allows TPO, or (2) the raw data indicated that the system is third party owned. The price clustering analysis resulted in an additional 709 systems being identified as likely appraised value systems, which were then removed from the data sample.

Thus, a total of 40,635 systems were removed from the data sample on the basis that the reported installed price was likely an appraised value (39,926 systems based solely on the combination of installer name and system ownership status, plus 709 systems based on either the installer name or system ownership status plus the fact that it was grouped within a known appraised value price cluster).

**Proxies for Completion Date:** The data provided by several PV incentive programs did not identify installation dates. In lieu of this information, the best available proxy was used (e.g., the date of the incentive payment or the post-installation site inspection).

**Incorporation of Data on Module and Inverter Characteristics.** A number of analyses within this report distinguish between systems based on characteristics of the module or inverters, including distinctions between building-integrated PV vs. rack-mounted systems, crystalline vs. thin-film modules, module efficiency, and microinverters vs. central inverters. The raw data provided by PV incentive program administrators generally included module and inverter manufacturer and model names, but did not include any further information about the characteristics of the components. The aforementioned information about component characteristics was therefore appended to the dataset by cross-referencing reported module manufacturer and model data against existing databases of PV component specification data, including SolarHub[38] and the California Solar Initiative's List of Eligible Modules.[39]

**Distinction between Chinese and non-Chinese Modules:** The analysis in Section 3 distinguishes between systems with Chinese and non-Chinese modules. This determination was made based on the location of the headquarters of the module manufacturer, where data on module manufacturer were provided.

**Conversion to 2013 Real Dollars:** Installed price and incentive data are expressed throughout this report in real 2013 dollars (2013$). Data provided by PV program administrators in nominal dollars were converted to 2013$ using the "Monthly Consumer Price Index for All Urban Consumers," published by the U.S. Bureau of Labor Statistics.[40]

**Conversion of Capacity Data to Direct Current (DC) Watts at Standard Test Conditions (DC-STC):** Throughout this report, all capacity and dollars-per-watt ($/W) data are expressed using DC-STC capacity ratings. Most PV incentive programs directly provided data in units of DC-STC; however, several programs provided capacity data only in terms of the California Energy Commission Alternating Current (CEC-AC) rating convention, which represents peak AC power output at PVUSA Test Conditions (PTC). DC-STC capacity ratings for systems funded through these programs were calculated according to the procedures described below.

---

[38] http://www.solarhub.com/
[39] http://www.gosolarcalifornia.org/equipment/pv_modules.php
[40] ftp://ftp.bls.gov/pub/special.requests/cpi/cpiai.txt

*CEC Emerging Renewables Program (ERP) and CEC New Solar Home Partnership (NSHP) Program*: The data provided for these programs included data fields identifying the module manufacturer, model, and number of modules for most PV systems. DC-STC ratings were identified for most modules by cross-referencing the information provided about the module type with the CSI's List of Eligible Photovoltaic Modules, which identifies DC-STC ratings for most of the modules employed in the systems funded through these programs. For modules not in this list, the DC-STC rating was found in the modules' specification sheets from the manufacturer. The DC-STC rating for each module was then multiplied by the number of modules to determine the total DC-STC rating for the system, as a whole. This approach was used to determine the DC-STC capacity rating for all of the systems in the NSHP dataset, and for 86% of the systems in the ERP dataset. For the remaining systems in the ERP dataset, either the module data fields were incomplete, or the module could not be cross-referenced with the CSI list, or the estimated DC-STC rating for the system was grossly inconsistent with the reported CEC-AC rating. In these cases, an average conversion factor of 1.200 $W_{DC\text{-}STC}/W_{CEC\text{-}AC}$ was used, which was derived based on the averages for other systems in the ERP dataset.

*CPUC Self-Generation Incentive Program (SGIP)*: The data provided for SGIP included data fields identifying module manufacturer and model (but not number of modules), and inverter manufacturer and model. DC-STC module ratings and DC-PTC module ratings (i.e., DC watts at PVUSA Test Conditions) were identified by cross-referencing the reported module type with the CSI's List of Eligible Photovoltaic Modules. Similarly, the rated inverter efficiency for each project was identified by cross referencing the reported inverter type with the CSI's List of Eligible Inverters, which identifies inverter efficiency ratings for most of the inverters used within the systems funded through SGIP.[41] These pieces of information (module DC-STC rating, module DC-PTC rating, and inverter efficiency rating), along with the reported CEC-AC rating for the system, were used to estimate the system DC-STC rating according to the following:

$$\text{System}_{DC\text{-}STC} = (\text{System}_{CEC\text{-}AC} / \text{Inverter Eff.}) * (\text{Module}_{DC\text{-}STC} / \text{Module}_{DC\text{-}PTC})$$

In cases where data on module manufacturer and model either was not provided or could not be matched with the CSI module list, then the DC-STC rating was calculated using the median ratio of module DC-STC to DC-PTC ratings for systems installed in the same year (0.88-0.90 $W_{DC\text{-}STC}/W_{DC\text{-}PTC}$). In cases where data on inverter manufacturer and model either was not provided or could not be matched with the CSI's inverter list, the inverter efficiency was stipulated based on the average inverter efficiency of systems in the SGIP dataset installed in the same year and for which inverter efficiency ratings could be identified. If neither the module nor inverter data were provided, then the DC-STC rating was calculated directly from the reported CEC-AC rating, using the median annual ratio of module DC-STC rating to system CEC-AC rating (1.19-1.22 $W_{DC\text{-}STC}/W_{CEC\text{-}AC}$).

[41] http://www.gosolarcalifornia.org/equipment/inverters.php

# Appendix B: Residential and Commercial PV Data Sample Summaries

**Table B-1. Residential and Commercial PV System Sample by PV Incentive Program**

| State | PV Incentive Program Administrator and Program Name | No. of Systems | Total $MW_{DC}$ | % of Total $MW_{DC}$ | Size Range ($kW_{DC}$) | Year Range |
|---|---|---|---|---|---|---|
| AR | State Energy Office - Renewable Technology Rebate Fund | 97 | 0.7 | 0.0% | 0.5 - 25 | 2010 - 2011 |
| AZ | Arizona Public Service - UFI and PBI programs | 15,760 | 293.4 | 6.3% | 0.3 - 3,903 | 2002 - 2013 |
| | Duncan Valley Electric Coop. - SunWatts Rebate Program | 4 | 0.0 | 0.0% | 0.5 - 11 | 2006 - 2009 |
| | Graham County Electric Coop. - SunWatts Rebate Program | 96 | 0.5 | 0.0% | 0.1 - 25 | 2005 - 2010 |
| | Mohave Electric Coop.- SunWatts Rebate Program | 258 | 1.9 | 0.0% | 0.7 - 47 | 2005 - 2013 |
| | Morenci Water & Electric - UFI and PBI programs | 3 | 0.0 | 0.0% | 5.8 - 20 | 2010 - 2011 |
| | Navopache Electric Coop. - Renewable Energy Incentive Program | 130 | 0.9 | 0.0% | 1.0 - 55 | 2003 - 2012 |
| | Sulpher Valley Electric Coop. - SunWatts Rebate Program | 822 | 5.7 | 0.1% | 0.1 - 984 | 2009 - 2013 |
| | Salt River Project - EarthWise Solar Energy Program | 5,368 | 47.2 | 1.0% | 0.5 - 999 | 2005 - 2013 |
| | Tucscon Electric Power - UFI andPBI programs | 3,393 | 49.4 | 1.1% | 0.1 - 3,375 | 2008 - 2013 |
| | Trico Electric Coop. - SunWatts Rebate Program | 469 | 3.2 | 0.1% | 0.4 - 346 | 2006 - 2013 |
| | UniSource Electric Services - UFI and PBI programs | 634 | 5.6 | 0.1% | 0.5 - 98 | 2010 - 2012 |
| CA | CA Center for Sustainable Energy - Rebuild a Greener San Diego Program | 154 | 0.8 | 0.0% | 1.9 - 7.1 | 2004 - 2008 |
| | CA Energy Commission - Emerging Renewables Program | 27,489 | 145.2 | 3.1% | 0.1 - 670 | 1998 - 2008 |
| | CA Energy Commission - New Solar Homes Partnership | 8,327 | 32.2 | 0.7% | 1.2 - 295 | 1999 - 2013 |
| | CA Public Utilities Commission - California Solar Initiative | 103,513 | 1413.2 | 30.1% | 0.9 - 4,726 | 2007 - 2013 |
| | CA Public Utilities Commission - Self Generation Incentive Program | 855 | 159.9 | 3.4% | 34 - 1,266 | 2002 - 2009 |
| | Los Angeles Dept. of Water & Power - Solar Incentive Program | 7,902 | 85.3 | 1.8% | 0.3 - 3,966 | 1999 - 2013 |
| | PacifiCorp - California Solar Incentive Program | 51 | 0.9 | 0.0% | 2.0 - 257 | 2011 - 2013 |
| | Sacramento Municipal Utility District - PV incentive programs (various) | 2,275 | 35.4 | 0.8% | 0.7 - 2,840 | 2005 - 2013 |
| CO | Xcel Energy - SolarRewards Program[a] | 14,472 | 144.8 | n/a | n/a | 2006 - 2013 |
| | Colorado Springs Utilities - Renewable Energy Rebate Program | 45 | 0.3 | 0.0% | 1.3 - 12 | 2011 - 2013 |
| CT | Clean Energy Finance Investment Authority - PV incentive programs (various) | 3,100 | 39.6 | 0.8% | 0.7 - 570 | 2004 - 2013 |
| DC | Dept. of Env. Protection - Renewable Energy Incentive Program | 764 | 3.8 | 0.1% | 0.9 - 101 | 2009 - 2013 |
| DE | Dept. of Natural Resources & Env. Control - Electric Coop. PV rebate program | 309 | 2.1 | 0.0% | 1.1 - 88 | 2007 - 2013 |
| | Dept. of Natural Resources & Env. Control - Municipal PV rebate program | 121 | 0.8 | 0.0% | 1.8 - 151 | 2007 - 2013 |
| | Dept. of Natural Resources & Env. Control - Delmarva PV rebate program | 575 | 4.0 | 0.1% | 0.9 - 64 | 2002 - 2013 |

| State | PV Incentive Program Administrator and Program Name | No. of Systems | Total $MW_{DC}$ | % of Total $MW_{DC}$ | Size Range ($kW_{DC}$) | Year Range |
|---|---|---|---|---|---|---|
| FL | Gainesville Regional Utilities - Solar Feed-In Tariff[b] | 245 | 18.1 | 0.4% | 2.3 - 1,040 | 2009 - 2013 |
| | Gainesville Regional Utilities - Solar-Electric System Rebate Program[b] | 166 | 1.9 | 0.0% | 1.9 - 100 | 2006 - 2013 |
| | Orlando Utilities Commission - Pilot Solar Program[b] | 57 | 2.7 | 0.1% | 1.1 - 1,040 | 2008 - 2012 |
| | Energy & Climate Commision - Solar Rebate Program[b] | 1,170 | 9.7 | 0.2% | 2.0 - 1,016 | 2006 - 2012 |
| IL | Dept. Commerce and Econ. Opp. - Solar and Wind Energy Rebate Program | 788 | 7.6 | 0.2% | 0.8 - 700 | 1999 - 2013 |
| MA | Clean Energy Center - PV incentive programs (various)[c] | 9,474 | 286.4 | 6.1% | 0.2 - 4,730 | 2001 - 2013 |
| | Dept. of Energy Resources - SREC Registration[c] | 203 | 46.7 | 1.0% | 0.7 - 4,800 | 2010 - 2013 |
| MD | Maryland Energy Administration - Solar Energy Grant Program | 3,710 | 29.1 | 0.6% | 0.7 - 200 | 2001 - 2013 |
| ME | Efficiency Maine - Renewable System Rebates Program | 550 | 3.5 | 0.1% | 0.9 - 171 | 2011 - 2013 |
| MN | Xcel Energy - SolarRewards Program[a] | 513 | 4.6 | n/a | n/a | 2010 - 2013 |
| | State Energy Office - Solar Electric Rebate Program | 354 | 1.9 | 0.0% | 0.5 - 40 | 2003 - 2011 |
| MO | Columbia Water & Light - Solar Rebates | 9 | 0.0 | 0.0% | 1.2 - 4.8 | 2007 - 2012 |
| NC | NC Sustainable Energy Association - NCUC dockets[d] | 1,461 | 371.5 | 7.9% | 0.7 - 5,903 | 2007 - 2013 |
| NH | NH Public Utilities Commission - Renewable Energy Rebate Program | 1,036 | 6.0 | 0.1% | 0.4 - 100 | 2002 - 2013 |
| NJ | NJ Board of Public Utilities - Customer Onsite Renewable Energy Program | 4,104 | 86.3 | 1.8% | 0.8 - 2,372 | 2001 - 2012 |
| | NJ Board of Public Utilities - Renewable Energy Incentive Program | 3,644 | 36.2 | 0.8% | 0.7 - 51 | 2009 - 2013 |
| | NJ Board of Public Utilities - SREC Registration Program | 14,751 | 753.5 | 16.1% | 0.4 - 8,135 | 2007 - 2013 |
| NM | Energy, Minerals & Nat. Res. Dept. - Solar Market Development Tax Credit | 3,781 | 19.3 | 0.4% | 0.4 - 249 | 2009 - 2013 |
| NV | NVEnergy - Renewable Generations Rebate Program | 1,605 | 44.5 | 0.9% | 0.4 - 1,145 | 2004 - 2013 |
| NY | NYSERDA - PV incentive programs (various) | 7,925 | 95.3 | 2.0% | 0.5 - 254 | 2003 - 2013 |
| OH | Dept. of Development - PV incentive programs (various) | 226 | 9.2 | 0.2% | 1.0 - 1,121 | 2005 - 2012 |
| OR | Dept. of Energy - Personal and Business Tax Credit Programs[e] | 1,685 | 27.6 | 0.6% | 0.1 - 3,000 | 1999 - 2013 |
| | Energy Trust of Oregon - Solar Electric Buy-Down Program[e] | 4,484 | 34.2 | 0.7% | 0.5 - 2,568 | 2003 - 2013 |
| | PacifiCorp - Solar Volumetric Incentive and Payments Program | 502 | 6.9 | 0.1% | 1.5 - 500 | 2010 - 2013 |
| PA | Dept. Community and Econ. Dev. - Grant programs (various) | 47 | 32.5 | 0.7% | 8.0 - 3,252 | 2010 - 2012 |
| | Dept. Env. Protection - Sunshine Solar PV Program | 6,667 | 93.3 | 2.0% | 1.0 - 922 | 2009 - 2013 |
| | Sust. Dev. Fund - Solar PV Grant Program | 200 | 0.7 | 0.0% | 1.1 - 12 | 2002 - 2008 |
| RI | Commerce RI - Solar and Renewable Energy Grant Programs | 24 | 0.1 | 0.0% | 1.0 - 9.8 | 2013 - 2013 |
| TX | Austin Energy - Power Saver Program | 3,056 | 19.0 | 0.4% | 0.2 - 300 | 1999 - 2013 |
| | Clean Energy Assoc. - IOU PV incentive programs | 1,236 | 13.9 | 0.3% | 0.4 - 300 | 2001 - 2013 |
| UT | PacifiCorp - Solar Incentive Program | 167 | 1.5 | 0.0% | 1.4 - 52 | 2011 - 2013 |

| State | PV Incentive Program Administrator and Program Name | No. of Systems | Total $MW_{DC}$ | % of Total $MW_{DC}$ | Size Range ($kW_{DC}$) | Year Range |
|---|---|---|---|---|---|---|
| VT | Renew. Energy Res. Ctr. - Small Scale Renewable Energy Incentive Program | 2,572 | 18.1 | 0.4% | 0.2 - 389 | 2003 - 2013 |
| WI | Focus on Energy - Renewable Energy Cash-Back Rewards Program | 1,438 | 11.2 | 0.2% | 0.2 - 273 | 2002 - 2013 |
| Non PV Incentive Program Data (other sources) | | 95 | 267.7 | 5.7% | 770 - 10,150 | 2008 - 2013 |
| ***Total[(a)]*** | | ***259,946*** | ***4,688*** | ***100%*** | ***0.1 - 10,150*** | ***1998 - 2013*** |

[(a)] Xcel Energy provided only aggregate program-level data for its PV incentive programs in Colorado and Minnesota. Those data are used only in limited instances within this report (in particular, in state-level comparison figures). The Xcel data is not included in the totals included at the bottom of this table.

[(b)] Florida systems that received incentives through both the Florida Energy & Climate Commission (FECC)'s Solar Rebate Program and one of the Florida utility programs were retained in the data sample for FECC and removed from the data sample for the utility program.

[(c)] Massachusetts systems that received incentives through both the Massachusetts Clean Energy Center (MassCEC) and the Dept. of Energy Resources (DOER) programs were retained in the data sample for the MassCEC and removed from sample for the DOER.

[(d)] Data provided by the North Carolina Sustainable Energy Association is not associated with a PV incentive program, but rather was compiled from regulatory filings submitted to the North Carolina Utilities Commission (NCUC) for a Report of Proposed Construction or for a Certificate of Public Convenience and Necessity.

[(e)] Oregon systems that received incentives through both the Oregon Dept. of Energy's tax incentive program and the Energy Trust of Oregon (ETO) were retained in the data sample for ETO and removed from sample for the Dept. of Energy.

**Table B-2. Residential and Commercial PV System Sample by Installation Year and System Size Range**

| System Size Range | Installation Year | | | | | | | | | | | | | | | | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | |
| **No. Systems** | | | | | | | | | | | | | | | | | |
| ≤10 kW | 28 | 150 | 168 | 1,257 | 2,247 | 3,128 | 5,102 | 5,056 | 7,936 | 11,383 | 11,866 | 21,471 | 30,869 | 35,128 | 42,956 | 42,392 | **221,137** |
| 10-100 kW | 5 | 11 | 11 | 38 | 166 | 316 | 514 | 636 | 893 | 1,228 | 1,424 | 2,509 | 5,003 | 6,027 | 7,263 | 7,102 | **33,146** |
| >100 kW | 0 | 1 | 1 | 7 | 28 | 36 | 41 | 105 | 114 | 153 | 396 | 339 | 583 | 1,205 | 1,534 | 1,120 | **5,663** |
| *Total* | *33* | *162* | *180* | *1,302* | *2,441* | *3,480* | *5,657* | *5,797* | *8,943* | *12,764* | *13,686* | *24,319* | *36,455* | *42,360* | *51,753* | *50,614* | ***259,946*** |
| **Capacity (MW)** | | | | | | | | | | | | | | | | | |
| ≤10 kW | 0.1 | 0.4 | 0.5 | 4.0 | 8 | 12 | 20 | 22 | 35 | 52 | 53 | 102 | 156 | 180 | 226 | 240 | **1,111** |
| 10-100 kW | 0.1 | 0.3 | 0.2 | 0.6 | 3 | 7 | 12 | 15 | 18 | 25 | 34 | 53 | 107 | 142 | 162 | 136 | **716** |
| >100 kW | 0.0 | 0.1 | 0.1 | 1.1 | 7 | 12 | 12 | 27 | 38 | 55 | 151 | 148 | 243 | 659 | 786 | 721 | **2,861** |
| *Total* | *0.2* | *0.8* | *0.8* | *6* | *18* | *31* | *44* | *64* | *92* | *132* | *238* | *303* | *506* | *981* | *1174* | *1098* | ***4,688*** |

**Table B-3. Residential and Commercial PV System Sample and Median Installed Price $(\$/W_{dc})$ by State and System Size**

| State | Size Range | | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| AR | ≤10 kW | No. Systems | - | - | - | - | - | - | - | - | - | - | - | - | 45 | 30 | - | - |
| | | Median Size | - | - | - | - | - | - | - | - | - | - | - | - | 3.5 | 4.3 | - | - |
| | | Median Price | - | - | - | - | - | - | - | - | - | - | - | - | 6.5 | 6.9 | - | - |
| | 10-100 kW | No. Systems | - | - | - | - | - | - | - | - | - | - | - | - | 8 | 14 | - | - |
| | | Median Size | - | - | - | - | - | - | - | - | - | - | - | - | * | * | - | - |
| | | Median Price | - | - | - | - | - | - | - | - | - | - | - | - | * | * | - | - |
| | >100 kW | No. Systems | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| | | Median Size | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| | | Median Price | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| AZ | ≤10 kW | No. Systems | - | - | - | - | 5 | 14 | 40 | 88 | 307 | 342 | 602 | 2495 | 4299 | 4225 | 5295 | 4633 |
| | | Median Size | - | - | - | - | * | * | 2.8 | 2.9 | 3.9 | 4.4 | 4.3 | 5.0 | 5.1 | 5.1 | 5.5 | 5.9 |
| | | Median Price | - | - | - | - | * | * | 8.2 | 8.1 | 8.5 | 7.9 | 7.6 | 7.5 | 6.3 | 5.5 | 4.8 | 4.1 |
| | 10-100 kW | No. Systems | - | - | - | - | - | 2 | 2 | 3 | 14 | 17 | 67 | 267 | 563 | 706 | 1320 | 1111 |
| | | Median Size | - | - | - | - | - | * | * | * | * | 10.5 | 14.8 | 13.2 | 12.9 | 13.3 | 12.7 | 12.5 |
| | | Median Price | - | - | - | - | - | * | * | * | * | 8.3 | 7.4 | 7.3 | 6.4 | 5.2 | 4.8 | 3.8 |
| | >100 kW | No. Systems | - | - | - | - | - | - | - | - | - | 3 | 8 | 11 | 46 | 132 | 139 | 186 |
| | | Median Size | - | - | - | - | - | - | - | - | - | * | * | * | 352.9 | 436.5 | 295.7 | 264.2 |
| | | Median Price | - | - | - | - | - | - | - | - | - | * | * | * | 6.3 | 6.4 | 5.8 | 5.3 |
| CA | ≤10 kW | No. Systems | 28 | 147 | 164 | 1225 | 2159 | 2744 | 4209 | 3630 | 5697 | 8806 | 8327 | 12480 | 15839 | 18749 | 24520 | 25273 |
| | | Median Size | 2.4 | 2.3 | 2.4 | 2.9 | 3.0 | 3.0 | 3.1 | 3.6 | 3.9 | 4.2 | 4.1 | 4.3 | 4.6 | 4.4 | 4.7 | 5.4 |
| | | Median Price | 12.0 | 12.2 | 11.3 | 11.0 | 10.9 | 9.9 | 9.2 | 8.7 | 8.8 | 9.0 | 8.7 | 8.4 | 7.2 | 6.6 | 5.7 | 4.9 |
| | 10-100 kW | No. Systems | 5 | 11 | 11 | 35 | 156 | 286 | 467 | 461 | 705 | 1014 | 922 | 1249 | 1756 | 1650 | 2392 | 3087 |
| | | Median Size | * | * | * | 11.6 | 11.9 | 12.0 | 14.4 | 17.2 | 14.0 | 13.7 | 14.4 | 13.8 | 13.3 | 14.1 | 12.9 | 12.4 |
| | | Median Price | * | * | * | 10.7 | 10.7 | 9.5 | 8.8 | 8.3 | 8.3 | 8.6 | 8.3 | 7.9 | 6.7 | 6.1 | 5.4 | 4.7 |
| | >100 kW | No. Systems | - | 1 | 1 | 7 | 27 | 35 | 40 | 89 | 75 | 120 | 314 | 182 | 176 | 378 | 550 | 404 |
| | | Median Size | - | * | * | * | 191.1 | 230.0 | 239.6 | 178.7 | 230.6 | 246.4 | 272.6 | 359.0 | 377.2 | 395.8 | 252.0 | 242.6 |
| | | Median Price | - | * | * | * | 9.5 | 8.4 | 8.3 | 8.1 | 8.1 | 7.7 | 7.6 | 7.8 | 6.2 | 5.0 | 5.0 | 4.3 |

| State | Size Range | | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO[a] | ≤10 kW | No. Systems | - | - | - | - | - | - | - | - | 323 | 1009 | 1448 | 2196 | 2260 | 1530 | 2431 | 2330 |
| | | Median Size | - | - | - | - | - | - | - | - | 3.4 | 4.0 | 4.3 | 5.0 | 5.4 | 5.5 | 5.5 | 5.8 |
| | | Median Price | - | - | - | - | - | - | - | - | 8.3 | 8.1 | 7.7 | 6.6 | 5.5 | 5.1 | 4.1 | 4.0 |
| | 10-100 kW | No. Systems | - | - | - | - | - | - | - | - | - | 6 | 23 | 55 | 148 | 197 | 81 | 205 |
| | | Median Size | - | - | - | - | - | - | - | - | - | * | 47.4 | 39.1 | 22.6 | 38.9 | 34.6 | 12.5 |
| | | Median Price | - | - | - | - | - | - | - | - | - | * | 7.3 | 5.7 | 5.1 | 4.6 | 3.7 | 3.7 |
| | >100 kW | No. Systems | - | - | - | - | - | - | - | - | - | - | 9 | 11 | 64 | 90 | 19 | 37 |
| | | Median Size | - | - | - | - | - | - | - | - | - | - | * | * | 101.7 | 101.6 | 209.3 | 181.0 |
| | | Median Price | - | - | - | - | - | - | - | - | - | - | - | * | 4.6 | 4.2 | 3.2 | 2.7 |
| CT | ≤10 kW | No. Systems | - | - | - | - | - | - | 1 | 32 | 89 | 164 | 252 | 401 | 389 | 322 | 242 | 626 |
| | | Median Size | - | - | - | - | - | - | * | 4.5 | 4.8 | 5.2 | 5.5 | 6.3 | 6.3 | 6.7 | 5.8 | 6.5 |
| | | Median Price | - | - | - | - | - | - | * | 9.5 | 9.8 | 9.9 | 9.2 | 8.7 | 7.8 | 6.5 | 5.1 | 4.0 |
| | 10-100 kW | No. Systems | - | - | - | - | - | - | 1 | 1 | 6 | 14 | 52 | 98 | 100 | 77 | 57 | 110 |
| | | Median Size | - | - | - | - | - | - | * | * | * | * | 11.1 | 10.9 | 10.8 | 10.8 | 10.8 | 11.0 |
| | | Median Price | - | - | - | - | - | - | * | * | * | * | 8.9 | 8.5 | 7.4 | 6.2 | 5.3 | 4.0 |
| | >100 kW | No. Systems | - | - | - | - | - | - | - | - | 1 | 4 | 21 | 22 | 7 | 9 | 2 | - |
| | | Median Size | - | - | - | - | - | - | - | - | * | * | 264.2 | 225.1 | * | * | * | - |
| | | Median Price | - | - | - | - | - | - | - | - | * | * | 8.2 | 8.0 | * | * | * | - |
| DC | ≤10 kW | No. Systems | - | - | - | - | - | - | - | - | - | - | - | 87 | 204 | 92 | 241 | 104 |
| | | Median Size | - | - | - | - | - | - | - | - | - | - | - | 3.0 | 4.1 | 4.3 | 4.2 | 3.4 |
| | | Median Price | - | - | - | - | - | - | - | - | - | - | - | 9.6 | 7.1 | 6.5 | 4.8 | 3.7 |
| | 10-100 kW | No. Systems | - | - | - | - | - | - | - | - | - | - | - | 3 | 5 | 8 | 13 | 6 |
| | | Median Size | - | - | - | - | - | - | - | - | - | - | - | * | * | * | * | * |
| | | Median Price | - | - | - | - | - | - | - | - | - | - | - | * | * | * | * | * |
| | >100 kW | No. Systems | - | - | - | - | - | - | - | - | - | - | - | - | - | 1 | - | - |
| | | Median Size | - | - | - | - | - | - | - | - | - | - | - | - | - | * | - | - |
| | | Median Price | - | - | - | - | - | - | - | - | - | - | - | - | - | * | - | - |

| State | Size Range | | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| DE | ≤10 kW | No. Systems | - | - | - | - | 1 | 3 | 3 | 2 | 27 | 49 | 125 | 171 | 162 | 224 | 116 | 20 |
| | | Median Size | - | - | - | - | * | * | * | * | 4.8 | 4.8 | 5.0 | 5.2 | 5.2 | 5.2 | 5.2 | 5.8 |
| | | Median Price | - | - | - | - | * | * | * | * | 8.0 | 8.0 | 7.8 | 7.8 | 6.9 | 5.6 | 5.6 | 4.2 |
| | 10-100 kW | No. Systems | - | - | - | - | 1 | 1 | 1 | - | 2 | 1 | 8 | 9 | 8 | 46 | 16 | 8 |
| | | Median Size | - | - | - | - | * | * | * | - | * | * | * | * | * | 13.0 | 17.4 | * |
| | | Median Price | - | - | - | - | * | * | * | - | * | * | * | * | * | 5.0 | 4.7 | * |
| | >100 kW | No. Systems | - | - | - | - | - | - | - | - | - | - | - | - | - | 1 | - | - |
| | | Median Size | - | - | - | - | - | - | - | - | - | - | - | - | - | * | - | - |
| | | Median Price | - | - | - | - | - | - | - | - | - | - | - | - | - | * | - | - |
| FL | ≤10 kW | No. Systems | - | - | - | - | - | - | - | - | 17 | 41 | 27 | 594 | 504 | 64 | 37 | 19 |
| | | Median Size | - | - | - | - | - | - | - | - | 3.4 | 4.8 | 5.0 | 5.0 | 5.1 | 6.8 | 5.0 | 7.0 |
| | | Median Price | - | - | - | - | - | - | - | - | 11.0 | 10.6 | 8.9 | 8.0 | 7.6 | 6.1 | 4.6 | 3.3 |
| | 10-100 kW | No. Systems | - | - | - | - | - | - | - | - | - | 6 | 13 | 68 | 107 | 37 | 35 | 24 |
| | | Median Size | - | - | - | - | - | - | - | - | - | * | * | 25.0 | 25.1 | 27.7 | 25.8 | 27.6 |
| | | Median Price | - | - | - | - | - | - | - | - | - | * | * | 7.3 | 7.2 | 5.2 | 5.0 | 3.0 |
| | >100 kW | No. Systems | - | - | - | - | - | - | - | - | - | - | - | 2 | 8 | 12 | 13 | 11 |
| | | Median Size | - | - | - | - | - | - | - | - | - | - | - | * | * | * | * | * |
| | | Median Price | - | - | - | - | - | - | - | - | - | - | - | * | * | * | * | * |
| GA | ≤10 kW | No. Systems | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| | | Median Size | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| | | Median Price | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| | 10-100 kW | No. Systems | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| | | Median Size | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| | | Median Price | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| | >100 kW | No. Systems | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 1 |
| | | Median Size | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | * |
| | | Median Price | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | * |

| State | Size Range | | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| HI | ≤10 kW | No. Systems | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| | | Median Size | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| | | Median Price | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| | 10-100 kW | No. Systems | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| | | Median Size | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| | | Median Price | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| | >100 kW | No. Systems | - | - | - | - | - | - | - | - | - | - | - | - | - | 2 | - | - |
| | | Median Size | - | - | - | - | - | - | - | - | - | - | - | - | - | * | - | - |
| | | Median Price | - | - | - | - | - | - | - | - | - | - | - | - | - | * | - | - |
| IL | ≤10 kW | No. Systems | - | 1 | 2 | 6 | 3 | 5 | 2 | 5 | 42 | 61 | 72 | 64 | 102 | 53 | 105 | 146 |
| | | Median Size | - | * | * | * | * | * | * | * | 1.9 | 2.0 | 2.8 | 3.2 | 3.4 | 4.3 | 4.8 | 5.0 |
| | | Median Price | - | * | * | * | * | * | * | * | 10.7 | 10.4 | 9.7 | 9.3 | 8.5 | 6.7 | 5.9 | 5.0 |
| | 10-100 kW | No. Systems | - | - | - | 1 | 2 | 11 | 4 | 2 | - | 3 | - | 1 | 23 | 5 | 28 | 34 |
| | | Median Size | - | - | - | * | * | * | * | * | - | * | - | * | 14.0 | * | 19.9 | 16.1 |
| | | Median Price | - | - | - | * | * | * | * | * | - | * | - | * | 8.5 | * | 5.7 | 3.8 |
| | >100 kW | No. Systems | - | - | - | - | - | - | - | - | - | - | - | - | 1 | - | 2 | 2 |
| | | Median Size | - | - | - | - | - | - | - | - | - | - | - | - | * | - | * | * |
| | | Median Price | - | - | - | - | - | - | - | - | - | - | - | - | * | - | * | * |
| KY | ≤10 kW | No. Systems | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| | | Median Size | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| | | Median Price | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| | 10-100 kW | No. Systems | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| | | Median Size | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| | | Median Price | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| | >100 kW | No. Systems | - | - | - | - | - | - | - | - | - | - | - | - | - | 1 | - | - |
| | | Median Size | - | - | - | - | - | - | - | - | - | - | - | - | - | * | - | - |
| | | Median Price | - | - | - | - | - | - | - | - | - | - | - | - | - | * | - | - |

| State | Size Range | | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| MA | ≤10 kW | No. Systems | - | - | - | 1 | - | 65 | 118 | 75 | 243 | 202 | 336 | 705 | 559 | 1017 | 2044 | 2697 |
| | | Median Size | - | - | - | * | - | 2.2 | 2.6 | 2.7 | 2.8 | 3.0 | 3.6 | 4.2 | 5.0 | 5.2 | 5.8 | 5.8 |
| | | Median Price | - | - | - | * | - | 10.9 | 9.3 | 9.7 | 10.0 | 9.6 | 9.1 | 8.8 | 7.3 | 6.2 | 5.0 | 4.5 |
| | 10-100 kW | No. Systems | - | - | - | - | 1 | 5 | 9 | 18 | 13 | 13 | 39 | 89 | 167 | 191 | 281 | 375 |
| | | Median Size | - | - | - | - | * | * | * | 27.1 | * | * | 17.8 | 30.2 | 30.0 | 32.3 | 16.9 | 13.8 |
| | | Median Price | - | - | - | - | * | * | * | 10.2 | * | * | 9.3 | 8.7 | 6.7 | 6.0 | 4.9 | 4.1 |
| | >100 kW | No. Systems | - | - | - | - | - | - | - | - | 3 | 2 | 8 | 18 | 57 | 79 | 134 | 117 |
| | | Median Size | - | - | - | - | - | - | - | - | * | * | * | 152.1 | 128.8 | 198.0 | 264.1 | 799.5 |
| | | Median Price | - | - | - | - | - | - | - | - | * | * | * | 7.8 | 5.8 | 5.1 | 4.0 | 3.4 |
| MD | ≤10 kW | No. Systems | - | - | - | 1 | - | - | - | 19 | 40 | 46 | 168 | 710 | 661 | 758 | 720 | 56 |
| | | Median Size | - | - | - | * | - | - | - | 2.3 | 2.2 | 2.4 | 3.2 | 4.1 | 4.9 | 5.2 | 5.2 | 6.2 |
| | | Median Price | - | - | - | * | - | - | - | 12.6 | 11.4 | 10.9 | 9.7 | 9.1 | 6.9 | 6.3 | 5.2 | 4.7 |
| | 10-100 kW | No. Systems | - | - | - | - | - | - | - | - | 1 | 1 | 6 | 28 | 91 | 157 | 209 | 14 |
| | | Median Size | - | - | - | - | - | - | - | - | * | * | * | 11.4 | 12.0 | 13.1 | 14.0 | * |
| | | Median Price | - | - | - | - | - | - | - | - | * | * | * | 7.7 | 6.0 | 5.4 | 4.3 | * |
| | >100 kW | No. Systems | - | - | - | - | - | - | - | - | - | - | - | - | 2 | 8 | 13 | 3 |
| | | Median Size | - | - | - | - | - | - | - | - | - | - | - | - | * | * | * | * |
| | | Median Price | - | - | - | - | - | - | - | - | - | - | - | - | * | * | * | * |
| ME | ≤10 kW | No. Systems | - | - | - | - | - | - | - | - | - | - | - | - | - | 3 | 244 | 258 |
| | | Median Size | - | - | - | - | - | - | - | - | - | - | - | - | - | * | 4.3 | 4.6 |
| | | Median Price | - | - | - | - | - | - | - | - | - | - | - | - | - | * | 4.0 | 3.5 |
| | 10-100 kW | No. Systems | - | - | - | - | - | - | - | - | - | - | - | - | - | 1 | 17 | 25 |
| | | Median Size | - | - | - | - | - | - | - | - | - | - | - | - | - | * | 11.8 | 12.2 |
| | | Median Price | - | - | - | - | - | - | - | - | - | - | - | - | - | * | 3.9 | 3.3 |
| | >100 kW | No. Systems | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 2 | - |
| | | Median Size | - | - | - | - | - | - | - | - | - | - | - | - | - | - | * | - |
| | | Median Price | - | - | - | - | - | - | - | - | - | - | - | - | - | - | * | - |

| State | Size Range | | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| MN[b] | ≤10 kW | No. Systems | - | - | - | - | - | 8 | 12 | 10 | 18 | 29 | 15 | 58 | 135 | 95 | 112 | 60 |
| | | Median Size | - | - | - | - | - | * | * | * | 2.7 | 2.6 | 3.2 | 3.8 | 4.1 | 4.0 | 4.7 | 4.2 |
| | | Median Price | - | - | - | - | - | * | * | * | 9.4 | 10.1 | 10.1 | 9.4 | 7.3 | 6.6 | 5.7 | 5.2 |
| | 10-100 kW | No. Systems | - | - | - | - | - | - | - | - | - | 2 | 3 | 1 | 18 | 20 | 39 | 34 |
| | | Median Size | - | - | - | - | - | - | - | - | - | * | * | * | 11.3 | 12.4 | 34.7 | 39.4 |
| | | Median Price | - | - | - | - | - | - | - | - | - | * | * | * | 6.2 | 4.9 | 4.8 | 5.1 |
| | >100 kW | No. Systems | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| | | Median Size | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| | | Median Price | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| MO | ≤10 kW | No. Systems | - | - | - | - | - | - | - | - | - | 1 | 1 | 1 | - | 2 | 4 | - |
| | | Median Size | - | - | - | - | - | - | - | - | - | * | * | * | - | * | * | - |
| | | Median Price | - | - | - | - | - | - | - | - | - | * | * | * | - | * | * | - |
| | 10-100 kW | No. Systems | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| | | Median Size | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| | | Median Price | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| | >100 kW | No. Systems | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| | | Median Size | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| | | Median Price | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| NC | ≤10 kW | No. Systems | - | - | - | - | - | - | - | - | - | 1 | - | - | 1 | 333 | 313 | 480 |
| | | Median Size | - | - | - | - | - | - | - | - | - | * | - | - | * | 4.4 | 4.8 | 4.8 |
| | | Median Price | - | - | - | - | - | - | - | - | - | * | - | - | * | 6.7 | 5.8 | 5.3 |
| | 10-100 kW | No. Systems | - | - | - | - | - | - | - | - | - | - | - | - | - | 67 | 27 | 39 |
| | | Median Size | - | - | - | - | - | - | - | - | - | - | - | - | - | 20.2 | 22.1 | 17.3 |
| | | Median Price | - | - | - | - | - | - | - | - | - | - | - | - | - | 5.4 | 5.0 | 4.0 |
| | >100 kW | No. Systems | - | - | - | - | - | - | - | - | - | - | - | - | - | 37 | 85 | 79 |
| | | Median Size | - | - | - | - | - | - | - | - | - | - | - | - | - | 625.0 | 1181.8 | 2354.2 |
| | | Median Price | - | - | - | - | - | - | - | - | - | - | - | - | - | 4.4 | 3.6 | 2.5 |

| State | Size Range | | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| NH | ≤10 kW | No. Systems | - | - | - | - | 1 | - | - | - | - | - | 34 | 167 | 238 | 89 | 196 | 241 |
| | | Median Size | - | - | - | - | * | - | - | - | - | - | 2.2 | 2.7 | 3.2 | 4.2 | 4.7 | 4.9 |
| | | Median Price | - | - | - | - | * | - | - | - | - | - | 9.6 | 8.3 | 6.4 | 5.7 | 4.6 | 3.8 |
| | 10-100 kW | No. Systems | - | - | - | - | - | - | - | - | - | - | - | - | 1 | 13 | 20 | 36 |
| | | Median Size | - | - | - | - | - | - | - | - | - | - | - | - | * | * | 21.3 | 27.6 |
| | | Median Price | - | - | - | - | - | - | - | - | - | - | - | - | * | * | 4.6 | 3.3 |
| | >100 kW | No. Systems | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| | | Median Size | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| | | Median Price | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| NJ | ≤10 kW | No. Systems | - | - | - | 3 | 29 | 85 | 254 | 578 | 689 | 567 | 601 | 931 | 2117 | 3555 | 3335 | 3156 |
| | | Median Size | - | - | - | * | 2.7 | 4.6 | 5.5 | 6.8 | 6.8 | 7.4 | 7.2 | 7.4 | 7.2 | 6.9 | 6.8 | 6.9 |
| | | Median Price | - | - | - | * | 11.1 | 10.1 | 9.8 | 9.4 | 9.3 | 9.2 | 8.8 | 8.6 | 7.4 | 6.1 | 4.6 | 4.0 |
| | 10-100 kW | No. Systems | - | - | - | - | 6 | 5 | 17 | 116 | 110 | 80 | 148 | 247 | 672 | 1168 | 1333 | 1230 |
| | | Median Size | - | - | - | - | * | * | 12.6 | 11.8 | 12.1 | 18.0 | 16.1 | 15.2 | 18.1 | 15.2 | 14.7 | 13.0 |
| | | Median Price | - | - | - | - | * | * | 10.0 | 9.3 | 9.2 | 9.1 | 8.6 | 8.5 | 6.9 | 5.7 | 4.8 | 3.9 |
| | >100 kW | No. Systems | - | - | - | - | 1 | 1 | 1 | 16 | 35 | 24 | 38 | 82 | 154 | 353 | 509 | 261 |
| | | Median Size | - | - | - | - | * | * | * | 215.2 | 255.4 | 290.5 | 270.6 | 227.7 | 250.5 | 273.9 | 257.1 | 254.8 |
| | | Median Price | - | - | - | - | * | * | * | 8.1 | 7.8 | 7.6 | 8.1 | 7.7 | 5.3 | 4.9 | 4.5 | 3.5 |
| NM | ≤10 kW | No. Systems | - | - | - | - | - | - | - | - | - | - | - | 226 | 705 | 771 | 1023 | 833 |
| | | Median Size | - | - | - | - | - | - | - | - | - | - | - | 3.4 | 3.6 | 3.8 | 4.3 | 4.9 |
| | | Median Price | - | - | - | - | - | - | - | - | - | - | - | 8.5 | 7.4 | 6.4 | 5.3 | 4.5 |
| | 10-100 kW | No. Systems | - | - | - | - | - | - | - | - | - | - | - | 9 | 27 | 37 | 73 | 75 |
| | | Median Size | - | - | - | - | - | - | - | - | - | - | - | * | 11.0 | 11.4 | 12.0 | 11.7 |
| | | Median Price | - | - | - | - | - | - | - | - | - | - | - | * | 6.4 | 5.9 | 4.7 | 4.0 |
| | >100 kW | No. Systems | - | - | - | - | - | - | - | - | - | - | - | 1 | 1 | 2 | 2 | 1 |
| | | Median Size | - | - | - | - | - | - | - | - | - | - | - | * | * | * | * | * |
| | | Median Price | - | - | - | - | - | - | - | - | - | - | - | * | * | * | * | * |

| State | Size Range | | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| NV | ≤10 kW | No. Systems | - | - | - | - | - | - | 3 | 55 | 69 | 90 | 77 | 166 | 211 | 134 | 53 | 141 |
| | | Median Size | - | - | - | - | - | - | * | 4.6 | 5.8 | 5.9 | 5.6 | 5.7 | 5.6 | 6.0 | 5.5 | 5.9 |
| | | Median Price | - | - | - | - | - | - | * | 8.3 | 8.5 | 8.5 | 8.5 | 8.0 | 6.7 | 5.7 | 5.0 | 4.2 |
| | 10-100 kW | No. Systems | - | - | - | - | - | - | - | 4 | 4 | 5 | 7 | 17 | 109 | 200 | 75 | 83 |
| | | Median Size | - | - | - | - | - | - | - | * | * | * | * | 34.9 | 34.1 | 37.0 | 38.0 | 18.0 |
| | | Median Price | - | - | - | - | - | - | - | * | * | * | * | 6.0 | 6.0 | 5.2 | 4.5 | 3.6 |
| | >100 kW | No. Systems | - | - | - | - | - | - | - | - | - | - | - | 1 | 5 | 67 | 17 | 12 |
| | | Median Size | - | - | - | - | - | - | - | - | - | - | - | * | * | 118.7 | 150.9 | * |
| | | Median Price | - | - | - | - | - | - | - | - | - | - | - | * | * | 5.1 | 4.2 | * |
| NY | ≤10 kW | No. Systems | - | - | - | - | - | 38 | 112 | 103 | 182 | 333 | 374 | 655 | 716 | 709 | 1233 | 1455 |
| | | Median Size | - | - | - | - | - | 3.0 | 2.8 | 3.1 | 4.2 | 4.6 | 4.7 | 5.1 | 5.0 | 5.2 | 6.4 | 6.8 |
| | | Median Price | - | - | - | - | - | 10.5 | 10.4 | 10.0 | 9.9 | 9.9 | 9.3 | 9.3 | 7.7 | 6.5 | 5.4 | 4.6 |
| | 10-100 kW | No. Systems | - | - | - | - | - | 6 | 9 | 15 | 22 | 28 | 48 | 125 | 254 | 321 | 633 | 519 |
| | | Median Size | - | - | - | - | - | * | * | 14.9 | 13.4 | 12.2 | 19.4 | 20.3 | 25.4 | 25.4 | 24.4 | 20.6 |
| | | Median Price | - | - | - | - | - | * | * | 8.9 | 9.2 | 9.5 | 9.2 | 8.9 | 7.7 | 6.9 | 5.3 | 4.9 |
| | >100 kW | No. Systems | - | - | - | - | - | - | - | - | - | - | - | - | 1 | 2 | 10 | 29 |
| | | Median Size | - | - | - | - | - | - | - | - | - | - | - | - | * | * | * | 166.4 |
| | | Median Price | - | - | - | - | - | - | - | - | - | - | - | - | * | * | * | 3.8 |
| OH | ≤10 kW | No. Systems | - | - | - | - | - | - | - | 20 | 19 | 30 | 26 | 3 | 6 | 3 | - | - |
| | | Median Size | - | - | - | - | - | - | - | 3.1 | 2.6 | 3.3 | 3.1 | * | * | * | - | - |
| | | Median Price | - | - | - | - | - | - | - | 11.2 | 13.0 | 10.4 | 9.4 | * | * | * | - | - |
| | 10-100 kW | No. Systems | - | - | - | - | - | - | - | 1 | 2 | 2 | 7 | 22 | 46 | 21 | 1 | - |
| | | Median Size | - | - | - | - | - | - | - | * | * | * | * | 17.5 | 44.8 | 50.0 | * | - |
| | | Median Price | - | - | - | - | - | - | - | * | * | * | * | 8.5 | 7.2 | 6.6 | * | - |
| | >100 kW | No. Systems | - | - | - | - | - | - | - | - | - | - | - | 1 | 11 | 5 | 2 | 2 |
| | | Median Size | - | - | - | - | - | - | - | - | - | - | - | * | * | * | * | * |
| | | Median Price | - | - | - | - | - | - | - | - | - | - | - | * | * | * | * | * |

| State | Size Range | | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| OR | ≤10 kW | No. Systems | - | 1 | 2 | 18 | 28 | 109 | 167 | 139 | 183 | 279 | 327 | 555 | 1313 | 1237 | 1237 | 349 |
| | | Median Size | - | * | * | 1.3 | 0.5 | 2.6 | 2.9 | 2.9 | 2.6 | 2.5 | 2.9 | 2.8 | 2.6 | 3.2 | 3.3 | 4.2 |
| | | Median Price | - | * | * | 11.3 | 12.2 | 8.4 | 8.2 | 8.4 | 9.2 | 9.7 | 9.1 | 8.5 | 6.8 | 6.1 | 5.3 | 4.7 |
| | 10-100 kW | No. Systems | - | - | - | - | - | - | 1 | 3 | 6 | 17 | 59 | 110 | 117 | 139 | 181 | 16 |
| | | Median Size | - | - | - | - | - | - | * | * | * | 23.8 | 21.6 | 27.7 | 21.8 | 19.6 | 29.6 | 22.6 |
| | | Median Price | - | - | - | - | - | - | * | * | * | 9.3 | 8.8 | 8.3 | 7.2 | 6.1 | 5.8 | 4.0 |
| | >100 kW | No. Systems | - | - | - | - | - | - | - | - | - | - | 7 | 17 | 27 | 10 | 16 | 1 |
| | | Median Size | - | - | - | - | - | - | - | - | - | - | * | 143.6 | 135.5 | * | 310.7 | * |
| | | Median Price | - | - | - | - | - | - | - | - | - | - | * | 7.9 | 7.8 | * | 4.9 | * |
| PA | ≤10 kW | No. Systems | - | - | - | - | 7 | 33 | 26 | 96 | 12 | 10 | 13 | 307 | 1943 | 1624 | 510 | 91 |
| | | Median Size | - | - | - | - | * | 4.1 | 4.7 | 2.7 | * | * | * | 5.3 | 5.8 | 6.1 | 6.5 | 6.7 |
| | | Median Price | - | - | - | - | * | 10.7 | 11.2 | 10.0 | * | * | * | 8.2 | 7.2 | 6.2 | 5.0 | 4.4 |
| | 10-100 kW | No. Systems | - | - | - | - | - | - | - | 1 | 1 | 1 | - | 66 | 716 | 880 | 330 | 59 |
| | | Median Size | - | - | - | - | - | - | - | * | * | * | - | 10.8 | 10.6 | 11.5 | 12.9 | 13.3 |
| | | Median Price | - | - | - | - | - | - | - | * | * | * | - | 8.1 | 6.6 | 5.6 | 4.6 | 4.2 |
| | >100 kW | No. Systems | - | - | - | - | - | - | - | - | - | - | - | 1 | 73 | 93 | 26 | - |
| | | Median Size | - | - | - | - | - | - | - | - | - | - | - | * | 191.4 | 203.3 | 208.9 | - |
| | | Median Price | - | - | - | - | - | - | - | - | - | - | - | * | 5.9 | 4.7 | 3.8 | - |
| RI | ≤10 kW | No. Systems | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 24 |
| | | Median Size | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 4.5 |
| | | Median Price | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 4.5 |
| | 10-100 kW | No. Systems | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| | | Median Size | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| | | Median Price | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| | >100 kW | No. Systems | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 1 |
| | | Median Size | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | * |
| | | Median Price | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | * |

| State | Size Range | | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| SC | ≤10 kW | No. Systems | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| | | Median Size | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| | | Median Price | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| | 10-100 kW | No. Systems | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| | | Median Size | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| | | Median Price | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| | >100 kW | No. Systems | - | - | - | - | - | - | - | - | - | - | - | - | - | 1 | - | - |
| | | Median Size | - | - | - | - | - | - | - | - | - | - | - | - | - | * | - | - |
| | | Median Price | - | - | - | - | - | - | - | - | - | - | - | - | - | * | - | - |
| TN | ≤10 kW | No. Systems | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| | | Median Size | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| | | Median Price | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| | 10-100 kW | No. Systems | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| | | Median Size | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| | | Median Price | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| | >100 kW | No. Systems | - | - | - | - | - | - | - | - | - | - | - | - | 2 | - | - | - |
| | | Median Size | - | - | - | - | - | - | - | - | - | - | - | - | * | - | - | - |
| | | Median Price | - | - | - | - | - | - | - | - | - | - | - | - | * | - | - | - |
| TX | ≤10 kW | No. Systems | - | 1 | - | 3 | - | 1 | 50 | 136 | 161 | 170 | 247 | 312 | 455 | 583 | 828 | 796 |
| | | Median Size | - | * | - | * | - | * | 3.0 | 3.0 | 3.2 | 3.2 | 3.2 | 3.5 | 4.5 | 5.4 | 5.8 | 6.0 |
| | | Median Price | - | * | - | * | - | * | 7.9 | 7.6 | 7.8 | 7.7 | 7.9 | 7.2 | 6.2 | 4.9 | 3.9 | 3.5 |
| | 10-100 kW | No. Systems | - | - | - | 2 | - | - | 2 | 10 | 4 | 9 | 21 | 50 | 115 | 121 | 94 | 93 |
| | | Median Size | - | - | - | * | - | - | * | * | * | * | 23.1 | 13.6 | 10.8 | 10.8 | 11.8 | 12.0 |
| | | Median Price | - | - | - | * | - | - | * | * | * | * | 7.9 | 6.4 | 5.9 | 6.5 | 4.6 | 3.4 |
| | >100 kW | No. Systems | - | - | - | - | - | - | - | - | - | - | - | 1 | 9 | 9 | 3 | 6 |
| | | Median Size | - | - | - | - | - | - | - | - | - | - | - | * | * | * | * | * |
| | | Median Price | - | - | - | - | - | - | - | - | - | - | - | * | * | * | * | * |

| State | Size Range | | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| UT | ≤10 kW | No. Systems | - | - | - | - | - | - | - | - | - | - | - | - | - | 23 | 32 | 68 |
| | | Median Size | - | - | - | - | - | - | - | - | - | - | - | - | - | 2.9 | 3.0 | 4.5 |
| | | Median Price | - | - | - | - | - | - | - | - | - | - | - | - | - | 6.1 | 5.2 | 3.8 |
| | 10-100 kW | No. Systems | - | - | - | - | - | - | - | - | - | - | - | - | - | 3 | 6 | 35 |
| | | Median Size | - | - | - | - | - | - | - | - | - | - | - | - | - | * | * | 23.3 |
| | | Median Price | - | - | - | - | - | - | - | - | - | - | - | - | - | * | * | 3.6 |
| | >100 kW | No. Systems | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| | | Median Size | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| | | Median Price | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| VT | ≤10 kW | No. Systems | - | - | - | - | - | 1 | 70 | 33 | 62 | 70 | 102 | 158 | 190 | 387 | 468 | 756 |
| | | Median Size | - | - | - | - | - | * | 1.8 | 1.8 | 2.1 | 2.4 | 2.9 | 3.3 | 4.0 | 4.2 | 5.0 | 5.3 |
| | | Median Price | - | - | - | - | - | * | 10.6 | 11.7 | 11.1 | 10.2 | 9.7 | 8.6 | 6.9 | 6.1 | 5.0 | 4.7 |
| | 10-100 kW | No. Systems | - | - | - | - | - | - | - | 1 | - | 4 | 3 | 6 | 18 | 57 | 78 | 98 |
| | | Median Size | - | - | - | - | - | - | - | * | - | * | * | * | 21.6 | 15.5 | 16.1 | 12.5 |
| | | Median Price | - | - | - | - | - | - | - | * | - | * | * | * | 5.5 | 6.1 | 4.8 | 4.2 |
| | >100 kW | No. Systems | - | - | - | - | - | - | - | - | - | - | - | - | - | 2 | 9 | 3 |
| | | Median Size | - | - | - | - | - | - | - | - | - | - | - | - | - | * | * | * |
| | | Median Price | - | - | - | - | - | - | - | - | - | - | - | - | - | * | * | * |
| WI | ≤10 kW | No. Systems | - | - | - | - | 14 | 22 | 35 | 35 | 79 | 92 | 140 | 225 | 51 | 131 | 147 | 144 |
| | | Median Size | - | - | - | - | * | 1.1 | 1.8 | 2.5 | 2.7 | 2.8 | 3.1 | 4.1 | 5.1 | 5.5 | 3.7 | 3.6 |
| | | Median Price | - | - | - | - | * | 11.5 | 10.6 | 9.8 | 9.1 | 10.0 | 9.6 | 9.5 | 8.9 | 6.5 | 5.5 | 4.8 |
| | 10-100 kW | No. Systems | - | - | - | - | - | - | 1 | - | 3 | 11 | 21 | 44 | 73 | 105 | 40 | 24 |
| | | Median Size | - | - | - | - | - | - | * | - | * | * | 15.4 | 14.6 | 19.3 | 20.0 | 19.0 | 13.9 |
| | | Median Price | - | - | - | - | - | - | * | - | * | * | 9.6 | 8.5 | 7.7 | 6.7 | 5.5 | 3.7 |
| | >100 kW | No. Systems | - | - | - | - | - | - | - | - | - | - | - | - | 1 | - | - | - |
| | | Median Size | - | - | - | - | - | - | - | - | - | - | - | - | * | - | - | - |
| | | Median Price | - | - | - | - | - | - | - | - | - | - | - | - | * | - | - | - |

(a) The summary statistics for CO are based on aggregate program-level statistics provided by Xcel Energy, rather than on project-level data; those data are also included in Figure 16 through Figure 18, but are not otherwise included within this document.

(b) The summary statistics for MN are derived from two different sources. Through 2010, the statistics are based on project-level data from MN SEO's PV incentive program, at which point the program largely ceased funding new systems. From 2011 onward, the statistics are instead based on aggregate program-level statistics provided by Xcel Energy; those data are also included in Figure 16 through Figure 18, but are not otherwise included within this document.

* Median system size and median price are omitted if fewer than 15 data points available.

## Key Report Contacts

Galen Barbose, Berkeley Lab
510-495-2593; glbarbose@lbl.gov

Samantha Weaver, Berkeley Lab
510-486-6375; slweaver@lbl.gov

Naïm Darghouth, Berkeley Lab
510-486-4570; ndarghouth@lbl.gov

## Download the Report

http://emp.lbl.gov/publications

## Disclaimer



## Acknowledgments

For their support of this project, the authors thank Minh Le, Elaine Ulrich, and Christina Nichols of the U.S. Department of Energy's Solar Energy Technologies Office.

For providing data and/or reviewing elements of this paper, the authors thank: Ben Airth (California Center for Sustainable Energy), Erik Anderson (PacifiCorp), Justin Baca (Solar Energy Industries Association), David Bane (Sulphur Springs Valley Electric Cooperative), Jim Barnett (Sacramento Municipal Utility District), Shauna Beland (Rhode Island Commerce Corporation), Mark Bolinger (Lawrence Berkeley National Laboratory), Richard Brewer (SunPower), Ted Burhans (Tucson Electric Power), Javier Camarillo (Imperial Irrigation District), Jerry Carey (North Carolina Sustainable Energy Association), Lucy Charpentier (Connecticut Clean Energy Fund), Carolyn Davidson (National Renewable Energy Laboratory), Walt Dinda (Pennsylvania Dept. of Environmental Protection), Suzanne Elowson (Vermont Renewable Energy Resource Center), Thomas Elzinga (Consumers Power, Inc.), David Feldman (National Renewable Energy Laboratory), Dana Fischer (Efficiency Maine Trust), Pauline Furfaro (Orlando Public Utilities), Douglas Gagne (National Renewable Energy Laboratory), Charlie Garrison (Honeywell), Wayne Hartel (Illinois Dept. Commerce and Economic Opportunity), Tim Harvey (Austin Energy), Brooke Holman (Columbia Water & Light), Jeff Johnson (Gainesville Regional Utilities), Michael Judge (Massachusetts Dept. of Energy Resources), Kate Kennedy (Salt River Project), James Loewen (California Public Utilities Commission), Jason Martin (NV Energy), Deborah Mathis (Colorado Springs Utilities), David McClelland (Energy Trust of Oregon), Tanya Mitchell (Trico Electric Cooperative), Le-Quyen Nguyen (California Energy Commission), Jon Osgood (New Hampshire Public Utilities Commission), Susannah Pedigo (Xcel Energy), Jason Perkins (California Public Utilities Commission), Kenneth Pritchett (Los Angeles Dept. of Water and Power), James Quirk (New York State Energy Research and Development Authority), Eric Ramras (Massachusetts Clean Energy Center), Tigh Savercool (Pennsylvania Dept. of Community and Economic Development), Kelli Schauffele (Arizona Public Service), Scott Schlossman (Gainesville Regional Utilities), Suzanne Sebastian (Delaware Division of Energy & Climate), Larry Sherwood (Interstate Renewable Energy Council), Rex Stepp (Arizona Public Service), Jennifer Szaro (Orlando Utilities Commission), Edward Trujillo (New Mexico Energy, Minerals and Natural Resources Department), Cliff Voliva (Oregon Department of Energy), Jaclyn Webb (Xcel Energy), Steve Weise (Clean Energy Associates), Laura Williams (California Center for Sustainable Energy), Caitlin Williamson (Wisconsin Focus on Energy), Ryan Wiser (Lawrence Berkeley National Laboratory), Daniel White (Washington D.C. Dept. of the Environment), and John Wold (Xcel Energy). We also thank Anthony Ma for assistance with cover design, formatting, and production. Of course, the authors are solely responsible for any remaining omissions or errors.

Berkeley Lab's contributions to this report were funded by the Office of Energy Efficiency and Renewable Energy (Solar Energy Technologies Office) of the U.S. Department of Energy under Contract No. DE-AC02-05CH11231.

BERKELEY LAB

Lawrence Berkeley
National Laboratory

September 2014