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Tracking the Sun VI: An Historical Summary of the Installed Price of Photovoltaics in the United States from 1998 to 2012

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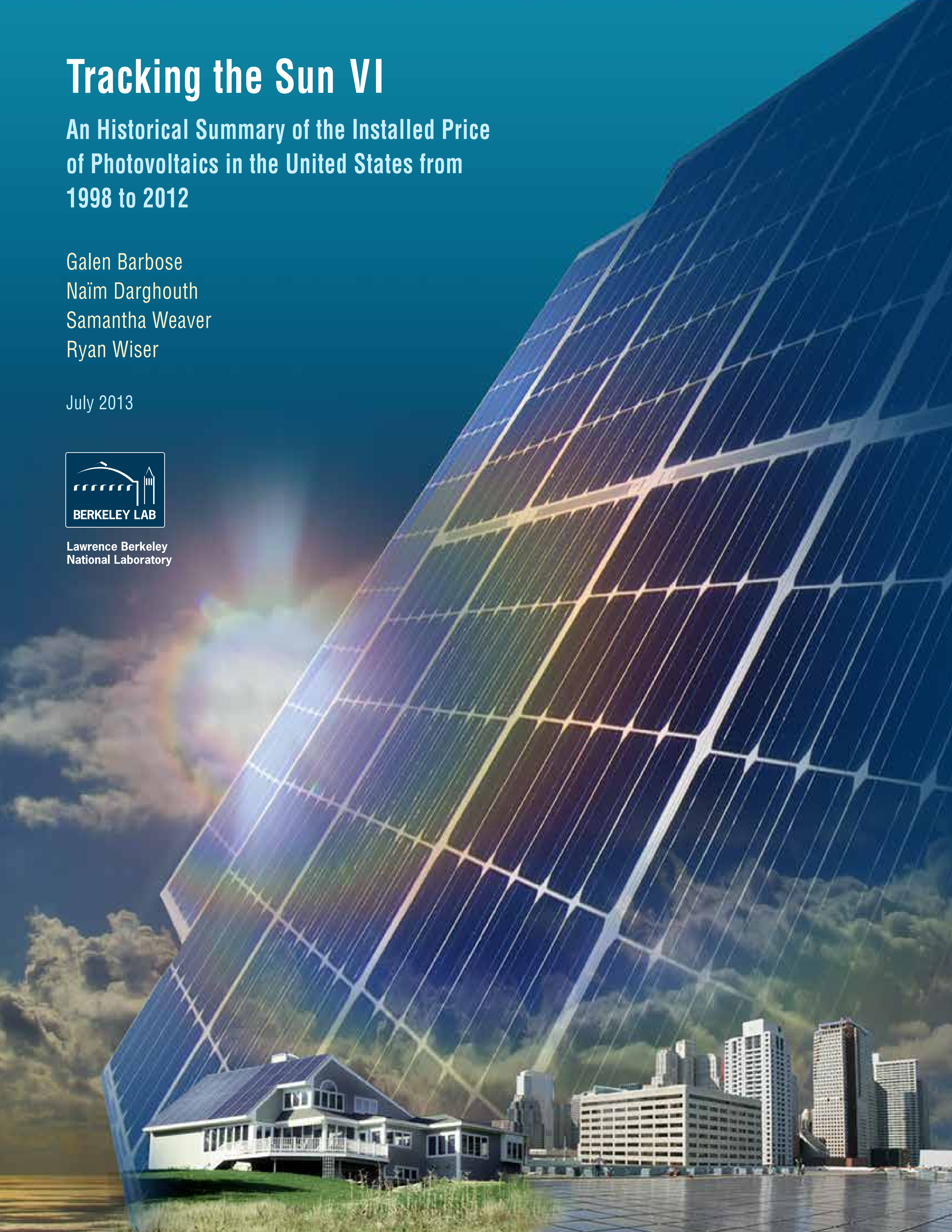

Tracking the Sun VI

An Historical Summary of the Installed Price of Photovoltaics in the United States from 1998 to 2012

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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 2012, with preliminary data for 2013. The analysis is based on project-level data for more than 200,000 individual residential, commercial, and utility-scale PV systems, representing 72% of all grid-connected PV capacity installed in the United States through 2012.

It is essential to note at the outset what the data presented within this report represent. First, the data are historical, focusing primarily on projects installed through the end of 2012, 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 2013); nor are the data representative of prices currently being quoted for prospective projects to be installed at a later date. For this reason and others (see Text Box 1, within the main body), the results presented in this report may differ from current PV price benchmarks. Second, this report focuses on the installed price of PV – that is, the up-front price paid by the PV system owner, prior to receipt of incentives. As such, it does not capture trends associated with PV performance or other factors that would affect the levelized cost of electricity for PV, nor does it capture trends in the net cost to the owner after receipt of all incentives. 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 represents an *appraised value* rather than a transaction price, and those projects were removed from the data sample (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 2012 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 2012, falling year-over-year by \$0.9/W (14%) for systems ≤10 kW, \$0.8/W (13%) for systems 10-100 kW, and \$0.3/W (6%) for systems >100 kW. Among projects installed in 2012, median installed prices were \$5.3/W for systems ≤10 kW, \$4.9/W for systems 10-100 kW, and \$4.6/W for systems >100 kW.
- Partial data for the first six months of 2013 indicate that installed prices have continued to fall, with the median installed price of projects funded through the California Solar Initiative declining by an additional \$0.5/W to \$0.8/W (10-15%) depending on system size, relative to systems installed throughout all of 2012.
- The recent decline in installed system prices is largely attributable to falling module prices, which fell by \$2.6/W from 2008 through 2012 (based on average annual selling prices), representing roughly 80% of the drop in total PV system prices for ≤10 kW systems over the same period. Movements in global module prices, however, do not necessarily translate into an immediate, commensurate change in the price paid by the system owner, with some evidence that system prices have lagged behind changes in module prices.

[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 2 MW in size.

- Over the longer-term, installed system prices have fallen also as a result of reductions in non-module costs (which may include such items as inverters, mounting hardware, labor, permitting and fees, customer acquisition, overhead, taxes, and installer profit). For example, non-module costs for ≤10 kW systems declined by approximately $2.5/W from 1998 to 2012, constituting 38% of the reduction in total installed system prices over that period. In recent years, however, non-module costs have remained relatively flat while module prices fell rapidly, and as a result, non-module costs have grown significantly as a share of total system costs.
- Cash incentives provided through state and utility PV incentive programs (i.e., rebates and performance based incentives) have fallen substantially over time, offsetting much of the installed price reductions from the perspective of customer-economics. From 2011 to 2012, the median pre-tax value of cash incentives provided through the PV incentive programs in the data sample declined by an amount equivalent to 50% to 150% of the corresponding drop in installed prices, depending on system size. Over the course of the past decade, the reduction in cash incentives equaled 82% to 88% of the installed price decline.
- International experience suggests that greater near-term price reductions in the United States are possible, as the median installed price of small residential PV installations in 2012 (excluding sales/value-added tax) was just $2.6/W in Germany, $3.1/W in Australia, $3.1/W in Italy, and $4.8/W in France, compared to $5.2/W in the United States.
- The distribution of installed prices across projects is quite wide. For example, among ≤10 kW systems installed in 2012, roughly 20% of systems had an installed price less than $4.5/W, while a similar percentage was priced above $6.5/W. The price distribution has narrowed somewhat over time, though no discernible narrowing has occurred in recent years.
- Installed prices exhibit significant economies of scale, with a median installed price of $7.1/W for systems ≤2 kW completed in 2012, compared to $4.4/W for commercial systems >1,000 kW. The installed price of utility-scale systems is even lower, as discussed further below. To a limited extent, these economies of scale help to explain the long-term decline in median installed prices, as typical PV system sizes have grown over time.
- Installed prices vary widely across states. Among ≤10 kW systems completed in 2012, for example, median installed prices range from a low of $3.9/W in Texas to a high of $5.9/W in Wisconsin, potentially reflecting a number of differences in state and local factors (e.g., market size, permitting requirements, competitiveness of the installer market, labor rates, sales tax exemptions, and incentive levels).
- Installed prices of the third party owned (TPO) systems retained in the data sample, which represent the sale price between an installer and a customer finance provider, are similar to the installed prices reported for customer owned systems. The growing prominence of third party ownership therefore does not appear to have had a significant direct impact on the overall median installed price trends presented within this report (given that appraised value systems have been removed from the data sample).
- Small PV systems with microinverters have higher installed prices than those with central inverters, with a differential in median installed prices of $0.4/W (8%) for ≤10 kW systems installed in 2012, and a similar differential in 2011. The increasing penetration of microinverters has thus modestly dampened the installed price decline for small systems. In

contrast, among larger systems sizes, no appreciable difference in installed price is evident between those with microinverters and those with central inverters.

- Installed prices are moderately higher for systems with high-efficiency modules. Among systems installed in 2012, the median installed price of those with module efficiencies >18% was roughly $0.5/W higher than for those with module efficiencies in the 14-16% range (the range typical of systems with standard polysilicon modules).
- Systems with Chinese-brand modules generally have lower installed prices than other systems, with an installed price differential of $0.3/W to $0.4/W among 2012 systems, depending on system size, and somewhat larger differences in prior years. However, 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 was considerably smaller.
- Installed prices for systems installed at tax-exempt customer sites are moderately higher than for similarly sized systems at residential and for-profit commercial customer sites. Among 2012 systems, the median price of tax-exempt systems was $0.3/W to $0.8/W higher than for residential and commercial systems, depending on system size range.
- The residential new construction market offers potential price advantages relative to residential retrofits. In particular, over the 2008 to 2012 period, the median installed price of rack-mounted systems in new construction was $0.2/W to $1.1/W lower than for comparably sized retrofit systems, when focusing on systems 2-4 kW in size (the size range typical of PV in residential new construction).
- Within the new construction market, BIPV systems exhibit significantly higher prices than rack-mounted systems, with a difference in median installed prices ranging from $0.7/W to $2.3/W over the 2008 to 2012 period. That comparison, however, does not account for any avoided roofing materials cost associated with BIPV.
- Within the residential and commercial market, ground-mounted systems with fixed-tilt have higher installed prices than similarly sized roof-mounted systems. In 2012, the median installed price of ground-mounted systems was $0.1/W to $0.7/W higher than that of roof-mounted systems, depending on system size (with a larger differential for smaller systems).
- The installed price of residential and commercial systems with tracking is, not surprisingly, notably higher than for fixed-tilt, ground-mounted systems. Among systems installed in 2012, the median installed price premium for tracking systems ranged from $0.7/W to $1.7/W (15% to 32%), depending on system size (again, with a larger differential for smaller system sizes). This difference in installed prices is roughly on par with the increased performance of tracking systems relative to fixed-tilt systems.

This report separately summarizes installed price data for utility-scale PV projects, defined for the purposes of this report as ground-mounted projects larger than 2 MW, and includes only fully operational projects for which all individual phases are in operation. Several important features of the utility-scale PV project data are worth noting, in addition to those noted earlier for the dataset as a whole. First, the sample size of utility-scale projects is relatively small (190 projects in total), and includes a number of smaller (i.e., 2-10 MW) projects and several projects with "atypical" characteristics, which may have higher installed prices than the prototypical large utility-scale PV projects currently under development. Second, reported installed prices for utility-scale projects often reflect transactions (e.g., EPC contracts or PPAs) that occurred one or more years before project completion. In some cases, those transactions may have been negotiated on a forward-looking basis, reflecting anticipated costs at the time of project construction. In other cases, the transactions may have been based on contemporaneous component pricing (or a conservative projection of component pricing), in which case the installed price data may not fully capture recent reductions in module costs or other changes in market conditions.

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

- Among projects completed in 2012, the capacity-weighted average installed price was \$3.3/W for systems with crystalline modules and fixed tilt, compared to \$3.6/W for crystalline systems with tracking and \$3.2/W for thin-film, fixed-tilt systems (though the sample sizes for these latter two configurations are relatively small).
- The installed price of utility-scale systems varies considerably across projects. Among the 106 projects in the data sample completed in 2012, for example, installed prices ranged from \$2.3/W to \$6.8/W, and similar levels of variability are evident in earlier years as well. This variation partly reflects differences in project size and configuration, though other factors are also clearly important.
- Discerning a time trend for the installed price of utility-scale PV is challenging, given the small and diverse sample of projects. Among crystalline, fixed-tilt systems, capacity-weighted average prices fell by \$2.8/W between the 2007-to-2009 period and 2012. In the latter years of the historical analysis period, however, those price reductions slowed, with just a \$0.2/W decline from 2011 to 2012. In contrast, thin-film systems exhibited relatively little installed price movement between the 2007-to-2009 period and 2012.
- Installed prices are somewhat lower and more uniform for larger utility-scale systems. Most projects >10 MW installed in 2012 ranged in price from \$2.5/W to \$4.0/W. Projects ≤10 MW were clustered within a similar range, but with a sizeable tail to the distribution with 20% of projects exceeding \$4.0/W and several above \$5.0/W.
- As to be expected, utility-scale systems with tracking generally have higher installed prices than fixed-tilt systems. Among crystalline systems installed in 2012, the capacity-weighted average price of systems with tracking was \$0.3/W higher than fixed-tilt systems if comparing utility-scale systems of all sizes, and was \$0.5/W among systems >10 MW.
- The price differential between utility-scale systems with crystalline and thin-film modules has varied considerably over time. Among fixed-tilt projects installed in 2012, the differences in installed prices were negligible, with thin-film systems registering a capacity-weighted average installed price \$0.1/W lower than crystalline systems. This contrasts to earlier years in the historical period, where thin-film systems enjoyed a sizeable price advantage.

1. Introduction

Installations of solar photovoltaic (PV) systems have been growing at a rapid pace in recent years. In 2012, approximately 31,000 megawatts (MW) of PV were installed globally, just above the 30,000 MW installed in 2011 and up from 17,000 MW in 2010 and 7,000 MW in 2009.[2,3] With roughly 3,300 MW of grid-connected PV capacity added in 2012, the United States was the world's fourth largest PV market in that year, behind Germany, Italy, and China.[4] Despite the significant year-on-year growth, however, the share of global and U.S. electricity supply met with PV 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 these incentive policies is 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 incentive policies and other initiatives have become more prevalent, and as PV deployment has accelerated, an increasing need has emerged for comprehensive and reliable data on the cost of PV systems.

To address this need, 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 sixth in the series, describes installed price trends for projects installed from 1998 through 2012, with some limited and preliminary results presented for projects installed in the first half of 2013. The analysis is based on project-level data from more than 200,000 residential, commercial, and utility-scale PV systems in the United States. The sample represents 72% of all grid-connected PV capacity installed in the United States through 2012 (among fully operational projects), comprising one of the most comprehensive and detailed sources of installed PV price data.[5] 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 installed price data are historical, focusing primarily on projects installed through the end of 2012, and therefore do not reflect the price of projects installed more recently (with the exception of the limited set of results presented for residential and commercial systems installed in the first half of 2013); nor are the data presented here representative of prices that are currently being quoted for prospective projects to be installed at a later date. For this reason and others (see Text Box 1), the results presented in this report likely differ from current PV price benchmarks. Second, this

[2] Throughout this report, all capacity numbers represent rated direct current (DC) module power output.
[3] EPIA (2013).
[4] SEIA/GTM Research (2012a) and REN21 (2013).
[5] The data for this report are collected in concert with the National Renewable Energy Laboratory's *OpenPV* project, an online data-visualization tool (https://openpv.nrel.gov) that includes most of the data contained within the present report as well additional data contributed by individual PV system owners and installers, and by other entities.

report focuses on the installed price of PV – that is, the up-front price paid by the PV system owner prior to receipt of incentives. As such, it does not capture trends associated with PV performance or other factors that would affect the levelized cost of electricity (LCOE) for PV, nor does it capture trends in the net cost to the owner after receipt of all incentives. Third, the utility-scale PV data presented in this report are based on a relatively small sample size (reflecting the small number of utility-scale systems installed through 2012), and include a number of smaller projects and "one-off" projects with atypical project characteristics.

It is also important to note 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 an appraised value – roughly 20,000 systems or 8% of the dataset – were removed from the sample; all other TPO systems were retained.[6]

This report is complemented by a number of other related studies and ongoing research activities. The first of these is an annual briefing issued jointly by LBNL and the National Renewable Energy Laboratory (NREL) summarizing historical, current, and projected PV installed prices, drawing upon data from the present report along with modeled installed price benchmarks and projections of near-term system pricing developed through research efforts underway at NREL.[7] Second, while the analysis presented within *Tracking the Sun* focuses on descriptive trends, a parallel analysis is underway to analyze those trends with more-sophisticated statistical techniques. Finally, a separate LBNL annual report series has been launched this year focusing on utility-scale solar projects, which will include data and trends related to not only installed price, but also operating costs, capacity factors, and PPA prices.

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 (microinverter 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, with a focus on Germany, and 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.

[6] TPO systems retained in the data sample consist of those financed by *non-integrated* companies that purchase PV systems from installation contractors; for these systems, the reported installed prices represent actual purchase prices paid to those installation contractors.
[7] Feldman et al. (forthcoming).

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

Various entities routinely publish benchmarks for the installed price of PV systems in the United States. The historical market price data presented in this report are likely to differ from price benchmarks issued near the time of report publication.[8] These differences may arise, in part, due to issues of timing. This report focuses on systems installed through the end of 2012, and installed prices for those systems generally reflect module and other component pricing at the time that installation contracts were signed (which could precede installation dates by one year or more for relatively large projects). In contrast, installed price benchmarks are generally based on contemporaneous module and other component pricing, which have fallen significantly in recent years. Preliminary data for systems installed through the California Solar Initiative in the first half of 2013, for example, show that installed prices have continued to fall relative to the values cited in this report for systems installed in 2012.

The historical market price data presented in this report may also differ from current installed price benchmarks for a number of other reasons, depending upon how the benchmarks are constructed:

- *System size*: The reported market prices reflect the system size distribution of projects within the data sample (as described in Section 2). Current price benchmarks may, instead, be based on prototypical system sizes that may differ significantly from those in the data sample.
- *Geographic location*: The reported market prices reflect the geographical distribution of projects within the data sample, which is weighted heavily towards California and New Jersey. Current price benchmarks may, instead, be based on national average costs and pricing.
- *PV component selection*: The reported market prices are based on the distribution of PV module and other component models employed within the projects in the data sample; the utility-scale systems in the sample, in particular, include many systems with high-efficiency (and relatively high-cost) modules. Current price benchmarks may, instead, be based on average component prices across the range of models available.
- *Utility-scale PV definition*: This report classifies all ground-mounted projects greater than 2 MW as "utility-scale PV," and therefore the data sample includes a number of PV systems that are considerably smaller than what might be considered prototypical "central-station" PV systems for the purpose of price benchmarking.
- *Atypical utility-scale PV project characteristics*: The data sample includes a number of "one-off" utility-scale projects with unique characteristics (e.g., brownfield developments, systems built to withstand hurricane winds, etc.) that likely led to higher installed prices. Current price benchmarks are, instead, generally based on more prototypical project characteristics.
- *Inefficient pricing*: Current price benchmarks are sometimes based on stipulated developer/owner profit margins. The reported market price data, in contrast, are based on whatever profit margin the developers/owners were able to capture or willing to accept. In markets with barriers to entry, developers and/or third-party owners may be able to price their projects above the theoretically "efficient" level based on underlying project costs. Conversely, some developers may be willing to accept "below-market" profit in order to capture market share. In either case, the underlying profit margin embedded in the reported market price data may differ from the assumptions within current PV price benchmarks.

[8] NREL published a set of installed price benchmarks (Goodrich et al. 2012), based on bottom-up modeling of system pricing, informed by in-depth interviews with installers and industry experts. A joint summary briefing prepared by NREL and LBNL (Feldman et al., forthcoming) compares updated versions of those benchmarks to the market price data reported here, and discusses specific reasons for differences.

2. Data Summary

The analysis presented in this report is derived 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 for systems funded through 47 PV incentive programs (see Table B-1 in the Appendix for a list of these programs and the associated sample sizes). Data for *utility-scale systems* were collected from a diverse set of sources, including the Section 1603 Grant Program, 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 2 MW in size. ***Utility-Scale PV*** refers to ground-mounted systems larger than 2 MW. These distinctions are independent of whether electricity is delivered to the customer-side or utility-side of the electrical meter.

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 2012 dollars (2012$), which required inflation adjustments to the nominal-dollar data provided by PV programs.
2. All capacity and dollars-per-watt ($/W) data are presented in terms of rated module power output under Standard Test Conditions (DC-STC), requiring that capacity data provided by several PV incentive programs be translated to DC-STC.[9]

A number of additional steps were then undertaken to clean and standardize the data. First, projects with clearly erroneous installed price or incentive data or with missing price or system size data were eliminated from the data sample. Second, all projects for which reported installed prices were deemed likely to represent an *appraised value*, rather than a purchase price paid to an installer, were eliminated from the data sample. This issue is specific to a subset of third party owned systems – namely, those systems installed by integrated companies that provide both the installation

[9] Various permutations of rating conventions may be used to describe the size of PV systems. The most common rating used by PV incentive programs, also used in this report, is the total nameplate capacity of the PV modules in direct current watts under standard test conditions.

service and the customer financing – and resulted in the removal of roughly 20,000 systems from the dataset, representing one-third of all third party owned systems in the raw data sample. The 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 project was 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 inverter, based on a combination of information sources. Finally, for utility-scale systems and large commercial systems for which installed price data were not available from other sources, installed prices were estimated based on reported Section 1603 grant amounts, by assuming that the grant is equal to 30% of the installed price.[10]

Sample Description

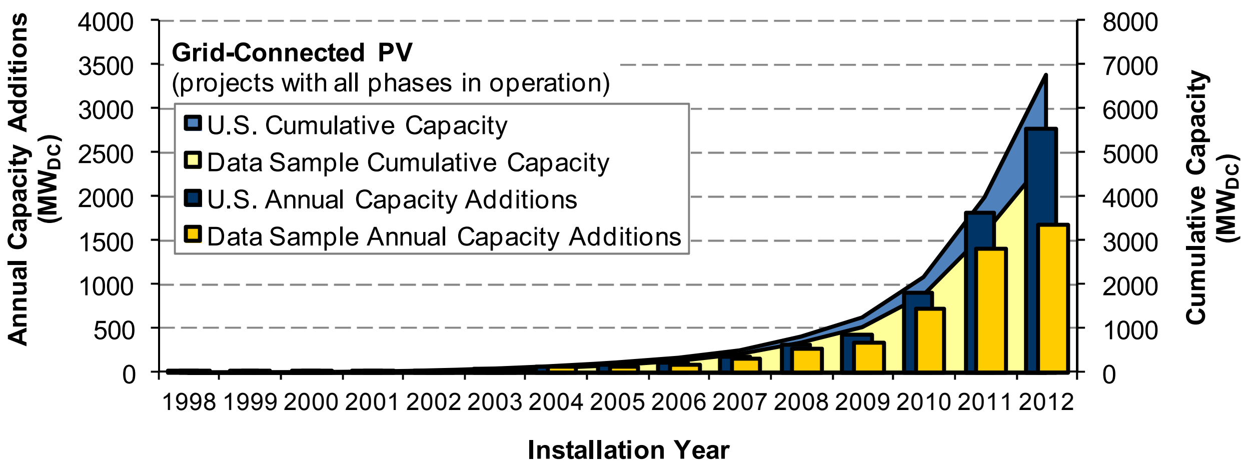
The final data sample, after all data cleaning was completed, consists of 208,529 residential and commercial PV systems totaling 3,231 MW, and 190 utility-scale systems totaling 1,595 MW (see Table 1). As to be expected, the vast majority of projects and capacity in the sample were installed within the latter years of the sample period, and this is especially true for utility-scale systems. 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. 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.

Table 1. 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	34	0	*34*	0.2	0	*0.2*
1999	165	0	*165*	0.8	0	*0.8*
2000	186	0	*186*	0.8	0	*0.8*
2001	1,308	0	*1,308*	5.7	0	*5.7*
2002	2,449	0	*2,449*	18	0	*18*
2003	3,461	0	*3,461*	31	0	*31*
2004	5,626	2	*5,628*	44	10	*54*
2005	5,754	0	*5,754*	64	0	*64*
2006	8,887	0	*8,887*	91	0	*91*
2007	12,936	2	*12,938*	133	22	*155*
2008	14,165	4	*14,169*	241	20	*261*
2009	24,664	5	*24,669*	288	61	*349*
2010	36,780	18	*36,798*	494	236	*730*
2011	42,397	53	*42,450*	878	502	*1380*
2012	49,717	106	*49,823*	940	744	*1684*
Total	***208,529***	***190***	***208,719***	***3,231***	***1,595***	***4,826***

[10] This is a simplified assumption and ignores that (a) some project costs may be deemed ineligible for the grant, in which case the grant amount would be *less* than 30% of total project costs, and that (b) the grant amount for some projects may be based on an appraised "fair market value" that is *greater* than the price paid to the installer. Section 1603 grant data was used to estimate installed prices for 474 MW (30%) of the utility-scale PV capacity in the data sample, and a negligible portion of the residential and commercial PV capacity in the data sample.

The combined 4,826 MW of PV capacity in the data sample represents 72% of all cumulative grid-connected PV capacity installed in the United States through 2012, and 61% of 2012 annual capacity additions (see Figure 1). To maintain consistency with the data sample, these percentages are based on only the installed U.S. PV capacity associated with fully operational projects where all phases were in operation by year-end 2012, and the U.S. totals shown in Figure 1 do not include operational phases of projects with other phases that were still under construction as of year-end 2012. The gap between the final cleaned data sample and the total U.S. grid-connected PV market consists of: utility-scale PV systems for which reliable installed price data could not be obtained, PV systems removed from our data sample, and residential and commercial PV systems not funded by any of the PV incentive programs that contributed data to the analysis.[11]



Data source for U.S. total grid-connected PV capacity additions: Sherwood (2013). LBNL modified those values by deducting the capacity associated with the operational phases of several large utility-scale PV projects that were still under construction as of year-end 2012.

Figure 1. Data Sample Compared to Total U.S. Grid-Connected PV Capacity

Geographical and Size Distribution: Residential and Commercial PV

The data sample includes residential and commercial systems spanning 29 states, again, representing the majority of all U.S. systems installed to-date.[12] As is the case for the entirety of the U.S. PV market, the residential and commercial PV capacity in the data sample is heavily weighted towards California and New Jersey, which represent 49% and 20% of the sample, respectively, in terms of total installed capacity (see the left-hand chart in Figure 2). Arizona, Massachusetts, Pennsylvania, North Carolina, and New York each represent 2-9% of the sample capacity, with the

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[11] The sample coverage in 2012 declined somewhat markedly from prior years. Approximately 50% of the gap between the sample and population for 2012 is associated with utility-scale projects for which reliable installed price data could not be obtained. In addition, appraised value systems removed from the data sample represent 8% of the gap, and missing data from Hawaii and Colorado represent 9% and 4% of the gap, respectively. Much of the remaining gap likely consists of projects installed without funding from state or utility incentive programs.

[12] Data from state and utility PV incentive programs were provided for 24 states; data for a small number of additional large commercial projects were obtained from other secondary data sources and included systems located in 5 additional states. Note that the sample is largely missing data from two key state solar markets: Colorado and Hawaii. Colorado is unrepresented because its primary PV incentive program administrator was unwilling to contribute project-level data to this research effort, although summary data were provided and were incorporated into the state-level comparisons presented in Figure 19 through Figure 21. Hawaii is unrepresented because its primary incentive program does not collect system-level installed-price data. All other major state PV markets are well represented in the final data sample.

remaining 22 states comprising 8% in aggregate.[13] The U.S. PV market has diversified significantly in recent years, however, and this is reflected in the geographical distribution of the 2012 capacity additions in the data sample, as shown on the right-hand chart in Figure 2. Of particular note, California, though still the largest market, represents a smaller share (39%) of the 2012 systems in the data sample, with correspondingly greater representation among the other leading state markets.

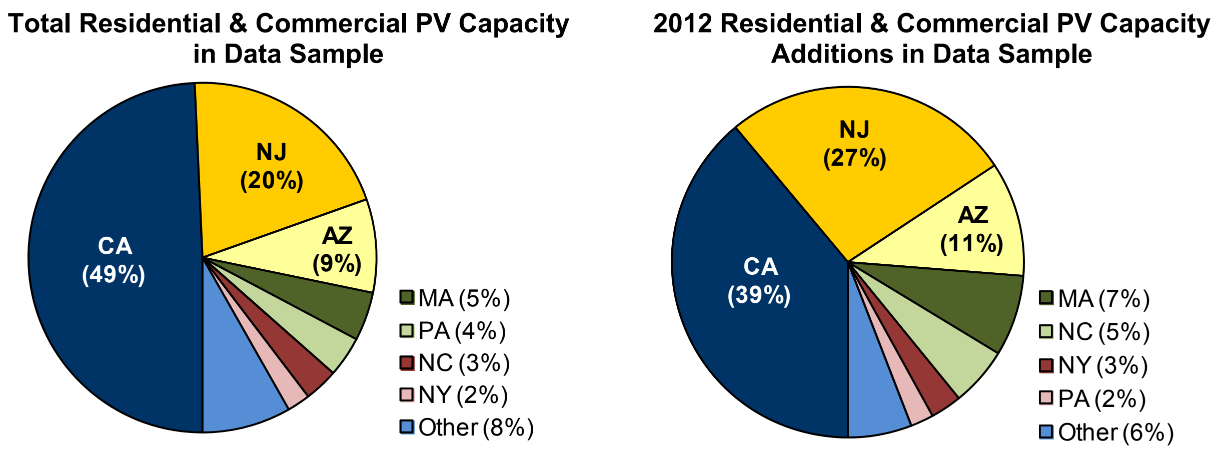


Figure 2. Residential & Commercial PV Sample Distribution among States

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 9 MW. In terms of the number of projects, the vast majority are relatively small systems, with more than 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, with the sample capacity split roughly into thirds among systems ≤30 kW, 30-500 kW, and >500 kW. As shown in Figure 4, large systems have represented an increasing portion of the residential and commercial PV capacity over time (see also Table B-2 in the appendix).

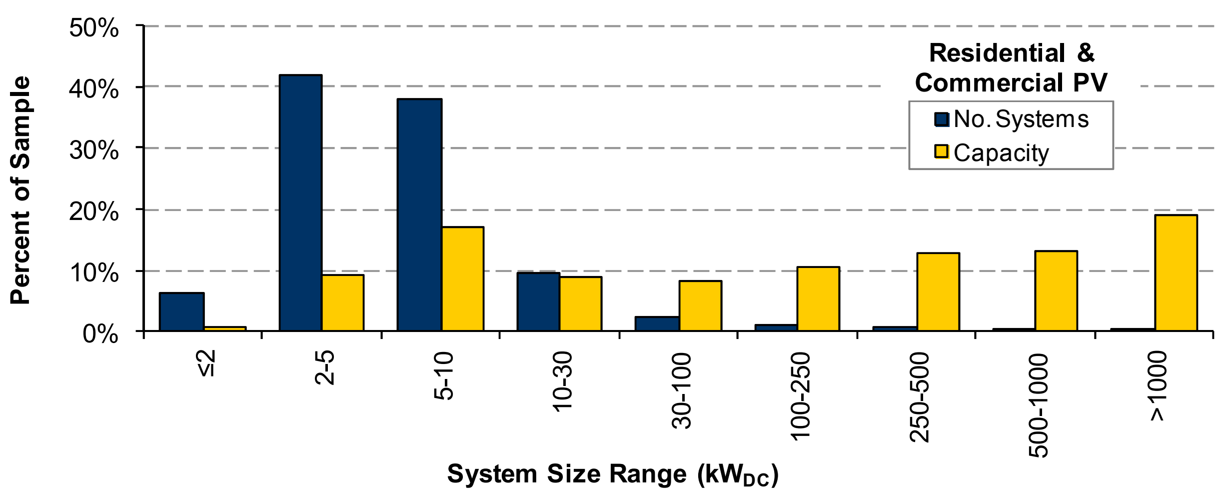


Figure 3. Residential & Commercial PV Sample Distribution by System Size

[13] The distribution of the residential and commercial PV data sample comports reasonably well with the geographical distribution of the overall U.S. PV market, with the exception of Colorado and Hawaii, which are largely absent from the sample for reasons explained previously.

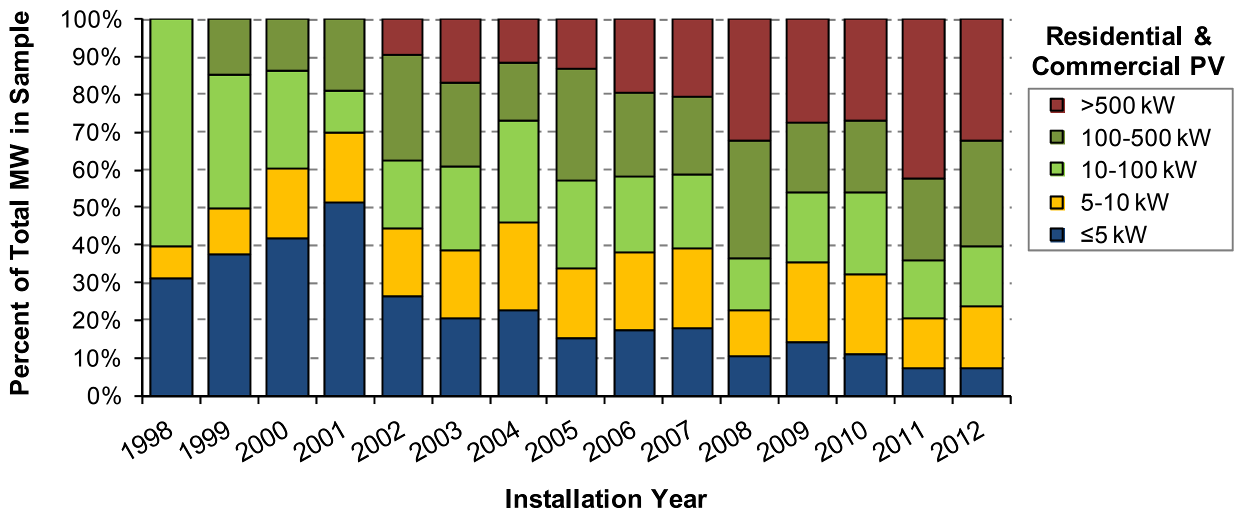


Figure 4. Residential & Commercial PV Sample Distribution by System Size over Time

Geographical and Size Distribution: Utility-Scale PV

The 190 utility-scale PV systems in the data sample are spread across 19 states, but with the vast majority (more than 80%) of the capacity located in eight states (California, North Carolina, New Jersey, Arizona, Nevada, New Mexico, Colorado, and Texas), as shown in Figure 5. 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 2 MW or larger. As such, the size of projects in the utility-scale PV data sample ranges widely, from 2 MW up to 60 MW. As indicated in Figure 6, most of the systems in the utility-scale PV data sample (77%) are smaller than 10 MW, though most of the sample capacity (61%) consists of systems larger than 10 MW.

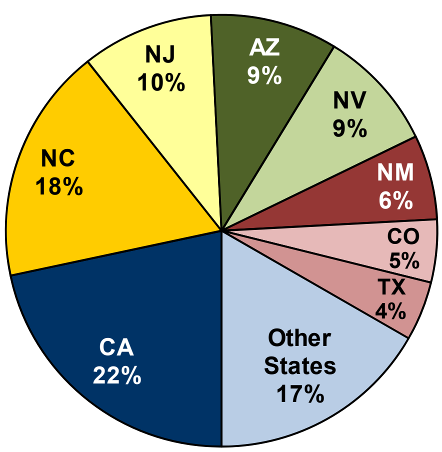


Figure 5. Utility-Scale PV Sample Capacity Distribution among States

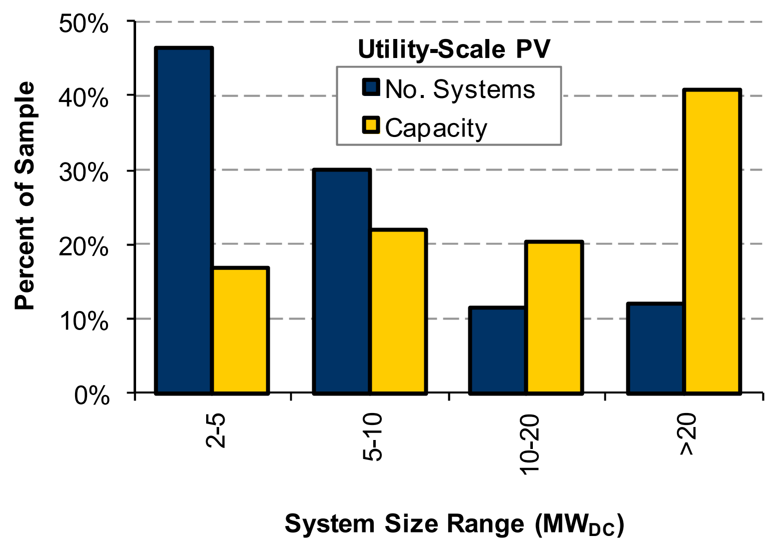


Figure 6. Utility-Scale PV Sample Distribution by System Size

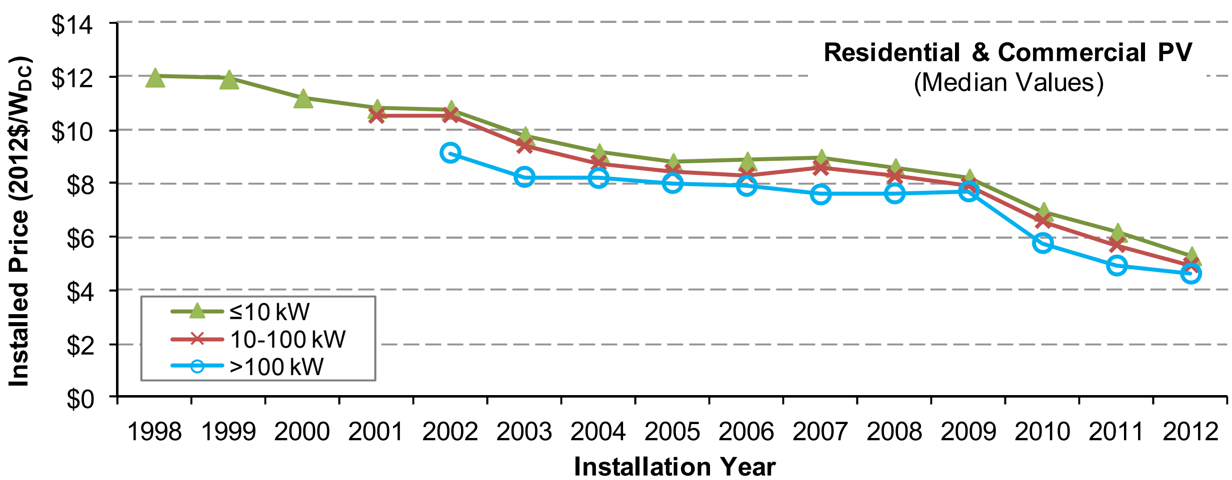
3. Installed Price Trends: Residential and Commercial PV

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, with some focus on Germany. 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 2012

Figure 7 presents the median installed price of all residential and commercial projects within the sample, segmented into three system size groupings, from 1998 through 2012. Among the roughly 50,000 residential and commercial PV systems in the sample installed in 2012, the median installed price was \$5.3/W for systems ≤10 kW, \$4.9/W for systems 10-100 kW in size, and \$4.6/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 7 are dominated by trends within California, which constitutes a large fraction of the total U.S. market and, as will be shown later, has relatively high PV prices 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 7. Installed Price of Residential & Commercial PV over Time

Over the entirety of the historical period depicted in Figure 7, installed prices have declined by about $0.5/W (6-7%) per year, on average, depending on the system size. 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 2011 to 2012, installed prices fell by $0.9/W (14%) for systems ≤10 kW, $0.8/W (13%) for systems 10-100 kW, and $0.3/W (6%) for systems >100 kW. Preliminary data for the first half of 2013 (Text Box 2) show that installed prices have continued to fall.

Text Box 2. Preliminary Price Trends for Systems Installed in 2013: A Focus on California

Early evidence suggests that the decline in prices for systems installed in 2013 is on pace to match – or perhaps even exceed – the decline observed in 2012. As an indication of this trend, Figure 8 compares the installed price of projects funded through the California Solar Initiative (CSI) in the first half (H1) of 2013 and over the entirety of 2012. As shown, the median installed price of CSI systems installed in H1 2013 fell by roughly $0.7/W (13%) for systems ≤10 kW, $0.5/W (10%) for systems 10-100 kW, and $0.8/W (15%) for systems >100 kW, relative to the median installed price for systems installed in 2012. If the same price reductions observed within the CSI program transpire more broadly and continue on the same trajectory as in the first half of the year, then national price reductions in 2013 will be even greater than those witnessed in 2012.[14] The first six months of 2013 have seen a gradual stabilization of module prices, which could dampen further reductions in installed system price. That said, the lag between movements in module prices and movements in installed system prices, along with possible further reductions in non-module costs, may allow for a continued reduction in installed prices over the remainder of the year.

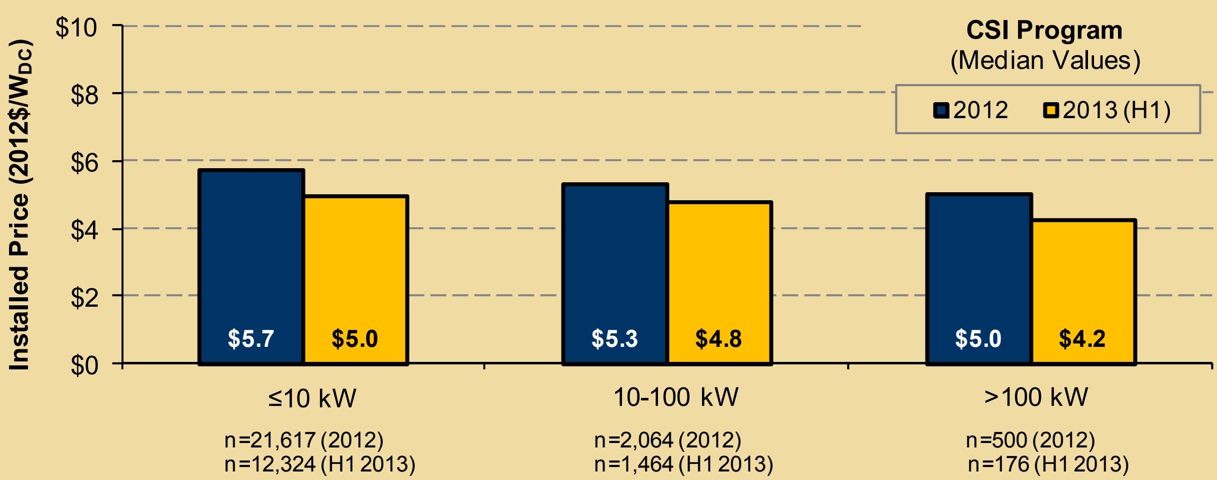


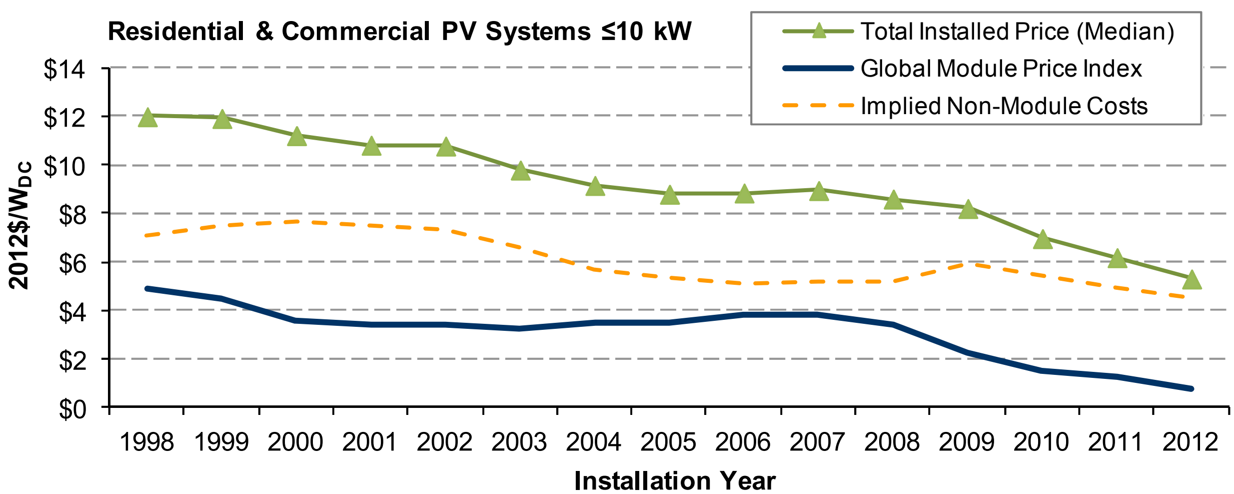
Figure 8. Installed Prices for the CSI Program in 2012 and the First Half of 2013

Recent Installed Price Declines Primarily Reflect Falling Module Prices

Figure 9, 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 $2.6/W in real 2012 dollars from 2008 to 2012 and

[14] SEIA/GTM Research (2013b) report that, nationally, installed prices in the first quarter of 2013 fell by 1.9% quarter-over-quarter in the residential sector, and by 8.1% in the non-residential (behind-the-meter) sector.

constituting roughly 80% of the total \$3.3/W decline in the installed price of ≤10 kW systems over that period. It is evident, however, that the year-by-year installed price declines did not proceed 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 2011 to 2012, total installed prices fell by a notably larger amount (\$0.9/W) than the decline in the module price index (\$0.5/W), potentially as a result of reductions in non-module costs over that time frame as well as module price reductions in preceding years. Notwithstanding the imperfect correlation, it is nevertheless clear that the installed price declines in recent years are primarily the result of rapidly falling module prices.



Notes: The Global Module Price Index is Navigant Consulting's module price index for large-quantity buyers (Mints 2012) and the successor index for first-buyer ASPs published by Paula Mints Solar PV Market Research (Mints 2013). "Implied Non-Module Costs" are calculated as the Total Installed Price minus the Global Module Price Index.

Figure 9. Installed Price, Module Price Index, and Implied Non-Module Costs over Time for Residential & Commercial PV Systems ≤10 kW

Over the longer term, however, installed prices have fallen also as a result of reductions in non-module costs (which include such items as inverters, mounting hardware, labor, permitting and fees, overhead, taxes, and installer profit).[16] The "implied non-module costs" presented in Figure 9 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.[17] Given the manner in which this residual term is calculated, it is not a

[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 line between module costs and non-module costs can become somewhat blurred in cases such as modules with integrated racking and AC modules with micro-inverters, which also impact design and installation costs.

[17] Inverters represent the single largest hardware cost within the residual "non-module cost" term. Over the course of 2012, average residential inverter prices in the U.S. declined from \$0.34/W to \$0.30/W (SEIA/GTM 2013a).

particularly reliable indicator of short-term movements in actual non-module costs, but it does provide a reasonable approximation for longer term trends.[18] Specifically, over the full 15-year period shown in Figure 9, implied non-module costs fell by approximately $2.5/W (36%), from $7.1/W in 1998 to $4.6/W in 2012.[19] This represents 38% of the decline in the total installed price for ≤10 kW systems over that period, clearly indicating the significant impact of non-module cost reductions over the long-term.

Within the latter half of the historical period, however, module prices have declined at a much faster pace than non-module costs, and non-module costs have consequently grown in terms of their relative share of total system costs. This shift in the cost structure of PV systems has heightened the emphasis within the industry and among policymakers on reducing non-module costs – particularly the variety of business process, or "soft", costs, which include such things as marketing and customer acquisition, system design, installation labor, and the costs associated with permitting and inspection processes.

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 10 shows the median cash incentive over time provided by the PV incentive programs within the data sample.[20] These data are presented on 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 (of anywhere from several months for small projects to a year or more for large projects) between the time that a project reserves its incentive and its installation date.

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[18] In effect, the calculated implied non-module costs reflect both actual non-module costs as well as the effect of any divergence between the module price index in a given year and the module prices actually paid by installers for systems installed in that year. Thus, for example, the increase in implied non-module costs in 2009 may not signify a true increase in actual non-module costs in that year, but may instead largely be an artifact of the lag between the precipitous drop in module prices in 2009 and the associated impact on total installed system prices.

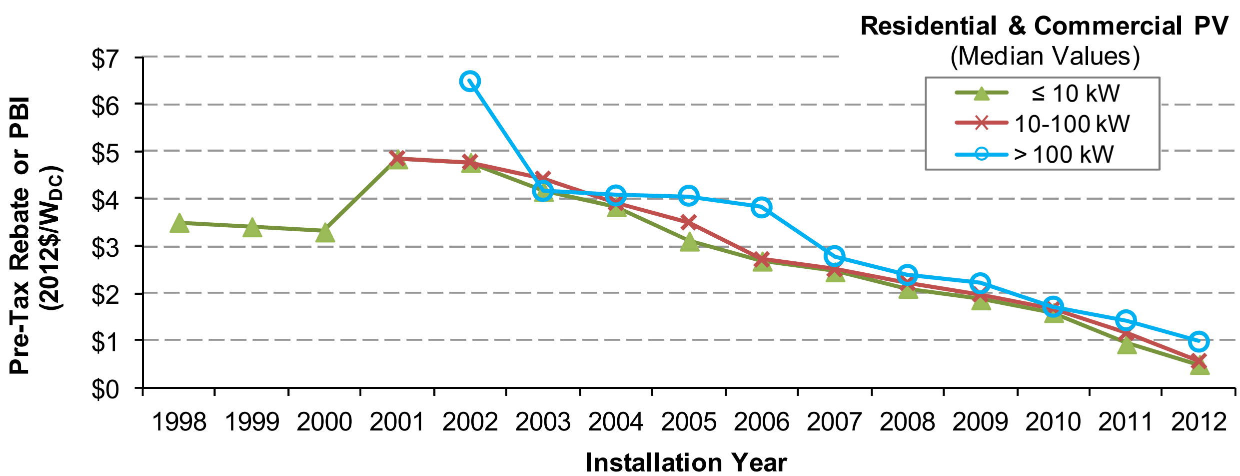
[19] Given the manner in which implied non-module costs are calculated, the decline in *actual* non-module costs over the 1998-2012 period could be greater than the amount estimated here, to the extent that total installed prices in 2012 did not completely absorb module price declines through 2012.

[20] Most of the PV incentive programs within the data sample provide cash incentives in the form of an up-front cash incentive (i.e., rebate), based either on system capacity, a percentage of installed cost, or a projection of annual energy production. Several programs instead provide performance-based incentives (PBIs), which are paid out over time based on a pre-scheduled PBI payment rate and 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). Several of the programs within the data sample are not incentive programs, per se, but are effectively registries for state SREC markets. SREC payments are not included in Figure 10, but their potential value is discussed within Text Box 3.

As shown in Figure 10, cash incentives have declined steadily and significantly over the past decade (on a per-kW basis). Among systems installed in 2012, median cash incentives ranged from \$0.5/W to \$1.0/W across the three system size categories shown, having fallen by more than \$4.0/W (roughly 85% to 90%) from their historical peak in 2001/2002. Within just the last year of the analysis period, median cash incentives fell by \$0.4/W to \$0.6/W across the size ranges shown. Although the incentive levels depicted in Figure 10 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 (see Table B-4 in the Appendix for incentive trends over time for each individual program).

From the perspective of the customer-economics of PV, the steady decline in cash incentives has offset reductions in installed prices, to varying degrees. 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 82% to 88% of the corresponding drop in installed prices, depending on system size. Within the last year of the analysis period, the reduction in cash incentives equaled 50% of the installed price decline for ≤10 kW systems and 150% for >100 kW systems.

The continued ratcheting down of cash incentives provided through state and utility PV incentive programs reflects a combination of drivers. In part, 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 3) – 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.



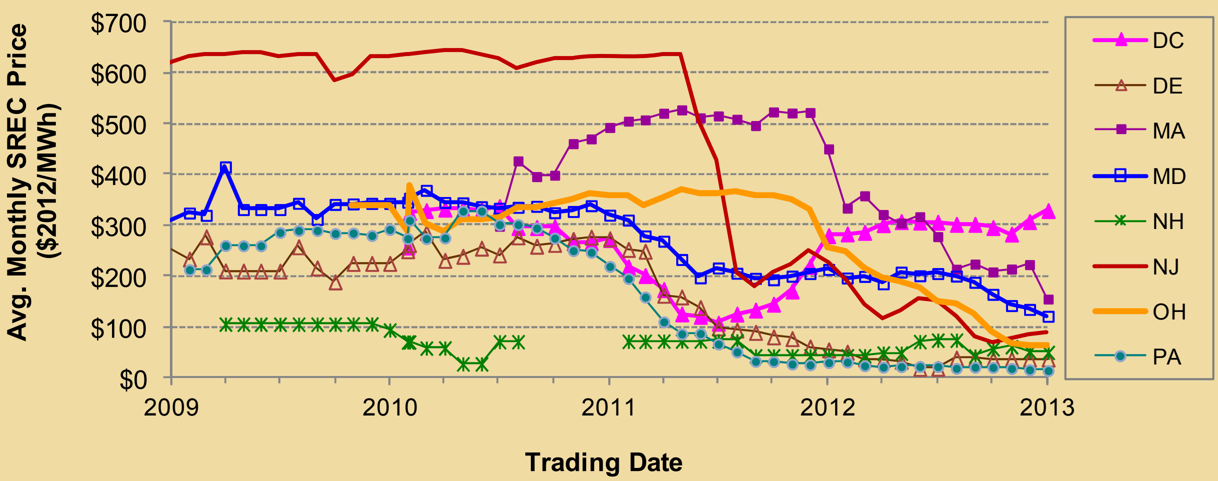
Notes: The figure depicts the pre-tax value of rebates and PBI payments provided through state/utility PV incentive programs, excluding systems that received incentives solely in the form of ongoing SREC payments over time. The high median incentive for >100 kW systems in 2002 reflects the large percentage 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 10. State/Utility Cash Incentives for Residential & Commercial PV

Text Box 3. 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 states (and, in some cases, in 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.

SREC spot-market prices across most markets have declined significantly within recent years, as illustrated in Figure 11, which shows monthly short-term SREC prices among solar set-aside states with active SREC trading. In general, these price declines have been driven by a surplus of available SRECs relative to solar set-aside compliance obligations in these markets, and have provided further pressure to reduce installed prices. Average annual SREC spot-market prices in 2012 ranged from a low of roughly $25/MWh in Pennsylvania to a high of roughly $300/MWh in Massachusetts and Washington DC.[21] By year-end 2012, however, short-term SREC prices stood at below $100/MWh in many major markets, with a number of states witnessing steep declines over the course of the year. Long-term (multi-year) SREC contract prices have seen corresponding declines, although the availability of such contracts and visibility into their pricing is limited. Within 2012, for example, FirstEnergy signed 10-year contracts for Pennsylvania SRECs at an average price of roughly $60/MWh, compared to average prices of roughly $100-200/MWh for contracts signed by another Pennsylvania utility in the prior year.



Sources: 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 11. Monthly SREC Prices for Current or Nearest Future Compliance Year

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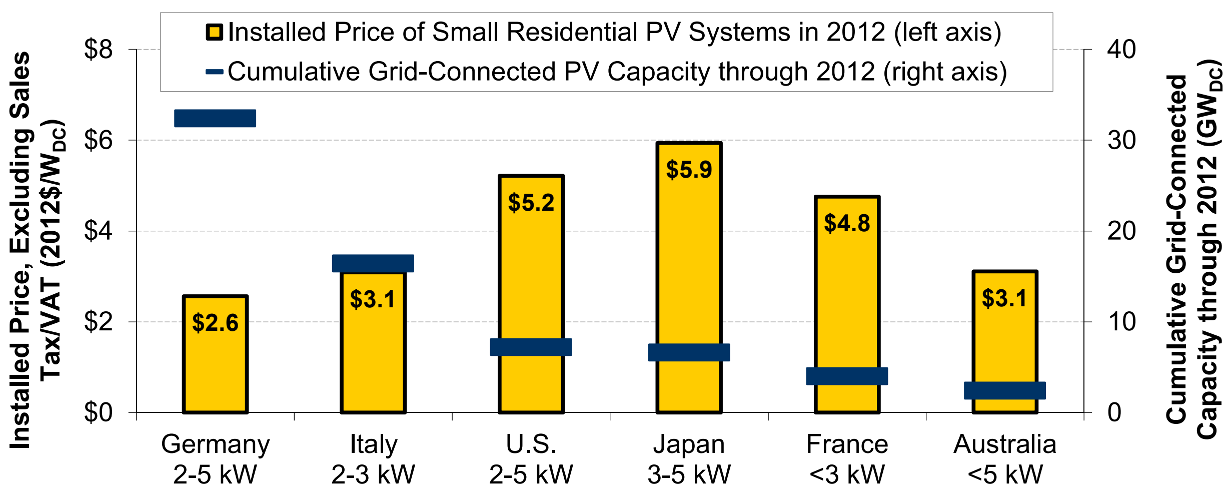
[21] For the purpose of comparison, an SREC price of $100/MWh extrapolated over 20 years (without specifying whether those sales occur via the spot market or long-term contract) is equivalent to an up-front, pre-tax incentive of roughly $0.75/W on a present value basis (assuming a 15% nominal discount rate, 1,200 kWh_{AC}/kW_{DC} in Year 1, and 0.5% degradation per year), which is roughly on par with the median state/utility cash incentive provided in 2012.

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 12 compares the installed price of *small residential systems* installed in 2012, *excluding sales or value-added tax (VAT)*, across most of the major national PV markets (Germany, Italy, France, Japan, Australia, and the United States).[22] The figure focuses on small residential systems, as that is the size class for which data are available over the widest set of countries. The data, however, are not perfectly comparable, as the specific system size ranges differ slightly from one country to another, as do the quality and transparency of the underlying data sources.[23] Nevertheless, the figure suggests that the installed price of small residential PV in the United States remains relatively high compared to many other major markets. In particular, of the five other countries shown in Figure 12, all but one (Japan) had lower prices than the United States. The pricing disparity is greatest in comparison to Germany, where the installed price for small residential PV in 2012 was 51% below the median U.S. price ($2.6/W vs. $5.2/W).



Notes: The U.S. data point represents the median price of 2-5 kW residential systems installed in 2012, and unlike other figures presented in this report excludes sales tax. Data for Germany are based on price quotes for individual systems, collected by EuPD (2013). All other installed price data represent the "turnkey price of typical PV applications" for the particular size range shown, as reported in each country's IEA PVPS Country Report (Castello et al. 2013, Durand 2013, Watt and Passey 2013, Yamada and Ikki 2013). Cumulative installed capacity data for each country derive from REN21 (2013).

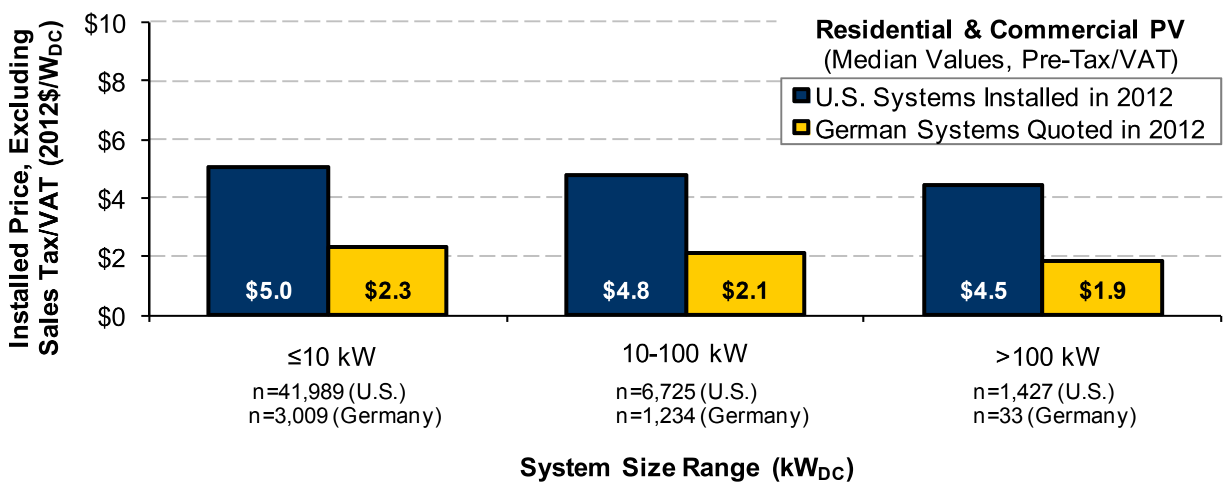
Figure 12. Comparison of the Installed Price for Small Residential PV Systems in 2012 across Major National Markets (Pre-Sales Tax/VAT)

These pricing disparities are not limited to small residential systems, as illustrated by Figure 13, which compares median installed prices between the United States and Germany across a broader range of residential and commercial system sizes, again excluding sales tax/VAT. Although the

[22] Comparable data for China, the third-largest PV market in 2012, were not available at the time of report publication.
[23] The installed price data for each country other than Germany and the U.S. derive from its respective IEA Programme on Photovoltaic Systems (PVPS) Country Report, and represent the reported "turnkey price of typical PV applications" of the particular size range identified. In general, little information is provided within the PVPS country reports about the underlying sources for the reported price data.

two sets of data are also not perfectly comparable – as the German data are based on price quotes for prospective systems issued in 2012, while the U.S. data are based on systems installed in 2012 – the figure further demonstrates the sizable U.S.-German PV price gap, with median installed prices in Germany that are 53% to 58% lower than in the United States, across the three size ranges shown.

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".[24] Those differences in soft costs may, in turn, be partly attributable to differences in the cumulative size of each market, on the theory that larger market size allows for price reductions through learning-by-doing and economies of scale. This theory is partially borne out by Figure 12, which shows that Germany and Italy had amassed roughly 32 GW and 16 GW of grid-connected PV capacity through 2012, far more than any other individual country. That said, the fact that Australia – a relatively small market in absolute terms – also had relatively low installed prices suggests that larger market size, alone, does not account for the entirety of installed price differences among countries.[25]



Notes: This figure relies upon price quotes for individual German PV systems obtained by EuPD through its quarterly survey of German installers and provided to LBNL (EuPD 2013).

Figure 13. Installed Price of Residential & Commercial U.S. PV Systems Installed in 2012 and German Systems Quoted in 2012 (Pre-Sales Tax/VAT)

Installed Prices Vary Widely Across Individual Projects

The preceding figures have focused on median installed prices among PV systems in the data sample. Considerable spread exists within those data, however, as illustrated in Figure 14 through Figure 16, 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

[24] See Seel et al. (2012)

[25] 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.

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 1998-2003 and 2004-2009. Since then, the spread in the installed price distributions has remained relatively stable, and significant variability in pricing has persisted across systems.

For example, among ≤10 kW systems installed in 2012, which had a median installed price of \$5.3/W, roughly 20% of systems had an installed price less than \$4.5/W, while a similar percentage was priced above \$6.5/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 also exhibit considerable spread, though somewhat less so than for the smaller systems. The fact that such variability in pricing 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 market as a whole, even within a given size category. The potential underlying causes for this variability are numerous, including project-specific details (e.g., related to system size, technology type, or configuration), as well as attributes of the individual installer and characteristics of the regional/local market (e.g., degree of installer competition and local retail rates or incentive levels). Some of these drivers for installed pricing variability are explored throughout the remainder of this report; LBNL also is engaged in separate analysis, using more sophisticated statistical methods, to further identify and explain the sources of this variability.

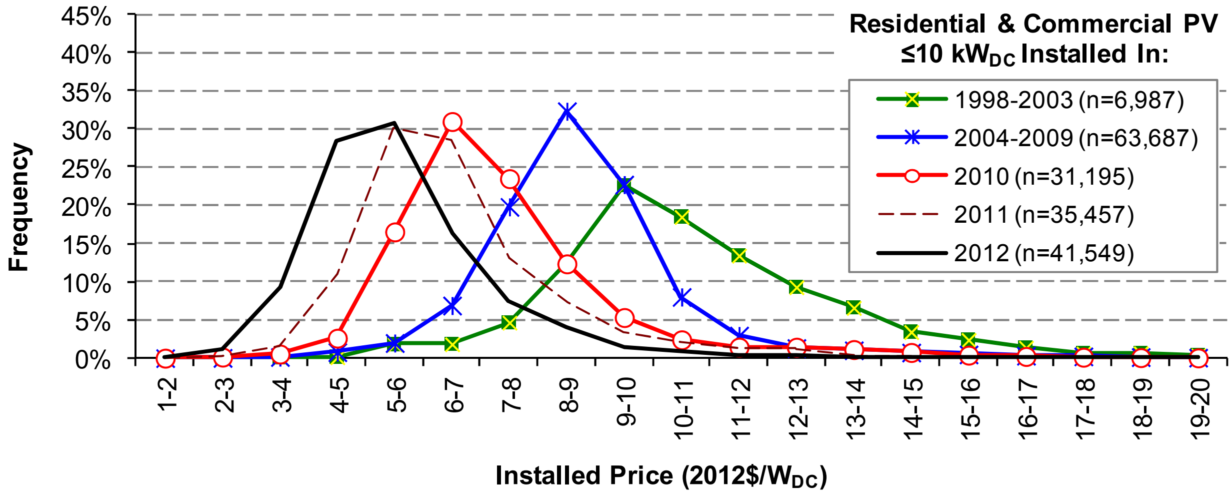


Figure 14. Installed Price Distribution for Residential & Commercial PV (≤10 kW Systems)

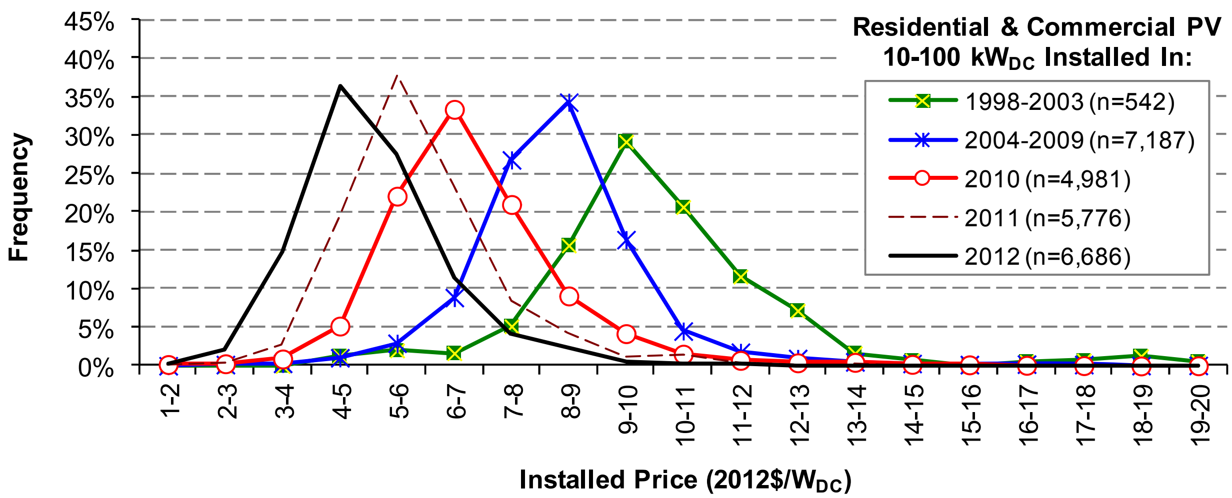


Figure 15. Installed Price Distribution for Residential & Commercial PV (10-100 kW Systems)

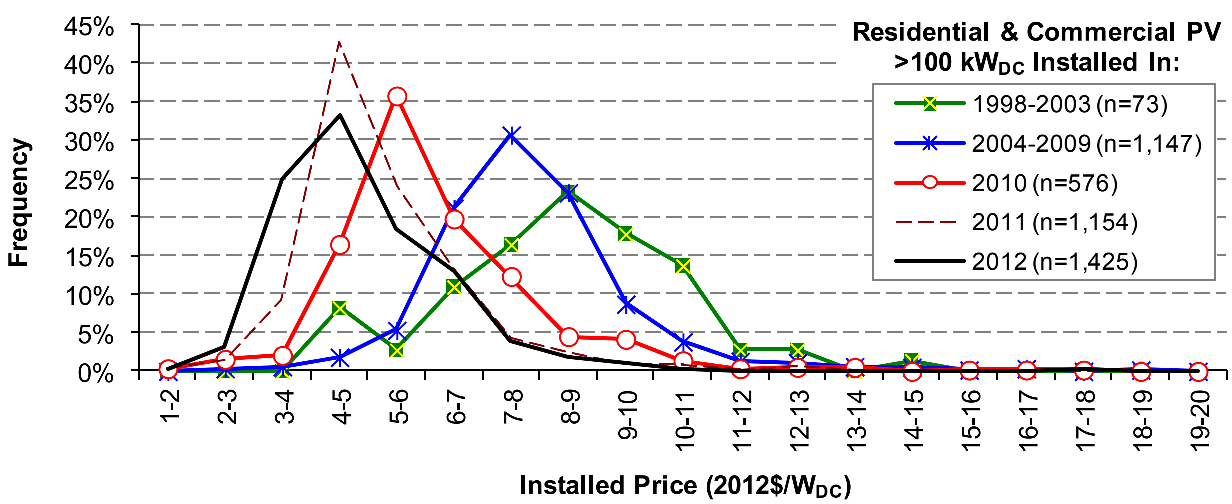


Figure 16. Installed Price Distribution for Residential & Commercial PV (>100 kW Systems)

Installed Prices Exhibit 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 7 and can be observed with greater resolution in Figure 17, which shows median installed prices by system size for all residential and commercial PV systems in the data sample installed in 2012. Across the two extremes (excluding utility-scale systems, which are addressed in Section 4), the median installed price for systems >1,000 kW in size ($4.4/W) is 38% lower than for systems ≤2 kW ($7.1/W). Particularly strong economies of scale arise at the low end of the size spectrum, as shown in Figure 18, which provides greater granularity for systems up to 10 kW in size and illustrates the significant price declines that accompany increases in system size up to 2-3 kW. Economies of scale continue to manifest with further increases in system size, but occur more gradually. Also important to note is that, even within the relatively narrow system size bins in Figure 17 and Figure 18, significant variability in pricing remains, as indicated by the percentile bands within the figures.

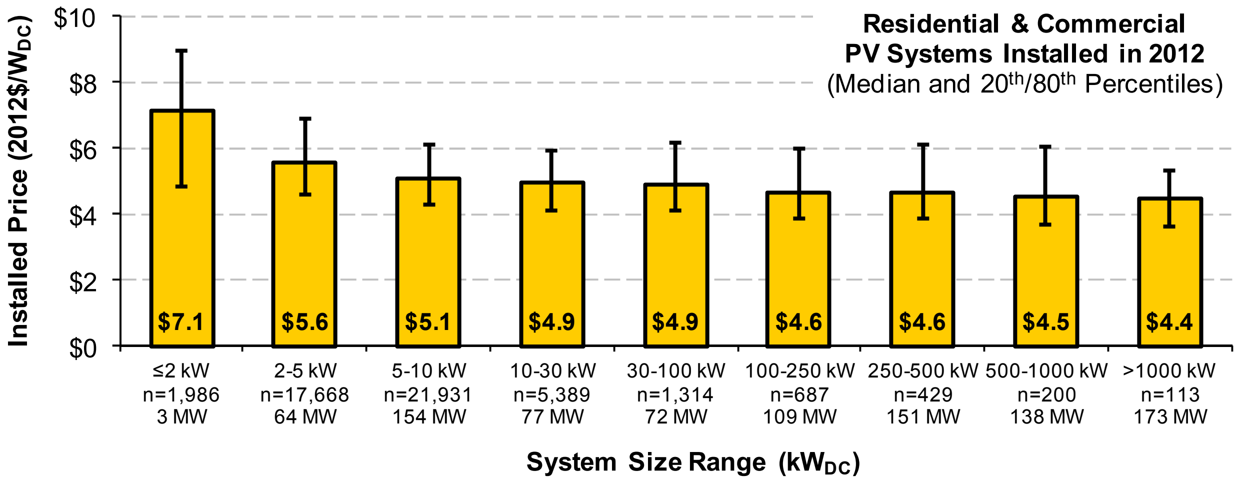


Figure 17. Installed Price of Residential & Commercial PV According to System Size (All Sizes)

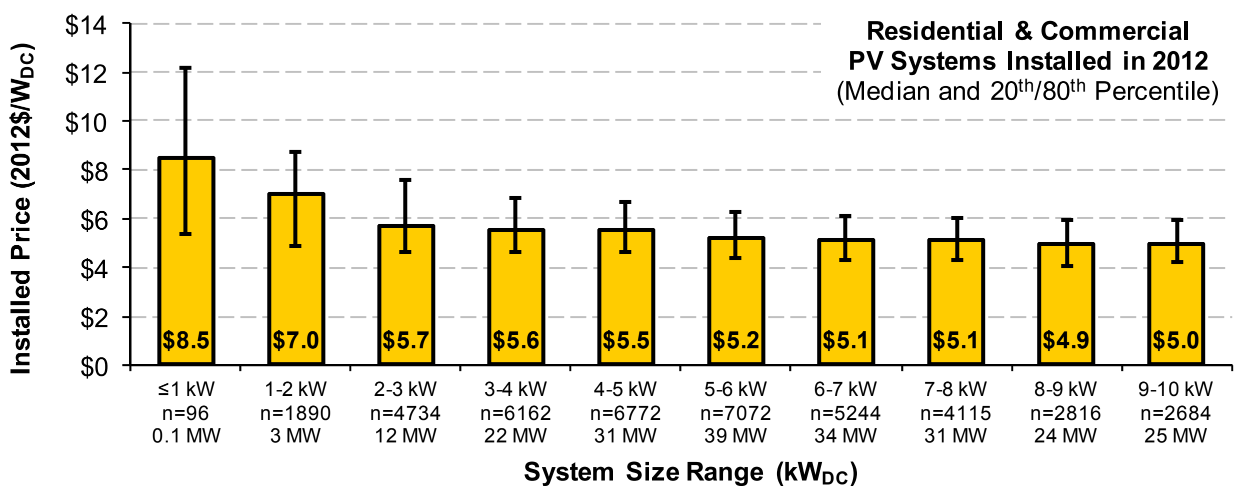


Figure 18. Installed Price of Residential & Commercial PV According to System Size (≤10 kW)

To a limited extent, the economies of scale exhibited in Figure 17 and Figure 18 help to explain the long-term decline in median installed prices shown previously in Figure 7 for systems in the ≤10 kW, 10-100 kW, and >100 kW size ranges. As Table 2 shows, median system sizes have risen over time within each of those size ranges, though by varying degrees. Among ≤10 kW systems, in particular, the long-term trend towards increasing median system sizes, from 2.4 kW in 1998 to 5.2 kW in 2012, likely contributed to the installed price decline over that period of time, given the significant scale economies within that range of system sizes. For the other two system size groups, however, the growth in median system sizes was relatively modest and uneven, and is unlikely to have had any material influence on the observed price declines over time, given the declining returns to scale at larger system sizes.

Table 2. Median System Sizes over Time

System Size	Installation Year														
	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
≤10 kW	2.4	2.3	2.3	2.8	3.0	3.0	3.0	3.7	3.9	4.2	4.0	4.5	4.9	4.9	5.2
10-100 kW	-	-	-	12	12	12	14	16	14	14	15	14	14	15	14
>100 kW	-	-	-	-	205	233	238	179	232	249	268	250	237	270	258

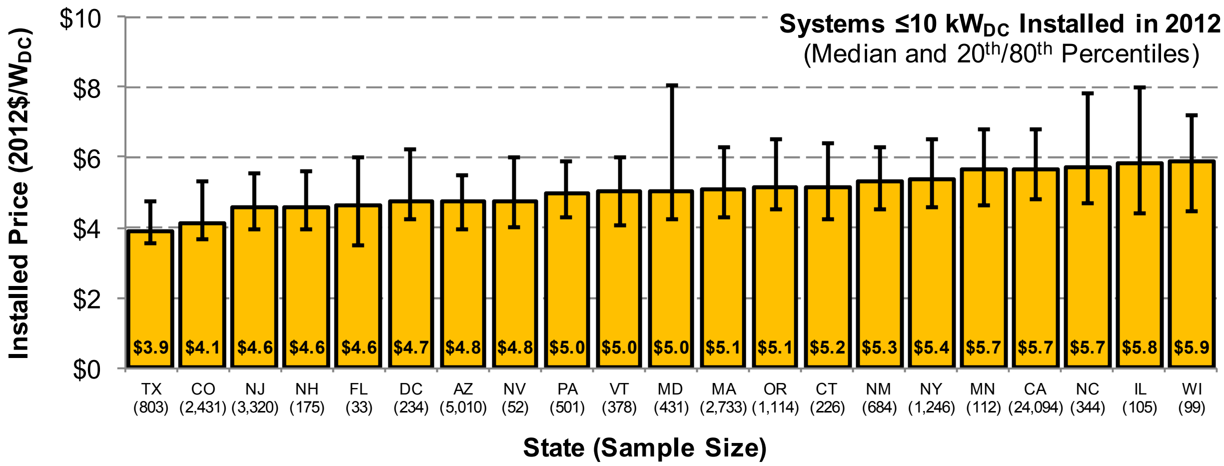
Notes: Median system sizes are shown here only if 15 or more observations are available for the corresponding size range. See Table B-2 for sample sizes by installation year for each system size range.

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 market conditions, Figure 19 through Figure 21 compare median installed prices across the states represented within the data sample, focusing on systems installed in 2012 (see Table B-3 in the Appendix for time series data on median installed prices by state).[26] The figures include only those states with at least 15 systems installed in 2012 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.

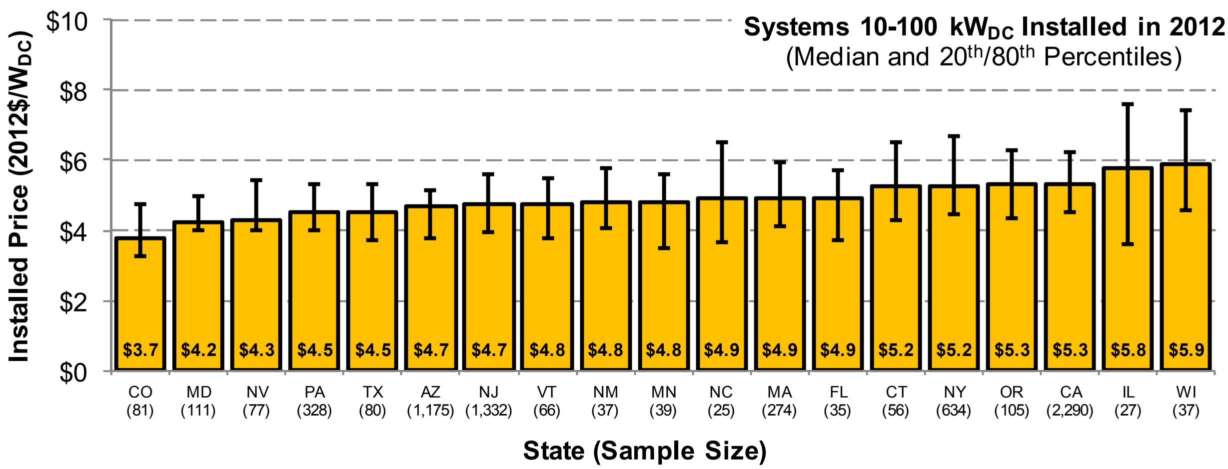
Within all three system size ranges, substantial differences in median installed prices can be observed across states. For systems ≤10 kW in size, median installed prices range from a low of \$3.9/W in Texas to a high of \$5.9/W in Wisconsin. Within the 10-100 kW size range, median installed prices range from \$3.7/W in Colorado to \$5.9/W in Wisconsin. Finally, for systems >100 kW, median installed prices range from \$3.2/W in Colorado to \$6.1/W in Arizona. Within all three size categories, California is a relatively high-cost state (as asserted previously), thereby pulling installed price statistics for the entire country upward owing to its large fractional share of the sample. Notwithstanding the potential significance of these cross-state differences in installed prices, it is again also important to observe the substantial pricing variation *within* each state; in many cases, that intra-state variability is at least as wide as the cross-state differences.

[26] 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.



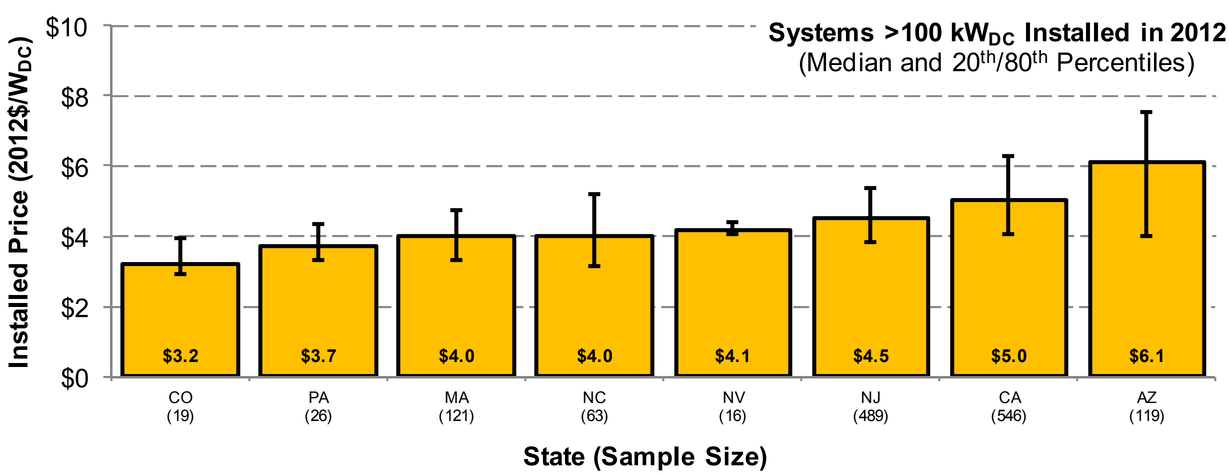
Notes: Median installed prices are shown only if 15 or more observations were available for a given state.

Figure 19. 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 20. 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 21. Installed Price of Residential & Commercial PV Systems by State (>100 kW Systems)

Differences in installed prices across states reflect an array of potential underlying drivers.[27] Larger or more mature state and regional PV markets can facilitate lower prices through greater competition and efficiency, more extensive bulk purchasing, and better access to low-cost products. That said, a strong correlation is not always evident between state market size and installed system prices – as evident by the relatively high installed prices in California, the country's largest state market – demonstrating that other factors also clearly play an important role. For example, states 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 across states also likely derives from differences in administrative and regulatory compliance costs (e.g., incentive applications, permitting, and interconnection) as well as differences in labor wages. State-level price variation can also arise from differences in the characteristics of the systems installed in each state, such as typical system size and the prevalence of tracking equipment, as well as differences in the make-up of the PV customer base.[28] For example, in California, roughly 50% of all non-residential PV systems installed in 2012 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 subsequently section). Finally, differing sales tax rates, which range from zero in Oregon and New Hampshire to a greater-than 9% average sales tax rate in California, and the fact that 12 of the 21 states represented in the figures exempt PV systems from state sales tax, translate to installed price differences of as much as $0.4/W across states.

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 roughly 60% of all systems installed in 2012 within our raw data sample.[29] 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

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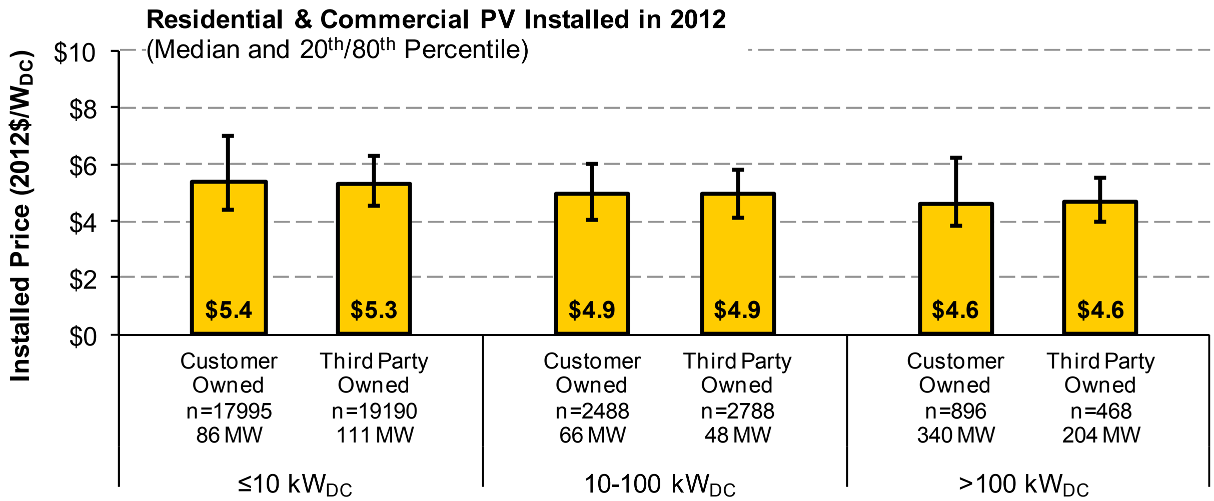
[27] Berkeley Lab is currently engaged in a study that will seek to better understand and quantify the underlying drivers for installed price variation across states.

[28] See Table B-3 in the Appendix for median system sizes by state.

[29] The penetration of third-party ownership varies significantly across customer segments. Among 2012 installations in the raw data sample, 65% of residential systems, 41% of systems hosted by tax-exempt customers, and 17% hosted by for-profit commercial customers are third-party owned. These percentages, as well as the value cited within the main body of the text, were derived prior to eliminating appraised value systems from the data sample.

cash sale transaction.[30] 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 4, which demonstrates the importance of having removed appraised value systems). In total, roughly 20,000 appraised value systems were removed from the data sample, including more than 10,000 systems installed in 2012 (see Appendix A for details on the screening method).

Focusing on the TPO systems retained in the data sample, Figure 22 and Table 3 compare reported installed prices between those TPO systems and customer owned systems. As shown, median installed prices for the two groups in 2012 are nearly identical across each of the three size categories shown, while prior to 2012, median installed prices for ≤10 kW TPO systems were modestly ($0.1/W to $0.4/W) lower than similarly sized customer-owned systems. The growing prominence of TPO models therefore does not appear to have had any substantial direct effect on the overall median installed price trends presented within this report (given that appraised value systems have largely been eliminated from the sample). The distribution of installed prices among TPO systems, however, is somewhat narrower than for customer owned systems, as indicated by the percentile bands in Figure 22. This reflects the fact that customer finance providers often purchase bundles of systems at a standard price from EPC contractors (as well as the likelihood that finance providers are better-informed buyers than a typical host customer, and thus less likely to overpay).



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

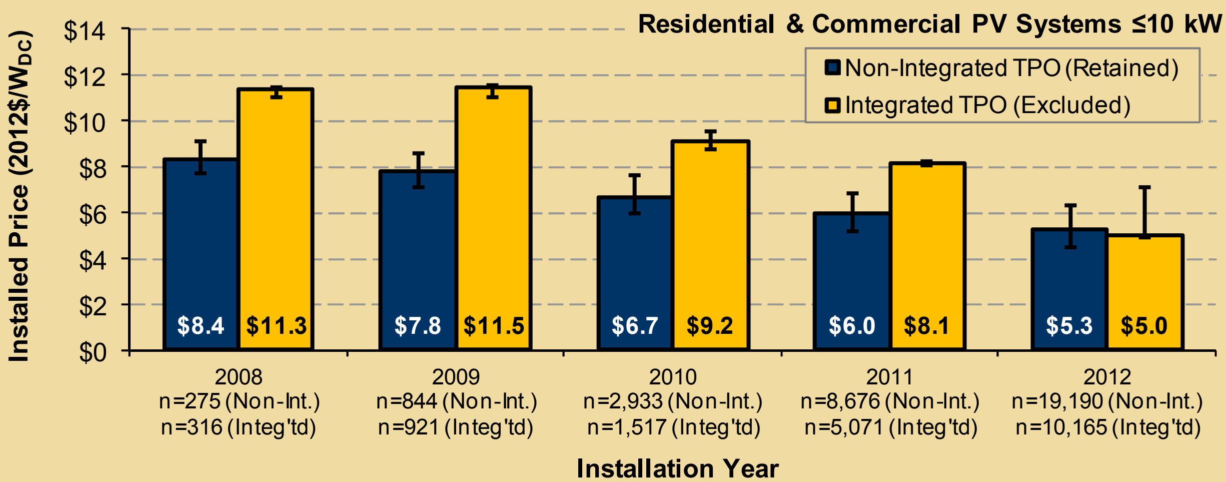
Figure 22. Installed Prices Reported for Host Customer Owned vs. Third Party Owned PV Systems

[30] 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.

Text Box 4. 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 23 compares reported installed prices between TPO systems that were otherwise excluded from the data sample (i.e., TPO systems financed by *integrated* providers) and TPO systems retained in the data sample (i.e., financed by non-integrated providers). For simplicity, the figure focuses on systems ≤10 kW, for the period from 2008 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 value that was used as the basis for the reported installed price was the same assessed "fair market value" as was 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).[31,32] 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 diminished.



Notes: The data for integrated TPO systems are included in this figure but excluded throughout all other elements of this report. The data reported here represent installed prices reported to state and utility PV incentive programs, which may differ from the installed prices 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 23. Installed Prices Reported for Integrated and Non-Integrated TPO PV Systems

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[31] 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.

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

Table 3. Median Installed Prices of Customer Owned vs. Third Party Owned PV over Time (2012$/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
2008	$8.6 (n=10142)	$8.4 (n=275)	$8.2 (n=1050)	$8.3 (n=70)	$7.6 (n=137)	$7.5 (n=162)
2009	$8.3 (n=17005)	$7.8 (n=844)	$7.9 (n=1862)	$7.8 (n=146)	$7.6 (n=200)	$7.8 (n=85)
2010	$7.1 (n=20739)	$6.7 (n=2933)	$6.7 (n=2771)	$6.6 (n=363)	$5.8 (n=365)	$5.6 (n=86)
2011	$6.4 (n=20626)	$6.0 (n=8676)	$5.7 (n=2823)	$5.7 (n=979)	$5.1 (n=660)	$4.9 (n=278)
2012	$5.4 (n=17995)	$5.3 (n=19190)	$4.9 (n=2488)	$4.9 (n=2788)	$4.6 (n=896)	$4.6 (n=468)

Increasing Penetration of Microinverters Has Dampened the Installed Price Decline for Small Systems but Has Had No Material Impact for Large Systems

Microinverters have made significant gains in market share in recent years owing in large part to their performance advantages relative to standard central string inverters, with one recent study estimating 4-12% higher annual energy production (Deline et al. 2012).[33] Those performance gains, however, come at some cost, with microinverter prices in 2012 exceeding standard residential inverter prices by roughly $0.3/W and standard commercial inverter prices by $0.4/W (SEIA/GTM 2013a). Microinverters may also either increase or decrease certain balance of systems or soft costs, such as installation labor and system design.

In order to understand the net impact of these underlying cost differences on the final installed price of PV systems, Figure 24 compares the installed price of systems with microinverters to those with central inverters, focusing on 2012 installations, and Table 4 presents time series data for the 2008 to 2012 period. The figure and table focus only on systems ≤10 kW and 10-100 kW, for which the 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, over the past two years at least, the median installed price of systems in the ≤10 kW size with microinverters has been notably higher than for systems with standard central inverters, with a difference of $0.4/W (8%) in 2012 and a similar amount in 2011. One implication is that the considerable growth in microinverters as a share of the data sample for systems in this size range – from 4% in 2009 to 28% in 2012 – has put some modest degree of upward pressure on the installed price of small systems. In addition, the fact that the installed price differential is similar to the price premium for the microinverter, itself, suggests that aggregate non-inverter BOS and soft costs are roughly equivalent between systems in this size range with microinverters and those with central inverters.[34]

In contrast, among 10-100 kW systems, the installed price differential between microinverter and central inverter systems over the past two years has been considerably smaller – and, in 2012,

[33] Performance gains from microinverters are associated primarily with their 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.

[34] Although the data do not permit exploration of this question, it is conceivable that installers may 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 this is the case, the fact that aggregate non-inverter BOS and soft costs are similar between systems with microinverters and those with central inverters would suggest that microinverters may deliver some net savings on non-inverter BOS and soft costs.

systems with microinverters had a moderately lower median installed price. The increasing market share of microinverters within this size class therefore likely has not had any material impact on the overall installed price trajectory, and the fact that the installed price differential between microinverter and central inverter systems is negligible suggests that microinverters may deliver net BOS/soft cost savings that fully offset the higher inverter costs. Given the small sample sizes within this size range, however, these conclusions must be considered only provisional.

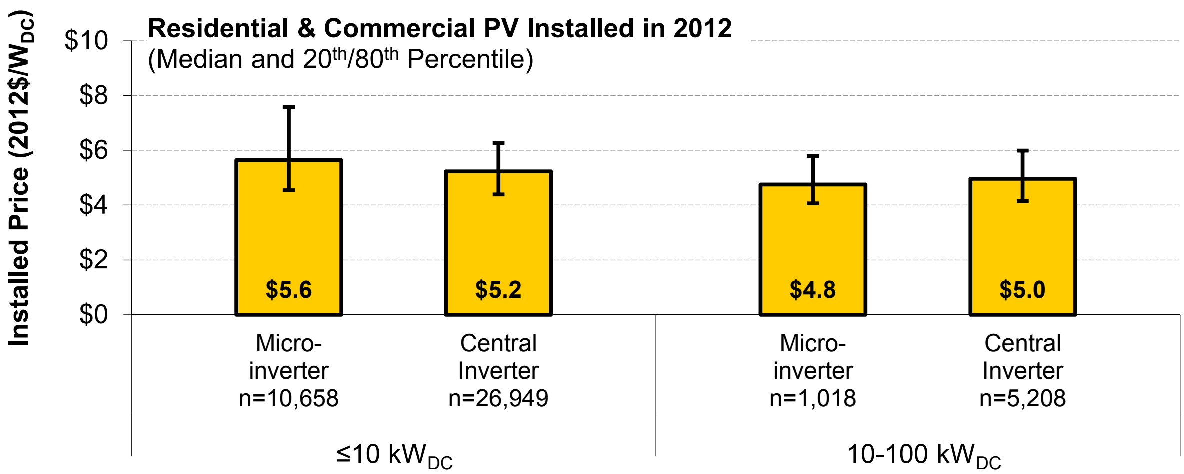


Figure 24. Installed Price Differences between Systems with Microinverters and Central Inverters

Table 4. Median Installed Prices of Microinverter vs. Central Inverter PV Systems over Time (2012$/W)

Installation Year	≤10 kW		10-100 kW	
	Microinverter	Central Inverter	Microinverter	Central Inverter
2008	$8.5 (n=38)	$8.6 (n=9689)	* (n=4)	$8.3 (n=1043)
2009	$8.1 (n=706)	$8.2 (n=16849)	$7.3 (n=52)	$7.9 (n=1975)
2010	$7.0 (n=3789)	$7.0 (n=22276)	$6.5 (n=390)	$6.6 (n=3711)
2011	$6.6 (n=7566)	$6.1 (n=23602)	$5.7 (n=720)	$5.7 (n=4418)
2012	$5.6 (n=10658)	$5.2 (n=26949)	$4.8 (n=1018)	$5.0 (n=5208)

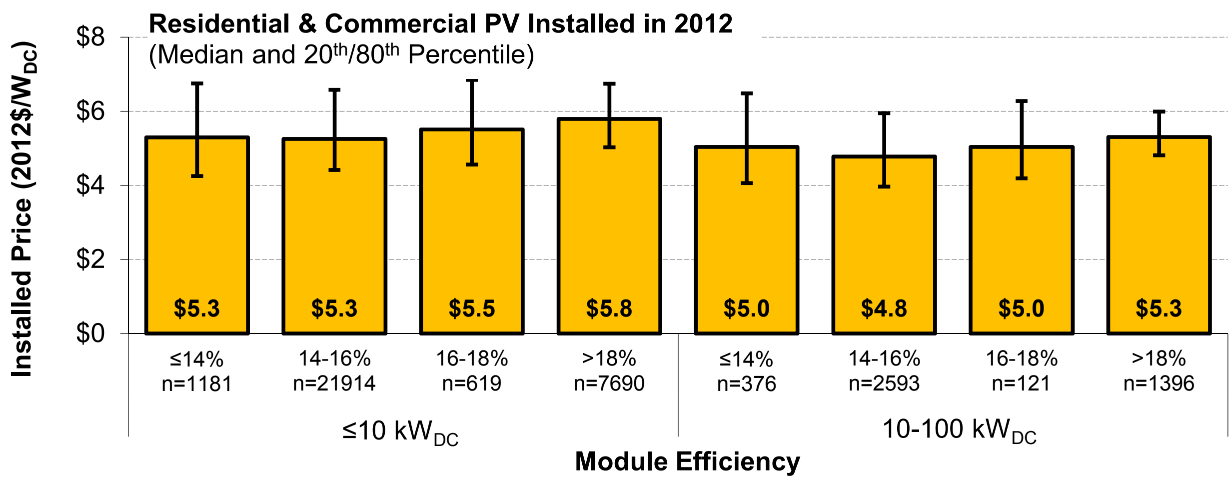
Notes: Results are omitted (*) if fewer than 15 observations are available.

Installed Prices Are Moderately 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 polysilicon modules, though the distribution of module efficiency levels has shifted over time as module efficiencies have increased across all technology types.

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; at the same time, however, high-efficiency modules are typically more expensive. To examine the net effect of these opposing cost drivers, Figure 25 compares installed prices according to module efficiency for systems installed in 2012, and Table 5 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. The price differential between systems with >18% modules and those with module efficiencies in the 14-16% range was roughly $0.5/W in 2012 and was somewhat larger in prior years. This trend suggests that the cost premium for high-efficiency modules has, thus far at least, generally outweighed associated 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. As the next section shows, however, this explanation is not borne out by the data, which show that the installed price of systems with Chinese vs. non-Chinese modules are similar when comparing within a given module efficiency range.



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 25. Installed Price Variation with Module Efficiency

Table 5. Median Installed Prices According to Module Efficiency over Time (2012$/W)

Installation Year	≤10 kW				10-100 kW			
	≤14%	14-16%	16-18%	>18%	≤14%	14-16%	16-18%	>18%
2008	$8.3 n=2,937	$8.2 n=650	$8.8 n=2,317	$8.8 n=678	$8.0 n=372	$8.1 n=52	$8.6 n=241	$8.6 n=88
2009	$7.9 n=5,999	$7.6 n=1,779	$8.5 n=2,286	$8.6 n=3,235	$7.6 n=603	$7.3 n=228	$8.2 n=244	$8.3 n=411
2010	$6.9 n=8,071	$6.5 n=7,827	$7.4 n=2,278	$7.7 n=2,930	$6.5 n=1,187	$6.4 n=1,195	$7.3 n=276	$7.4 n=416
2011	$6.2 n=4,656	$6.0 n=14,946	$6.8 n=871	$6.9 n=4,670	$5.7 n=850	$5.6 n=2,052	$6.5 n=138	$6.2 n=482
2012	$5.3 n=1,181	$5.3 n=21,914	$5.5 n=619	$5.8 n=7,690	$5.0 n=376	$4.8 n=2,593	$5.0 n=121	$5.3 n=1,396

Systems with Chinese-Brand Modules Generally Have Lower Installed Prices than Other Systems, But Not If Comparing Among Similar Module Efficiencies

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 over recent years, contributing to steep reductions in global module selling prices. In addition, Chinese-brand modules are generally somewhat lower-priced than modules manufactured in Europe, the United States, or Japan. Module spot market price indices published by UBS, for example, peg recent prices for Chinese modules at roughly \$0.2/W to \$0.3/W below those for EU/US/Japanese brands (Meymandi and Chin 2013). 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 26 compares the installed price of systems with Chinese and Non-Chinese modules installed in 2012, and Table 6 presents the corresponding time series data. As shown, the relationships differ critically depending on whether one controls for module efficiency. Across all module efficiencies, installed prices are modestly lower for systems with Chinese-brand modules, with an installed price differential of \$0.3/W to \$0.4/W among 2012 systems, depending on system size, and somewhat larger differences in prior years. This gap in system installed prices is roughly on par with 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 has generally be negligible (and of inconsistent direction). In other words, among systems employing standard-efficiency polycrystalline modules, there is no clear difference in installed prices between those with Chinese-brand modules and those with non-Chinese modules. Collectively, these results suggest that the increasing prevalence of Chinese-brand modules may have contributed modestly to installed price reductions in the United States, but only to the extent that Chinese-brand modules displaced higher efficiency non-Chinese brands.

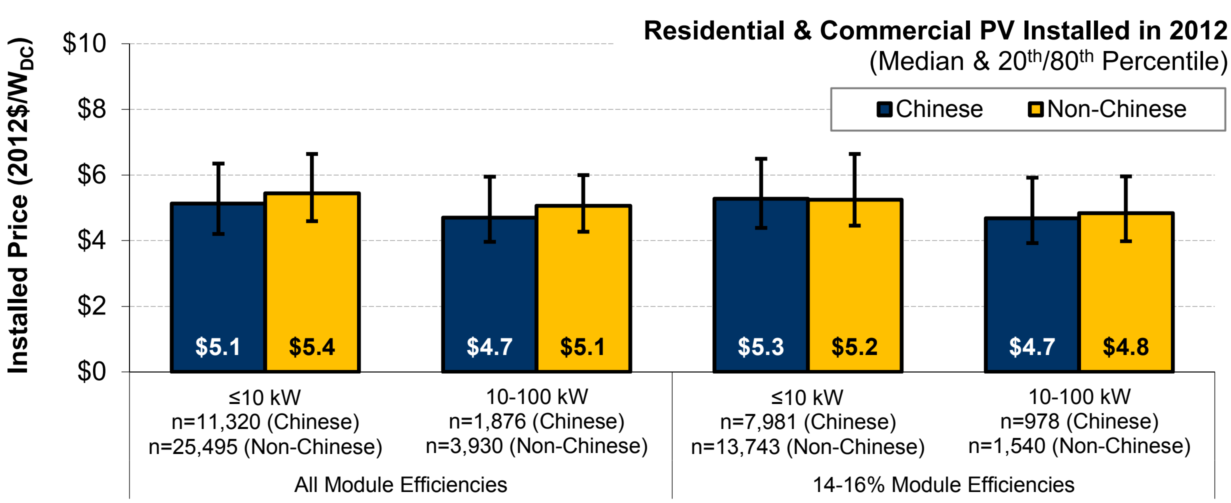


Figure 26. Installed Price of PV Systems with Chinese vs. Non-Chinese Modules

Table 6. Median Installed Prices of PV Systems with Chinese vs. Non-Chinese Modules over Time (2012$/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
2008	$8.4 (n=1137)	$8.5 (n=8945)	$8.0 (n=127)	$8.3 (n=1092)	$7.7 (n=28)	$8.3 (n=619)	* (n=1)	$8.0 (n=51)
2009	$7.8 (n=3569)	$8.3 (n=14365)	$7.5 (n=374)	$8.0 (n=1720)	$7.9 (n=338)	$7.5 (n=1428)	$7.3 (n=69)	$7.2 (n=158)
2010	$6.6 (n=6159)	$7.1 (n=19633)	$6.3 (n=1183)	$6.8 (n=2917)	$6.4 (n=2016)	$6.5 (n=5742)	$6.1 (n=370)	$6.4 (n=813)
2011	$6.0 (n=9355)	$6.3 (n=21041)	$5.4 (n=1732)	$5.9 (n=3149)	$6.1 (n=5476)	$6.0 (n=9388)	$5.5 (n=747)	$5.7 (n=1283)
2012	$5.1 (n=11320)	$5.4 (n=25495)	$4.7 (n=1876)	$5.1 (n=3930)	$5.3 (n=7981)	$5.2 (n=13743)	$4.7 (n=978)	$4.8 (n=1540)

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

Figure 27 and Table 7 compare median installed prices across three host-customer sectors: residential, commercial (for-profit), and tax-exempt (i.e., government, schools, and non-profit). The figure focuses specifically on systems installed in 2012, while the table provides a time series comparison for the period 2008 to 2012. Note that, for the purpose of this section only, a distinction is made between commercial/for-profit host customers and tax-exempt host customers; elsewhere both are included within the general "commercial" designation.

In general, differences across host customer segments within each size range are relatively small. The most consistent trend, both across system sizes and over time, is that tax-exempt systems generally have higher installed prices than similarly sized residential and commercial systems. Among 2012 systems, specifically, the median price of systems hosted by tax-exempt customers was $0.3/W to $0.8/W higher than residential and commercial systems within each size range, with the most sizeable disparity occurring among >100 kW systems. 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, and more complex government procurement processes. In addition, a relatively high proportion of 2012 systems hosted by tax-exempt customers were installed in California (49%), compared to the proportion of commercial systems in California (17%), and as previously noted, installed prices are generally higher in California.

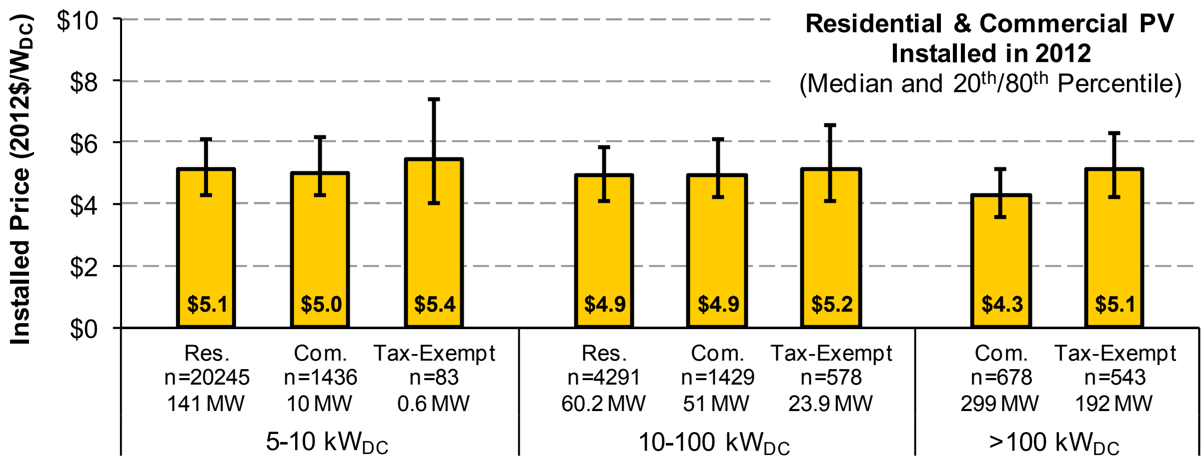


Figure 27. Installed Price Variation across Host Customer Sectors

Table 7. Median Installed Price by Host Customer Sector over Time (2012$/W)

Installation Year	5-10 kW			10-100 kW			>100 kW	
	Residential	Commercial	Tax-Exempt	Residential	Commercial	Tax-Exempt	Commercial	Tax-Exempt
2008	$8.4 (n=3771)	$8.7 (n=166)	$8.4 (n=50)	$8.2 (n=708)	$8.2 (n=374)	$8.5 (n=130)	$7.4 (n=254)	$9.4 (n=60)
2009	$7.9 (n=8509)	$8.5 (n=218)	$8.6 (n=53)	$7.8 (n=1569)	$8.2 (n=609)	$8.4 (n=175)	$7.5 (n=189)	$7.9 (n=109)
2010	$6.7 (n=14231)	$6.8 (n=321)	$6.9 (n=70)	$6.6 (n=3062)	$6.7 (n=1040)	$7.0 (n=440)	$5.7 (n=289)	$5.9 (n=146)
2011	$5.9 (n=15912)	$5.7 (n=440)	$5.8 (n=92)	$5.7 (n=3367)	$5.8 (n=1189)	$5.7 (n=604)	$4.8 (n=520)	$5.3 (n=369)
2012	$5.1 (n=20245)	$5.0 (n=1436)	$5.4 (n=83)	$4.9 (n=4291)	$4.9 (n=1429)	$5.2 (n=578)	$4.3 (n=678)	$5.1 (n=543)

Residential New Construction Offers Potential 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 28 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 2-4 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 installed price differences between rack-mounted and building-integrated PV within residential new construction.

As evident within Figure 28, 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, from $0.2/W to

$1.1/W, with a difference of $0.7/W in 2012. Some caution is warranted in generalizing from these trends, both because of the small sample size of residential new construction systems 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 electrician or roofer and is invoiced as part of a larger job.

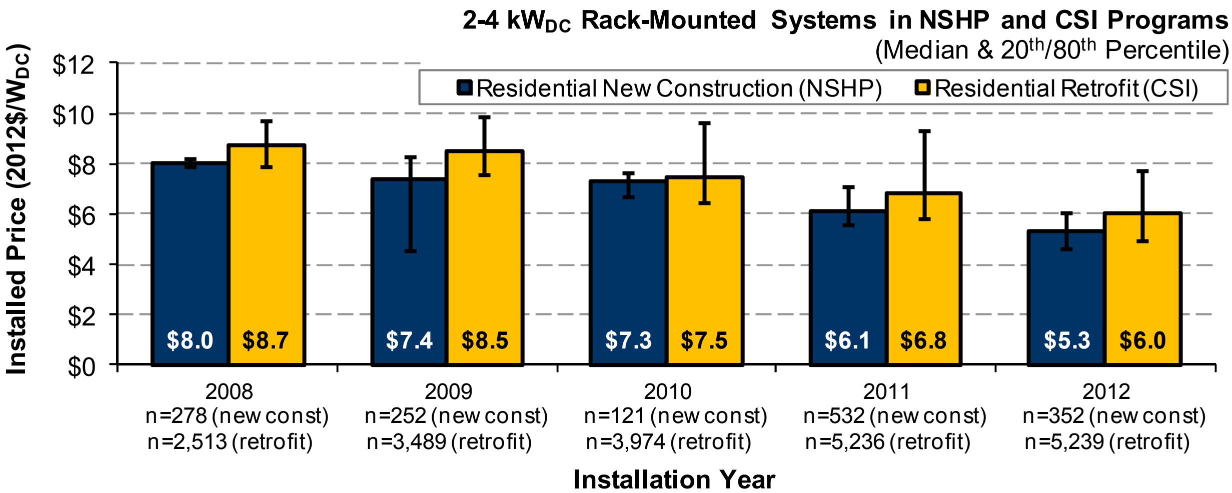


Figure 28. Installed Price of Residential Retrofit vs. New Construction

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.[35]

As a measure of the net impact of these countervailing factors, Figure 29 compares the installed price of BIPV and rack-mounted systems in residential new construction. This figure again focuses specifically on 2-4 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 ranging from $0.7/W to $2.3/W over the five-year period. Note, though, that by focusing on just the installed price of the PV system, 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

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

systems, nor do they account for performance differences between BIPV and rack-mounted systems that may impact LCOE.

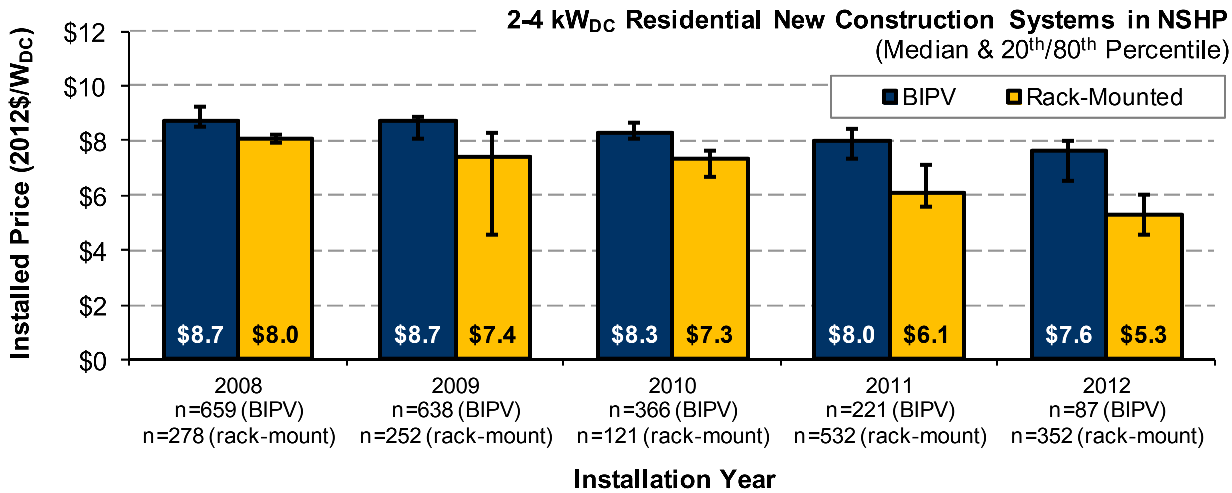


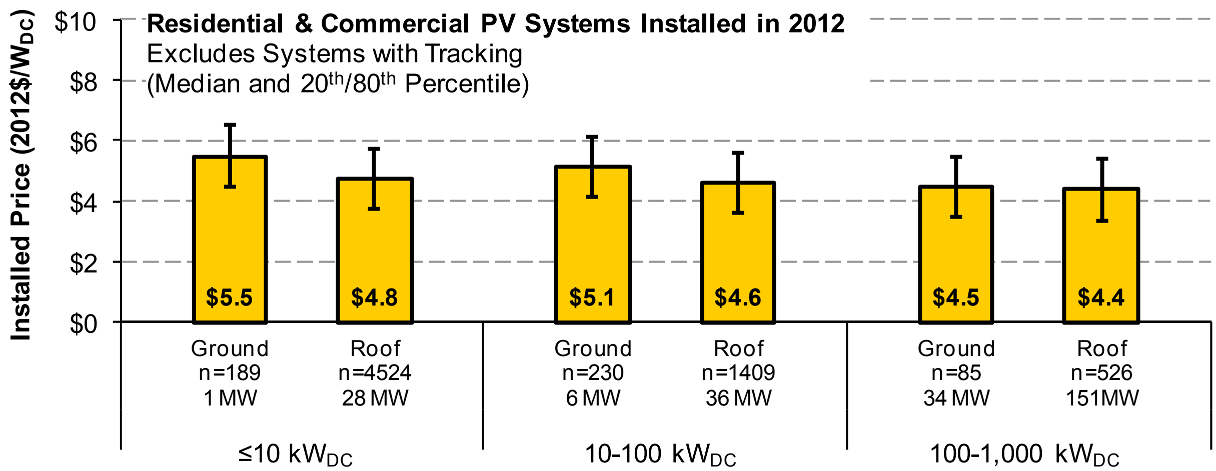
Figure 29. Installed Price of BIPV vs. Rack-Mounted Systems in Residential New Construction

Ground-Mounted Systems Smaller than 1 MW Have Higher Installed Prices than Similarly Sized Roof-Mounted Systems

While residential and commercial PV systems are primarily roof-mounted, a modest number of ground-mounted systems exist among the relatively small subsample of systems in the dataset for which data on mounting location (roof vs. ground) are available. Figure 30 and Table 8 compare installed prices between these roof- and ground-mounted systems, focusing on systems less than 1,000 kW (1 MW) in size and limited to only fixed-tilt systems (i.e., excluding systems with tracking). A similar comparison of roof- vs. ground-mounted systems larger than 1,000 kW is contained within Section 4, which incorporates data for utility-scale projects.

Although the sample sizes are small, Figure 30 and Table 8 show that ground-mounted systems within the size ranges shown exhibit a consistently higher median installed price than comparably sized roof-mounted systems, with the largest price differentials generally occurring among smaller systems. (As the later section on utility-scale projects demonstrates, the same trend does not necessarily exist among projects > 1,000 kW.) In 2012, for example, the median installed price of ground-mounted systems exceeded that of roof-mounted systems by $0.7/W for systems ≤10 kW, $0.5/W for systems 10-100 kW, and $0.1/W for systems 100-1,000 kW. The price differentials in preceding years vary to some degree but are generally consistent with those observed in 2012. The higher installed price of ground-mounted projects in these size ranges may be offset, to some degree, by higher performance – if, for example, ground-mounted projects are able to be more optimally oriented, which may be an issue particularly for residential systems where roof orientations and space constraints can force sub-optimal designs.

The higher installed price of ground-mounted systems 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 30. Installed Price of Ground- vs. Roof-Mounted Systems

Table 8. Median Installed Price of Ground- vs. Roof-Mounted Systems over Time (2012$/W)

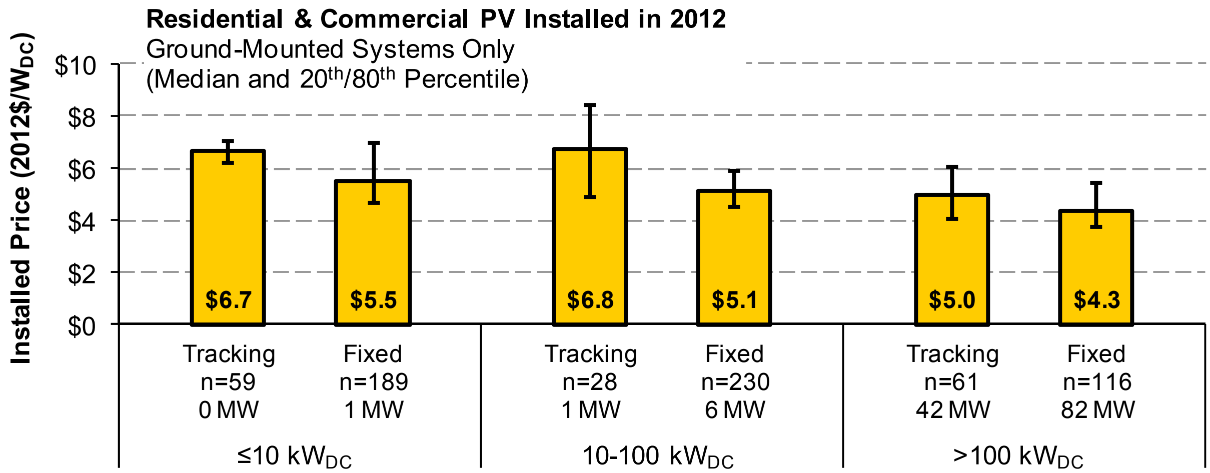
Installation Year	≤10 kW		10-100 kW		100-1,000 kW	
	Ground-Mounted	Roof-Mounted	Ground-Mounted	Roof-Mounted	Ground-Mounted	Roof-Mounted
2008	$9.5 (n=69)	$8.7 (n=703)	$9.0 (n=24)	$8.5 (n=117)	* (n=2)	$8.7 (n=17)
2009	$8.7 (n=95)	$8.4 (n=1267)	$8.5 (n=41)	$8.2 (n=236)	* (n=8)	$7.5 (n=58)
2010	$7.9 (n=152)	$7.1 (n=2670)	$7.3 (n=101)	$6.5 (n=703)	$5.8 (n=18)	$5.3 (n=164)
2011	$6.4 (n=197)	$6.0 (n=4299)	$5.6 (n=199)	$5.6 (n=1246)	$5.3 (n=35)	$4.8 (n=360)
2012	$5.5 (n=189)	$4.8 (n=4524)	$5.1 (n=230)	$4.6 (n=1409)	$4.5 (n=85)	$4.4 (n=526)

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 Notably Higher Installed Prices than Fixed-Tilt Systems

Although tracking equipment is most typically associated with large utility-scale PV projects, a small portion of the residential and commercial PV systems within the data sample include tracking equipment. Figure 31 and Table 9 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 mounting location (roof vs. ground).

As to be expected, systems with tracking equipment exhibit consistently higher installed prices than their fixed-tilt counterparts, with the largest differentials occurring for smaller systems. Among systems installed in 2012, the median installed price premium for tracking systems ranges from $0.7/W to $1.7/W (or 15% to 32%) higher than fixed-tilt, ground-mounted systems, across the three size ranges shown. Installed price differences in previous years are generally similar in magnitude, though the trends are somewhat volatile given the small underlying sample sizes. 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, which is roughly within the same range as the installed price differential.



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.

Figure 31. Installed Price of Tracking vs. Fixed-Tilt, Ground-Mounted Systems

Table 9. Median Installed Price of Tracking vs. Fixed-Tilt, Ground-Mounted Systems over Time (2012$/W)

Installation Year	≤10 kW		10-100 kW		>100 kW	
	Tracking	Fixed-Tilt	Tracking	Fixed-Tilt	Tracking	Fixed-Tilt
2008	$10.2 (n=44)	$9.5 (n=69)	* (n=9)	$9.0 (n=24)	$7.6 (n=21)	* (n=2)
2009	$10.2 (n=73)	$8.7 (n=95)	* (n=7)	$8.5 (n=41)	$7.7 (n=35)	* (n=9)
2010	$9.2 (n=93)	$7.9 (n=152)	$8.1 (n=21)	$7.3 (n=101)	$6.4 (n=22)	$5.7 (n=26)
2011	$8.1 (n=123)	$6.4 (n=197)	$7.1 (n=31)	$5.6 (n=199)	$5.1 (n=30)	$5.1 (n=54)
2012	$6.7 (n=59)	$5.5 (n=189)	$6.8 (n=28)	$5.1 (n=230)	$5.0 (n=61)	$4.3 (n=116)

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 190 projects installed through year-end 2012. As indicated previously, utility-scale PV is defined for the purpose of this analysis to consist of ground-mounted systems >2 MW, irrespective of whether the systems are interconnected on the utility-side or customer-side of the meter. Note also that the utility-scale PV projects sample includes only *fully operational* projects for which all individual phases are in operation; for the purpose of our analysis, separate project phases are not treated as individual projects.

The section begins by describing the range in the installed price of the utility-scale systems in the data sample and trends over time, before describing differences in installed prices according to project size and system configuration (crystalline fixed-tilt vs. crystalline tracking vs. thin-film fixed-tilt), and then comparing the installed price between utility-scale systems and similarly sized large commercial rooftop systems. Other aspects of utility-scale solar projects, including not only installed price, but also operating costs, capacity factors, and PPA prices, will be examined in a forthcoming LBNL companion report.

The utility-scale installed price data presented in this section must be interpreted with the following considerations in mind.

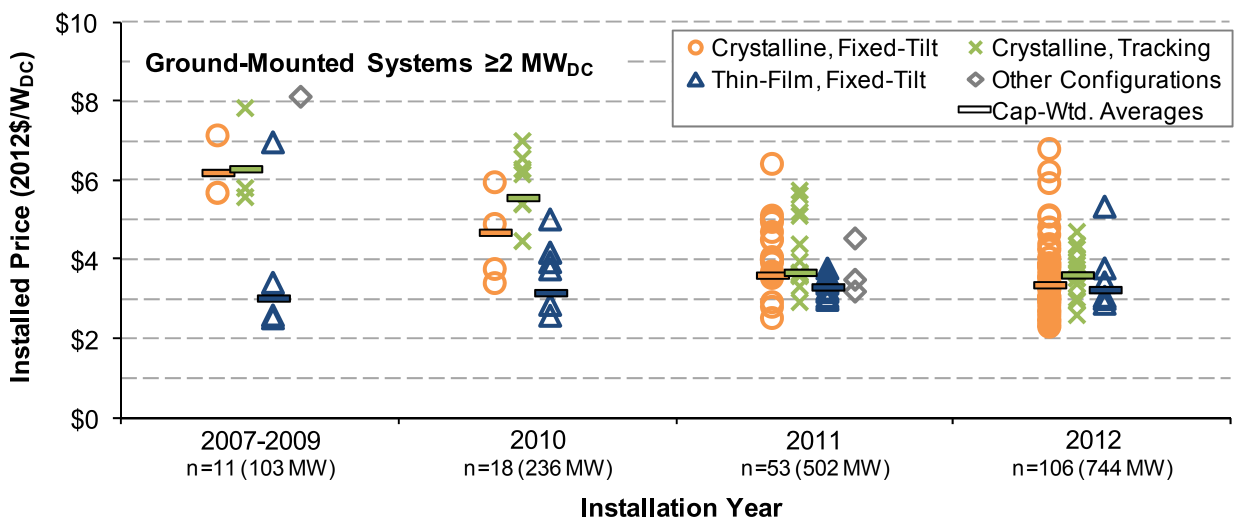
- *Small sample size including atypical utility PV projects*. The utility-scale PV project sample generally reflects the population of projects that had been constructed in the United States through year-end 2012. As such, the sample is relatively small, and it includes a large number of systems in the 2-10 MW size range as well as a number of "one-off" projects with atypical characteristics (e.g., brownfield developments, projects built to withstand hurricane winds, etc.). All else being equal, the installed price of these small or otherwise atypical utility-scale projects is likely to be higher than that of prototypical large utility-scale PV projects.
- *Lag in component pricing and market conditions.* Reported installed prices for utility-scale projects often reflect transactions (e.g., EPC contracts or PPAs) that occurred one or more years before project completion. In some cases, those transactions may have been negotiated on a forward-looking basis, reflecting anticipated costs at the time of project construction. In other cases, the transactions may have been based on contemporaneous component pricing (or a conservative projection of component pricing), in which case the installed price data may not fully capture recent reductions in module costs or other changes in market conditions.
- *Reliability of data sources*. The installed price data for utility-scale PV projects are derived from varied sources and, in some instances, are arguably less reliable than the data presented for residential and commercial systems.
- *Focus on installed price rather than levelized cost*. It is worth repeating again that focusing on upfront installed price trends ignores performance-related differences and other factors influencing the levelized cost of electricity (LCOE), which is ultimately the more meaningful metric for comparing the cost of utility-scale PV systems.

For the above reasons and others (see Text Box 1), the data presented here may not correspond to recent price benchmarks for utility PV.

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

Figure 32 distinguishes among utility-scale systems according to system configuration (crystalline vs. thin-film modules and fixed-tilt vs. tracking). Among crystalline, fixed-tilt systems installed in 2012, the capacity-weighted average installed price was $3.3/W.[36] This compares to $3.6/W for crystalline systems with tracking and $3.2/W for thin-film, fixed tilt systems (though the sample sizes for these latter two configurations are relatively small). Importantly, these capacity-weighted averages represent only central tendencies; as with residential and commercial PV, the installed price of utility-scale PV systems also varies widely. Among the 106 projects in the sample completed in 2012, for example, installed prices ranged from $2.3/W to $6.8/W, and similar levels of variability are evident for the other time periods shown. In part, this wide distribution reflects differences in project size (which range from 2 MW to 60 MW for systems installed in 2012) and differences in system configuration, both of which are examined further in the following section.

Discerning a meaningful time trend within the utility-scale data is challenging, given the small and diverse sample of projects, and again bearing in mind the lag between component pricing and other market conditions and the time the system is installed. Focusing again on crystalline fixed-tilt systems, capacity-weighted average prices fell by $2.8/W over the entire historical period shown (noting the small sample size of just two systems in the 2007-2009 period). Those price reductions slowed considerably within the last year of the analysis period, with just a $0.2/W decline from 2011 to 2012 (not unlike the $0.3/W decline for >100 kW commercial systems shown earlier in the report in Figure 7). A similar pattern and magnitude of installed price declines is also observed among crystalline systems with tracking, for which the capacity-weighted average installed price fell by $2.7/W over the entire historical period, but by only $0.1/W from 2011 to 2012. Among thin-film systems, however, capacity-weighted average installed prices have remained largely unchanged over time, and in fact were $0.2/W higher in 2012 than during the 2007-2009 period.



Notes: Other Configurations includes a thin-film system with tracking, two systems with silicon ribbon modules, and a system with a combination of fixed and tracking arrays.

Figure 32. Installed Price of Utility-Scale PV over Time

[36] For utility-scale PV, we use capacity-weighted averages rather than median values (as was used for residential and commercial systems), owing to the large number of relatively small (2-5 MW) systems within the utility-scale PV project data sample but the arguably greater relevance of the larger projects.

Project Size and System Configuration Impact the Installed Price of Utility-Scale PV, Though Other Factors Are Also Clearly Important

The wide range of prices noted in the preceding section is partially attributable to differences in project size. As shown in Figure 33, which focuses specifically on projects completed in 2012, the 16 projects larger than 10 MW are clustered within a relatively narrow band, from roughly \$2.5/W to \$4.0/W. In contrast, the installed price distribution for projects smaller than 10 MW has a much longer tail, with roughly 20% of projects priced above \$4.0/W and 5% within the \$5.0/W to \$6.8/W range. Among crystalline, fixed-tilt systems, the capacity-weighted average price of systems >10 MW was \$3.1/W, compared to \$3.5/W for systems ≤10 MW. These project size-based trends undoubtedly reflect underlying scale economies, though other factors also likely contribute (e.g., larger projects may be more likely to be developed by more experienced and/or vertically integrated companies).

Technological differences also contribute, to some extent, to the observed variability in installed prices (noting again that a comparison of installed price ignores associated performance differences that impact LCOE). In particular, and as one would expect, the installed price of systems with tracking is generally higher than that of fixed-tilt systems. This can be seen in Figure 33, where most tracking systems are located above the trendline. Across the full size spectrum of utility-scale projects installed in 2012, the capacity-weighted average installed price of crystalline systems with tracking was \$0.3/W higher than of fixed-tilt crystalline systems (\$3.6/W vs. \$3.3/W), as illustrated previously in Figure 32. Among systems >10 MW, specifically, the installed price differential was somewhat higher, \$0.5/W (\$3.6/W vs. \$3.1/W). In contrast, one can observe in both Figure 32 and Figure 33 the absence of any appreciable difference in average installed prices between thin-film and crystalline systems installed in 2012 (with average prices of \$3.3/W and \$3.2/W, respectively). In earlier years, thin-film systems had significantly lower installed prices than crystalline systems, but those differences eroded in recent years as crystalline silicon module prices precipitously fell.

Notwithstanding the aforementioned trends, it is clear that wide variability exists within each technology class and size range, clearly demonstrating that significant underlying drivers for installed prices exist beyond project size and configuration. These may include, for example, whether projects are built on public vs. private land, whether land is leased or owned, and design requirements associated with specific climatic conditions, among other differences.

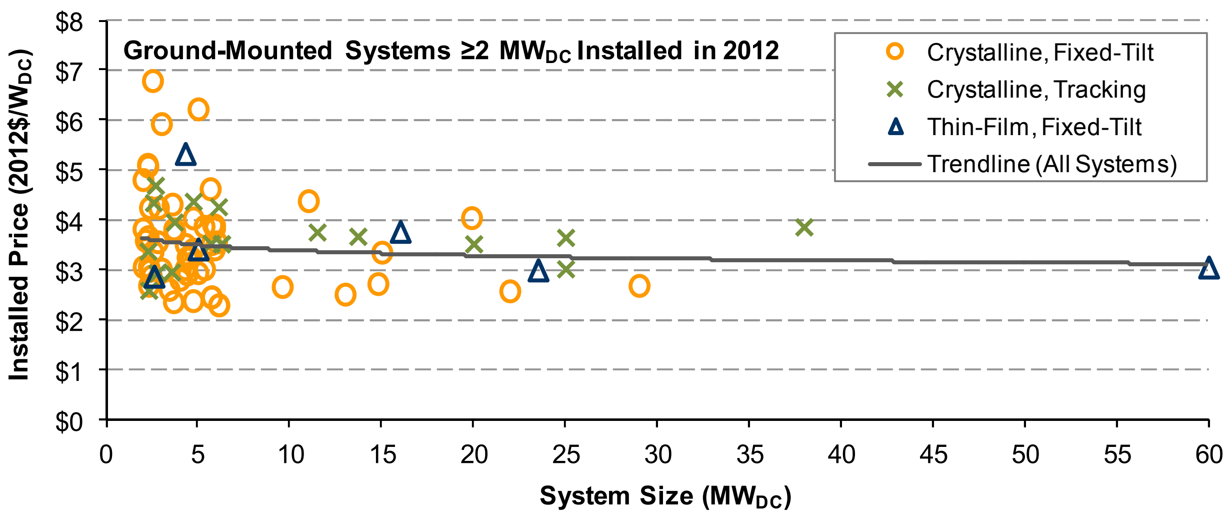


Figure 33. Installed Price of Utility-Scale PV According to System Size and Configuration

Within the 1-5 MW Size Class, Ground-Mounted Systems Had Lower Installed Prices than Roof-Mounted Systems in 2012, But Not in Earlier Years

Section 3 (Figure 30) compared roof-mounted and ground-mounted systems within the residential and commercial market, focusing on systems <1 MW. Recent years, however, have seen the completion of many large, multi-MW roof-mounted commercial systems that are effectively the same size as small utility-scale systems. Figure 34 compares roof-mounted and ground-mounted systems in this size class (1-5 MW specifically) and including only fixed-tilt systems.[37] As shown, among 1-5 MW systems installed in 2012, ground-mounted systems were lower priced than roof-mounted systems, with a difference of $0.7/W in median installed prices ($3.7/W vs. $4.4/W). This result contrasts to the findings among residential and commercial systems shown previously, where ground-mounted systems were found to instead have *higher* installed prices than roof-mounted systems (with a difference of $0.7/W for systems ≤10 kW, $0.5/W for systems 10-100 kW, and $0.1/W for systems 100-1,000 kW).

Any conclusions about the relative installed price of ground-mounted vs. roof-mounted systems in the 1-5 MW size range must be tempered, however, as the observed relationship is not robust over time. As shown in Figure 34, in 2010 and 2011, roof-mounted systems had lower median installed prices than ground-mounted systems. Moreover, the median installed price of roof-mounted systems in this size range actually rose slightly over the three-year period shown, from $4.2/W in 2010 to $4.4/W in 2012. This latter trend lends some cause for caution and suggests that the relationships observed in Figure 34 are perhaps being driven, in part, by idiosyncratic characteristics of the small data sample, rather than fundamental underlying cost and market drivers. The data are therefore somewhat inconclusive as to the relative cost of multi-MW roof-mounted systems compared to similarly sized ground-mounted systems.

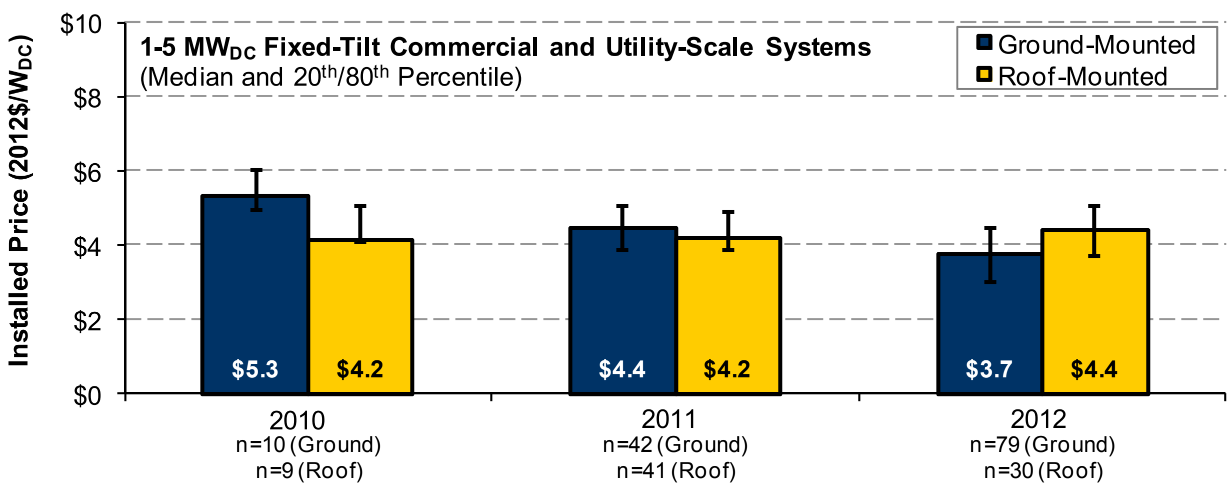


Figure 34. Installed Price of Ground-Mounted vs. Roof-Mounted PV Systems 1-5 MW in Size

[37] Note that for the purposes of this figure only, we've suspended the distinction made elsewhere in this report between utility-scale and commercial systems, and thus the ground-mounted systems include some systems (those that are 1-2 MW in size) that would otherwise be considered commercial scale and some that are considered utility scale (2-5 MW).

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. 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) has declined substantially since 1998, though both the pace and source of those cost reductions have varied over time. Prior to 2005, installed price reductions were associated primarily with a decline in *non-module* costs. Starting in 2005, however, installed price reductions began to stall, as the supply-chain and delivery infrastructure struggled to keep pace with rapidly expanding global demand. Starting in 2008, global module prices began a steep downward trajectory, driving installed price reductions of 40% among residential and commercial installations from 2008 through 2012.

Non-module costs, in contrast, have remained relatively stagnant since 2005. Trends in non-module costs may be particularly relevant in gauging the impact of state and utility PV deployment programs. Unlike module prices, which are primarily established through global markets, non-module costs consist of a variety of cost components 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. Historical non-module costs reductions from 1998-2005 suggest that PV deployment policies have, in the past, succeeded in spurring cost reductions; however, the fact that non-module costs have remained largely unchanged since 2005 highlights the potential need to identify new and innovative mechanisms to foster greater efficiency and competition within the delivery infrastructure.

Preliminary data for California systems installed in the first half of 2013 indicate that installed prices have continued to decline. Notwithstanding this success, further price reductions will be necessary if the U.S. PV industry is to continue its expansion as incentive programs ratchet down financial support. Given the limits to further reductions in module prices, additional deep reductions in installed prices will require significant reductions in soft costs.

Lower installed prices in Germany and other major international markets suggest that deep near-term soft cost reductions in United States are, in fact, possible and may accompany increased market scale. It is also evident, however, 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 have relatively small PV markets. Achieving deep reductions in soft cost may require some combination of incentive policy designs that provide a stable and straightforward value proposition, targeted policies aimed at specific soft costs (for example, permitting and interconnection), and basic and applied research and development.

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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.

Projects Removed from the Data Sample: The raw data received from all PV incentive program administrators initially consisted of 240,633 PV systems installed through 2012. Projects were removed from the data sample under any of the following conditions:

- missing installed price data (3,949 systems) or system size data (912 systems)
- installed price less than \$1.5/W (162 systems) or greater than \$20/W (449 systems)
- systems with battery back-up (151 systems)
- self-installed systems (2,110 systems)
- systems listed within the raw data from multiple PV incentive programs, in which case multiple data records for individual systems were consolidated (8,621 systems)
- systems for which the reported installed price was deemed likely to be an appraised value (19,839 systems).

Additional details on the last two of these conditions are provided below. In total, 32,104 systems from the initial sample were removed from the dataset as a result of the aforementioned screens. (Note that multiple screening conditions apply to some systems, and thus the total number of systems removed is not equal to the sum of the number of systems that satisfy each of the individual conditions.)

Systems in Multiple PV Incentive Programs: 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 4,564 systems listed within both ETO's and OR DOE's programs, 3,935 systems in both the Massachusetts DOER's and the MassCEC's programs, 62 systems within the Florida Energy & Climate Commission's program and either GRU's or OPUC's programs, and 60 systems from the California SGIP and either SMUD's or LADWP's programs.

Identification and Removal of Appraised Value Systems: Following the application of all other screens, systems were then removed from the remaining 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 first based on the reported *installer name* and *system ownership type* (i.e., host customer owned vs. TPO). Those two data fields were provided for 64% of systems in the raw data sample, including the PV incentive programs from most of the major TPO markets (California, New Jersey, Arizona, Massachusetts, and Maryland). For this subset of programs, 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 (18,635 systems). 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. This approach was applied to the 12 programs that provided data only on installer name (18% of systems) and the 3 programs that provided data only on system ownership type (7% of systems). 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 18,635 systems referenced above that were identified as appraised value systems based solely on the combination of installer name and system ownership type. Among those systems, roughly 90% were clustered into fifteen groups with an identical reported installed price.[38] 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:

- The raw data indicated that the installer name is an integrated TPO provider and the system is located in a state/utility service territory that allows TPO or
- The raw data indicated that the system is third party owned.

The price clustering analysis resulted in an additional 1,204 systems being identified as likely appraised value systems, which were then removed from the data sample. Thus, a total of 19,839 systems were removed from the data sample on the basis that the reported installed price was likely an appraised value (18,635 systems based solely on the combination of installer name and system ownership status, plus 1,204 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). This represents roughly 8% of all systems in the raw data sample and 18% of 2012 systems.

It is also worth noting that, in addition to the appraised value price clusters, a sizeable number of additional systems were clustered in other identically priced groups but were not deemed likely to be appraised value and therefore were not removed from the data sample. Many of these price clusters consist of a large number of systems associated with individual large-volume installers (Trinity Heating and Air, Salt River Solar and Wind, Verengo, and several others). Most of these major installers provide installation services for *non-integrated* TPO finance providers (e.g., SunRun). Based on discussions with PV incentive program managers and installers, we believe that these price clusters consist of "batches" of systems sold as a group to non-integrated TPO finance providers, and that the identical reported installed price for systems in those clusters reflects the actual average per-kW price of the transaction between an installer and a non-integrated TPO finance provider. As such, these reported prices do not represent an appraised value, and the systems were therefore retained in the data sample. Other price clusters within the data sample were, instead, associated with "round" numbers (e.g., there were 1,666 systems with a nominal installed price of exactly $6.50/W and 1,567 systems with an installed price of exactly $6.00). Systems in these price clusters typically were dispersed across a large number of different installers and included many known host customer owned systems; they were therefore deemed unlikely to represent appraised values and were retained in the data sample.

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).

[38] In order to identify identically priced systems, we relied on reported installed price data in *nominal* dollar values, rounded to three decimal places.

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[39] and the California Solar Initiative's List of Eligible Modules.[40]

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 2012 Real Dollars: Installed price and incentive data are expressed throughout this report in real 2012 dollars (2012$). Data provided by PV program administrators in nominal dollars were converted to 2012$ using the "Monthly Consumer Price Index for All Urban Consumers," published by the U.S. Bureau of Labor Statistics.[41]

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, four programs (the CEC's Emerging Renewables Program and New Solar Home Partnership program, the CPUC's Self-Generation Incentive Program, and SMUD's Residential Retrofit and Commercial PV 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). In addition, three programs (NM's Solar Market Development Tax Credit, NVEnergy's Renewable Generations Rebate Program, and VT's RERC Small Scale Renewable Energy Incentive Program) only specified module model and number of models per system. DC-STC capacity ratings for systems funded through these seven programs were calculated according to the procedures described below. In addition, DC-STC capacity ratings were estimated for a number of utility-scale PV projects when only AC capacity ratings were available, also described below.

CEC Emerging Renewables Program (ERP), CEC New Solar Home Partnership (NSHP) Program, and SMUD Residential Retrofit and Commercial PV Programs: 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 and SMUD datasets, 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.

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

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.[42] 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:

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

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 $W_{\text{DC-STC}}/W_{\text{DC-PTC}}$). 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 $W_{\text{DC-STC}}/W_{\text{CEC-AC}}$).

NM Solar Market Development Tax Credit, NVEnergy Renewable Generations Rebate Program, and VT RERC Small Scale Renewable Energy Incentive Program: The data provided for these programs did not specify the total PV system capacity, but did specify module model and number of modules for each system. We determined the nameplate DC-STC rating for each module model, based on the CSI's List of Eligible Photovoltaic Modules and/or from module manufacturer specification sheets, and then calculated the *system* DC-STC rating as the product of the module DC-STC rating and the number of modules.

Utility-Scale PV Projects: Only AC capacity ratings were available for a number of utility-scale systems in the data sample. In some of those instances, data on module model (and thus the DC capacity rating of the individual modules) and number of modules were available, which were used to derive the DC capacity rating for the system. Lacking that information, the DC capacity was estimated based on the average DC-to-AC ratio of those systems for which both capacity ratings were known.

Conversion of Reported PBI Payments to 2012$/W: Six PV incentive programs in the data sample provided performance-based incentives (PBIs), paid out over time based on actual energy generation and a pre-specified payment rate, to some or all systems. In order to facilitate comparison with up-front rebates provided to the other systems in data sample, PBI payments were translated into an equivalent up-front payment by calculating the net present value (NPV) of the expected PBI payment amount. The approach taken to calculate the NPV of the PBI payment differed somewhat across programs, depending on the data provided and the nature of the PBI payment.

AR Energy Office Renewable Technology Rebate Fund: In this program, all systems receive a single PBI payment based on total energy production during the first year of operation. The program administrator provided data on the estimated or actual PBI payment for each system. These data were used as-is, with no discounting.

APS Renewable Energy Incentive Program, CPUC California Solar Initiative, and SRP EarthWise Solar Energy Program: These three programs provided PBI payments to a subset of the participating projects

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

(typically the larger non-residential projects). The PBI payments in these programs are paid out on a monthly or quarterly basis over multi-year periods (for APS: 10, 15, or 20 years; for CSI: 5 years; and for SRP: 20 years). In the case of APS, the PBI contract period for each system was not specified, and we therefore assumed 15 years. The program administrators provided the estimated total PBI payment for each system receiving a PBI, over the duration of the PBI contract term. Lacking any specific information otherwise, we assumed that these program administrators estimated lifetime PBI payments by multiplying the estimated first-year energy production for each system by the PBI payment rate and the PBI contract term, without any discounting and without accounting for system degradation over time. As such, we calculated the NPV of the PBI payments by first dividing the estimated total PBI amount for each system by the PBI contract term, in order to estimate the first-year PBI payment. Nominal PBI payments in subsequent years were estimated by applying a 0.5% annual degradation factor to the first-year PBI payment. The NPV of annual PBI payments over the contract term was then calculated assuming a 7% nominal discount rate.

Orlando Utilities Commission Pilot Solar Program. Under this program, all participating systems receive a monthly PBI paid out over the life of the system. The data provided by the program administrator included the total annual PBI payment in 2010-2012 for each system. For systems installed prior to 2012, we used the average PBI amount from all full years of operation (e.g., for 2010 systems, we used the average PBI from 2011 and 2012) to calculate the NPV of all payments over the life of the system, assuming a 20 year lifetime, a degradation factor of 0.5%/yr, and an annual discount rate of 7%. For systems installed in 2012, we could not use the provided PBI data, as those are for an incomplete year; instead, we used the average annual PBI payment per kW ($/kW/yr) of all systems installed prior to 2012 to estimate the annual PBI payment per kW that each 2012 system would receive over the course of its first complete year of operation. We then followed the same procedure and assumptions as for the pre-2012 systems in order to estimate the NPV of the lifetime PBI payments (i.e., 20-year lifetime, 0.5% annual degradation, and 7% nominal discount rate).

Austin Energy Power Saver Program: This program provides PBI payments to a small sub-set of all participating projects, issued over a 10-year period. The program administrator, however, did not provide estimates for either estimated PBI payment or estimated annual system production. Therefore, we did not calculate the NPV of PBI payments for these systems, and treated these systems as having missing incentive data.

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	APS - Renewable Energy Incentive Program	11,786	208.3	6.4%	0.3 - 3,903	2002 - 2012
	SRP - EarthWise Solar Energy Program	4,169	35.4	1.1%	0.5 - 599	2005 - 2012
	Sulphur Springs - SunWatts Rebate Program	420	3.2	0.1%	0.1 - 984	2009 - 2012
	TEP - Renewable Energy Credit Purchase Program	2,855	28.4	0.9%	0.6 - 3,400	2008 - 2012
	Trico - SunWatts Incentive Program	385	3.6	0.1%	0.4 - 1,000	2006 - 2012
CA	CCSE - Rebuild a Greener San Diego Program	154	0.8	0.0%	1.9 - 7.1	2004 - 2008
	CEC - Emerging Renewables Program	27,494	145.2	4.5%	0.1 - 670	1998 - 2008
	CEC - New Solar Homes Partnership	5,904	22.8	0.7%	1.2 - 154	1999 - 2012
	CPUC - California Solar Initiative	81,690	1088.8	33.7%	0.9 - 1,796	2007 - 2012
	CPUC - Self Generation Incentive Program	855	159.9	4.9%	34 - 1,266	2002 - 2009
	LADWP - Solar Incentive Program	6,245	71.3	2.2%	0.3 - 1,461	1999 - 2012
	Pacific Power - California Solar Incentive Program	17	0.5	0.0%	3.1 - 257	2011 - 2012
	SMUD - Residential Retrofit and Commercial PV Programs	1,724	30.8	1.0%	1.0 - 1,175	2005 - 2012
CT	CCEF - Solar PV Program	2,162	14.4	0.4%	0.7 - 70	2005 - 2012
	CCEF - Onsite Renewable DG Program	184	19.9	0.6%	1.6 - 570	2004 - 2012
DC	DEP - Renewable Energy Incentive Program	645	3.2	0.1%	0.9 - 101	2009 - 2012
FL	GRU - Solar Feed-In Tariff[a]	209	13.9	0.4%	2.3 - 1,007	2009 - 2012
	GRU - Solar-Electric System Rebate Program[a]	117	1.2	0.0%	1.9 - 74	2007 - 2012
	OUC - Pilot Solar Program[a]	57	2.7	0.1%	1.1 - 1,040	2008 - 2012
	Energy & Climate Commission - Solar Rebate Program[a]	1,169	9.7	0.3%	2.0 - 1,016	2006 - 2012
IL	DCEO - Solar and Wind Energy Rebate Program	606	5.4	0.2%	0.8 - 700	1999 - 2012
MA	MassCEC - multiple PV incentive programs[b][c]	7,199	140.7	4.4%	0.2 - 2,000	2002 - 2012
	DOER - SREC Registration[c]	36	4.9	0.2%	1.0 - 761	2010 - 2012
MD	MEA - Solar Energy Grant Program	2,767	21.9	0.7%	0.7 - 200	2008 - 2012
MN	MSEO - Solar Electric Rebate Program	406	2.1	0.1%	0.5 - 40	2003 - 2011
MO	Columbia Water & Light - Solar Rebates	6	0.0	0.0%	1.2 - 5.1	2008 - 2012
NC	NCSEA (project data compiled from NCUC dockets)[d]	1,473	95.6	3.0%	0.7 - 5,885	2003 - 2012

State	PV Incentive Program Administrator and Program Name	No. of Systems	Total MW_{DC}	% of Total MW_{DC}	Size Range (kW_{DC})	Year Range
NH	NHPUC - Renewable Energy Rebate Program	750	2.6	0.1%	0.4 - 5.7	2002 - 2012
NJ	NJCEP - Customer Onsite Renewable Energy Program	4,104	86.0	2.7%	0.8 - 2,372	2001 - 2012
	NJCEP - Renewable Energy Incentive Program	3,627	36.1	1.1%	0.7 - 51	2009 - 2012
	NJCEP - SREC Registration Program	10,056	508.7	15.7%	0.4 - 8,135	2007 - 2012
NM	EMNR Dept - Solar Market Development Tax Credit	2,494	11.6	0.4%	0.4 - 249	2009 - 2012
NV	NV Energy - Renewable Generations Rebate Program	1,437	40.8	1.3%	0.4 - 1,174	2004 - 2012
NY	NYSERDA - PV Incentive Programs	5,936	66.7	2.1%	0.5 - 254	2003 - 2012
OH	ODOD - multiple PV incentive programs[e]	226	9.2	0.3%	1.0 - 1,121	2005 - 2012
OR	DOE - income tax credit programs	1,007	7.7	0.2%	0.1 - 974	1998 - 2012
	ETO - Solar Electric Buy-Down Program	4,478	31.5	1.0%	0.5 - 1,749	2003 - 2012
	Pacific Power - Solar Volumetric Incentive and Payments Program	328	4.3	0.1%	2.0 - 500	2010 - 2012
PA	DCED - grant programs	45	26.3	0.8%	8.0 - 2,000	2010 - 2012
	DEP - Sunshine Solar PV Program	6,483	91.4	2.8%	1.0 - 922	2009 - 2012
	SDF - Solar PV Grant Program	200	0.7	0.0%	1.1 - 12	2002 - 2008
TX	Austin Energy - Power Saver Program	2,238	11.7	0.4%	0.2 - 136	1999 - 2012
	IOU (AEP, Entergy, Oncor, SWEPCO, TNMP) - Solar Incentive Programs	1,297	14.2	0.4%	0.4 - 300	2009 - 2012
UT	RMP - Solar Incentive Program	28	0.2	0.0%	1.6 - 27	2011 - 2012
VT	RERC - Small Scale Renewable Energy Incentive Program	1,520	10.5	0.3%	0.2 - 358	2003 - 2012
WI	Focus on Energy - Renewable Energy Cash-Back Rewards Program	1,396	8.5	0.3%	0.2 - 273	2002 - 2012
Non PV Incentive Program Data (other sources)		48	127.3	3.9%	770 - 9,002	2008 - 2012
	Total	***208,529***	***3,231***	***100%***	***0.1 - 9,002***	***1998 - 2012***

[a] Some systems received incentives from both the Florida Energy & Climate Commission (FECC)'s Solar Rebate Program as well as from one of the Florida utility programs. In order to avoid double-counting, those systems were retained in the data sample for FECC's program and removed from the data sample for the utility program.

[b] The MassCEC PV programs include systems that were funded through predecessor programs offered by the Massachusetts Technology Collaborative, prior to creation of MassCEC.

[c] Some systems received incentives from both the MassCEC PV programs and the MA DOER SREC Registration Program. In order to avoid double-counting, those systems were retained in the data sample for the MassCEC program and removed from data sample for the MA DOER program.

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

[e] The data provided by the ODOD includes PV systems funded through a number of programs, including State Energy Plan, Advanced Energy Fund, ARRA Block Grants, and the Energy Loan Fund.

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	
No. Systems																
0-5 kW	26	138	151	1,101	1,776	2,277	3,527	3,296	5,128	7,378	8,149	12,797	16,108	18,516	19,654	**100,022**
5-10 kW	3	15	23	163	480	835	1,545	1,714	2,750	4,163	4,214	9,034	15,103	16,945	21,931	**78,918**
10-100 kW	5	11	11	37	165	313	513	639	895	1,239	1,403	2,501	4,991	5,779	6,703	**25,205**
100-500 kW	0	1	1	7	25	30	34	94	92	122	309	246	441	834	1,116	**3,352**
>500 kW	0	0	0	0	3	6	7	11	22	34	90	86	137	323	313	**1,032**
Total	*34*	*165*	*186*	*1,308*	*2,449*	*3,461*	*5,626*	*5,754*	*8,887*	*12,936*	*14,165*	*24,664*	*36,780*	*42,397*	*49,717*	***208,529***
Capacity (MW)																
0-5 kW	0.1	0.3	0.3	2.9	4.7	6.4	10.0	9.7	15.8	23.5	25.4	41.2	52.5	61.6	67.2	**322**
5-10 kW	0.0	0.1	0.2	1.1	3.2	5.6	10.5	12.0	19.0	28.8	28.8	61.3	104.0	118.2	153.6	**546**
10-100 kW	0.1	0.3	0.2	0.6	3.2	6.9	11.9	15.0	18.4	25.7	33.2	52.3	107.2	137.1	149.1	**561**
100-500 kW	0.0	0.1	0.1	1.1	5.0	6.8	6.9	18.9	20.6	27.9	74.9	54.4	94.1	188.3	260.1	**759**
>500 kW	0.0	0.0	0.0	0.0	1.7	5.3	5.1	8.4	17.7	27.1	78.2	79.2	136.0	373.3	310.4	**1,042**
Total	*0.2*	*0.8*	*0.8*	*5.7*	*17.9*	*31.1*	*44.4*	*64.0*	*91.5*	*133.0*	*240.6*	*288.4*	*493.8*	*878.5*	*940.3*	***3,231***

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
AR	≤10 kW	No. Systems	-	-	-	-	-	-	-	-	-	-	-	-	45	30	-
		Median Size	-	-	-	-	-	-	-	-	-	-	-	-	3.5	4.3	-
		Median Price	-	-	-	-	-	-	-	-	-	-	-	-	6.4	6.8	-
	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	86	295	321	537	2402	4077	3908	5010
		Median Size	-	-	-	-	*	*	2.8	3.0	3.9	4.4	4.5	5.1	5.1	5.1	5.5
		Median Price	-	-	-	-	*	*	8.1	7.9	8.3	7.7	7.4	7.4	6.2	5.4	4.8
	10-100 kW	No. Systems	-	-	-	-	-	1	2	3	13	16	58	248	511	592	1175
		Median Size	-	-	-	-	-	*	*	*	*	10.5	14.6	13.2	12.9	13.1	12.5
		Median Price	-	-	-	-	-	*	*	*	*	8.0	7.2	7.1	6.3	5.1	4.7
	>100 kW	No. Systems	-	-	-	-	-	-	-	-	-	3	8	9	46	119	119
		Median Size	-	-	-	-	-	-	-	-	-	*	*	*	349.4	432.6	321.3
		Median Price	-	-	-	-	-	-	-	-	-	*	*	*	6.4	6.4	6.1
CA	≤10 kW	No. Systems	28	149	164	1225	2161	2746	4210	3630	5718	9051	9007	13159	16168	19531	24094
		Median Size	2.4	2.3	2.4	2.9	3.0	3.0	3.1	3.6	3.9	4.2	4.0	4.2	4.6	4.4	4.8
		Median Price	11.8	12.0	11.1	10.8	10.8	9.8	9.1	8.6	8.7	8.9	8.6	8.2	7.1	6.4	5.7
	10-100 kW	No. Systems	5	11	11	35	156	285	467	461	709	1014	930	1277	1763	1667	2290
		Median Size	*	*	*	11.6	11.9	12.0	14.4	17.2	14.0	13.7	14.4	13.8	13.3	14.1	12.8
		Median Price	*	*	*	10.5	10.6	9.3	8.7	8.2	8.2	8.5	8.2	7.8	6.6	6.0	5.3
	>100 kW	No. Systems	-	1	1	7	27	35	40	89	75	121	313	178	178	374	546
		Median Size	-	*	*	*	191.1	230.0	239.6	178.7	230.6	245.5	274.9	309.8	386.7	388.9	257.5
		Median Price	-	*	*	*	9.4	8.3	8.2	8.0	7.9	7.6	7.5	7.8	6.1	5.0	5.0

State	Size Range		1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
CO	≤10 kW	No. Systems	-	-	-	-	-	-	-	-	323	1009	1448	2196	2260	1530	2431
		Median Size	-	-	-	-	-	-	-	-	3.4	4.0	4.3	5.0	5.4	5.5	5.5
		Median Price	-	-	-	-	-	-	-	-	8.3	8.1	7.7	6.6	5.5	5.1	4.1
	10-100 kW	No. Systems	-	-	-	-	-	-	-	-	-	6	23	55	148	197	81
		Median Size	-	-	-	-	-	-	-	-	-	*	47.4	39.1	22.6	38.9	34.6
		Median Price	-	-	-	-	-	-	-	-	-	*	7.3	5.7	5.1	4.6	3.7
	>100 kW	No. Systems	-	-	-	-	-	-	-	-	-	-	9	11	64	90	19
		Median Size	-	-	-	-	-	-	-	-	-	-	*	*	101.7	101.6	209.3
		Median Price	-	-	-	-	-	-	-	-	-	-	*	*	4.6	4.2	3.2
CT	≤10 kW	No. Systems	-	-	-	-	-	-	1	32	87	164	252	401	390	323	226
		Median Size	-	-	-	-	-	-	*	4.5	4.8	5.2	5.5	6.3	6.3	6.7	5.8
		Median Price	-	-	-	-	-	-	*	9.4	9.6	9.8	9.1	8.6	7.7	6.5	5.2
	10-100 kW	No. Systems	-	-	-	-	-	-	1	1	6	14	51	98	100	77	56
		Median Size	-	-	-	-	-	-	*	*	*	*	11.0	10.9	10.8	10.8	10.8
		Median Price	-	-	-	-	-	-	*	*	*	*	8.7	8.4	7.3	6.1	5.2
	>100 kW	No. Systems	-	-	-	-	-	-	-	-	1	4	21	22	7	9	2
		Median Size	-	-	-	-	-	-	-	-	*	*	264.2	225.1	*	*	*
		Median Price	-	-	-	-	-	-	-	-	*	*	8.0	7.9	*	*	*
DC	≤10 kW	No. Systems	-	-	-	-	-	-	-	-	-	-	-	87	202	92	234
		Median Size	-	-	-	-	-	-	-	-	-	-	-	3.0	4.0	4.3	4.2
		Median Price	-	-	-	-	-	-	-	-	-	-	-	9.5	7.0	6.4	4.7
	10-100 kW	No. Systems	-	-	-	-	-	-	-	-	-	-	-	3	5	8	13
		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
FL	≤10 kW	No. Systems	-	-	-	-	-	-	-	-	16	41	28	578	499	64	33
		Median Size	-	-	-	-	-	-	-	-	3.5	4.8	5.0	5.0	5.1	6.8	5.0
		Median Price	-	-	-	-	-	-	-	-	10.7	10.4	9.1	7.9	7.5	6.0	4.6
	10-100 kW	No. Systems	-	-	-	-	-	-	-	-	-	6	11	65	105	37	35
		Median Size	-	-	-	-	-	-	-	-	-	*	*	25.0	25.0	27.7	25.8
		Median Price	-	-	-	-	-	-	-	-	-	*	*	7.2	7.2	5.1	4.9
	>100 kW	No. Systems	-	-	-	-	-	-	-	-	-	-	-	2	7	12	13
		Median Size	-	-	-	-	-	-	-	-	-	-	-	*	*	*	*
		Median Price	-	-	-	-	-	-	-	-	-	-	-	*	*	*	*
HI	≤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	-	-	-	-	-	-	-	-	-	-	-	-	-	*	-
IL	≤10 kW	No. Systems	-	1	2	6	3	5	2	5	42	61	72	64	102	53	105
		Median Size	-	*	*	*	*	*	*	*	1.9	2.0	2.8	3.2	3.4	4.3	4.8
		Median Price	-	*	*	*	*	*	*	*	10.5	10.2	9.6	9.2	8.4	6.6	5.8
	10-100 kW	No. Systems	-	-	-	1	2	11	5	2	-	3	-	1	23	5	27
		Median Size	-	-	-	*	*	*	*	*	-	*	-	*	14.0	*	19.8
		Median Price	-	-	-	*	*	*	*	*	-	*	-	*	8.3	*	5.8
	>100 kW	No. Systems	-	-	-	-	-	-	-	-	-	-	-	-	1	-	2
		Median Size	-	-	-	-	-	-	-	-	-	-	-	-	*	-	*
		Median Price	-	-	-	-	-	-	-	-	-	-	-	-	*	-	*

State	Size Range		1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
MA	≤10 kW	No. Systems	-	-	-	-	-	65	119	74	243	203	335	701	554	1108	2733
		Median Size	-	-	-	-	-	2.2	2.6	2.7	2.8	3.0	3.6	4.2	5.0	5.1	5.6
		Median Price	-	-	-	-	-	10.7	9.2	9.5	9.8	9.5	9.0	8.7	7.2	6.2	5.1
	10-100 kW	No. Systems	-	-	-	-	1	5	9	18	13	13	39	88	167	187	274
		Median Size	-	-	-	-	*	*	*	27.1	*	*	17.8	30.2	30.0	32.3	16.5
		Median Price	-	-	-	-	*	*	*	10.0	*	*	9.1	8.6	6.6	6.0	4.9
	>100 kW	No. Systems	-	-	-	-	-	-	-	-	3	2	8	18	57	77	121
		Median Size	-	-	-	-	-	-	-	-	*	*	*	152.1	128.8	197.3	255.6
		Median Price	-	-	-	-	-	-	-	-	*	*	*	7.7	5.8	5.0	4.0
MD	≤10 kW	No. Systems	-	-	-	-	-	-	-	-	-	-	126	385	684	726	431
		Median Size	-	-	-	-	-	-	-	-	-	-	4.0	4.5	4.9	5.3	5.0
		Median Price	-	-	-	-	-	-	-	-	-	-	9.7	8.1	6.8	6.0	5.0
	10-100 kW	No. Systems	-	-	-	-	-	-	-	-	-	-	3	22	92	171	111
		Median Size	-	-	-	-	-	-	-	-	-	-	*	10.8	12.0	13.7	14.8
		Median Price	-	-	-	-	-	-	-	-	-	-	*	6.9	5.9	5.2	4.2
	>100 kW	No. Systems	-	-	-	-	-	-	-	-	-	-	1	-	1	8	7
		Median Size	-	-	-	-	-	-	-	-	-	-	*	-	*	*	*
		Median Price	-	-	-	-	-	-	-	-	-	-	*	-	*	*	*
MN	≤10 kW	No. Systems	-	-	-	-	-	8	12	10	18	33	35	70	169	95	112
		Median Size	-	-	-	-	-	*	*	*	2.7	2.6	2.8	3.7	4.1	4.0	4.7
		Median Price	-	-	-	-	-	*	*	*	9.3	9.9	10.3	9.9	8.2	6.6	5.7
	10-100 kW	No. Systems	-	-	-	-	-	-	-	-	-	2	3	3	28	20	39
		Median Size	-	-	-	-	-	-	-	-	-	*	*	*	10.5	12.4	34.7
		Median Price	-	-	-	-	-	-	-	-	-	*	*	*	8.4	4.9	4.8
	>100 kW	No. Systems	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		Median Size	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		Median Price	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

State	Size Range		1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
MO	≤10 kW	No. Systems	-	-	-	-	-	-	-	-	-	-	2	-	1	1	2
		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	3	4	21	44	87	160	214	331	344
		Median Size	-	-	-	-	-	*	*	*	3.0	2.5	3.1	4.0	4.1	4.4	4.8
		Median Price	-	-	-	-	-	*	*	*	10.3	10.8	9.5	8.7	7.1	6.6	5.7
	10-100 kW	No. Systems	-	-	-	-	-	-	-	-	-	5	5	14	30	71	25
		Median Size	-	-	-	-	-	-	-	-	-	*	*	*	25.7	22.1	28.9
		Median Price	-	-	-	-	-	-	-	-	-	*	*	*	6.3	5.2	4.9
	>100 kW	No. Systems	-	-	-	-	-	-	-	-	-	1	2	5	10	34	63
		Median Size	-	-	-	-	-	-	-	-	-	*	*	*	*	545.4	473.8
		Median Price	-	-	-	-	-	-	-	-	-	*	*	*	*	4.4	4.0
NH	≤10 kW	No. Systems	-	-	-	-	1	-	-	-	-	-	34	167	236	137	175
		Median Size	-	-	-	-	*	-	-	-	-	-	2.2	2.7	3.2	4.1	4.7
		Median Price	-	-	-	-	*	-	-	-	-	-	9.4	8.2	6.4	5.5	4.6
	10-100 kW	No. Systems	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		Median Size	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		Median Price	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	>100 kW	No. Systems	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		Median Size	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		Median Price	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

State	Size Range		1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
NJ	≤10 kW	No. Systems	-	-	-	3	29	85	254	578	689	567	602	931	2111	3549	3320
		Median Size	-	-	-	*	2.7	4.6	5.5	6.8	6.8	7.4	7.2	7.4	7.2	6.9	6.8
		Median Price	-	-	-	*	11.0	10.0	9.6	9.3	9.1	9.0	8.7	8.5	7.3	6.0	4.6
	10-100 kW	No. Systems	-	-	-	-	6	5	17	116	110	80	148	247	671	1164	1332
		Median Size	-	-	-	-	*	*	12.6	11.8	12.1	18.0	16.1	15.2	18.1	15.2	14.8
		Median Price	-	-	-	-	*	*	9.8	9.2	9.1	8.9	8.5	8.3	6.8	5.6	4.7
	>100 kW	No. Systems	-	-	-	-	1	1	1	16	35	24	38	79	153	342	489
		Median Size	-	-	-	-	*	*	*	215.2	255.4	290.5	270.6	221.0	250.5	265.5	247.0
		Median Price	-	-	-	-	*	*	*	8.0	7.7	7.5	8.0	7.6	5.3	4.8	4.5
NM	≤10 kW	No. Systems	-	-	-	-	-	-	-	-	-	-	-	227	705	768	684
		Median Size	-	-	-	-	-	-	-	-	-	-	-	3.4	3.6	3.7	4.3
		Median Price	-	-	-	-	-	-	-	-	-	-	-	8.4	7.3	6.3	5.3
	10-100 kW	No. Systems	-	-	-	-	-	-	-	-	-	-	-	8	27	37	37
		Median Size	-	-	-	-	-	-	-	-	-	-	-	*	11.0	11.4	11.5
		Median Price	-	-	-	-	-	-	-	-	-	-	-	*	6.3	5.8	4.8
	>100 kW	No. Systems	-	-	-	-	-	-	-	-	-	-	-	1	1	1	-
		Median Size	-	-	-	-	-	-	-	-	-	-	-	*	*	*	-
		Median Price	-	-	-	-	-	-	-	-	-	-	-	*	*	*	-
NV	≤10 kW	No. Systems	-	-	-	-	-	-	3	57	70	91	80	173	232	127	52
		Median Size	-	-	-	-	-	-	*	4.5	5.8	5.9	5.6	5.7	5.7	6.0	5.4
		Median Price	-	-	-	-	-	-	*	8.2	8.4	8.4	8.4	7.9	6.7	5.5	4.8
	10-100 kW	No. Systems	-	-	-	-	-	-	-	7	6	5	8	21	122	213	77
		Median Size	-	-	-	-	-	-	-	*	*	*	*	34.3	34.0	36.6	40.0
		Median Price	-	-	-	-	-	-	-	*	*	*	*	6.2	5.6	5.1	4.3
	>100 kW	No. Systems	-	-	-	-	-	-	-	-	-	-	-	1	7	69	16
		Median Size	-	-	-	-	-	-	-	-	-	-	-	*	*	119.4	136.1
		Median Price	-	-	-	-	-	-	-	-	-	-	-	*	*	4.8	4.1

State	Size Range		1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
NY	≤10 kW	No. Systems	-	-	-	-	-	38	112	103	182	333	374	655	716	709	1246
		Median Size	-	-	-	-	-	3.0	2.8	3.1	4.2	4.6	4.7	5.1	5.0	5.2	6.4
		Median Price	-	-	-	-	-	10.4	10.3	9.9	9.8	9.7	9.1	9.1	7.6	6.4	5.4
	10-100 kW	No. Systems	-	-	-	-	-	6	9	15	22	28	48	125	254	321	634
		Median Size	-	-	-	-	-	*	*	14.9	13.4	12.2	19.4	20.3	25.4	25.4	24.4
		Median Price	-	-	-	-	-	*	*	8.7	9.1	9.4	9.1	8.8	7.6	6.8	5.2
	>100 kW	No. Systems	-	-	-	-	-	-	-	-	-	-	-	-	1	2	4
		Median Size	-	-	-	-	-	-	-	-	-	-	-	-	*	*	*
		Median Price	-	-	-	-	-	-	-	-	-	-	-	-	*	*	*
NY	≤10 kW	No. Systems	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		Median Size	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		Median Price	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	10-100 kW	No. Systems	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		Median Size	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		Median Price	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	>100 kW	No. Systems	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3
		Median Size	-	-	-	-	-	-	-	-	-	-	-	-	-	-	*
		Median Price	-	-	-	-	-	-	-	-	-	-	-	-	-	-	*
OH	≤10 kW	No. Systems	-	-	-	-	-	-	-	20	19	30	26	3	6	3	-
		Median Size	-	-	-	-	-	-	-	3.1	2.6	3.3	3.1	*	*	*	-
		Median Price	-	-	-	-	-	-	-	11.0	12.8	10.2	9.3	*	*	*	-
	10-100 kW	No. Systems	-	-	-	-	-	-	-	1	2	2	7	22	46	21	1
		Median Size	-	-	-	-	-	-	-	*	*	*	*	17.5	44.8	50.0	*
		Median Price	-	-	-	-	-	-	-	*	*	*	*	8.3	7.1	6.5	*
	>100 kW	No. Systems	-	-	-	-	-	-	-	-	-	-	-	1	11	5	-
		Median Size	-	-	-	-	-	-	-	-	-	-	-	*	*	*	-
		Median Price	-	-	-	-	-	-	-	-	-	-	-	*	*	*	-

State	Size Range		1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
OR	≤10 kW	No. Systems	1	2	8	30	37	95	136	112	176	271	281	533	1260	1209	1114
		Median Size	*	*	*	0.9	0.7	2.9	3.0	3.0	2.8	2.7	3.0	2.8	2.6	3.2	3.3
		Median Price	*	*	*	11.1	10.6	8.4	7.9	8.3	9.2	9.5	8.9	8.3	6.6	5.9	5.1
	10-100 kW	No. Systems	-	-	-	-	-	-	1	3	6	27	48	84	107	121	105
		Median Size	-	-	-	-	-	-	*	*	*	20.2	25.7	26.3	22.1	20.4	26.9
		Median Price	-	-	-	-	-	-	*	*	*	9.6	8.6	7.9	6.8	5.7	5.3
	>100 kW	No. Systems	-	-	-	-	-	-	-	-	-	1	8	11	14	4	8
		Median Size	-	-	-	-	-	-	-	-	-	*	*	*	*	*	*
		Median Price	-	-	-	-	-	-	-	-	-	*	*	*	*	*	*
PA	≤10 kW	No. Systems	-	-	-	-	7	33	26	96	12	10	13	304	1932	1617	501
		Median Size	-	-	-	-	*	4.1	4.7	2.7	*	*	*	5.3	5.8	6.1	6.5
		Median Price	-	-	-	-	*	10.5	11.1	9.8	*	*	*	8.1	7.1	6.1	5.0
	10-100 kW	No. Systems	-	-	-	-	-	-	-	1	1	1	-	66	715	879	328
		Median Size	-	-	-	-	-	-	-	*	*	*	-	10.8	10.6	11.5	13.0
		Median Price	-	-	-	-	-	-	-	*	*	*	-	7.9	6.5	5.6	4.5
	>100 kW	No. Systems	-	-	-	-	-	-	-	-	-	-	-	1	72	89	26
		Median Size	-	-	-	-	-	-	-	-	-	-	-	*	190.3	200.7	208.9
		Median Price	-	-	-	-	-	-	-	-	-	-	-	*	5.8	4.6	3.7
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	-	-	-	-	-	-	-	-	-	-	-	-	-	*	-

State	Size Range		1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
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	-	-	-	1	49	136	161	170	244	450	483	590	803
		Median Size	-	*	-	-	-	*	3.0	3.0	3.2	3.2	3.2	3.9	4.7	5.5	5.8
		Median Price	-	*	-	-	-	*	7.8	7.5	7.7	7.6	7.7	7.3	6.1	5.1	3.9
	10-100 kW	No. Systems	-	-	-	1	-	-	1	11	4	9	20	61	112	125	80
		Median Size	-	-	-	*	-	-	*	*	*	*	23.1	13.0	10.8	10.6	11.5
		Median Price	-	-	-	*	-	-	*	*	*	*	7.8	6.6	5.8	7.3	4.5
	>100 kW	No. Systems	-	-	-	-	-	-	-	-	-	-	-	4	8	8	3
		Median Size	-	-	-	-	-	-	-	-	-	-	-	*	*	*	*
		Median Price	-	-	-	-	-	-	-	-	-	-	-	*	*	*	*
UT	≤10 kW	No. Systems	-	-	-	-	-	-	-	-	-	-	-	-	-	24	1
		Median Size	-	-	-	-	-	-	-	-	-	-	-	-	-	3.0	*
		Median Price	-	-	-	-	-	-	-	-	-	-	-	-	-	6.1	*
	10-100 kW	No. Systems	-	-	-	-	-	-	-	-	-	-	-	-	-	3	-
		Median Size	-	-	-	-	-	-	-	-	-	-	-	-	-	*	-
		Median Price	-	-	-	-	-	-	-	-	-	-	-	-	-	*	-
	>100 kW	No. Systems	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		Median Size	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		Median Price	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

State	Size Range		1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
VT	≤10 kW	No. Systems	-	-	-	-	-	1	67	29	50	59	88	147	176	368	378
		Median Size	-	-	-	-	-	*	1.8	1.8	2.0	2.4	2.9	3.5	4.0	4.4	4.8
		Median Price	-	-	-	-	-	*	10.1	11.5	10.6	10.1	9.3	8.4	6.7	6.0	5.0
	10-100 kW	No. Systems	-	-	-	-	-	-	-	-	-	3	3	5	16	56	66
		Median Size	-	-	-	-	-	-	-	-	-	*	*	*	19.9	15.5	16.4
		Median Price	-	-	-	-	-	-	-	-	-	*	*	*	5.5	6.0	4.8
	>100 kW	No. Systems	-	-	-	-	-	-	-	-	-	-	-	-	-	1	7
		Median Size	-	-	-	-	-	-	-	-	-	-	-	-	-	*	*
		Median Price	-	-	-	-	-	-	-	-	-	-	-	-	-	*	*
WI	≤10 kW	No. Systems	-	-	-	-	13	20	38	38	79	92	140	234	249	183	99
		Median Size	-	-	-	-	*	1.3	1.7	2.5	2.7	2.8	3.1	4.0	3.6	3.0	4.1
		Median Price	-	-	-	-	*	11.5	10.5	9.8	9.1	9.9	9.4	9.4	8.3	11.7	5.9
	10-100 kW	No. Systems	-	-	-	-	-	-	1	-	3	11	21	43	89	5	37
		Median Size	-	-	-	-	-	-	*	-	*	*	15.4	14.4	14.3	*	20.0
		Median Price	-	-	-	-	-	-	*	-	*	*	9.4	8.4	7.5	*	5.9
	>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.

Table B-4. Median Cash Incentives for Residential & Commercial PV by PV Incentive Program

State	Program Administrator and Program Name		1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
AR	State Energy Office - Renewable Technology Rebate Fund	No. Systems	-	-	-	-	-	-	-	-	-	-	-	-	53	44	-
		Median Incentive ($/W)	-	-	-	-	-	-	-	-	-	-	-	-	2.2	2.0	-
AZ	APS - Renewable Energy Incentive Program	No. Systems	-	-	-	-	5	15	42	67	207	240	367	1545	2522	2728	4048
		Median Incentive ($/W)	-	-	-	-	*	2.5	4.1	4.0	3.9	3.3	3.2	3.2	3.0	1.8	0.6
	SRP - EarthWise Solar Energy Program	No. Systems	-	-	-	-	-	-	-	22	100	94	109	621	1206	711	1306
		Median Incentive ($/W)	-	-	-	-	-	-	-	3.6	3.4	3.3	3.2	3.2	2.7	1.4	0.7
	Sulphur Springs - SunWatts Rebate Program	No. Systems	-	-	-	-	-	-	-	-	-	-	-	132	123	78	87
		Median Incentive ($/W)	-	-	-	-	-	-	-	-	-	-	-	4.1	3.3	2.8	2.4
	TEP - Renewable Energy Credit Purchase Program	No. Systems	-	-	-	-	-	-	-	-	-	-	101	274	664	1025	791
		Median Incentive ($/W)	-	-	-	-	-	-	-	-	-	-	3.2	3.2	3.1	2.0	0.6
	Trico - SunWatts Incentive Program	No. Systems	-	-	-	-	-	-	-	-	1	6	26	87	118	75	72
		Median Incentive ($/W)	-	-	-	-	-	-	-	-	*	*	4.1	3.6	2.8	1.5	0.5
CA	CCSE - Rebuild a Greener San Diego Program	No. Systems	-	-	-	-	-	-	1	22	68	62	1	-	-	-	-
		Median Incentive ($/W)	-	-	-	-	-	-	*	3.9	3.8	3.5	*	-	-	-	-
	CEC - Emerging Renewables Program	No. Systems	33	154	176	1135	2018	2932	4535	3856	6112	5857	686	-	-	-	-
		Median Incentive ($/W)	3.5	3.4	3.3	4.8	4.8	4.1	3.8	3.0	2.7	2.5	2.4	-	-	-	-
	CEC - New Solar Homes Partnership	No. Systems	-	2	-	1	-	1	1	-	11	265	1114	1363	860	1425	861
		Median Incentive ($/W)	-	*	-	*	-	*	*	-	*	2.5	2.4	2.5	2.4	2.4	2.3
	CPUC - California Solar Initiative	No. Systems	-	-	-	-	-	-	-	-	-	3493	7848	12188	15493	18485	24183
		Median Incentive ($/W)	-	-	-	-	-	-	-	-	-	2.2	1.9	1.5	1.0	0.5	0.3
	CPUC - Self Generation Incentive Program	No. Systems	-	-	-	-	16	76	149	193	148	145	113	15	-	-	-
		Median Incentive ($/W)	-	-	-	-	4.7	4.3	4.4	4.1	3.4	2.8	2.5	2.3	-	-	-
	LADWP - Solar Incentive Program	No. Systems	-	5	-	131	310	57	31	79	137	312	417	799	1390	1093	1484
		Median Incentive ($/W)	-	*	-	7.0	6.9	6.7	4.0	3.3	3.9	4.0	4.0	3.7	3.1	2.5	1.3
	Pacific Power - California Solar Incentive Program	No. Systems	-	-	-	-	-	-	-	-	-	-	-	-	-	1	16
		Median Incentive ($/W)	-	-	-	-	-	-	-	-	-	-	-	-	-	*	1.1
	SMUD - Residential Retrofit and Commercial PV Programs	No. Systems	-	-	-	-	-	-	-	30	26	52	69	248	361	552	386
		Median Incentive ($/W)	-	-	-	-	-	-	-	2.9	2.5	2.0	1.9	1.7	1.4	1.1	0.8
	SMUD - SolarSmart Program	No. Systems	-	-	-	-	-	-	-	31	87	168	270	476	466	387	277
		Median Incentive ($/W)	-	-	-	-	-	-	-	5.3	5.1	4.8	4.5	4.4	3.9	2.2	1.6

State	Program Administrator and Program Name		1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
CT	CCEF - Solar PV Program	No. Systems	-	-	-	-	-	-	2	2	7	14	54	45	31	22	7
		Median Incentive ($/W)	-	-	-	-	-	-	*	*	*	*	4.6	4.3	4.1	2.5	*
	CCEF - Onsite Renewable DG Program	No. Systems	-	-	-	-	-	-	-	-	-	-	-	90	207	101	247
		Median Incentive ($/W)	-	-	-	-	-	-	-	-	-	-	-	3.2	2.9	2.7	1.3
DC	DEP - Renewable Energy Incentive Program	No. Systems	-	-	-	-	-	-	-	-	-	-	-	24	42	104	39
		Median Incentive ($/W)	-	-	-	-	-	-	-	-	-	-	-	**	**	**	**
FL	GRU - Solar Feed-In Tariff[(a)]	No. Systems	-	-	-	-	-	-	-	-	-	20	28	35	4	6	24
		Median Incentive ($/W)	-	-	-	-	-	-	-	-	-	1.6	1.6	1.3	*	*	0.9
	GRU - Solar-Electric System Rebate Program[(a)]	No. Systems	-	-	-	-	-	-	-	-	-	-	11	13	13	3	17
		Median Incentive ($/W)	-	-	-	-	-	-	-	-	-	-	*	*	*	*	**
	OUC - Pilot Solar Program[(a)]	No. Systems	-	-	-	-	-	-	-	-	16	27	-	573	552	-	1
		Median Incentive ($/W)	-	-	-	-	-	-	-	-	4.5	4.4	-	4.0	4.2	-	*
	Energy & Climate Commission - Solar Rebate Program[(a)]	No. Systems	-	1	2	7	5	16	7	7	42	64	72	65	126	58	134
		Median Incentive ($/W)	-	*	*	*	*	7.4	*	*	3.4	3.0	2.7	2.6	2.6	1.9	1.5
IL	DCEO - Solar and Wind Energy Rebate Program	No. Systems	-	-	-	-	1	70	128	92	259	218	382	807	774	1367	3101
		Median Incentive ($/W)	-	-	-	-	*	5.3	5.4	5.1	4.0	3.4	3.7	3.7	2.2	0.9	0.4
MA	MassCEC - multiple PV incentive programs[(b)(c)]	No. Systems	-	-	-	-	-	-	-	-	-	-	-	-	4	5	27
		Median Incentive ($/W)	-	-	-	-	-	-	-	-	-	-	-	-	**	**	**
	DOER - SREC Registration[(b)]	No. Systems	-	-	-	-	-	-	-	-	-	-	130	407	777	905	548
		Median Incentive ($/W)	-	-	-	-	-	-	-	-	-	-	2.6	1.3	0.9	0.5	0.3
MD	MEA - Solar Energy Grant Program	No. Systems	-	-	-	-	-	8	12	10	18	35	38	73	197	15	-
		Median Incentive ($/W)	-	-	-	-	-	*	*	*	2.3	2.2	2.1	2.1	1.9	1.8	-
MN	MSEO - Solar Electric Rebate Program	No. Systems	-	-	-	-	-	-	-	-	-	-	2	-	1	1	2
		Median Incentive ($/W)	-	-	-	-	-	-	-	-	-	-	*	-	*	*	*
MO	Columbia Water & Light - Solar Rebates	No. Systems	-	-	-	-	-	1	3	4	21	50	94	179	254	435	432
		Median Incentive ($/W)	-	-	-	-	-	**	**	**	**	**	**	**	**	**	**
NC	NCSEA - project data compiled from NCUC dockets	No. Systems	-	-	-	-	1	-	-	-	-	-	34	167	236	137	175
		Median Incentive ($/W)	-	-	-	-	*	-	-	-	-	-	2.8	2.4	2.0	1.1	0.9
NH	NHPUC - Renewable Energy Rebate Program	No. Systems	-	-	-	3	36	91	272	710	834	669	732	562	163	29	3
		Median Incentive ($/W)	-	-	-	*	6.3	6.8	6.6	6.4	5.8	4.9	4.6	4.0	3.7	2.7	*

State	Program Administrator and Program Name		1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
NJ	NJCEP - Customer Onsite Renewable Energy Program	No. Systems	-	-	-	-	-	-	-	-	-	-	-	619	1975	962	71
		Median Incentive ($/W)	-	-	-	-	-	-	-	-	-	-	-	1.9	1.6	0.8	0.7
	NJCEP - Renewable Energy Incentive Program	No. Systems	-	-	-	-	-	-	-	-	-	2	56	76	795	4060	5067
		Median Incentive ($/W)	-	-	-	-	-	-	-	-	-	**	**	**	**	**	**
	NJCEP - SREC Registration Program	No. Systems	-	-	-	-	-	-	-	-	-	-	-	236	732	805	721
		Median Incentive ($/W)	-	-	-	-	-	-	-	-	-	-	-	**	**	**	**
NM	EMNR Dept - Solar Market Development Tax Credit	No. Systems	-	-	-	-	-	-	3	64	76	96	88	195	361	409	145
		Median Incentive ($/W)	-	-	-	-	-	-	*	4.8	3.6	2.8	2.6	2.3	2.1	4.1	4.0
NV	NV Energy - Renewable Generations Rebate Program	No. Systems	-	-	-	-	-	44	121	118	204	361	422	780	971	1031	1884
		Median Incentive ($/W)	-	-	-	-	-	5.0	4.9	4.7	4.6	4.4	4.2	4.2	2.8	1.8	1.5
NY	NYSERDA - PV Incentive Programs	No. Systems	-	-	-	-	-	-	-	21	21	32	33	26	63	29	1
		Median Incentive ($/W)	-	-	-	-	-	-	-	6.1	4.5	3.7	3.6	3.6	3.1	3.0	*
OH	ODOD - multiple PV incentive programs(d)	No. Systems	1	2	8	30	37	22	20	25	50	90	102	154	171	170	125
		Median Incentive ($/W)	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**
OR	DOE - income tax credit programs	No. Systems	-	-	-	-	-	73	117	90	132	209	235	474	1160	1026	962
		Median Incentive ($/W)	-	-	-	-	-	5.3	4.7	3.5	2.3	2.2	2.1	2.1	1.8	1.8	1.1
	ETO - Solar Electric Buy-Down Program	No. Systems	-	-	-	-	-	-	-	-	-	-	-	-	50	138	140
		Median Incentive ($/W)	-	-	-	-	-	-	-	-	-	-	-	-	**	**	**
	Pacific Power - Solar Volumetric Incentive and Payments Program	No. Systems	-	-	-	-	-	-	-	-	-	-	-	-	4	27	14
		Median Incentive ($/W)	-	-	-	-	-	-	-	-	-	-	-	-	*	1.1	*
PA	DCEC - grant programs	No. Systems	-	-	-	-	-	-	-	-	-	-	-	371	2713	2558	841
		Median Incentive ($/W)	-	-	-	-	-	-	-	-	-	-	-	2.4	1.8	0.8	0.7
	DEP - Sunshine Solar PV Program	No. Systems	-	-	-	-	7	33	26	97	13	11	13	-	-	-	-
		Median Incentive ($/W)	-	-	-	-	*	6.3	5.9	5.7	*	*	*	-	-	-	-
	SDF - Solar PV Grant Program	No. Systems	-	1	-	1	-	1	50	147	165	179	264	341	181	306	602
		Median Incentive ($/W)	-	**	-	**	-	**	5.7	5.5	4.8	4.7	4.5	4.5	2.5	2.9	2.4
TX	Austin Energy - Power Saver Program	No. Systems	-	-	-	-	-	-	-	-	-	-	-	174	422	417	284
		Median Incentive ($/W)	-	-	-	-	-	-	-	-	-	-	-	2.6	2.6	2.0	1.9
	IOU (AEP, Entergy, Oncor, SWEPCO, TNMP) - Solar Incentive Programs	No. Systems	-	-	-	-	-	-	-	-	-	-	-	-	-	27	1
		Median Incentive ($/W)	-	-	-	-	-	-	-	-	-	-	-	-	-	1.5	*
UT	RMP - Solar Incentive Program	No. Systems	-	-	-	-	-	1	67	29	50	62	91	152	192	425	451
		Median Incentive ($/W)	-	-	-	-	-	*	3.0	2.9	2.0	1.9	1.8	1.9	1.6	0.8	0.6

State	Program Administrator and Program Name		1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
VT	RERC - Small Scale Renewable Energy Incentive Program	No. Systems	-	-	-	-	13	20	39	38	82	103	161	277	339	188	136
		Median Incentive ($/W)	-	-	-	-	*	2.9	2.4	2.8	2.7	2.1	2.0	2.0	1.9	2.2	0.8
WI	Focus on Energy - Renewable Energy Cash-Back Rewards Program	No. Systems	-	-	-	-	-	-	-	-	-	-	-	-	53	44	-
		Median Incentive ($/W)	-	-	-	-	-	-	-	-	-	-	-	-	2.2	2.0	-

* Median cash incentive data are omitted if fewer than 15 data points are available.

**Median cash incentive data are omitted for programs providing only SREC payments or feed-in tariff payments over time (the GRU Feed-in-Tariff program, the MA DOER SREC Registration Program, the NJCEP SREC Registration Program, and the Pacific Power Solar Volumetric Incentive Payments Program). Incentive data are also omitted for the NM Solar Market Development Tax Credit Program, which provides incentives in the form of a tax credit. Finally, incentive data were not available for systems provided by the NCSEA (who is not an incentive program administrator, but rather, provided LBNL with project data compiled from regulatory filings).

[a] Systems that received an incentive from one of the Florida utility programs in the data sample as well as from the Florida Energy & Climate Commission (FECC)'s Solar Rebate Program were retained in the data sample for FECC's program and removed from the data sample for the utility program.

[b] Systems that received an incentive through both the MA DOER SREC Registration Program and the MassCEC PV programs were retained in the data sample for the MassCEC program and removed from data sample for the MA DOER program.

[c] The MassCEC PV programs include systems that were funded through predecessor programs offered by the Massachusetts Technology Collaborative, prior to creation of MassCEC.

[d] The data provided by the ODOD includes PV systems funded through a number of programs, including State Energy Plan, Advanced Energy Fund, ARRA Block Grants, and the Energy Loan Fund.

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