IREC Interstate Renewable Energy Council, Inc.

U.S. Solar MARKET TRENDS 2013

JULY 2014 *Larry Sherwood*

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EXECUTIVE SUMMARY

Solar energy markets are booming in the United States due to falling photovoltaic (PV) prices, strong consumer demand, available financing, renewable portfolio standards (RPSs), and financial incentives from the federal government, states and utilities. Thirty-four percent more PV capacity was installed in 2013 than the year before. Developers completed three large concentrating solar power (CSP) plants with a combined capacity of nearly 0.8 GW_{AC} at the end of 2013. Solar installations accounted for 31 percent of all electric power installations completed in 2013.

The federal Investment Tax Credit (ITC) of 30 percent of the installed cost is an important foundational incentive for most installations. Installed prices for distributed PV installations fell by at least 11 percent in 2013 and have fallen by 44 percent since 2009. The prices of some individual system components, especially modules, have fallen even more. Lower prices increase consumer demand for solar installations.

Important CURRENT TRENDS

Photovoltaic

- **California was the most important market in 2013.** Fifty-seven percent of U.S. capacity installed in 2013 occurred in the Golden State, and the capacity installed during 2013 was 161 percent greater than what was installed in 2012.
- **Residential capacity installed in 2013 grew by 68 percent in the U.S.**, fueled by the increasing use of leases and third-party ownership of these systems. Over 145,000 residential PV systems were installed during the year.
- **Utility sector capacity installed grew by 47 percent.** Ten PV installations, each larger than 100 MW_{DC}, were completed in 2013.
- **Hawaii had the highest per capita installed capacity of PV systems.** More than 75 percent of grid-connected PV system capacity installed in 2013 was concentrated in California, Arizona and North Carolina.

Parabolic trough system at Solana Generating Station near Phoenix, Arizona

Residential PV Installation in Colorado

Concentrating Solar Power

- **The most CSP capacity ever installed in the United States in a single year was in 2013.** Three new CSP solar plants with a total capacity of 766 MW_{AC} were completed, the first in the U.S. since 2010.

Over the near term, the prospect for growth in solar installations is bright in all sectors. The residential sector is growing in a large number of states, and many utility sector projects are under construction or contracted and will be completed in 2014 or later. The federal ITC, continued falling prices, state RPSs, and on-going net metering policies will sustain the market.

About IREC

The Interstate Renewable Energy Council, Inc. (IREC) is a non-profit organization accelerating the use of renewable energy since 1982. Today, IREC is a nationally recognized thought leader, stakeholder coordinator, independent expert resource and facilitator of regulatory reform. Our work expands consumer access to clean energy; generates information and objective analysis grounded in best practices and standards; and leads national efforts to build a quality-trained clean energy workforce, including a unique credentialing program for training programs and instructors. IREC is an accredited American National Standards Developer. www.irecusa.org.

1. INTRODUCTION

The solar market, while relatively young, is an increasingly important and vital part of the American economy. What are the trends in this market, and what forces are at work? Which sectors of the market are strongest, and why? What are the prospects for solar energy in the near future?

This report answers these questions by providing public data on U.S. solar electric installations by technology, state and market sector. Public data on solar installations help industry, government and non-profit organizations improve their efforts to increase the number (and capacity) of solar installations across the United States. Analysis of multi-year installation trends and state installation data helps these stakeholders learn more about state solar markets, and evaluate the effectiveness of marketing, financial incentives and education initiatives.

Different solar energy technologies create energy for different end uses. This report covers solar technologies that produce electricity, including photovoltaics (PV) and concentrating solar power (CSP). Other solar technologies provide hot water, space heat and space cooling, but they are not addressed in this report.

PV cells are semi-conductor devices that generate electricity when exposed to the sun. Manufacturers assemble the cells into modules, which can be installed on buildings or parking structures, or as ground-mounted arrays. Modern PV was invented in the 1950s and first used to power satellites. As prices declined, PV systems were installed in many off-grid installations, (i.e., installations not connected to the utility grid). In the last decade, grid-connected applications have become the largest sector for PV installations. PV is used in large and small installations, either on the customer or utility side of the meter.

CSP systems use mirrors and collecting receivers to heat a fluid to a high temperature (from 300°F to more than 1,000°F), and then run the heat extracted from the fluid through a traditional turbine power generator or Stirling engine. CSP can also be paired with existing or new traditional power plants, providing high-temperature heat into the thermal cycle. These generating stations typically produce bulk power on the utility side of the meter rather than generating electricity on the customer side of the meter. CSP plants were first installed in the United States in the early 1980s, with installations continuing through the early 1990s. Most of these installations still generate power today. Until recently, few new systems had been installed since the early 1990s. Installations have resumed, with three large plants completed in 2013 and additional plants under construction for completion in future years. In another application, concentrating solar thermal can provide high-temperature solar process heat for industrial or commercial applications. A few such systems are installed each year. Concentrating PV systems are classified in this report as PV installations and not as CSP installations.

With respect to PV, the United States is only a small, but growing, part of a robust global solar market. China and Japan had the largest growth of

PV installation on outdoor deck covering in California

any country in 2013, and are now the largest markets for PV. With this development, the largest markets moved out of Europe for the first time in many years. U.S. installations accounted for about 12 percent of the global total in 2013 and ranked third globally. Germany and other European markets had been the largest global markets for many years. However, in Germany, less PV capacity was installed in 2013 than in 2012.

This report compares market trends on the basis of capacity installed and number of installations.

- **Annual capacity installed** or the capacity installed in a specific year refers to the capacity in megawatts (MW) or gigawatts (GW) installed in that specific year.
- **Cumulative capacity installed** refers to the capacity of installations in all years through 2013.
- When the report discusses the **annual number of installations**, it means the number of separate installations of any size completed that year.
- The **cumulative number of installations** means the total number of all the installations that have been built, irrespective of size, in all years.

The data collection methods and the assumptions used in this report are described in detail in Appendices A and B.

Non-profit PV installation in Austin, Texas

2. TOTAL SOLAR INSTALLATIONS

In 2013, solar installations (including both PV and CSP) accounted for 31 percent of new electricity generation installed during the year (Figure 1). In 2012, PV installations accounted for 12 percent of new additions. The electricity generated by PV and CSP installations supplied 0.4 percent of all electricity generation in the U.S. during 2013.

Recently, electricity consumption in the nation has been relatively flat. Overall electricity consumption grew by only 0.2 percent in 2013 (compared with 2012) and was two percent less than total electricity consumption in 2010. The low growth is partly due to the weaker economy in recent years and partly due to energy efficiency improvements.

Thus, additions to the grid are not supplying electricity growth, but are instead offset by reductions in the electricity currently supplied to the grid, such as the retirement of older power plants or the reduced use of existing power plants. This presents a conflict, which is increasingly apparent, between utilities and solar proponents. When the total capacity of solar installations was much smaller, the new capacity was easily absorbed. Now, as PV installations are becoming larger and more numerous, decisions must be made about how to integrate this capacity into the grid. Not surprisingly, the affected parties have differing opinions on how to do this. Low growth in electricity sales intensifies this conflict. Regional differences and the high concentration of solar installations in a few states demonstrate the varying impact in different parts of the country.

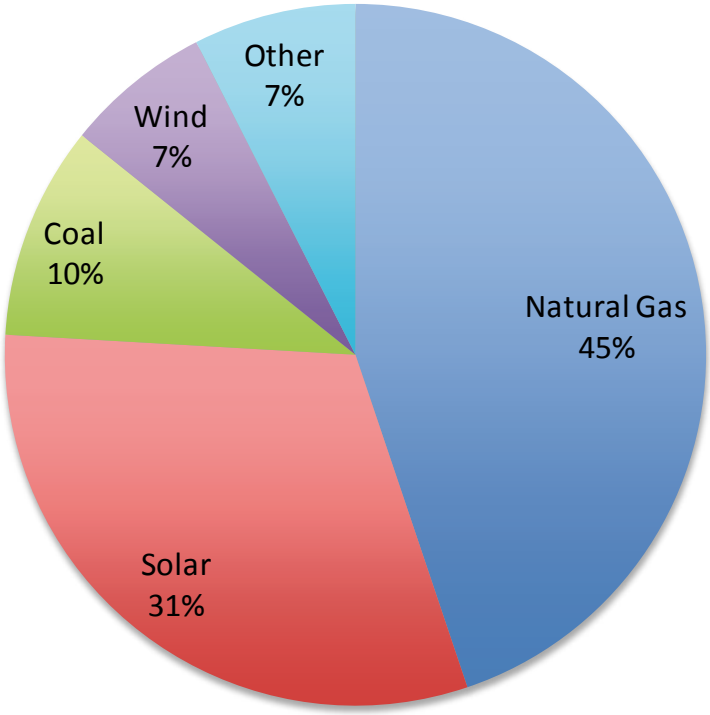


Figure 1: New U.S. Electric Generation Installed in 2013 by Technology
Source: Energy Information Agency (EIA 2014) with IREC PV data

Solar power tower at Ivanpah Solar Electric Generation Station in California

Workers installing PV modules

3. PHOTOVOLTAICS

Overall Trends in Installations and Capacity

2013 was another banner year for PV, with large increases in both the number and capacity of facilities. The capacity of 2013 PV installations increased by 34 percent to 4.6 GW_{DC} compared with 2012 (Figure 2). However, while the annual capacity growth rate was strong, it was the lowest rate since 2006. The compound annual growth rate for the last 10 years is an astounding 55 percent. In 2013, the capacity installed of utility installations increased by 48 percent compared with 2012, and distributed installations, largely on residential, commercial and government buildings, increased by 17 percent. The residential portion of distributed capacity increased by 68 percent in 2013. California led national growth with a 161 percent increase in capacity installed in 2013 (compared with 2012). In fact, without California, the installation trends were not positive – 18 percent less PV capacity was installed outside California in 2013 compared with 2012.

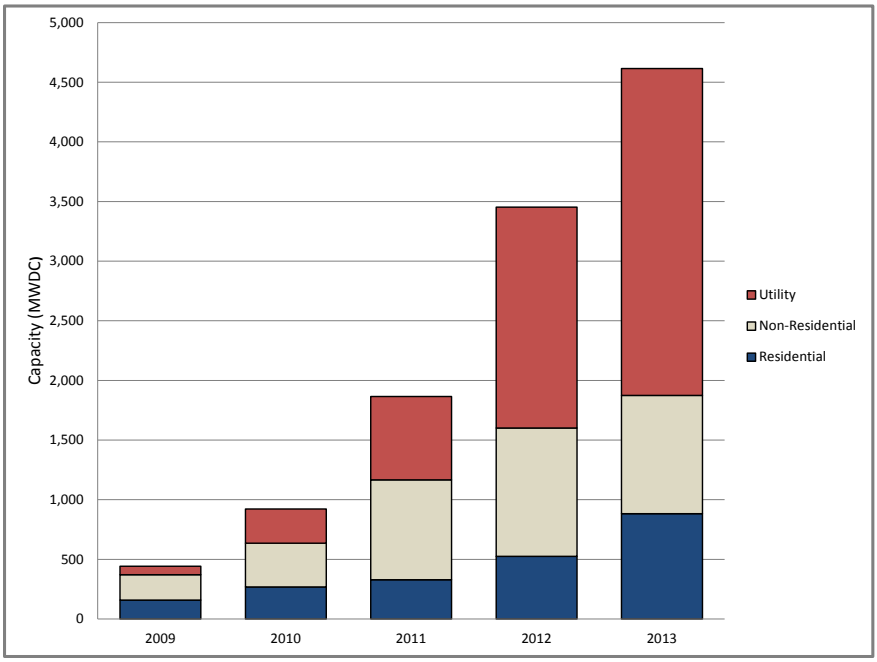


Figure 2: Annual Installed U.S. Grid-Connected PV Capacity by Sector (2009-2013)

The cumulative installed grid-connected PV capacity increased to 12.1 GW_{DC} (Figure 3), 82 percent of which was installed in just the last three years. In 2013, 0.9 GW_{DC} were installed on residential buildings, 1.0 GW_{DC} at non-residential sites, and 2.7 GW_{DC} in the utility sector (Figure 2).

Some PV installations are off-grid, and are power facilities that are too expensive to connect to the grid,

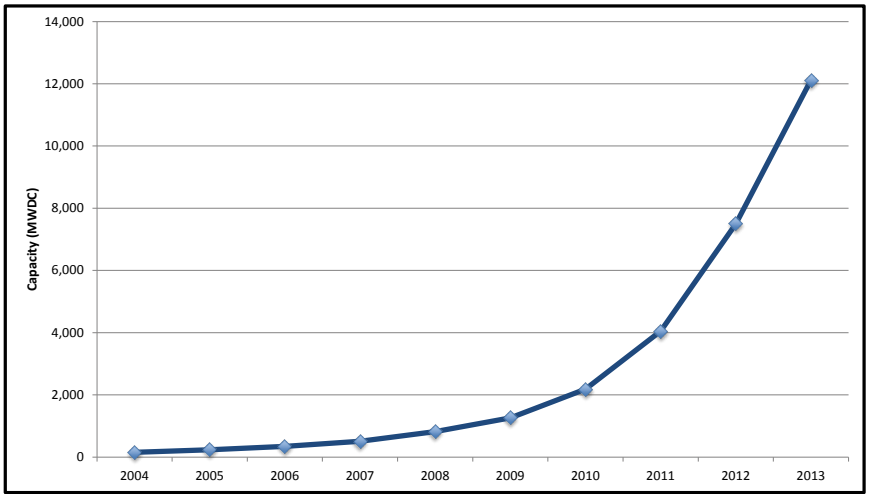


Figure 3: Cumulative U.S. Grid-Connected PV Installations (2004-2013)

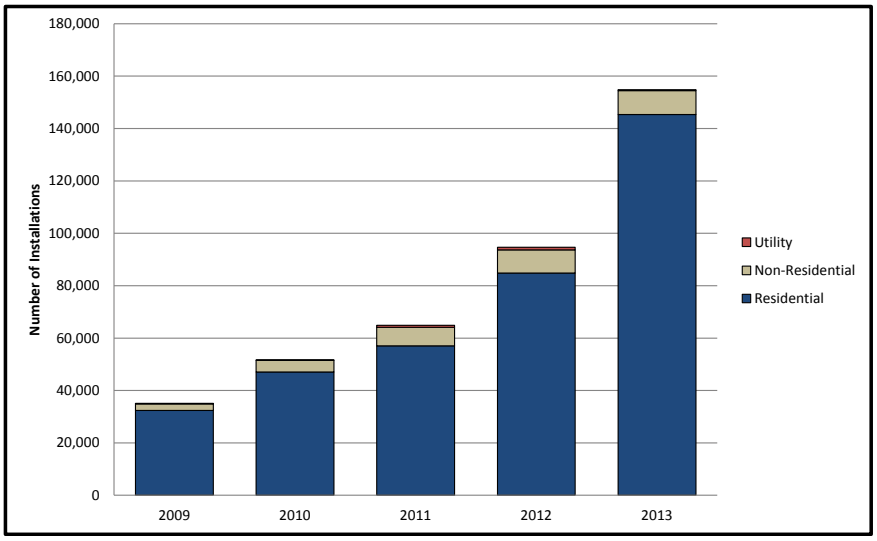


Figure 4: Number of Annual U.S. Grid-Connected PV Installations (2009-2013)

such as cabins, telecommunications facilities and road signs. Based on anecdotal information, the size of this market is very small compared with grid-connected installations. IREC has not collected data for off-grid installations, and they are not included in this report's charts.

Almost 155,000 grid-connected PV installations were completed in 2013, a 64 percent increase over the number of installations in 2012. Residential systems accounted for 94 percent of these individual installations (Figure 4). By contrast, residential systems accounted for only 19 percent of the PV capacity installed in 2013. At the end of 2013, 471,000 PV installations were connected to the U.S. grid, including 420,000 residential installations.

Important Factors Driving 2013 Installation Growth Vary by Sector and State

- **Federal ITC.** The federal ITC remained stable at 30 percent, which means the owner can claim a tax credit of 30 percent of the project cost. Additionally, the accelerated depreciation schedule for commercial installations was unchanged. Tax credits for both residential and commercial installations are set to continue at current levels through the end of 2016, when the residential ITC will expire and the commercial ITC will revert from 30 percent to 10 percent. With this stable incentive, developers and installers can plan and market their products, and consumers can make rational decisions without arbitrary incentive deadlines.
- **Lower Installed Costs.** The total installed cost for distributed PV installations fell 11 percent in 2013 and has fallen 44 percent over the past four years. The cost decline is even greater for utility installations. Falling module costs is the primary reason for cost declines over the long-term, but all cost components have fallen, including inverter costs and soft costs such as permitting.
- **Federal Cash Grants.** In February 2009, as part of the American Recovery and Reinvestment Act (ARRA), Congress enacted the U.S. Treasury Grant in Lieu of Tax Credits Program. This program, commonly known as the 1603 Treasury Grant Program, provided commercial installations with the alternative of a cash grant instead of the tax credit. The program was originally scheduled to expire at the end of 2010, but was extended through the end of 2012. The expiration of this program inspired many project developers to begin construction late in 2012 in order to qualify, with project completion scheduled in 2013 through 2016. In 2013, 981 completed solar electric projects were awarded $1.8 billion in cash grants (Treasury 2014). These totals reflect 70 percent fewer projects and 16 percent fewer grant dollars than the 2012 totals. Solar projects received 41 percent of 1603 Treasury Grant funding in 2013, compared with only 17 percent in 2011.

Residential PV installation in California

Portion of 250 MW_{AC} California Solar Valley Solar Ranch

- **State RPS Requirements.** States encourage investments in utility-scale solar plants with Renewable Portfolio Standard (RPS) policies. An RPS generally requires utilities to generate or procure a certain percentage of electricity from renewable energy. Some states have a "solar carve-out" that also requires a certain percentage of the renewable generation come from solar energy. The terms of each state's RPS are different, but this policy is generally most important for utility-sector installations. In some states, RPS guidelines have led to solar renewable energy credit (SREC) markets, which in turn have resulted in increased demand for and installation of distributed solar. SREC markets are most developed in the Mid-Atlantic states and in Massachusetts. Of the 11 states and territories with more than 10 MW of utility sector installations in 2013, nine have an RPS, usually with a solar carve-out.
- **Federal Loan Guarantees.** As part of ARRA, the U.S. Department of Energy was authorized to offer loan guarantees for renewable energy and other energy projects. The program expired in September 2011, but projects that received loan guarantees by that date are still being completed. In 2013, all three CSP installations and three of the four largest PV installations received $7.2 billion in loan guarantees from this program for at least a portion of the project's capital cost.
- **Third-Party Ownership.** The dominant ownership model for utility and non-residential distributed installations has long been third-party ownership. In recent years, this ownership model has expanded to the residential sector, and is now the dominant ownership model in all sectors. This structure may take the form of a lease or a power purchase agreement (PPA). In each case, a third party owns the system, and the system user makes regular payments to the owner. For distributed systems, the system is located at the consumer's facility or home, and the consumer uses the electricity generated on-site. Under third-party ownership, the consumer avoids paying the large up-front capital cost of a PV system.
- **Net Metering.** Net metering is a simple option for consumers to offset their monthly electricity bills by producing their own energy. It allows customers to send excess energy from an on-site renewable energy system back to the grid, and receive a 1:1 kilowatt-hour credit for that energy. In 2013, 95 percent of distributed installed capacity was net-metered.
- **State and Utility Rebates.** State and utility financial incentives have historically been one of the most important factors driving PV growth, especially for residential and commercial distributed installations. However, the importance of rebates is declining. The impact of these rebates varies greatly from state to state. As the cost of PV installations has decreased, rebate levels have dropped and some states have eliminated rebate programs altogether. The largest rebate program in the country, the California Solar Initiative (CSI), methodically reduced rebates for years. Although rebates for this program ended in 2013, PV markets continue to grow in California.

Grid-Connected PV Installations by Sector

The growth rate of grid-connected PV varies by market sector: residential, non-residential and utility. Distributed installations on the customer's side of the meter produce electricity used on-site; these include both residential and non-residential facilities. Examples of non-residential facilities are government buildings, retail stores and military installations. In contrast, utility installations are on the utility's side of the meter (if a meter is involved) and produce bulk electricity for the grid. Table 1 shows examples of installations in each sector.

Table 1: SAMPLE U.S. PV INSTALLATIONS BY SECTOR

Sector	Example Installations
Residential	• Residential installation owned by homeowner or building owner; electricity generated is used on-site. • Residential installation owned by third party, with electricity sold to or used by the homeowner or building owner.
Non-Residential	• Non-residential installation owned by building owner; electricity generated is used on-site. • Non-residential installation owned by third party, with electricity sold to the building owner and used on-site.
Utility	• Installation owned by utility; electricity generated goes into bulk power grid. • Installation owned by third party; electricity generated goes into bulk power grid. • Installation owned by building owner (residential or commercial); electricity generated goes into bulk power grid through a feed-in tariff, PPA or other agreement.

Utility Sector Installations

Utility sector PV installations increased by 48 percent in 2013 compared with 2012 (Figure 5). Factors that influence the large growth in utility sector installations include RPSs, lower installed costs and federal loan guarantees.

In 2013, 77 utility sector plants larger than 5 MW_{DC} were installed, with a total capacity of 2.6 GW_{DC}. These large facilities accounted for 93 percent of the utility sector installations in 2013. An additional six facilities of 5 MW_{DC} or larger were installed in the non-residential sector, with a combined capacity of 53 MW_{DC}. In total, these 83 generators larger than 5 MW_{DC} comprise 57 percent of the total PV capacity installed in 2013.

Of the 10 largest PV installations in the United States, eight were completely or partially installed in 2013 (Table 2), and **all** provide electricity for California customers. The seven largest installations, which provide electricity fully or partially for Pacific Gas & Electric (PG&E), are located in Arizona, California and Nevada. The

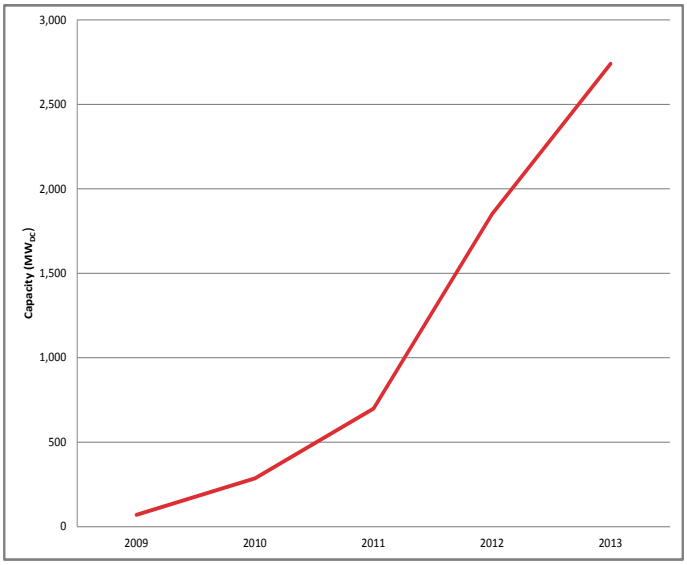


Figure 5: Annual Installed U.S. Grid-Connected Utility Sector PV Capacity (2009-2013)

Table 2: TEN LARGEST U.S. PV INSTALLATIONS

Plant Name	Location	Size (MW_{DC})	Year Built	Owner	Utility Purchaser
1. Desert Sunlight Solar Farm	Riverside County, CA	367	2013	NextEra, Energy Financial Services, Sumitomo	SCE and PG&E
2. Topaz	San Luis Obispo County, CA	360*	2013	Mid American Solar	PG&E
3. California Valley Solar Ranch	San Luis Obispo County, CA	292	2012-13	NRG Energy	PG&E
4. Agua Caliente	Yuma, AZ	289*	2012	NRG & MidAmerican Solar	PG&E
5. Antelope Valley Solar	Northern Los Angeles County, CA	266	2013	Exelon	PG&E
6. Mesquite Solar 1	Arlington, AZ	207	2011-12	Sempra U.S. Gas and Power	PG&E
7. Copper Mountain Solar 1 & 2	Boulder City, NV	192	2010-12	Sempra U.S. Gas and Power1**	PG&E
8. Campo Verde Solar Facility	Imperial County, CA	161	2013	Southern Company & Turner Renewables	SDG&E
9. Tenaska Imperial South	El Centro, CA	150	2013	Tenaska	SDG&E
10. Centinela Solar Energy	El Centro, CA	145	2013		SDG&E
10. Arlington Valley Solar Energy	Arlington, AZ	145	2013	Arlington Valley Solar Energy	SDG&E

* Indicates capacity constructed through 2013. This plant is still under construction; its total capacity will be larger.

** Copper Mountain Solar 2 is also owned by Consolidated Edison Development.

remaining installations, which provide electricity for San Diego Gas & Electric (SDG&E), are located in California and Arizona.

State RPS requirements are encouraging investments in utility-scale solar plants. California is, by far, the most important utility-sector market; 71 percent of 2013 utility sector PV installations were in California. In 2013, 1.6 GW_{DC} or 94 percent of the utility sector facilities were installed in states with RPS requirements. Eighty-nine percent of utility installations are located in only three states: Arizona, California and North Carolina. The three CSP plants completed in 2013 are also located in California and Arizona.

In 2012, Colorado, New Jersey and Nevada led all states in utility sector installations. In 2013, utility sector installations dropped by more than 360 MW_{DC} (compared with 2012) in these three states. Because RPS requirements are being met in Colorado, no new utility-scale installations are needed. In New Jersey, both utility and distributed installations saw declines in 2013 related to the fall in SREC prices in 2012. In Nevada, 126 MW_{DC} were installed in 2012 to supply electricity to California markets. There were no such installations in Nevada in 2013. The cumulative total in all other states showed a modest increase of 11 percent in 2013 compared with 2012.

Financing is also important. Five of the six largest PV installations received a federal loan guarantee for at least a portion of their installation costs, and these loan guarantees supported 779 MW_{DC} of PV in 2013. In addition, all three CSP installations described in Section 4 received a federal loan guarantee. Although this federal program is known for high-profile failed loan guarantees to Solyndra and other manufacturers, none of the guaranteed loans for specific solar installations have failed, and these loan guarantees are a crucial component of

the overall financial package for these projects. Federal tax incentives, grants and the lower cost of PV modules also made these investments attractive.

Figure 6 shows the ownership status of utility sector installations, 92 percent of which are PPAs. For PPAs in the utility sector, a third party builds and owns the PV facility, and the electricity is sold to a utility through a long-term PPA. The owners of many of these solar projects include the unregulated subsidiaries of utility companies.

About two percent of the utility sector installations take the form of feed-in tariff programs or similarly structured incentive programs. Under these programs, the utility pays the generator for the PV electricity produced and then sells that electricity as part of the utility's regular electricity sales. These are defined as utility sector installations because the electricity serves utility customers generally, rather than providing power for the customer where the installation is located. However, the size of these installations is more similar to the size of distributed installations, with an average capacity of 241 kW_{DC}. By contrast, the average size of the other utility sector installations is over 20,000 kW_{DC}.

Construction began or continued in 2013 on many additional utility sector installations, and utilities and developers have announced plans for more projects in the next few years. In 2013, Xcel Energy announced plans to purchase electricity from a

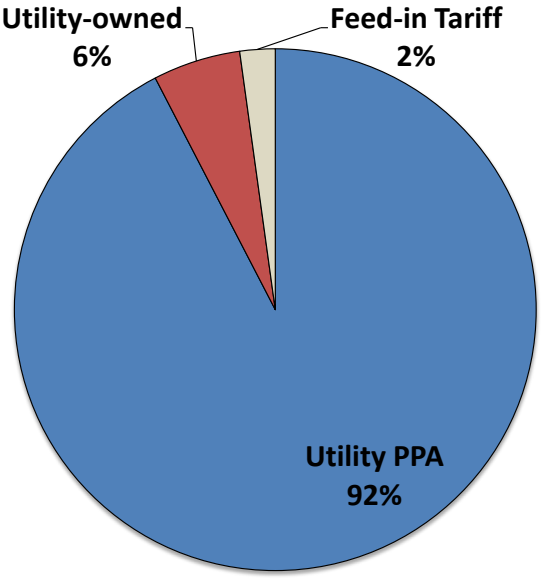


Figure 6: Ownership Status for 2013 U.S. Utility-Sector PV Installations

170 MW_{DC} PV plant to be built in Colorado. Because Xcel has nearly met its RPS requirement, the utility's decision to purchase electricity from this plant is based on economics — not on regulatory requirements. This may signal a change in the utility sector market in state and regional markets that are not based upon RPS requirements, similar to the change happening in the residential markets as state incentive programs are phased out.

PV modules at 250 MW_{AC} California Solar Valley Solar Ranch

Distributed Installations

Distributed installations provide electricity for use at the host customer's site, such as a home or business. In 2013, the amount of distributed grid-connected PV capacity installed annually in the United States increased 17 percent to 1.9 GW_{DC}. More than 154,000 distributed PV systems were installed in 2013, a 65 percent increase over the number of distributed PV systems installed in 2012. For the second year in a row, distributed PV growth was strongest in the residential sector. On a capacity basis, installations declined in the non-residential sector compared with 2012. Residential capacity installed in 2013 accounted for 47 percent of distributed installations. Just two years ago, in 2011, residential installations accounted for only 28 percent of distributed installations.

The top five states for distributed capacity installed in 2013 were California, Massachusetts, New Jersey, Arizona and Hawaii. The only state in the top ten for distributed capacity installed with a drop in installations compared with 2012 was New Jersey, where installed capacity sank by 37 percent. SRECs are an important factor in the New Jersey market; the price fell significantly in 2012, which lead to a decrease in new capacity installed in 2013 (compared with 2012). However, residential capacity in New Jersey installed increased by 3 percent in 2013.

In 2013, 95 percent of the residential and non-residential distributed PV installations were net-metered (Figure 7). This market share for net-metered systems has remained consistent for several years. The rules governing net metering transactions vary widely from state to state and from utility to utility. Some states are currently reviewing their net metering policies and considering changes. Depending on which, if any, changes are implemented, the future of the distributed solar market could change. About five percent of the distributed PV systems are non-exporting, meaning that all of the solar generated electricity is used on the customer's grid-connected site.

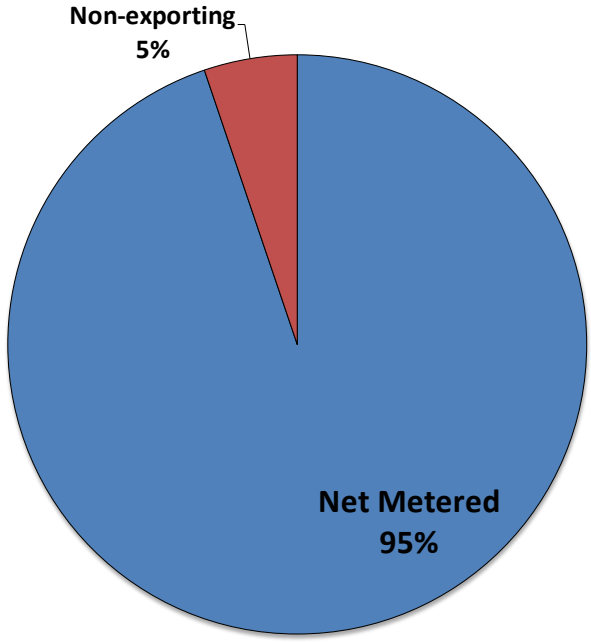


Figure 7: Generation Status for 2013 U.S. Distributed PV Installations

About one percent of distributed PV systems use a shared renewables model. A shared renewables installation is interconnected to the utility distribution system, and the electricity generated is credited to subscribers of the installation. Shared renewables allows customers who are otherwise unable to take advantage of a PV system, such as renters or property owners with inadequate solar access, to do so.

Residential PV installation in California

Growth continues in the residential sector

Residential PV installation in Connecticut

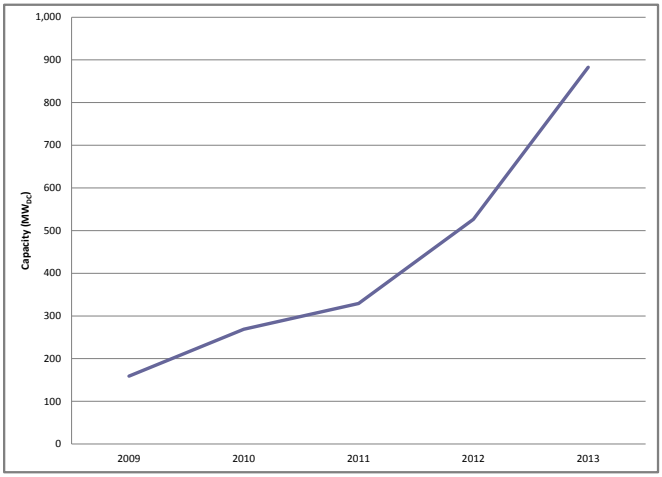


Figure 8: Annual Installed U.S. Grid-Connected Residential Sector PV Capacity (2009-2013)

Residential Sector Installations

The number of residential installations increased by 68 percent in 2013 compared with 2012 (Figure 8). Residential installations accounted for 19 percent of the total U.S. solar market on a capacity basis in 2013, but they accounted for 94 percent of the number of installations in the same year. The average size of a residential PV system decreased two percent, to 6.1 kW_{DC}. Factors that influence the growth in residential installations include the federal ITC, lower installed costs, retail PPAs and solar leases, net metering, and state and utility incentives. In addition, installers are becoming more sophisticated in marketing and generating leads; this has helped expand the market.

In California, twice as much residential PV capacity was installed in 2013 as was installed in 2012. California installations constituted 45 percent of the nation's total residential PV installations for 2013.

Outside California, residential capacity installed in 2013 increased by 49 percent compared with 2012. Beyond California, the states with the most residential capacity installed in 2013 were Hawaii, Arizona, New Jersey and Colorado. In Hawaii, 12 percent of all single-family residential dwellings had PV by the end of 2013.

For residential consumers, the federal tax credit for PV remained stable in 2013 and is set to remain in effect through the end of 2016. Stable incentives encourage more homeowners to purchase solar. In addition to federal incentives, most residential installations occur in states with state or local incentives.

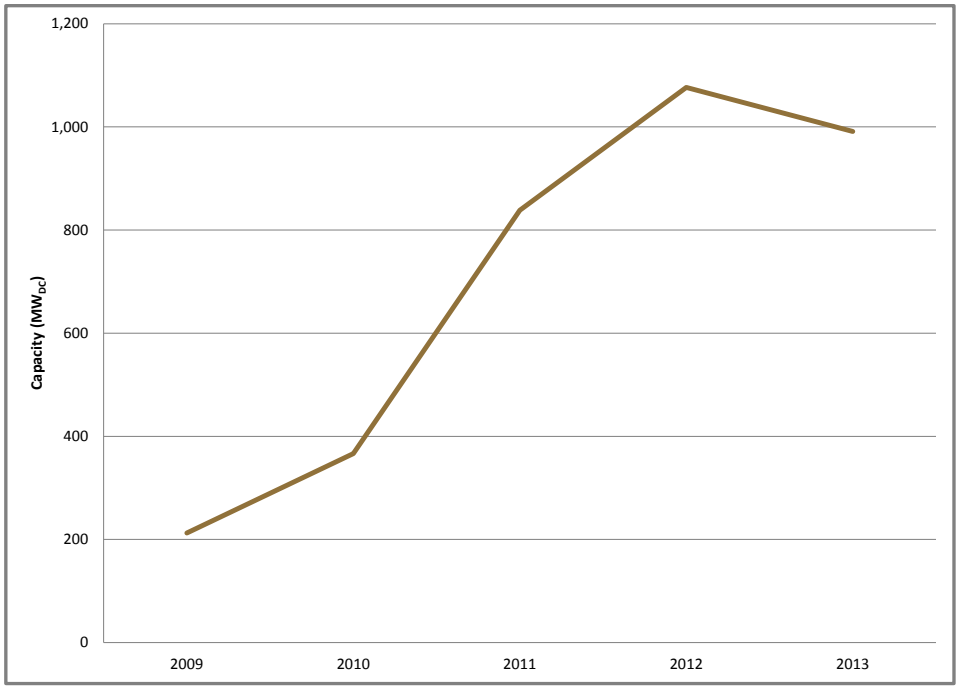


Figure 9: Annual Installed U.S. Grid-Connected Non-Residential Sector PV Capacity (2009-2013)

Non-Residential Sector Installations

The capacity of PV solar installed in 2013 in the non-residential sector, which includes government buildings, retail stores and military installations, decreased by eight percent compared with 2012 (Figure 9). The average size of a non-residential distributed installation decreased 11 percent to 109 kW_{DC}. The largest 2013 installation in this sector was a 20 MW_{DC} installation at an Apple data center in North Carolina. This installation complemented a similar size facility installed for Apple in 2012.

Of the Top Ten states for non-residential capacity installed in 2013, only Massachusetts, Arizona and North Carolina saw growth. The drop in non-residential installations was severe in New Jersey, Ohio and Pennsylvania. With the end of the Treasury Grant Program in 2012, projects that began construction by the end of 2012 remain eligible for the program, but no new projects can now be accepted. When incentive programs end, it is typical to see a surge of applications before the deadline and then a drop-off in installations after the deadline has passed. Falling PV prices and continued availability of the federal ITC meant that the loss of this incentive resulted in only a small drop in installations, but not a dramatic drop. This shows the underlying strength of the market.

Government PV installation in Salt Lake City, Utah

Grid-Connected Installations by State

In 2013, more than three-quarters of grid-connected PV capacity installed was concentrated in California, Arizona, North Carolina and Massachusetts (Table 3). California represents 57 percent of all U.S. PV capacity installed in 2013. In the rest of the country, 18 percent less PV capacity was installed in 2013 than in 2012.

Of the Top Ten States for 2013 capacity installations, California, North Carolina and Georgia more than doubled their totals from the prior year. Georgia and Texas joined the Top Ten Installation list for 2013 replacing Nevada and Colorado. Colorado and Nevada both saw a large decrease in utility installations — 66 MW_{DC} and 200 MW_{DC}, respectively. Although Colorado saw a 49 percent increase in distributed capacity installed, it was not enough to offset the large drop in utility installations.

State policies affect PV installations, with most installations happening in the few states with favorable solar policies. All states in the top ten for distributed installations have established an RPS, which tends to encourage larger installations

Worker installing PV system

Table 3: 2013 ANNUAL TOP TEN U.S. STATES
Ranked by Grid-Connected PV Capacity Installed in 2013

2013 Rank by State	2013 (MW_{DC})	2012 (MW_{DC})	2012-2013 Percent Change	2013 Market Share	2012 Rank
1. California	2,608	998	161%	57%	1
2. Arizona	424	732	- 42%	9%	2
3. North Carolina	261	122	114%	6%	6
4. Massachusetts	223	138	62%	5%	5
5. New Jersey	202	417	- 52%	4%	3
6. Hawaii	153	120	28%	3%	7
7. Georgia	89	8	974%	2%	24
8. Texas	76	55	38%	2%	11
9. New York	61	56	9%	1%	10
10. Maryland	59	80	- 26%	1%	9
All Other States	460	727	- 37%	5%	--
Total	**4,615**	**3,453**	**34%**	**--**	**--**

2012 and 2013 columns include installations completed in those years. “2013 Market Share” means share of 2013 installations. “2012 Rank” is the state ranking for installations completed in 2012.

(although RPS requirements and structures vary widely from state to state). California's requirement had the biggest impact of any state's RPS, but it does not have a solar carve-out. Most of the other Top Ten Installation states have RPSs with solar carve-outs.

Though their impact on the total market is declining, rebates are important state policies, especially for smaller installations. Five years ago, owners of most PV installations received a cash rebate from a state or utility incentive program, and this rebate was arguably the most important element of the financial package. In that era, no state had a significant amount of installations without a rebate program. For the past three years, incentive expenditures have been declining, in part because incentive levels have declined, and in part because some states have phased out these programs. Despite lower incentive expenditures, the installed capacity of PV facilities with rebate support continues to increase. When PV is less expensive, less incentive money is necessary to encourage installations.

Cumulatively, 66 percent of PV capacity is installed in just three states — California, Arizona and New Jersey (Table 4). These three states have had large amounts of capacity installed year after year.

On a cumulative per-capita basis, Hawaii moved into the top position in 2013. The per capita Top Ten Cumulative States are the same as in 2012, but the order of rankings has changed (Table 5).

Table 4: CUMULATIVE TOP TEN U.S. STATES Ranked by Grid-Connected PV Cumulative Installed Capacity through 2013

	MW_{DC}	Market Share
1. California	5,183	43%
2. Arizona	1,563	13%
3. New Jersey	1,185	10%
4. North Carolina	469	4%
5. Massachusetts	445	4%
6. Nevada	424	3%
7. Colorado	360	3%
8. Hawaii	358	3%
9. New Mexico	257	2%
10. New York	241	2%
All Other States	1,635	13%
TOTAL	**12,120**	**--**

Table 5: PER CAPITA TOP TEN U.S. STATES Ranked by Grid-Connected PV Cumulative Installed Capacity per Capita (W_{DC}/person) through 2013

	Cumulative through 2013 (W_{DC}/person)	2013 Installations (W_{DC}/person)
1. Hawaii	255.1	108.9
2. Arizona	235.9	63.9
3. Nevada	152.0	16.8
4. California	135.2	68.0
5. New Jersey	133.1	22.7
6. New Mexico	123.1	23.5
7. Colorado	68.4	11.0
8. Delaware	67.8	18.0
9. Massachusetts	66.5	33.3
10. Vermont	66.2	21.6
NATIONAL AVERAGE	**37.9**	**14.4**

Non-profit PV installation in Austin, Texas

Information on Top State Markets

PV market activity often has more to do with state policies and incentives than with the amount of available sunlight or solar resource. Most of the top states for grid-connected PV have favorable solar policies. Electricity prices are also a factor; many installations are in states with higher than average prices. As solar prices fall, electricity prices and rate policies become an increasingly important factor in state markets. This section describes the market conditions in the states with the largest number of installations.

California is the most important market for solar in the United States. In 2013, 57 percent of PV capacity, and 67 percent of CSP capacity installed were in California. All market sectors are strong in California.

California has an RPS requirement of 20 percent by 2013, and 33 percent by 2020. This policy includes all renewable technologies, and it inspired many PV installations in 2013. This requirement led to 1.9 GW_{DC}[1] of utility sector PV solar installations in California in 2013. In addition, a 145 MW_{DC} utility PV installation in Arizona supplies electricity for California, and two CSP plants totaling 516 MW_{AC} also supply electricity. A full 76 percent of all utility sector capacity installed in 2013 was either in California or supplies electricity for the California market.

California is also a leader in distributed installations. In 2007, California launched the $3 billion *Go Solar California* campaign. The largest part of this campaign is the California Solar Initiative (CSI), overseen by the California Public Utilities Commission (CPUC). The CSI awards rebates and performance-based incentives to customers serviced by the state's three investor-owned electric utilities: PG&E, SCE and SDG&E. With $158 million in CSI incentives, more than 375 MW_{DC} of distributed PV were installed in 2013 through this program. Program incentives are based on actual system performance of larger systems and expected system performance of smaller systems. The program stopped accepting new applications in 2013, but systems with reservations may still be installed in the future. Incentive levels were reduced over the duration of the program in 10 "steps," based on the aggregate capacity of PV installed. The average incentive paid per watt in 2013 was 81 percent lower than the average incentive paid in 2007, the first year of the program. The CSI was prudently designed as a long-term program, so the industry in California could rely on long-term policy stability. Because the incentives stepped down over time, the transition to an incentive-free market has been smooth. Even though the CSI incentives are coming to a close, PV installations continue to increase. California's steep, tiered electric rate schedule and large peak period time-of-use rates, combined with net metering, provide enough of an incentive for consumers to continue to install PV systems.

Residential PV installation in California

1 Note that California agencies typically report in MW_{AC} and the data are presented here in MW_{DC}.

Rural PV installation in Colorado

In addition, the California Energy Commission (CEC) administers the New Solar Home Partnership Program for PV installations on new homes, and the CPUC manages the Multi-Family Affordable Solar Housing and the Single-Family Affordable Solar Housing Programs. California's municipal utilities have also installed and incentivized the installation of many systems. The capacity of distributed installations by California public utilities increased by 48 percent to 125 MW_{DC} in 2013.

The result of these programs is that 35 percent of all 2013 distributed PV capacity installed in the U.S. was in California. California has long had strong incentives and a solid net metering policy. Now, as incentives are dwindling, dropping PV prices and high electricity rates are propelling continued sustained growth in distributed installations.

Arizona ranks second for PV capacity installed in 2013, though the capacity installed was 42 percent less than what was installed in 2012. The 250 MW_{AC} Solana Generating Station, a CSP plant, was completed in 2013. However, the numbers are skewed because some of the utility PV capacity installed in Arizona supplied electricity to California utilities. If only installations in Arizona that supply electricity for Arizona are considered, the state would still rank number two, and the decline in PV capacity installed would be a much more modest five percent. Installation of distributed PV increased by 31 percent in 2013. Including the CSP plant means that Arizona shows significant solar growth in 2013.

Arizona's current RPS requires that 15 percent of electricity must be generated from renewable sources by 2025. Distributed generation must provide 30 percent of that energy, divided equally among residential and non-utility, non-residential installations. Solar water heaters may also provide RECs for RPS compliance in Arizona. Starting in 2014, new residential PV customers of Arizona Public Service will pay a fee of $.70 per kilowatt to participate in net metering.

In **New Jersey**, an RPS with a solar carve-out has built a strong PV market. The solar requirement was 306 GWh in 2011, increasing to 5,316 GWh in 2026. In the early years of New Jersey's PV growth, rebates were the most important driver, peaking in 2006 at $78 million in expenditures. In 2013, only two residual rebates were granted. New Jersey's capacity-based rebate program has been converted into a performance-based incentive that involves payments based on the actual energy production of a PV system. This performance-based

program created a market for SRECs, which New Jersey utilities use to comply with the RPS. However, New Jersey SREC prices crashed in 2012, falling to less than half the price that had been seen in previous years. The state made policy changes to stabilize its long-term SREC market. Even so, the new PV capacity installed in 2013 fell by over 50 percent compared with 2012. New Jersey was the number two state market for many years, but it fell to number three in 2012 and to number five in 2013.

North Carolina has an RPS with a 0.2 percent solar carve-out by 2018. North Carolina also has a 35 percent state tax credit, one of the highest tax credits in the country. Most North Carolina PV system owners sell the electricity generated to utility companies or, until recently, to NC GreenPower. North Carolina has established a system to track RECs and record compliance with the state's RPS and solar carve-out.

Massachusetts has a long history of providing rebates for PV installations. In 2010, Massachusetts awarded $37 million in rebates for 14 MW_{DC} of PV installations. These installations represented 63 percent of the PV capacity installed in Massachusetts that year. In 2013, the state awarded $5.5 million in rebates for 15 MW_{DC} of PV installations. Thus, 87 percent fewer rebate dollars funded seven percent more installed PV capacity. During the same period, the amount of installed capacity *not* supported by rebates increased from 9 MW_{DC} to 208 MW_{DC}. This can be attributed to the Massachusetts RPS, which has a solar carve-out of 0.163 percent in 2012 and 0.2744 percent in 2013. Massachusetts uses an SREC market for compliance with the RPS requirements.

Hawaii has the highest electricity rates in the country. The 2013 average price of nearly $0.33/kWh is more than twice the rate in any other state, and almost three-and-a-half times the national average electricity price. Hawaii also has a personal state solar income tax credit. Some 92 percent of Hawaii installations were distributed in 2013. The financial benefits of PV are more favorable in Hawaii than in any other state. On a per capita basis, Hawaii had, by far, the most installed capacity of distributed PV.

Georgia had the highest growth in PV capacity installed of any top state, with 10 times the capacity installed in 2013 compared with 2012. In 2012, the Georgia Public Service Commission approved the Georgia Power Advanced Solar Initiative. This authorizes Georgia Power to purchase up to 90 MW of distributed installations from small and medium size projects and 120 MW from utility scale projects. In 2013, 22 MW_{DC} of distributed installations and 58 MW_{DC} of utility installations were installed through this program.

In **New York,** the New York State Energy Research and Development Authority and the Long Island Power Authority have operated long-term significant rebate programs. New York also has a customer-sited carve-out under its RPS Program that funds many of the current NY policy initiatives. Because of these programs, installations have increased steadily over the years.

Commercial PV installation in New York City

4. CONCENTRATING SOLAR POWER

Three new CSP solar plants with a total capacity of 766 MW_{AC} were completed in the United States in 2013 (Figure 10). These were the first CSP plants completed in the country since 2010 and, by far, the most ever installed in a single year. The cumulative installed CSP capacity more than

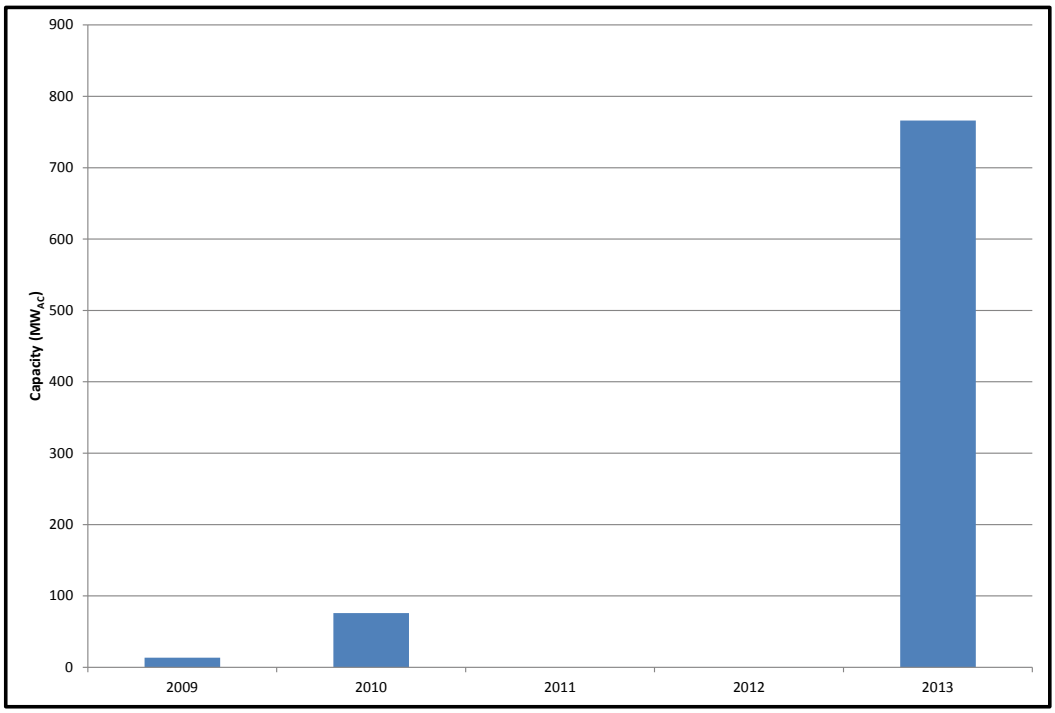
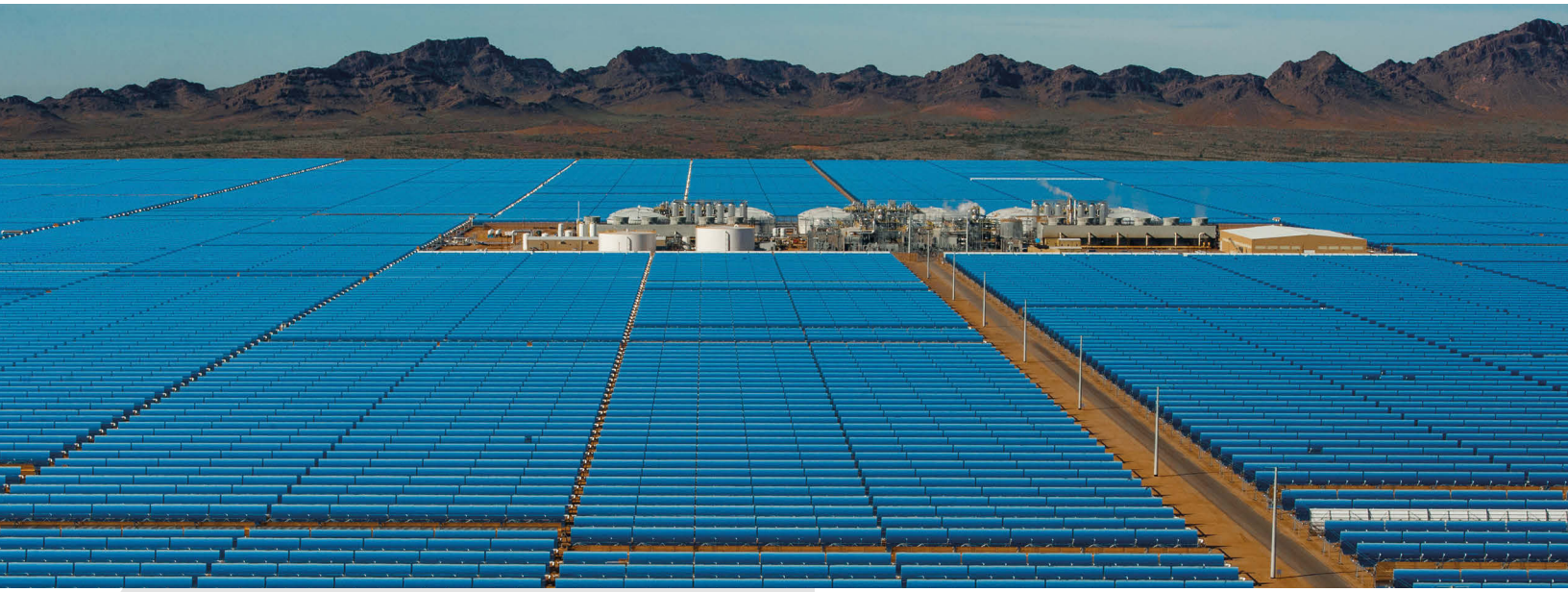


Figure 10: Annual Installed U.S. CSP Capacity (2009-2013)



Parabolic trough system at Solana Generating Station near Phoenix, Arizona

Solar power towers at Ivanpah Solar Electric Generation Station in California

doubled in 2013, to 1275 MW_{AC} (Figure 11). The three CSP plants are:

- **Solana Generating Station**, Phoenix, Arizona, 250 MW_{AC}. A parabolic trough system developed by Abengoa Solar, with the electricity sold to Arizona Public Service.

- **Genesis Solar Plant**, Blythe, California, 125 MW_{AC}. A parabolic trough system developed by Genesis Solar, with the electricity sold to PG&E.

- **Ivanpah Solar Electric Generating Station**, San Bernardino, California, 391 MW_{AC}. Three power towers developed by BrightSource Energy, Inc., with the electricity sold to PG&E and SCE.

The Ivanpah plant is the first large-scale commercial use of power tower technology in the United States.

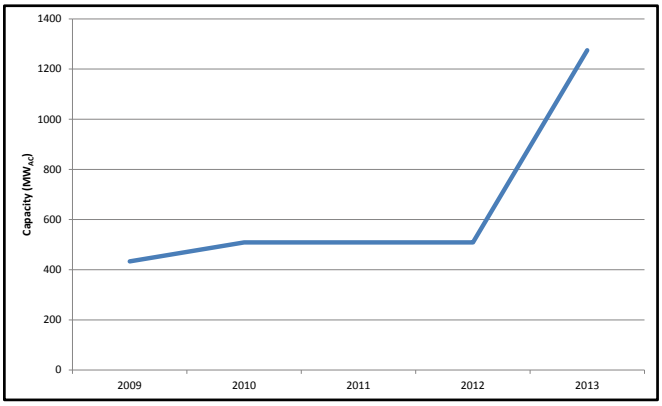


Figure 11: Cumulative Installed U.S. CSP Capacity (2009-2013)

In 2014, CSP plants generating over 300 MW are likely to be completed in California and Nevada. Additional plants are under construction for completion in future years.

Commercial PV installation in Austin, Texas

5. PROSPECTS FOR THE FUTURE

What can we expect for the future of U.S. solar markets? The short-term prospects for continued strong growth are good. As the federal ITC expires for residential installations and declines for commercial installations at the end of 2016, we can expect that implicit deadline to have both positive and negative impacts on the market.

Growth continues in the residential sector. Although the market is concentrated in several states, many states have growing numbers of homeowners installing solar. The future of net metering will be studied in many states, and the outcomes of numerous cost/benefit studies and policy debates will affect residential markets.

The non-residential distributed PV sector was the weakest sector in 2013, and that trend will likely continue. Changes to the New Jersey program made in 2012 will help stabilize the market in that important state and may help fuel modest growth in 2014.

Numerous utility PV projects under construction or approved mean that this sector will continue to grow in 2014. However, the growth in this sector is extremely concentrated in a few states. As those states meet their RPS requirements, future installations will need to be justified on economics. The slow growth of U.S. electricity consumption means that most utilities will not be aggressively pursuing new power options.

Concentrating solar power projects face a similar market dynamic. A number of plants are under construction and will be completed over the next few years. New orders will require a different market model than installations in the pipeline now.

6. CONCLUSION

PV markets continue to grow in the United States. More than 4.6 GW_{DC} of PV installations were completed at 155,000 sites in 2013. The capacity installed in 2013 was 36 percent greater than the amount installed in 2012. The markets for each solar technology are generally concentrated in a few states.

Growth is largest for small installations (residential) and the largest installations (utility-scale). The residential market is making the transition away from markets based on state and utility rebates and incentives. The utility sector now faces a similar transition away from markets based on renewable portfolio standard (RPS) policies.

These markets depend on a combination of federal and state policies and financial incentives, the most significant of which include:

- Federal ITC
- U.S. 1603 Treasury Grant Program
- Federal loan guarantees
- State RPSs, especially those with solar requirements
- Net metering
- State, utility, or local rebates or other financial payments

In addition to government policies, the following factors are important contributors to the growth of solar markets:

- Lower installed costs for PV installations
- Availability of capital for third-party ownership of systems

The U.S. solar market growth will continue in 2014, with larger utility sector projects leading the way.

Parabolic trough system at Solana Generating Station near Phoenix, Arizona

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DISCLAIMER

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Page 27: Residential PV installation in Austin, Texas
Photo courtesy of Austin Energy

Residential PV installation in Austin, Texas

Appendix A

DATA SOURCES

Grid-Connected PV

State data were obtained for grid-connected PV installations from the following sources:

- State agencies or organizations administering state incentive programs;
- Utility companies; and
- Energy Information Agency data on New Electricity Generation Plants and Net Metered Systems (EIA 2014 and EIA 2013)

The Solar Electric Power Association (SEPA) publishes an annual report on installation by utility that is based on an annual utility survey (Makyhoun, Taylor & Clark 2014). Since 2010, IREC has collaborated with SEPA and exchanged data. This collaboration results in better and more extensive installation data. With the growth of the PV market, data collection becomes more complex and multiple sources help improve data quality.

The data quality depends on the source. Certainly, this study misses some installations. Data based on incentives paid have historically been the most reliable data. As rebates fund a smaller share of PV installations each year, incentive databases become less important data sources.

Off-Grid PV

IREC does not collect data for these installations, and they are not included in this report's charts.

Solar Heating and Cooling

Previous editions of this report included data for solar heating and cooling installations. However, this year's report does not include this data.

APPENDIX B

ASSUMPTIONS

Solar Capacity

Capacity measures the maximum power that a system can produce. For a solar energy system, the capacity is the output under "ideal" full sun conditions. Capacity is typically measured in watts (W), kilowatts (kW) or megawatts (MW). A kilowatt of one technology usually does not produce the same amount of energy, commonly measured in kilowatt-hours (kWh) for electricity, as a kilowatt of another technology. Thus, capacity for one energy technology is not directly comparable to the capacity for another technology.

This study reports PV capacity in direct current (DC) watts under Standard Test Conditions ($W_{DC\text{-}STC}$) of 1000 W/m^2 solar irradiance and 25° C PV module temperature. This is the capacity number that manufacturers and others typically report; it is also the basis for rebates in many states.

A number of states and utilities report capacity in alternating current (AC) watts. The California Energy Commission calculates AC watts by multiplying DC watts under PVUSA Test Conditions by the inverter efficiency at 75 percent of load. The resulting capacity ($W_{AC\text{-}PTC}$) is a more accurate measure of the maximum power output under real world conditions.

The California Solar Initiative (CSI) reports installation capacity in both DC and AC watts. Therefore, the average ratio between AC and DC watts can be determined for each year. According to the CSI data in 2010, AC watts were 86.2 percent of DC watts. In 2013 the ratio increased to 87.2 percent. In cases where the capacity was reported in AC watts, IREC used 86.5 percent to convert the data to DC watts.

Number of Installations

For grid-connected PV installations, this study uses actual data on the number of installations. For the data, which show residential and non-residential installations, real data are used whenever possible. For data sources which only report the size of the installations, this study assumes all installations less than 10 kW_{DC} are residential installations.

The results for cumulative installations include all new installations in previous years. No accounting was made for systems that are no longer operational.

Date of Installation

This report uses the best data available on the date of installation. Ideally, this is based on the date when the installation was connected and producing power. Calendar Year (CY) is used as the year basis for all data.

In some cases, data are available for when the applicant finished the installation and applied for the incentive payment. When this information is available, it was used as the installation date.

In many cases, the agency that administers an incentive program reports the date on which the incentive payment was made. If these are the only data available, this is the installation date used in this report.

Net Metering

In states where net-metering data was unavailable, IREC assumed that systems meeting the local rules for net-metered systems were net-metered.

Changes from Last Year's Report

This edition of this report uses the best available data for all years at the time of publication. Some data from past years were updated. Thus, installed capacity and number of installations shown in this report for 2012 and earlier are not always identical to what was reported in the 2012 or earlier editions of this report.

APPENDIX C

GRID-CONNECTED PV INSTALLATIONS BY U.S. STATE

State	Capacity Installed in 2013 (MW_{DC})				Cumulative Installed Capacity (MW_{DC})
	Residential	Non-Residential	Utility	Total	
Alabama	0.3	0.5	*	0.8	1.9
Alaska	0.1	0.1	*	0.2	0.2
Arizona	82.6	94.1	247.0	423.7	1,563.1
Arkansas	0.1	0.1	*	0.2	1.8
California	397.4	260.7	1,949.6	2,607.7	5,183.4
Colorado	31.1	25.9	1.1	58.0	360.4
Connecticut	10.5	21.3	5.8	37.5	77.1
Delaware	2.0	10.1	4.6	16.7	62.8
District of Columbia	1.5	1.1	*	2.6	16.5
Florida	9.1	7.3	4.0	20.4	137.3
Georgia	0.8	21.5	66.2	88.5	109.9
Hawaii	108.4	32.8	11.8	153.0	358.2
Idaho	0.4	0.4	*	0.7	1.8
Illinois	0.1	0.4	*	0.5	43.4
Indiana	0.8	0.4	43.8	45.0	49.4
Iowa	1.3	2.1	*	3.4	4.6
Kansas	0.3	0.3	*	0.6	1.1
Kentucky	0.9	2.2	*	3.2	7.9
Louisiana	27.4	0.6	*	28.0	46.6
Maine	2.2	0.4	*	2.5	5.3
Maryland	21.6	37.1	*	58.7	175.4
Massachusetts	28.7	166.7	27.3	222.6	445.0
Michigan	1.2	1.1	*	2.3	22.2
Minnesota	0.6	1.2	2.0	3.8	15.1
Mississippi	0.1	0.2	*	0.3	1.0
Missouri	16.0	14.4	*	30.4	48.9
Montana	0.6	0.3	*	0.9	3.0
Nebraska	0.1	0.1	*	0.2	0.6
Nevada	4.8	7.5	34.6	46.9	424.0
New Hampshire	2.8	1.4	*	4.1	9.6
New Jersey	41.7	150.1	10.5	202.3	1,184.6
New Mexico	10.3	13.6	25.2	49.1	256.6
New York	24.2	33.1	3.8	61.1	240.5
North Carolina	2.5	23.1	235.5	261.1	469.0
North Dakota	0.1	*	*	0.1	0.2
Ohio	3.0	10.5	5.0	18.5	98.4
Oklahoma	0.3	0.1	*	0.4	0.7
Oregon	4.8	1.7	*	6.4	62.8
Pennsylvania	7.3	8.5	*	15.9	180.2
Rhode Island	*	*	5.7	5.7	7.6
South Carolina	0.3	0.2	3.0	3.5	8.0
South Dakota	*	*	*	*	*
Tennessee	3.2	16.1	0.5	19.8	64.8
Texas	14.7	13.9	47.0	75.6	215.9
Utah	2.8	3.2	*	6.0	16.0
Vermont	4.6	2.2	6.7	13.6	41.5
Virginia	1.6	0.5	0.1	2.2	12.6
Washington	6.5	1.4	*	7.9	27.4
West Virginia	0.4	0.1	*	0.5	2.2
Wisconsin	0.6	0.7	*	1.4	22.5
Wyoming	0.2	0.2	*	0.4	1.0
Territories	*	0.1	*	0.1	29.9
TOTAL	**882.8**	**991.2**	**2,740.6**	**4,614.7**	**12,120.1**

* = less than 100 kW_{dc} or data not available