U.S. SOLAR MARKET TRENDS 2009

July 2010

Larry Sherwood

IREC Interstate Renewable Energy Council

EXECUTIVE SUMMARY

SOLAR MARKETS ARE BOOMING in the United States due to rising energy prices, strong consumer demand, and financial incentives from the federal government, states and utilities. Over 107,000 new solar heating, cooling, and solar electric installations were completed in 2009, an increase of 18% compared to the number of systems installed in 2008. The majority of the market share for each solar technology is concentrated in a few states.

Photovoltaic trends:

- The capacity of photovoltaic (PV) installations completed in 2009 grew by 40% compared to the capacity installed in 2008. Despite the global recession, this growth rate was strong, but lower than in recent years.
- PV capacity installed in 2009 tripled in the utility sector and doubled in the residential sector, but it did not grow in the non-residential sector. Poor economic conditions and a difficult financing environment especially affected non-residential installations.
- The amount of PV capacity installed in Arizona, Florida, Massachusetts, New Jersey and Texas installed in 2009 was at least double the capacity installed in each state in 2008. California remains the largest U.S. market, with about half of the U.S. installed capacity completed in 2009.

Solar heating and cooling trends:

- There were 10% more solar water heating installations (low-temperature thermal) completed in 2009 than in 2008.
- In the continental 48 states, the annual installed capacity has more than quintupled since 2005. Residential installations dominate the market.
- Hawaii is still the largest state market for solar water heaters, with more than one-quarter of the installations completed in 2008.
- The capacity of solar pool heating installations has declined in each of the past three years.

Concentrating solar power trends:

- Four new concentrating solar power (CSP) plants were connected to the grid in 2009, with a combined capacity of 13.5 MW. These plants were small demonstrations of new technologies in preparation for large CSP plants in the future.

Over the long term, the prospect for growth in solar installations is bright. Early indicators point to accelerating market growth in 2010 due to the long-term extension of the federal solar investment tax credit (ITC), recent federal legislation that allows utilities to take advantage of the ITC, and a deadline to start construction in 2010 to participate in the federal cash grant program. Companies have announced plans for many large solar electric projects, including both PV and CSP projects. Some of these projects will begin construction in 2010, and a few will be completed in 2010. Many more CSP plants will begin construction and come on-line in 2011 and beyond. Financing, siting and transmission issues will determine when, and if, these project can be constructed.

About the Interstate Renewable Energy Council

The Interstate Renewable Energy Council (IREC) is a premier resource for current information, education, credentialing and best practices regarding renewable energy. IREC has worked to remove barriers to renewable energy use since 1982. Throughout its 28-year history, the organization has been instrumental in rulemaking for connecting distributed power to the utility grid, workforce development, consumer protection and stakeholder coordination.

INTRODUCTION

DIFFERENT SOLAR ENERGY technologies create energy for different end uses. Two solar technologies, photovoltaics (PV) and concentrating solar power (CSP), produce electricity. A third technology, solar thermal collectors, produces heat for water heating, space heating or cooling, pool heating or process heat.

Photovoltaic 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, parking structures or in ground-mounted arrays. PV was invented in the 1950s and first used to power satellites. As PV prices declined, PV systems were installed in many off-grid installations – installations not connected to the utility grid. In the last decade, and especially in the last several years, grid-connected installations have become the largest sector for PV installations.

Concentrating solar power (CSP) systems use mirrors and collecting receivers to heat a fluid to a high temperature (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, and installations continued through the early 1990s. Although many of these installations continue to generate power today, few new systems had been installed since the early 1990s until recently. Installations have resumed, with several small plants constructed in 2009 and a significant number of announcements for new plants projected to be completed between 2010-2015. In another application, concentrating solar thermal can provide high temperature solar process heat for industrial or commercial applications. A few systems are installed each year using this technology.

Solar thermal energy is used to heat water, to heat and cool buildings, and to heat swimming pools. A variety of flat plate, evacuated tube and concentrating collector technologies produce the heat needed for these applications. Solar water heating systems were common in southern California in the early 1900s before the introduction of natural gas. Many systems were sold in the United States in the late 1970s and early 1980s. In the mid-1980s, the expiration of federal solar tax credits and the crash of energy prices led to an industry slow-down. Since 2006, the solar heating and cooling market has grown each year.

This report provides public data on U.S. solar 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. In addition, these data allow for a better understanding of the environmental and economic impact of solar installations.

For all solar technologies, the United States is only a small part of a robust world solar market. Product availability and pricing generally reflect this status. Germany is the top market for PV; Spain is the top market for CSP; and China is the largest market for solar thermal collectors. The grid-connected PV market in Ontario, Canada, ranks as one of the largest markets in North America. Ontario's market is discussed briefly in Section 2. (Other than Ontario's market, this report does not analyze markets outside the United States.)

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

2. PHOTOVOLTAICS

Overall Trends in Installations and Capacity

Annual U.S. grid-connected PV installations grew by 40% in 2009 compared with installations in 2008 to 435 MW_{DC}, raising the cumulative installed grid-connected capacity to 1.25 GW_{DC}, a new industry milestone (See Figure 1). Although PV growth was strong in 2009, the annual growth rate was significantly less than the rate in 2007 (61%) and in 2008 (84%). Considering the poor economy in 2009, this growth was still impressive. The capacity of PV systems installed in 2009 was four times the capacity of PV installed in 2006. More than 34,000 sites installed PV in 2009, an 81% increase over the number of 2008 installations. Most of these installations are mounted on buildings, but some are ground-mounted or pole-mounted installations.

Some PV installations are off-grid. Based on anecdotal information, off-grid installations likely totaled 40-60 MW in 2009, but IREC has not collected data for these installations, and they are not included in this report's charts.

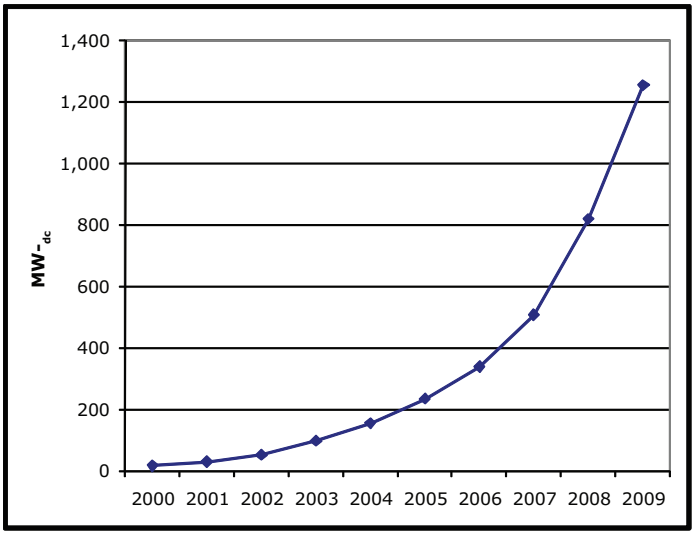


Fig. 1: Cumulative U.S. Grid-tied Photovoltaic Installations (2000-2009)

The following factors helped drive PV growth in 2009:

- Many states continue to offer financial incentives for PV, and system installation growth more than doubled in New Jersey, Florida, Arizona, Massachusetts, and Texas. Each of these states has one or more significant financial incentive and/or a renewable portfolio standard (RPS) program with a specific solar mandate (or customer-sited mandate).
- Federal tax incentives were renewed and expanded in October 2008, and further revised in February 2009. These incentives played a significant role in the markets for 2009, but the impact varies greatly by market sector. (These effects are described in the next section.)
- During 2009, the price of PV modules began to fall. For systems installed under the California Solar Initiative, the installed cost decreased by 7% in the fourth quarter of 2009 compared with the fourth quarter of 2008.

Grid-Connected Installations by Sector

The growth rate of grid-connected PV varied significantly by market sector, with large growth in the residential and utility sectors, and no growth in the non-residential sector. Non-residential facilities include government buildings, retail stores and military installations. The larger average size of these facilities results in a larger aggregated capacity. Residential and non-residential installations are generally on the customer's side of the meter and produce electricity used on-site. In contrast, utility installations are on the utility's side of the meter and produce bulk electricity for the grid. Table 1 shows examples of installations in each sector. Figure 2 shows the annual PV installation capacity data, segmented by residential, non-residential and utility installations.

Table 1: SAMPLE 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 the homeowner or building owner
Non-Residential	• Non-residential installation owned by building owner; electricity generated is used on-site • 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; electricity generated goes into bulk power grid through a feed-in tariff or similar incentive

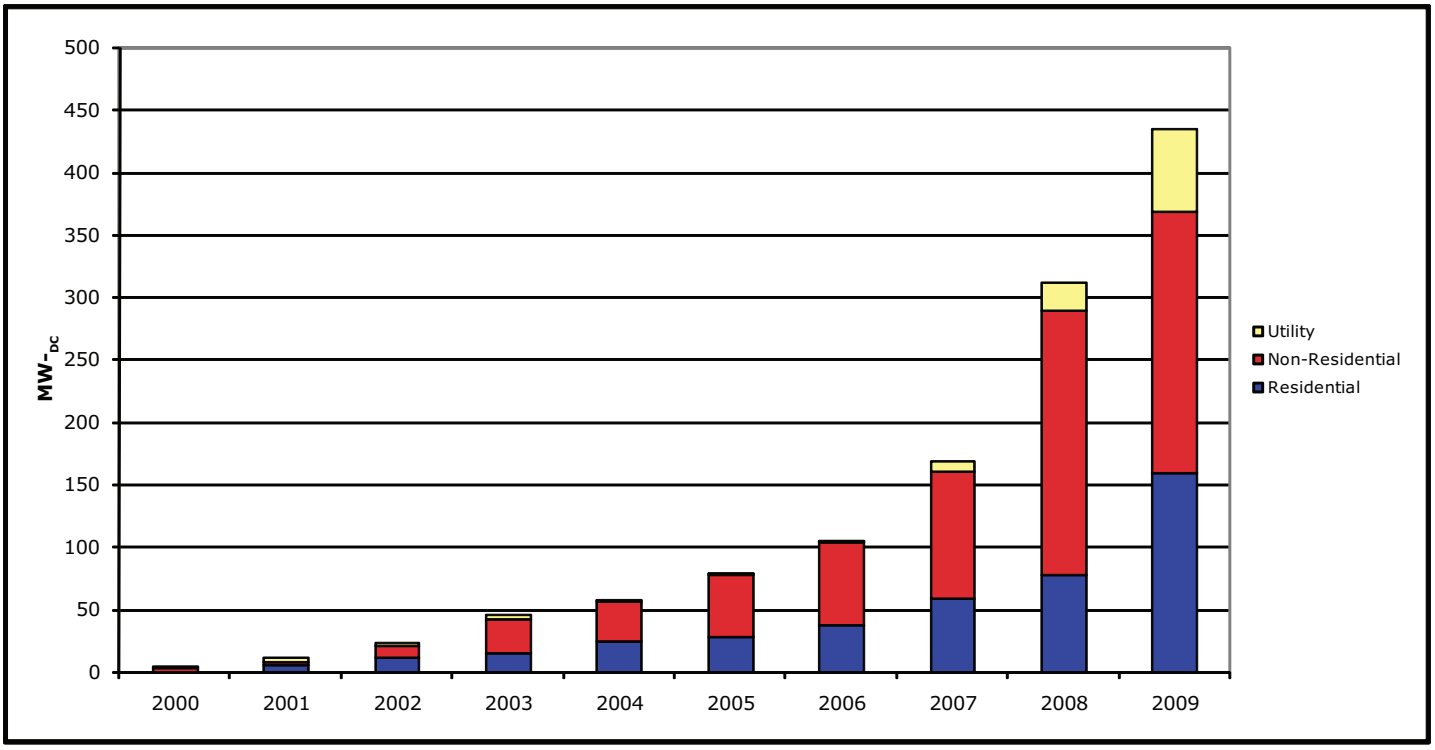


Fig. 2: Annual Installed Grid-Connected PV Capacity by Sector (2000-2009)

Residential capacity installed in 2009 more than doubled compared with capacity installed in 2008 and represented 36% of all new grid-connected PV capacity. This market share is consistent with residential installations in 2005, 2006 and 2007, and is significantly higher than the 27% market share for residential installations in 2008.

In October 2008, the residential federal investment tax credit (ITC) was renewed and the $2,000 cap was removed for residential installations beginning in January 2009. In the final quarter of 2009, this policy change caused some homeowners to delay new installations until 2009 in order to receive a larger federal tax credit. These consumer decisions negatively impacted the number of residential installations in 2008 and positively impacted the number in 2009.

The non-residential sector experienced no growth in capacity installed in 2009 compared with capacity installed in 2008. This was a dramatic change from the past several years, when the non-residential sector experienced large growth rates.

A number of factors led to the lack of growth in the capacity of non-residential installations in 2009 compared with the 2008 installations. First, for most of 2008, the future of the residential and businesses ITCs was uncertain; the residential ITC was scheduled to expire and the commercial ITC was scheduled to decrease from 30% to 10% on January 1, 2009. Developers signed many contracts for new installations with a delivery date before the end of 2008. This resulted in a rush of installations in the last quarter of 2008, but few orders for installation in 2009. When the ITC was extended in October 2008, the economy soured and credit markets froze. Obtaining orders and financing for new projects was very difficult in this environment. The American Recovery and Reinvestment Act of 2009, enacted in February 2009, included a provision for cash grants instead of tax credits. However, the rules for this program were not published until July 2009, further slowing orders. In the last half of 2009, federal incentive rules were clear, credit markets improved slightly, and federal stimulus funds flowed. However, these improvements came too late for 2009 installations. Growth in the non-residential sector should return in 2010.

Virtually all of the larger installations and many of the medium-sized non-residential installations use power purchase agreements (PPAs). In addition, several companies now provide PPAs for residential customers in specific states or utility service

territories. In these agreements, a third party finances and owns the solar installation and receives the available tax advantages and other incentives. The third party then leases the system or sells the solar-generated electricity to the building or site owner through a long-term contract.

In several states, regulators are considering defining third-party owners of solar equipment as utilities (i.e. the PPA model discussed previously). Such rulings are very unfavorable to the third-party solar PPA model. If such rulings are made, third-party owners in these states may still be able to lease solar facilities to customers (as opposed to owning and operating solar facilities) without being classified as utilities, but their ability to use the federal ITC will need to be clarified. If a third-party PPA provider has the same legal obligations as a utility, the cost of doing business generally becomes prohibitively expensive.

Utility installations, defined here as installations for bulk power on the utility's side of the meter, tripled in 2009 and represented 16% of grid-connected PV capacity installed in 2009. A 25-MW_{AC} installation in Florida and a 21-MW_{AC} installation in California were the largest PV systems installed in 2009 — and the two largest PV installations ever installed in the United States. The renewal of the federal ITC in October 2008 allowed utilities to use federal credits for the first time. This change, along with solar carve-outs within some states' renewable portfolio requirements, led to dramatic growth in utility sector installations. Announcements of projects to be installed in 2010 indicate continued rapid growth of PV projects in the utility sector.

Size of Grid-Connected PV Installations

The average size of a grid-connected PV residential installation has grown steadily from 2.1 kW_{DC} in 2000 to 5.2 kW_{DC} in 2009 (see Figure 3). The average size of a non-residential system decreased to 90 kW_{DC} in 2009 from 115 kW_{DC} in 2008, though the long-term trend is an increase in the average size in this sector as well (see Figure 4). The average size of grid-connected PV installations varies from state-to-state, depending on available incentives, interconnection standards, net metering regulations, solar resources, retail electricity rates, and other factors. The Interstate Renewable Energy Council provides summary tables of state net metering and interconnection policies (IREC 2010a and IREC 2010b), and the Database for State Incentives for Renewables & Efficiency provides summary tables of state and utility financial incentives (DSIRE 2010a)

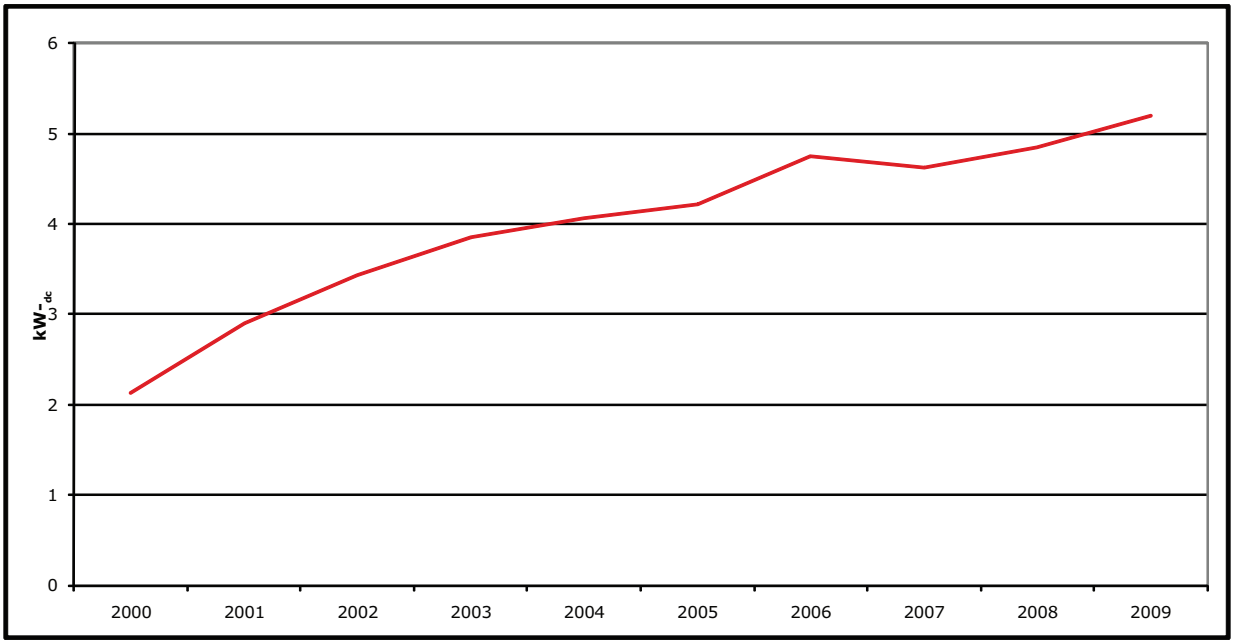


Fig. 3: Average Capacity of U.S. Grid-Connected Residential PV Installations (2000-2009)

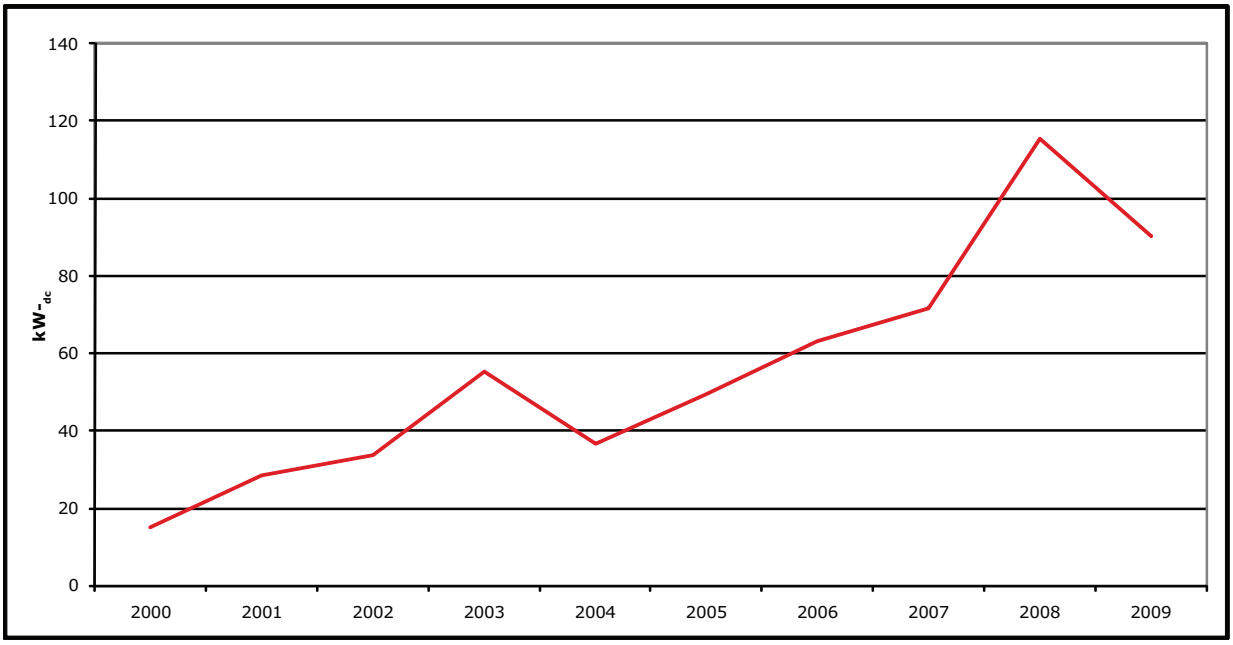


Figure 4: Average Capacity of U.S. Grid-Connected Non-Residential PV Installations (2000-2009)

Although the number of utility PV installations remains small, the average system size is over 400 kW_{DC}. Just six utility installations greater than 1 MW_{DC} totaled 60 MW_{DC}, or 14% of the capacity total of U.S. systems installed in 2009. Large utility installations attract significant attention, but small installations also occur in the utility sector. In New Jersey, PSE&G began installing 200-W PV systems mounted on power poles. These installations totaled more than 1 MW in 2009 and will continue into 2010.

Feed-in tariff incentives generate electricity for the utility sector and represent a small, but growing, segment of the U.S. PV market. With a feed-in tariff, the utility purchases all the output of the PV system at guaranteed prices, which are typically higher than retail electricity prices.

Over 34,000 grid-connected PV installations were completed in 2009, with 92% of these at residential locations (see Figure 5). By contrast, residential systems accounted for only 36% of the PV capacity installed in 2009, as discussed previously. At the end of 2009, 104,000 PV installations were connected to the U.S. grid, including over 93,000 residential installations. The average size of non-residential systems is more than ten times the average size of residential systems.

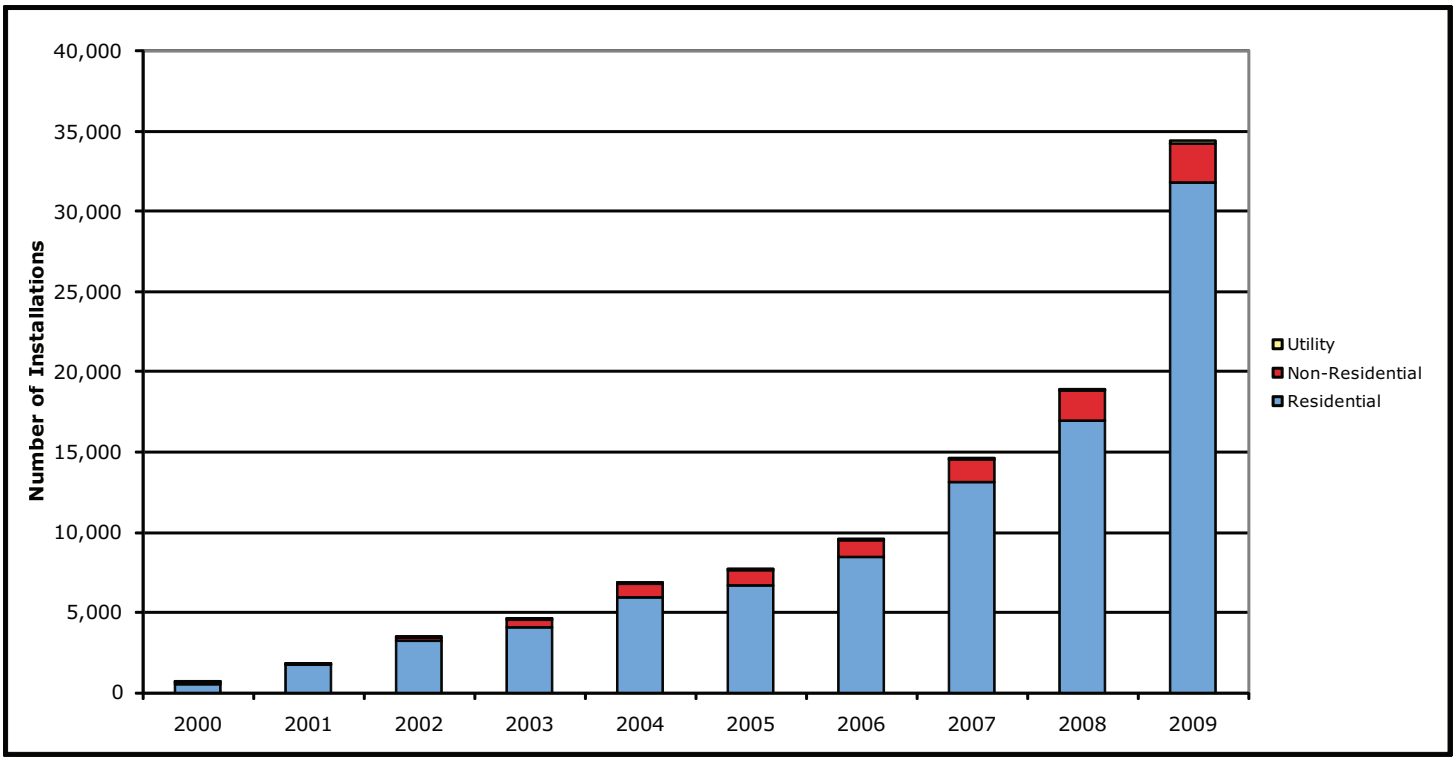


Fig. 5: Number of Annual U.S. Grid-Connected PV Installations (2000-2009)

Grid-Connected Installations by State

In 2009, installations of grid-connected PV systems were concentrated in California, New Jersey, Florida, Arizona and Colorado, as shown in Table 2. Eighty percent of grid-connected PV capacity installed in 2009 occurred in these five states, and 92% occurred in the top ten states. The market share for annual installations in California slipped below 50% for the first time. Although markets are growing in California, they are growing much faster in other states.

The market more than doubled in New Jersey, Florida, Arizona, Massachusetts and Texas. Florida's rank increased the most of any state, largely due to a single 28-MW_{DC} utility installation. Of the states with over 1 MW_{DC} installed in 2009, only Nevada saw a decline in the capacity of systems installed in 2009 compared with those installed in 2008. Nevada was home to one large single installation in both 2007 and 2008. No similar installation was completed in Nevada in 2009.

Table 2: TOP TEN STATES
Ranked by Grid-Connected PV Capacity Installed in 2009

2009 Rank by State	2009 (MW_{DC})	2008 (MW_{DC})	08-09 % change	2009 Market Share	2008 Rank
1. California	212.1	197.6	7%	49%	1
2. New Jersey	57.3	22.5	155%	13%	2
3. Florida	35.7	0.9	3668%	8%	16
4. Colorado	23.4	21.7	8%	5%	4
5. Arizona	21.1	6.2	243%	5%	8
6. Hawaii	12.7	8.6	48%	3%	5
7. New York	12.1	7.0	72%	3%	7
8. Massachusetts	9.5	3.5	174%	2%	11
9. Connecticut	8.7	7.5	16%	2%	6
10. North Carolina	7.8	4.0	96%	2%	10
All Other States	34.2	24.6	41%	7%	--
Total	**434.6**	**311.3**	**40%**	**--**	**--**

2008 and 2009 columns include installations completed in those years. "2009 Market Share" means share of 2009 installations. "2008 Rank" is the state ranking for installations completed in 2008.

Table 3: TOP TEN STATES
Ranked by Grid-Connected PV Cumulative Installed Capacity through 2009

	MW_{DC}	Market Share
1. California	768	61%
2. New Jersey	128	10%
3. Colorado	59	5%
4. Arizona	46	4%
5. Florida	39	3%
6. Nevada	36	3%
7. New York	34	3%
8. Hawaii	26	2%
9. Connecticut	20	2%
10. Massachusetts	18	1%
All Other States	83	7%
Total	**1,256**	**--**

Table 4: TOP TEN STATES
Ranked by Cumulative Installed PV Capacity per Capita (W_{DC}/person) through 2009

	Cumulative through 2009 (W_{DC}/person)	2009 Installations (W_{DC}/person)
1. California	20.8	5.7
2. Hawaii	20.2	9.8
3. New Jersey	14.6	6.6
4. Nevada	13.8	1.0
5. Colorado	11.8	4.7
6. Arizona	7.0	3.2
7. Connecticut	5.6	2.5
8. Delaware	3.7	1.6
9. Oregon	3.7	1.7
10. Vermont	2.7	1.0
National Average	**4.2**	**1.4**

Table 4 shows the cumulative per capita grid-connected PV capacity through 2009. Even with the largest population in the country, California has the highest total capacity of installations per capita – a capacity that is almost five times the national average. Both Hawaii and New Jersey installed more PV on a per-capita basis than California in 2009. The large number of installations in a few states raises the national average, but 43 states have a per-capita PV installation rate that is less than the national average. As a point of reference, Germany, with less solar resource than most U.S. states, has more than 100 W installed per capita, considerably more than the average 4.2 W installed per capita in the United States.

Incentives by State

Solar electric market activity has more to do with state incentives and policies than with the amount of available solar resources. All of the top states for grid-connected PV offer financial incentives and/or have a RPS policy with a solar mandate. The combination of state and/or local incentives and the federal ITC created strong markets for most of the installations around the country. There are relatively few installations in locations with no state, utility or local incentives and with no RPS policy with a solar mandate. This section describes the incentives offered in the states with the largest number of installations.

In 2007, **California** launched the 10-year, $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 for customers serviced by the state's three investor-owned electric utilities -- Pacific Gas & Electric, Southern California Edison, and San Diego Gas & Electric. With $264 million in CSI incentives, over 155 MW_{DC} of PV was installed in 2009 through this program.[1] These incentives are based on actual system performance for larger systems and expected system performance for smaller systems. Incentive levels are reduced over the duration of the program in 10 "steps," based on the aggregate capacity of solar installed. The CSI was prudently designed as a 10-year program, so the industry in California can rely on long-term policy stability.

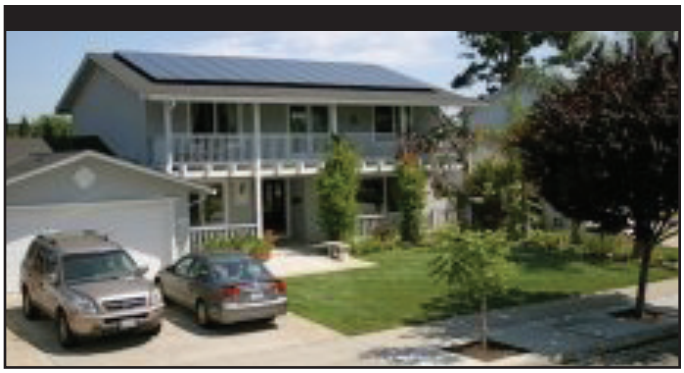
In addition, the California Energy Commission (CEC) administers the New Solar Home Partnership program for PV installations on new homes and the CPUC manages the Multi-Family Affordable Solar Housing and the Single-Family Affordable Solar Housing Programs.

Beginning in 2008, California required municipal utilities to offer solar incentives. Installations in municipal utility service territories in California totaled over 21 MW_{DC} in 2009. A number of municipal utilities have offered incentives for many years, and the larger municipal utilities, in Sacramento and Los Angeles, have installed a large number of PV systems over the past decade or more.

In addition, California has an RPS requirement of 20% by 2010 and 33% by 2020. This includes all renewable technologies and partially inspired some PV installations in 2009. The RPS requirement will lead to more utility-sector solar installations in future years.

In **New Jersey**, a generous (albeit inconsistent) state rebate program and an RPS with a solar requirement have helped build a strong PV market. The solar requirement is 306 GWh in 2011 increasing to 5,316 GWh in 2026. Now, for larger installations, the 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 solar renewable energy credits (SRECs), which New Jersey utilities use to comply with the RPS. In 2009, new installations with a combined capacity of 34 MW_{DC} were selling SRECs, representing 60% of new installations in New Jersey. Smaller PV installations, which are typically residential, will continue to receive rebate payments.

Florida offered state customer rebates for PV, solar water heating, and solar pool heating installations. However, this program expired on June 30, 2010. In addition, Gainesville Regional Utilities offers a feed-in tariff program. By themselves, these programs provided growth for Florida's PV market. In addition, Florida Power & Light installed a 25 MW_{AC} (28 MW_{DC}) PV plant in south Florida. This plant is now the largest PV installation in the United States.



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

In 2005, **Colorado** voters passed Amendment 37, which created an RPS with a solar mandate equal to 0.4% of retail electricity sales. Later, the legislature doubled the overall RPS requirements and the solar mandate. Xcel Energy is by far the largest utility in the state; over 85% of 2009 Colorado PV installations were part of Xcel's programs. Xcel offers capacity-based rebates for smaller, customer-sited PV systems. For these systems, part of the capacity credit involves a purchase of the renewable energy credits (RECs) for 20 years, based on expected performance. For larger PV systems, Xcel purchases the RECs based on actual energy production. Smaller Colorado utilities also offer incentives; their customers installed nearly 3 MW_{DC} in 2009.

Arizona's solar policy has evolved over the past several years. For a number of years, Arizona had an RPS known as the "Environmental Portfolio Standard." Although no utility ever met the standard, Arizona ranked second for PV capacity installed each year from 1997 through 2004. More recent changes included a requirement that 30% of the RPS be met through customer-sited installations, and that half of this amount come from the residential sector. Solar water heaters may also provide RECs for RPS compliance in Arizona. PV capacity installed in 2009 more than tripled in Arizona compared with the capacity installed in 2008. Arizona (along with California, Nevada, Colorado and New Mexico) is a very favorable site for future utility-scale PV and CSP plants.

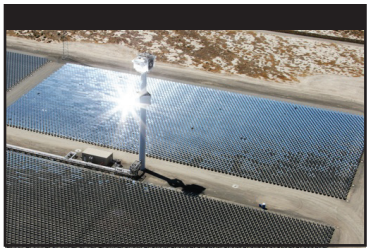
Hawaii has the highest electricity rates in the country and a state solar tax credit. Hawaii also has an established local solar industry that is perceived as credible. As a result, companies and individuals were ready to install solar when the price was right. The financial benefits of a PV are often more favorable in Hawaii than in any other U.S. state. These factors made Hawaii the number one state in per-capita solar installations for 2009.

In **New York**, both the New York State Energy Research and Development Authority (NYSERDA) and the Long Island Power Authority (LIPA) provide PV rebates; most systems in the state have been installed through these two programs. The installed PV capacity in New York has been growing steadily every year, with growth rates higher than the national rates in both 2008 and 2009. In 2009, the capacity of installations completed was 85% higher than in 2008. On a capacity basis, only 29% of the 2009 New York installations were non-residential, compared with 64% in the United States. Interconnection and net metering restrictions in New York make large installations difficult, though legislation passed in 2008 promises to improve this situation. LIPA announced plans for several large installations totaling 50 MW that will begin construction in 2010.

Connecticut and **Massachusetts** provide rebates administered by non-profit organizations funded with system benefit charges paid by electricity consumers (Connecticut Clean Energy Fund and the Massachusetts Clean Energy Center). Each state's PV market has grown strongly in the last few years. However, in Connecticut, funding restraints may restrain future growth.

Although this report covers U.S. installations, the market across the border in the province of **Ontario, Canada**, is also noteworthy. In 2009, three Ontario installations added a total of about 40 MW. If Ontario were a U.S. state, it would have ranked third on IREC's list of states. At the end of 2009, the Ontario Power Authority had 486 MW under contract, indicating that Ontario could well become the largest North American market in 2010. A feed-in tariff program begun in 2008 jump-started the burgeoning Ontario market.

3. CONCENTRATING SOLAR POWER



Four small concentrating solar power plants with a combined capacity of 13.5 MW were connected to the grid in 2009 (see Figure 6). These plants are located in California, Arizona and Hawaii. A total of 65 MW of CSP capacity were added in 2006 and 2007, and nine CSP plants with a total capacity of 354 MW were constructed in California from 1982 to 1991. These plants continue to operate today.

The future prospects for CSP plants look bright. Developers may complete several new plants in 2011. Several different companies have announced plans totaling over 10,000 MW of generating capacity, and some have begun to receive required approvals from government agencies for these projects. Financing, siting and transmission issues will determine when, and if, these project will be constructed.

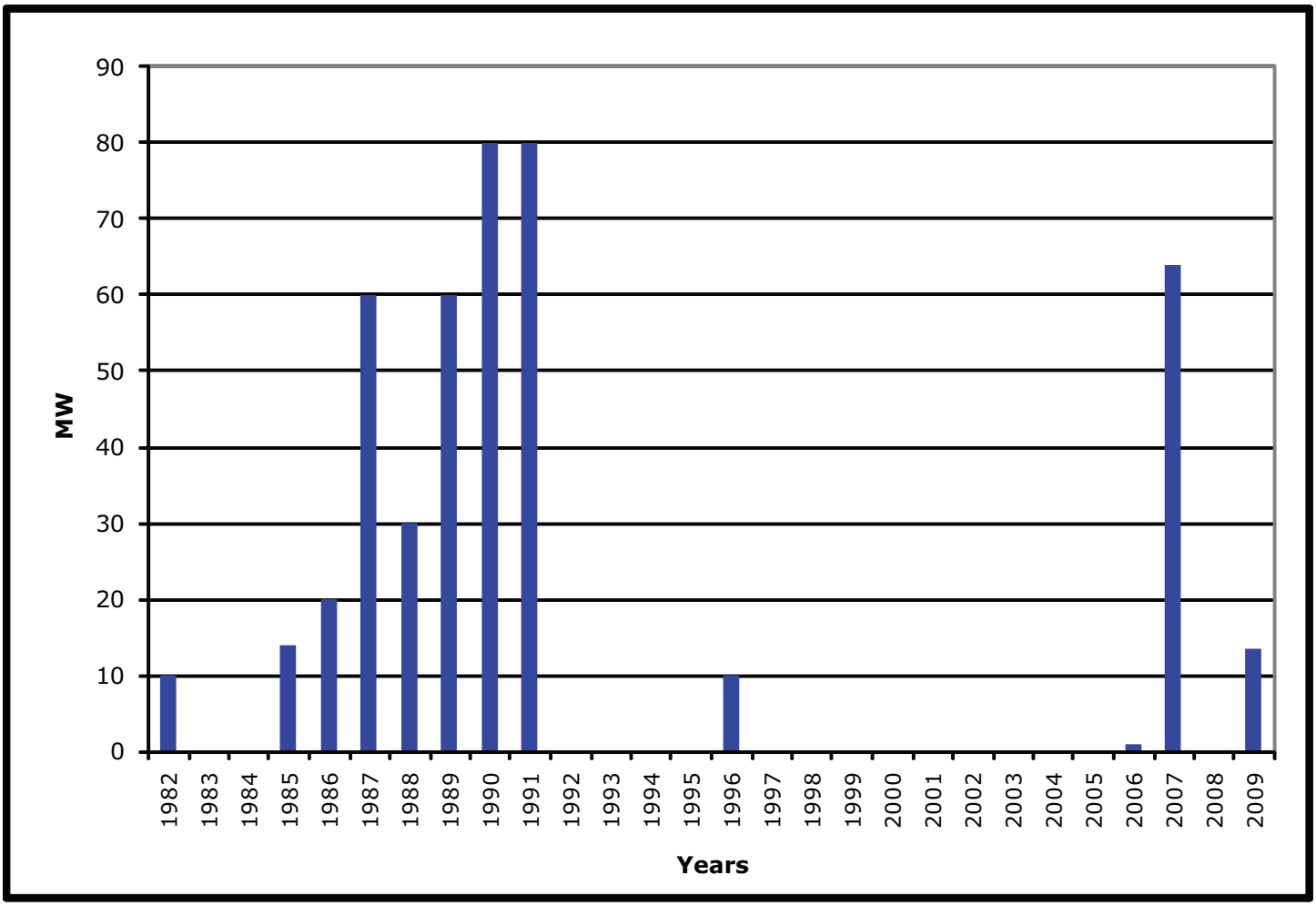


Figure 6: Annual Installed U.S. CSP Capacity (1982-2009)

4. SOLAR HEATING AND COOLING

Solar thermal collectors can heat hot water for domestic or commercial use or heat spaces such as houses or offices. Solar thermal collectors can also provide heat for industrial processes or space cooling.

Figure 7 shows that the annual installed capacity of solar thermal systems for solar water heating and space heating grew by 40% in 2008 and was projected to grow by 10% in 2009 (SEIA 2010). In 2006, the new federal residential ITC and the expanded business ITC, together with rising conventional energy prices, contributed to a dramatic increase in the U.S. solar water heating market. Congress further enhanced the residential credits in February 2009 with the removal of the $2,000 cap.

The improved federal incentives were offset somewhat by the economic downturn, resulting in slower growth in 2009 compared with 2008 and 2007.

Prior to 2006, about half of the solar water heaters sold each year in the United States were installed in Hawaii. By 2008, the national capacity of systems installed each year was four times the capacity installed in 2005, and installations outside Hawaii increased by seven times (see Figure 7). Data for solar thermal installations comes from the U.S. Energy Information Administration and lag the data from other sources by a year. These data are only available through 2008. 2009 installation estimates come from the Solar Energy Industries Association (SEIA 2010).

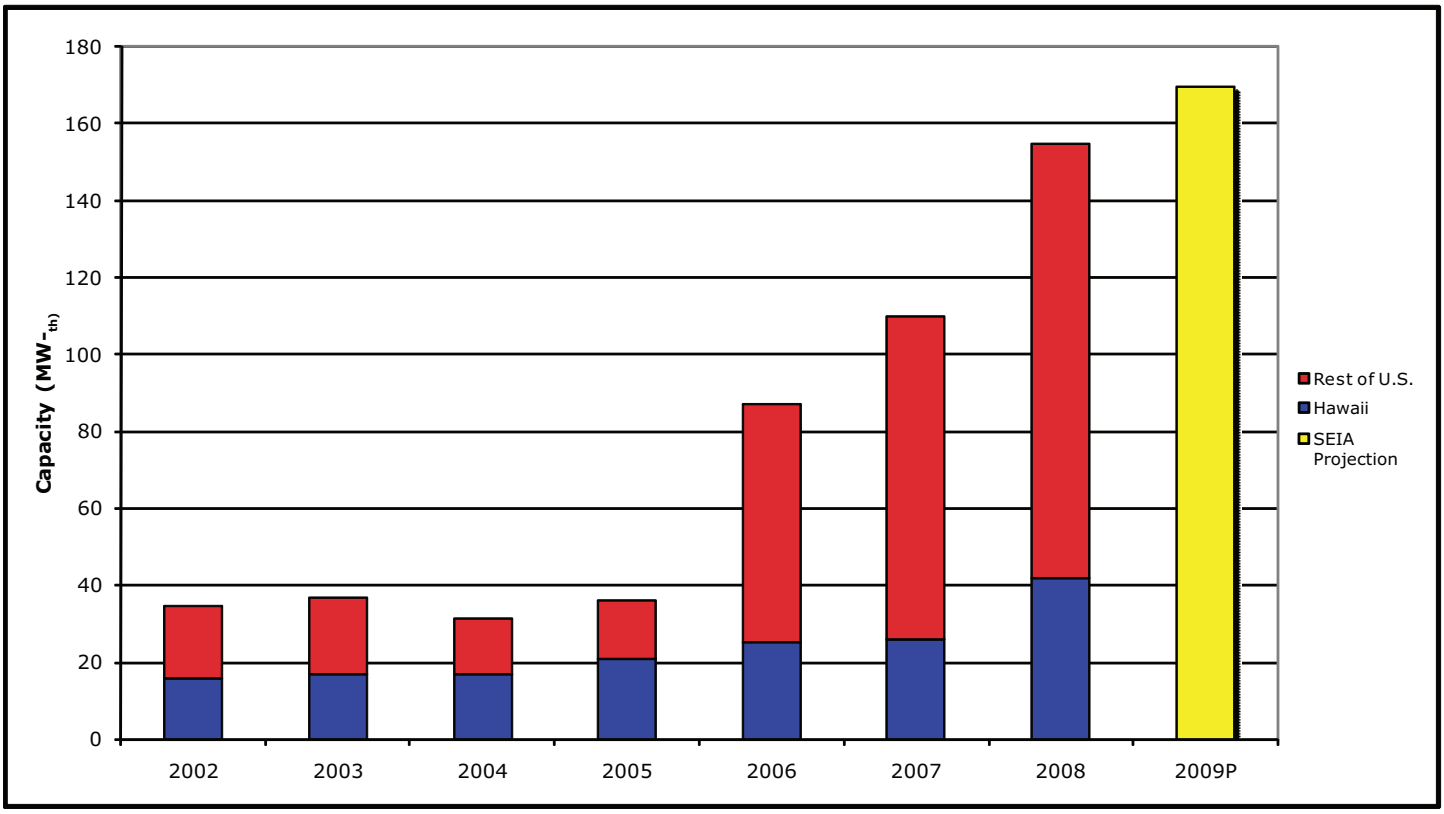


Fig. 7: Annual Installed U.S. Capacity for Solar Heating and Cooling (2002-2009)
Based on analysis of collector shipment data from EIA, and 2009 projection from SEIA.

Figure 8 shows that, like PV installations, solar water heating and space heating installations are concentrated in a few states (and Puerto Rico). After Hawaii, California, Puerto Rico and Florida lead the country in solar water heating installations. Hawaii has been the number one state for solar water heating installations for many years. High energy prices and strong government policies have built the solar water heating market in Hawaii. In addition, installation costs are lower in Hawaii than in most other locations in the United States because freezing is not a concern.

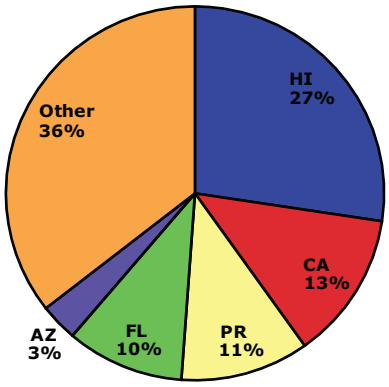


Fig. 8: Installed U.S. Solar Heating and Cooling Capacity by State for 2008
Based on analysis of EIA data for 2008

4.3 Solar Pool Heating

Figure 9 shows the annual installed capacity for solar pool heating systems from 2000 to 2009. Annual pool heating installations were projected to have fallen by 10% in 2009 compared to 2008 (SEIA 2010). Annual installations also fell in 2008 and 2007 compared with the previous years.

To a certain extent, the sales of solar pool heating systems follow the sales of pools. The economic decline in the real estate markets in Florida and California likely led to the decrease in pool installations and thus the decline in the installed capacity of solar pool systems in recent years.

For solar pool heating systems, installations are concentrated in just a few states, notably Florida and California (see Figure 10). Unlike other solar technologies, only a few states offer incentives for solar pool heating systems, and those incentives are modest.

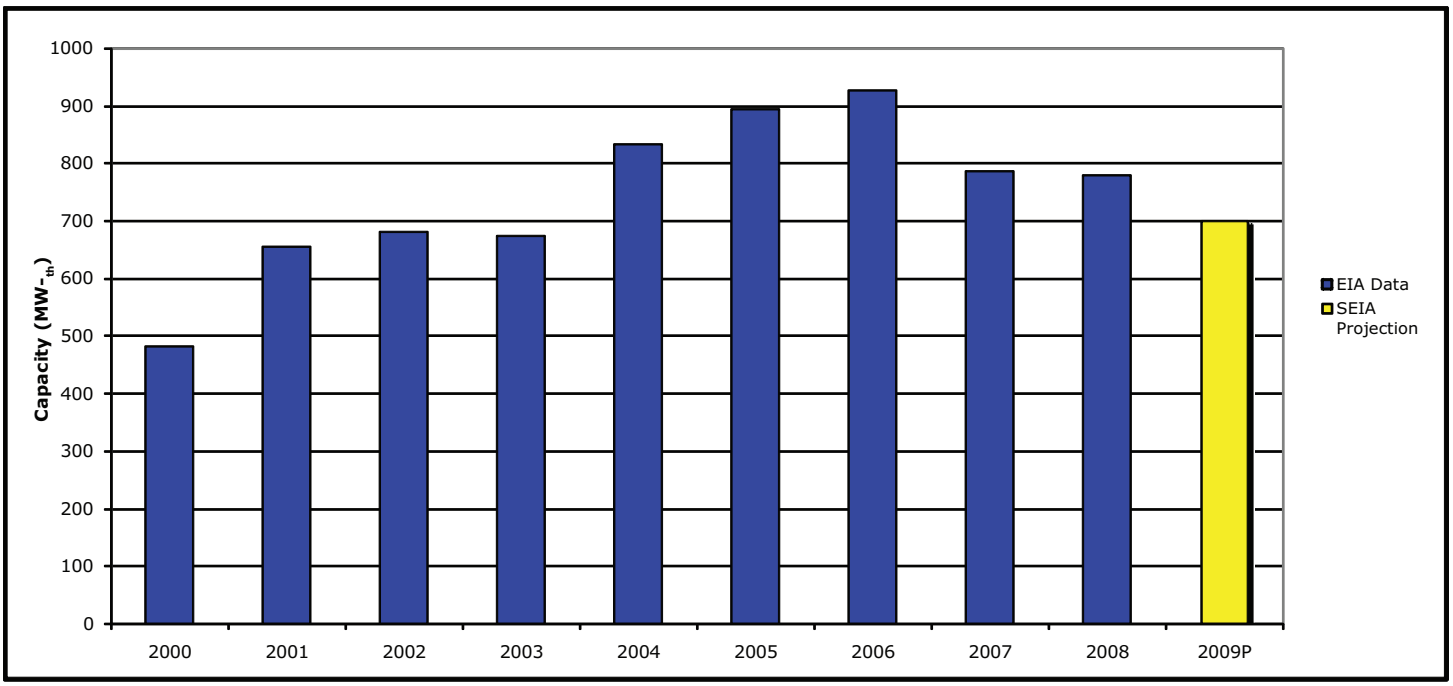


Fig. 9: Annual Installed Capacity for Solar Pool Heating (2000-2009)
Based on collector shipment data from EIA and 2009 projection from SEIA.

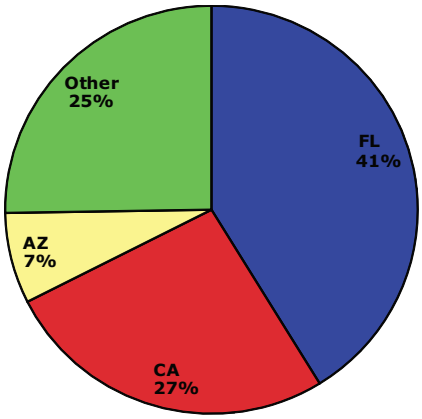


Fig. 10: U.S. Solar Pool Heating Capacity Installed in 2008 by State
Based on EIA Data for 2008

5. NUMBER OF INSTALLATIONS

The number of all solar installations installed in 2009 grew by 18% to over 107,000 installations (compared to the number installed in 2008), as shown in Figure 10. This figure includes grid- connected and off-grid PV, solar heating and cooling, solar pool heating and solar thermal-electric. Through 2005, over half of these installations were for solar pool heating. However, because of the expanded federal ITCs and the slump in the new pool market, the market shares of the different solar technologies has changed significantly since 2006. Grid-connected PV and solar water heating installations experienced the largest growth during this period and in 2009 together represented 68% of all solar installations.

These charts show only the number of installations for each technology, not the relative energy contribution. Since grid-connected PV installations are larger on average, the energy contribution from PV installations will be larger than the relative number of installations.

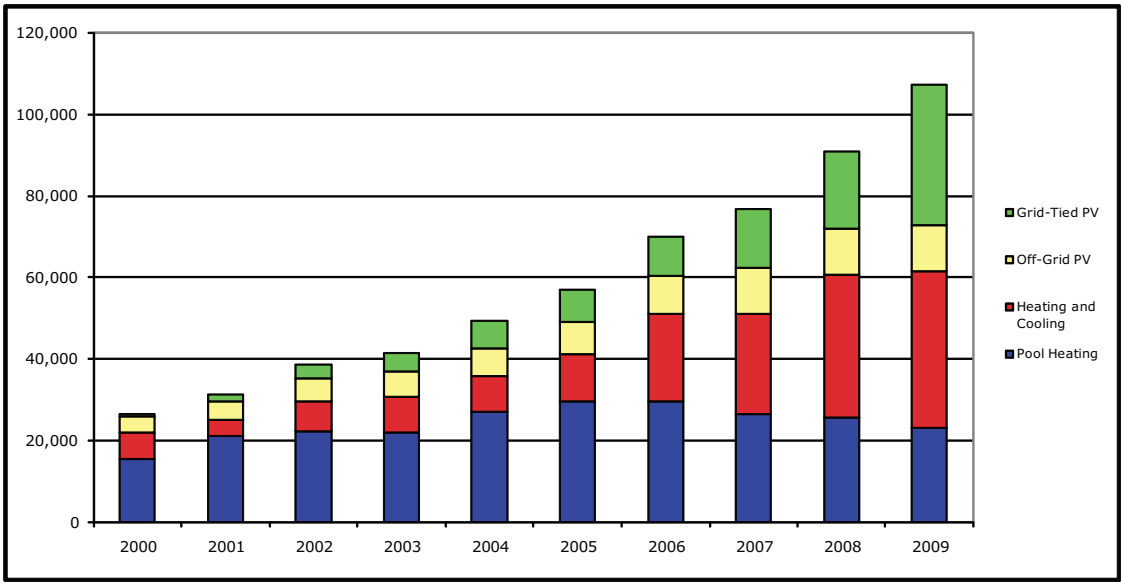


Fig. 11: Number of Annual U.S. Solar Installations by Technology (2000-2009)

Table 3 shows that the cumulative total of U.S. solar installations from1994-2009 is 762,000.

TABLE 3: CUMMULATIVE U.S.SOLAR INSTALLATIONS BY TECHNOLOGY, 1994-2009

Solar Pool Heating	332,000
Solar Heating and Cooling	233,000
Grid-Connected Photovoltaics	104,000
Off-grid Photovoltaics	93,000
Total	**762,000**

6. PROSPECTS FOR 2010 AND 2011

Early indicators predict 50% to 100% growth of grid-connected PV installations in 2010, compared to grid-connected PV installations in 2009. Other solar technologies should also see increased growth in 2010, with the possible exception of solar pool heating. The long-term extension of the federal ITC, new rules that allow electric utilities to use the ITC, the establishment of a grant alternative to the commercial ITC, and federal stimulus spending will all help drive market growth. In addition, improved capital availability will allow consumers and businesses to take advantage of these financial incentives.

Companies have announced plans for many large solar projects, including CSP projects, utility-owned projects and projects owned by third parties. Many of these projects will be completed in 2010, and many more will start construction in 2010 in order to take advantage of the federal cash grant program, which is currently set to expire at the end of 2010. Completion of these latter projects will likely occur between 2011 and 2013.

Electric utility announcements point to growth in installations on the utility side of the meter, producing bulk electricity for the grid. In 2010, utilities could install more than four times the capacity installed in 2009. Many of these installations will be large arrays owned by the utility or a third party. Others will involve siting PV on residential or commercial buildings.

A number of states are using federal stimulus funds to increase funds that provide rebates for PV and/or solar water heating installations. Most of these installations will be completed in 2010. In addition, some stimulus funds are paying for the cost of solar installations on government buildings and, again, most of these installations will be completed in 2010.

Prices for PV modules fell throughout 2009, and many analysts expect prices to continue to fall in 2010. Lower PV prices increase the potential of installations in states without state, local or utility incentives. However, in 2010, installations will continue to be concentrated in states with strong financial incentives and other strong solar policies, which will remain critical to market growth.

7. CONCLUSION

In spite of poor economic conditions, solar markets continue to grow in the United States due to consumer interest in green technologies, concern about energy prices, and financial incentives available from the federal government, states, local governments and utilities. Over 107,000 solar installations were completed in 2009. The markets for each solar technology are concentrated in a few states.

The number of new grid-connected PV installations grew by 40% in 2009 compared with the number installed in 2008. The two largest PV systems installed in 2009 together accounted for 12% of the annual installed PV capacity. The PV market is expanding to more states, and installations doubled in more than seven states. However, California remains the dominant market.

Solar water heating installations have boomed since the enhanced federal ITC took effect in 2006 and grew by an additional 10% in 2009. In the continental 48 states, the annual installed capacity of solar water heating systems has quintupled since 2005. Hawaii remains the largest domestic market for solar water heaters.

Four new concentrating solar power plants were connected to the grid in 2009. The future prospects for CSP look bright, with thousands of megawatts of installations planned for the next five years.

U.S. market growth will accelerate in 2010, especially for grid-connected PV installations. Federal tax policies and stimulus spending will drive this accelerated market growth.

ACKNOWLEDGEMENTS

This work was funded by the U.S. Department of Energy through the Solar Energy Technologies Program. The author appreciates the data supplied by many national, state and utility offices and programs, and the assistance of Justin Baca from the Solar Energy Industries Association with the collection of some of this data. The author also thanks Justin Baca, Solar Energy Industries Association; Jon Guice, AltaTerra Research Network; Rusty Haynes, North Carolina Solar Center; Mike Taylor; Solar Electric Power Association; Jane Weissman, Interstate Renewable Energy Council for their reviews of the draft report. Jane Weissman, executive director of the Interstate Renewable Energy Council, supported this work and Janet Meyer provided valuable editorial assistance.

PHOTO CREDITS:

Cover **Title**
Courtesy of

Pg 7 **Title**
Courtesy of

Pg 9 **Title**
Courtesy of
Title
Courtesy of

Pg 10 **Title**
Courtesy of
Title
Courtesy of

Pg 11 **Title**
Courtesy of
Title
Courtesy of

Pg 12 **Title**
Courtesy of

Pg15 **Title**
Courtesy of

Pg 16 **Title**
Courtesy of
Title
Courtesy of

Pg 19 **Title**
Courtesy of

Pg 20 **Title**
Courtesy of

APPENDIX A
DATA SOURCES

Grid-Connected Photovoltaics

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

- State agencies or organizations administrating state incentive programs (data most commonly available from states with incentives);
- Utility companies (data most commonly available from utilities that manage incentive programs or from interconnection agreements); and
- Non-profit organizations (data most commonly collected through surveys or from installations facilitated by local programs).

The data quality depends on the source. Certainly, this study misses some installations. Data based on incentives paid are usually the most reliable. Since grid-connected PV is the technology most reliant on incentives, the state-by-state installation data for grid-connected PV are the best.

Off-Grid Photovoltaics

In 2009, off-grid installations likely totaled 40-60 MW, but IREC has not collected data for these installations and they are not included in this report's charts.

Solar Heating and Cooling

Some sources report data on state solar heating and cooling applications, but many do not. The U.S. Energy Information Administration (EIA) annually reports the shipments of solar thermal collectors to each state and the shipments by market sector and end use (i.e. shipments to California and total shipments for pool heating use)(EIA 1994-2008). However, the EIA does not report shipments by state and market sector (i.e. shipments to California for pool heating use). The pool heating market is very different than the hot water and space heating markets, and the goal of this analysis is to learn the distribution of installations for both of these market segments. EIA did not design its survey to provide this information.

Luckily, most pool heating collector manufacturers only ship collectors for that market. EIA provided the author with data titled, Solar Thermal Collector Shipments by State of Destination for Companies that Shipped only Collectors to be used for Pool Heating. These shipments account for 95% of the total pool shipments reported elsewhere by EIA.

IREC then calculated the difference between the "Total Solar Thermal Collector Shipments by State" and the "Shipments from Companies that Shipped Collectors to be used for Pool Heating." This difference is assumed to be the shipments for hot water and space heating.

This analysis provides a general picture of the state distribution of solar heating and cooling installations, especially for states with the largest number of installations. However, there are problems with these data. Hot water and space heating installations are small compared with the number of pool heating installations, and solar thermal exports are rising. Both these factors make analysis of EIA data difficult. In addition, manufacturers report to EIA where they shipped the collectors. Most shipments go to wholesale and retail distributors. The final destination and installation of the collectors may be in a different state and is not reported to the EIA.

The resulting state analysis was compared with state installation data obtained from state rebate programs and published on the DSIRE Solar Portal (DSIRE 2010b). While not a perfect match, the general trends are confirmed (i.e., the top states and the general proportion of collectors sold there). In general, this analysis shows a higher use of thermal collectors for solar water heating than other state sources show.

EIA data for 2009 will not be available until early 2011. The Solar Energy Industries Association estimates that the solar hot market grew by 10% in 2009 and the solar pool heating market decreased by 10% in 2009 (SEIA 2010). These estimates are included in the solar heating and cooling market estimates.

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) or kilowatts (kW). 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.

Occasionally data are only reported in terms of capacity or the number of installations, but not both. In these cases, typical data from other sources are used to obtain both pieces of data.

Photovoltaics

This study reports PV capacity in direct current (DC) watts under Standard Test Conditions ($W_{DC\text{-}STC}$). 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% 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 2007 AC watts were 84% of DC watts, in 2008 the ratio was 85.5%, and in 2009 the ratio was 86.2%. In cases where the data reported to IREC was in AC watts, IREC used the CSI ratios to convert the data to DC watts.

Solar Thermal

Data sources usually report solar thermal capacity in area (square feet). Representatives from the International Energy Agency's Solar Heating and Cooling Programme and several major solar thermal trade organizations developed a factor to convert aperture area of solar thermal collector to capacity (W_{TH}) (IEA 2004). The factor is 0.7 kW_{TH}/m2 (.065 kW_{TH}/ft2). This study uses the IEA factor to convert EIA data reported in square feet to MW_{TH}.

Number of Installations

Many data sources report installed capacity rather than the number of installations. This is especially true for solar thermal systems. So, a method is needed to convert capacity to installations.

This study uses the following average installation sizes:

Off-Grid Residential PV: 2 $kW_{DC\text{-}STC}$
Off-Grid Non-Residential PV: 10 $kW_{DC\text{-}STC}$
Solar Water Heating Residential: 50 ft2 (4.6 m2)
Solar Water Heating Non-Residential: 500 ft2 (46 m2)
Solar Space Heating: 250 ft2 (23 m2)
Solar Pool Heating Residential: 432 ft2 (40 m2)
Solar Pool Heating Non-Residential: 4,320 ft2 (401 m2)

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. Analysis of data from the California Solar Initiative (CSI), which do include both residential and commercial data, indicates that the 10 kW_{DC} assumption probably under estimates the number of residential installations. In the CSI program, about 20% of the residential installations by capacity are larger than 10 kW_{DC}. The number of non-residential installations smaller than 10 kW_{DC} is considerably smaller.

For solar thermal installations, an estimate was made of residential and non-residential installations based on EIA data.

The results for cumulative installations include all new installations for the past 15 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 for grid-connected PV installations, this is based on the date when the installation was connected and producing power.

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 and incentive program reports the date on which the incentive payment was made. This is the date used for the installation date in past editions of this report. This is usually a month or more after the installation was complete. However, if these are the only data available, this is the installation date used in this report. Calendar Year (CY) is used as the year basis for all data. When data is reported on a Fiscal Year that is July 1 – June 30, this report assumes that half of the installations are in the first CY and half are in the second CY.

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, the number of installations in 2008 and earlier does not always agree with the numbers published in the 2008 edition of this report.

APPENDIX C

GRID CONNECTED PHOTOVOLTAIC INSTALLATONS BY STATE

State	Capacity Installed in 2008 (MW_{DC})	Capacity Installed in 2009 (MW_{DC})	Cumulative Installed Capacity (MW_{DC})
Alabama	*	0.1	0.2
Alaska	*	*	*
Arizona	6.2	21.1	46.2
Arkansas	*	0.2	0.2
California	197.6	212.1	768.0
Colorado	21.7	23.4	59.1
Connecticut	7.5	8.7	19.7
Delaware	0.6	1.4	3.2
District of Columbia	0.2	0.3	1.0
Florida	0.9	35.7	38.7
Georgia	*	0.1	0.2
Hawaii	8.6	12.7	26.2
Idaho	*	0.1	0.2
Illinois	0.4	1.7	4.5
Indiana	*	0.3	0.3
Iowa	*	*	*
Kansas	*	*	*
Kentucky	*	*	*
Louisiana	*	0.2	0.2
Maine	*	*	0.3
Maryland	1.9	2.8	5.6
Massachusetts	3.5	9.5	17.7
Michigan	*	0.3	0.7
Minnesota	0.3	0.9	1.9
Mississippi	*	*	0.1
Missouri	*	0.1	0.2
Montana	0.1	*	0.7
Nebraska	*	*	*
Nevada	14.9	2.5	36.4
New Hampshire	0.1	0.5	0.7
New Jersey	22.5	57.3	127.5
New Mexico	0.6	1.4	2.4
New York	7.0	12.1	33.9
North Carolina	4.0	7.8	12.5
North Dakota	*	*	*
Ohio	0.4	0.6	2.0

APPENDIX C CONTINUED...

State	Capacity Installed in 2008 (MW_{DC})	Capacity Installed in 2009 (MW_{DC})	Cumulative Installed Capacity (MW_{DC})
Oklahoma	*	*	*
Oregon	4.8	6.4	14.0
Pennsylvania	3.0	3.4	7.3
Rhode Island	*	*	0.6
South Carolina	*	0.1	0.1
South Dakota	*	*	*
Tennessee	*	0.5	0.9
Texas	1.2	4.2	8.6
Utah	*	0.4	0.6
Vermont	0.4	0.6	1.7
Virginia	0.2	0.3	0.8
Washington	0.8	2.1	5.2
West Virginia	*	*	*
Wisconsin	1.7	2.2	5.3
Wyoming	*	*	0.1

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

REFERENCES

DSIRE 2010a, Database of State Incentives for Renewables and Efficiency, Financial Incentives for Renewable Energy, downloaded from http://www.dsireusa.org/summarytables/finre.cfm, DSIRE, 2010

DSIRE 2010b, Database of State Incentives for Renewables and Efficiency, State Rebates for Solar Water Heating Projects, downloaded 6/24/10 from http://www.dsireusa.org/solar/comparisontables/ , DSIRE, 2010

EIA 1994-2008, Energy Information Administration, Solar Thermal Collector Manufacturing Activities, U.S. Department of Energy, 1994-2008 editions

IEA 2004, International Energy Agency, Recommendation: Converting solar thermal collector area into installed capacity, IEA, 2004

IREC 2010a, Interstate Renewable Energy Council, State and Utility Net Metering Rules for Distributed Generation, downloaded from http://irecusa.org/irec-programs/connecting-to-the-grid/net-metering, IREC, 2010

IREC 2010b, Interstate Renewable Energy Council, State Interconnection Standards for Distributed Generation, downloaded from http://irecusa.org/irec-programs/connecting-to-the-grid/interconnection, IREC, 2010

SEIA 2010, Solar Energy Industries Association, 2009 Solar Industry Year in Review, SEIA, 2010.