U.S. Solar Market Trends

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ABSTRACT

Grid-connected photovoltaic installations grew by 60% in 2006. California and New Jersey have the largest markets and installations more than doubled in New Jersey, Nevada, Colorado, Connecticut, and many other states with smaller markets. The off-grid growth has been steady, but significantly lower.

For the first time in more than a decade, a solar thermal electric plant was installed in 2006. More than 350 MW installed in the 1990's still generates electricity today.

Solar water heating and solar space heating installations grew in 2006 after years of flat installation numbers. Hawaii dominates this market, with nearly half of the market.

Solar pool heating accounts for the largest number of installations and has grown at an average rate of 10% since 1998. However, installations decreased by 7% in 2006. Installations in California and Florida together are 73% of the pool heating market.

1. INTRODUCTION

The U.S. solar market consists of four segments: photovoltaics, solar thermal electric, solar thermal hot water (including space heating), and solar thermal pool heating. Passive solar energy is also used for space heating and daylighting, but is beyond the scope of this paper. Because solar space heating is a relatively minor market, its data are combined with solar hot water.

Industry, government, and non-profit organizations are all working to increase the number of solar installations across the U.S. Multi-year installation trends and state installation data help these sectors learn more about the state markets and evaluate the effectiveness of marketing, financial incentives and education initiatives. In addition, these data allow analysis of the environmental and economic impact of solar installations.

This study was conducted for the U.S. Department of Energy's Solar America Initiative. Because the predecessor to the Solar America Initiative – the Million Solar Roofs Initiative – began in mid-1997, this paper details U.S. solar installations for 1998 – 2006.

2. DATA SOURCES

2.1 Grid-Connected Photovoltaics

State data were obtained for grid-connected photovoltaic 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 who manage incentive programs or from interconnection agreements);
- Non-Profit Organizations (data most commonly collected through surveys or from installations facilitated by local programs); and
- Renewable Electric Plant Information System (REPiS) from the National Renewable Energy Laboratory (1) (data available only through 2002 in most cases).

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, its state-by-state installation data are the best.

2.2 Off-Grid Photovoltaics

National data for off-grid photovoltaic capacity were obtained from PV Energy Systems (2). Other sources provide much less data on off-grid photovoltaic installations than grid-connected ones. The best grid-connected data come from incentive programs, which usually do not fund off-grid applications. Therefore state data are not reported for off-grid photovoltaic installations.

2.3 Solar Thermal

Some sources report data on state solar thermal 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)(3). However, the EIA data does not report shipments by state and market sector (i.e. shipments to California for pool heating use). The pool collector market is very different than the hot water and space heating markets and we would like to know the distribution of installations for both of these market segments. EIA did not design their survey to provide this information.

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

This study 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 thermal installations, especially for states with the largest number of installations. However, there are problems with this 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 other sources. 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 hot water than other state sources show.

EIA data for 2006 will not be available until the fall of 2007. Pool data from the Solar Energy Research and Education Foundation (SEREF) is used for 2006 (4).

3. ASSUMPTIONS

3.1 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 does not produce the same amount of energy (kWh) 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 as capacity or number of installations, but not both. In these cases typical data from other sources are used to obtain both pieces of data.

3.1.1 Photovoltaics

This study reports PV capacity in DC Watts under Standard Test Conditions ($W_{DC\text{-}STC}$). This is the capacity number that manufacturers and others typically report and is the basis for rebates in many states.

The notable exception to reporting DC Watts is the California Energy Commission (CEC), which reports AC Watts. CEC 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.

Based on an analysis of California systems installed in 2003:

$$W_{AC\text{-}PTC} = W_{DC\text{-}STC} \times .83.$$

This study converted data reported in AC Watts to DC Watts using this formula.

3.1.2 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}) (5). The factor is 0.7 kW_{TH}/m^2 (.065 kW_{TH}/ft^2). This study uses the IEA factor to convert EIA data reported in square feet to MW_{TH}.

3.2 Number of Installations

Many data sources report installed capacity and not the number of installations. This is especially true for solar thermal systems. So a factor is needed to convert capacity to installations.

This study uses the following average installation sizes:
Off-Grid Residential Photovoltaics: 2 $kW_{DC\text{-}STC}$
Off-Grid Non-Residential Photovoltaics: 10 $kW_{DC\text{-}STC}$
Solar Hot Water: 50 ft^2 (4.6 m^2)
Solar Space Heating: 250 ft^2 (23 m^2)
Solar Pool Heating: 350 ft^2 (33 m^2)

For grid-connected photovoltaic installations, this study uses actual data on number of installations. For the data, which shows residential and non-residential installations, real data is used as much as possible. For data sources which only report the size of the installations, this study assume all installations less than 10 kW_{DC} are residential installations. Analysis of data from Los Angeles Department of Water and Power, which does include both residential and commercial data, indicates that the 10 kW_{DC} assumption is reasonable.

4. SOLAR INSTALLATION DATA

4.1 Photovoltaics

U.S. photovoltaic installations increased by 47% in 2006 (see Figure 1) and grid-connected installations increased by 60% to more than 100 MW_{DC} for the year. Grid-connected PV installations doubled every two years since 2002. The off-grid market growth has been steady, but significantly slower. The market share of grid-connected installations has increased from only 16% in 1998 to 52% in 2002 and now is 72% of the PV installations by capacity.

Consumer concerns about rising energy prices after Hurricane Katrina, the start of federal solar tax credits, and sustained or growing state incentives drove the robust sales. Concerns about PV supply shortages were real throughout the year. However, flat markets in Germany and Japan and increasing module production meant that PV modules were available for the U.S. market.

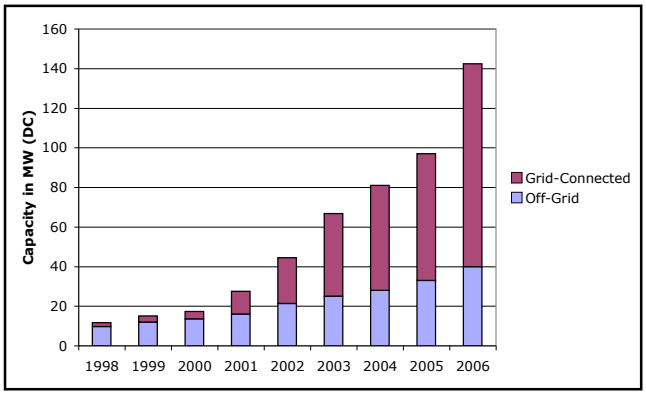
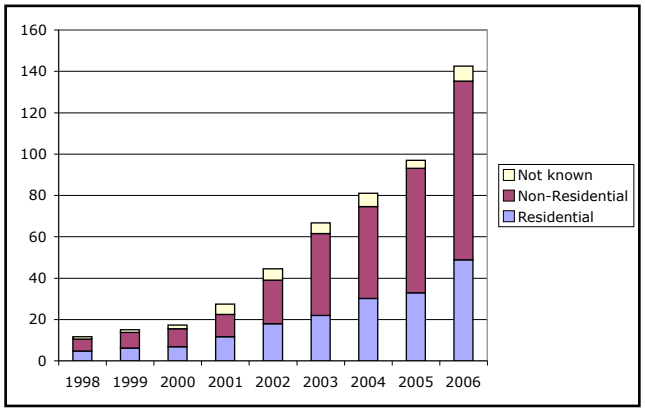


Fig. 1: Annual Installed Photovoltaic Capacity
Off-Grid data from PV Energy Systems

Figure 2 shows the same annual PV installation data segmented by residential and non-residential installations. Both residential and non-residential installations grew significantly in 2006. However, the long-term trend shows non-residential systems increasing their share of the market. In 2001, non-residential installations were 48% of the market and only 28% of the grid-connected market. By 2006 the non-residential market share increased to 64%. Since the average size of non-residential systems is more than ten times the average size of residential systems, the number of residential installations is still larger than non-residential installations.



Fig, 2: Annual Installed Photovoltaic Capacity
Off-Grid Data from PV Energy Systems

The trend toward more non-residential installations should continue because the new federal tax credits are more generous for commercial installations. In California, the largest incentive programs in the country have changed to a performance-based incentive basis. Early reports indicate that the commercial market is booming and the residential market has stagnated.

Installations of grid-connected photovoltaic installations have been concentrated in California, New Jersey, New York, and Arizona as shown in Tables 1 and 2. California dominates the market with 75% of all grid-connected PV installations. As noted earlier, no comprehensive data exists for off-grid installations by state.

TABLE 1: TOP TEN STATES – 2006 INSTALLED GRID-CONNECTED PHOTOVOLTAIC CAPACITY (MW_{DC})

	2006	**2005**	**05-06%**
1. California	70.6	52.0	36%
2. New Jersey	17.9	5.5	223%
3. New York	2.7	1.4	91%
4. Nevada	2.6	0.5	436%
5. Arizona	2.1	1.6	34%
6. Massachusetts	1.5	0.6	127%
7. Colorado	0.9	0.2	421%
8. Texas	0.7	0.6	20%
9. Connecticut	0.5	0.2	210%
10. Oregon	0.5	0.4	50%
All Other States	2.4	1.0	140%
Total	102.4	63.9	60%

In 2006, California installations increased by 36% to 71 MW and New Jersey installations more than tripled to 18 MW (see Table 1). On a per capita basis, New Jersey installed slightly more capacity in 2006 than California. In addition to New Jersey, the market more than doubled in Nevada, Colorado, Massachusetts, and Connecticut plus many states with smaller PV markets.

TABLE 2: TOP TEN STATES – CUMMULATIVE INSTALLED CAPACITY PER CAPITA (W_{DC}/person)

1. California	6.4
2. New Jersey	3.1
3. Arizona	2.6
4. Nevada	1.5
5. Hawaii	1.1
6. Delaware	0.9
7. Vermont	0.8
8. Massachusetts	0.5
9. New York	0.5
10. Oregon	0.4
National Average	1.0

Although new state markets emerged in 2006, the market remains very concentrated in a few states. From 2003 through 2005, 96% of grid-connected installations were in the top five states. In 2006, as new state markets developed, the top five states still accounted for 94% of installations.

All of the top states for grid-connected PV installations have financial incentives. Federal tax credits appear to encourage more installations throughout the country. However, there are relatively few installations in locations with no state or local incentives. However, quantifying installations in states with no state or local incentives is more difficult.

Table 2 shows the cumulative per capita grid-connected PV capacity. Even with California's very large population, it has more than twice the per capita installed capacity as any other state and more than six times the national average. No mater how one analyzes the data, California dominates the PV market. Three small states, Hawaii, Delaware, and Vermont show significant solar installations on a per capita basis.

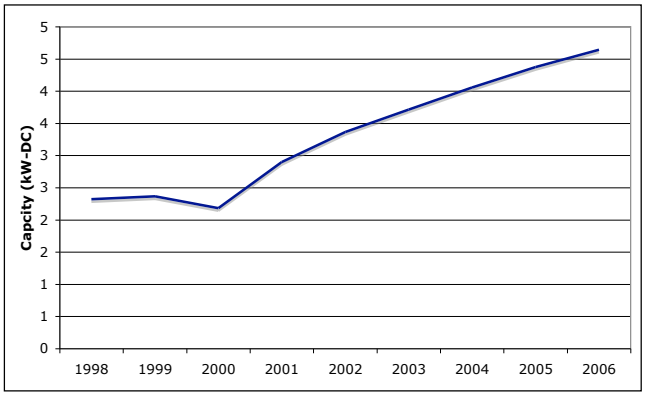


Fig. 3: Average Size of Grid-Connected Residential Photovoltaic Installations

The average size of a grid-connected PV residential installation has grown steadily (see Figure 3). In 2004 the average size exceeded 4.6 kW_{DC}, more than twice the average in 1997. The average size varies from state-to-state and is typically larger in states with rebates than in states without rebates.

The average size of grid-connected PV non-residential installations was 53 kW_{DC} in 2006. The average has varied between 38 and 55 kW_{DC} and does not show a consistent trend. Although there are larger numbers of very large installations, mid-size system installations are also growing so the average size is not increasing.

4.2 Solar Thermal Electric

A one MW solar thermal electric plant was completed in Arizona in 2006. This is the first new solar thermal electric plant in over fifteen years. Solar thermal electric plants with a capacity of 354 MW were constructed in California from 1985 to 1991 and continue to operate today.

A 64 MW solar thermal electric plant is under contraction in Nevada and completion is expected during 2007.

4.3 Solar Hot Water and Space Heating

Unlike the photovoltaic market, the solar hot water and space heating markets have been generally flat with some variations from year-to-year (see Figure 4).

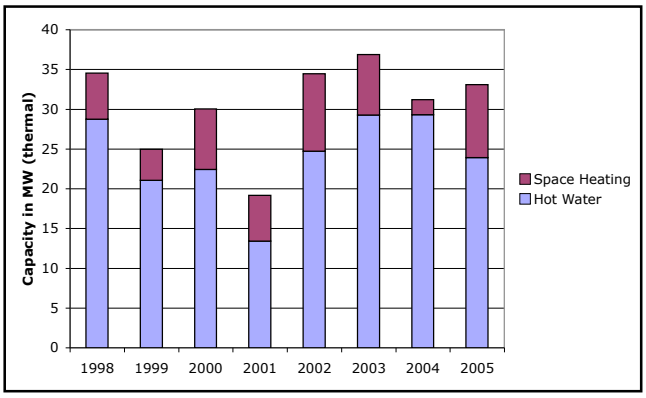


Fig. 4: Annual Installed Solar Thermal Capacity
Based on collector shipment data from EIA.

Although complete information on the solar hot water in 2006 in not yet available, information from a few utilities which provide solar hot water financial incentives show installations in their programs grew by 30% in 2006. With the launch of the federal solar tax credit in 2006, it is likely installations increased even more in parts of the country with no local incentives. Thus 30% is probably a low estimate of the installation increase in 2006.

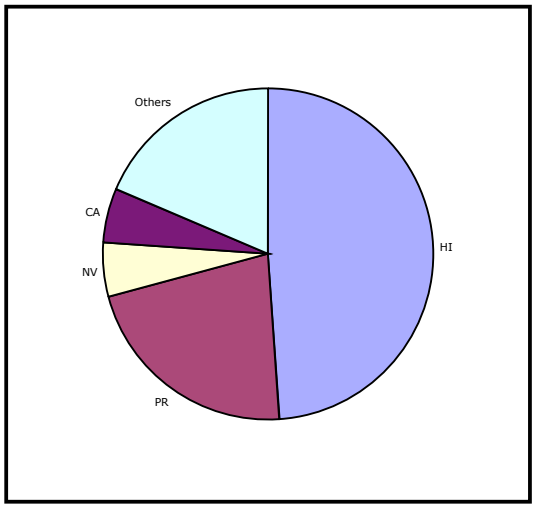


Fig. 5: Installed Solar Thermal Capacity by State
Based on analysis of EIA data for 2001-2005.

This is consistent with state data showing stable markets or variations from year to year, but no significant state markets with steady sustained growth. The solar hot water market is significantly larger than the solar space heating market. Since a solar space heating system is larger, this means that the number of solar space heating installations is quite small.

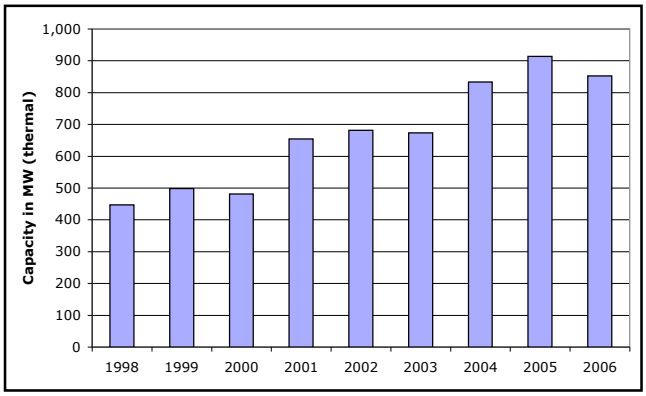


Fig. 6: Annual Installed Pool Heating Capacity
Based on collector shipment data from EIA and SEREF.

Like photovoltaic installations, Figure 5 shows that solar water heating and space heating installations are concentrated in a few states and territories. However the states with the most installed capacity are different for solar hot water than for photovoltaics. Hawaii represents almost half of the solar thermal market and Puerto Rico over 20%.

4.3 Solar Pool Heating

Figure 6 shows the annual installed capacity for solar pool heating systems during 1998 to 2006. Installed capacity grew an average of 10% during the period, but decreased

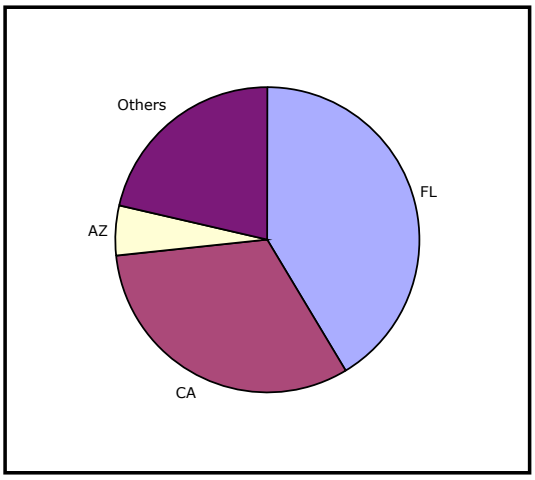


Fig. 7: Installed Pool Heating Capacity by State
Based on EIA Data for 2001-2005

7% in 2006.The installed capacity and annual installations of pool systems are significantly larger than for either photovoltaic or solar hot water installations.

Figure 7 shows that the trend continues for pool heating systems of the installations concentrated in a few states with Florida and California leading the way. Unlike other solar technologies, virtually no incentives exist for solar pool heating systems.

Pool installation trends are often different than for other technologies. Perhaps the residential construction slowdown in 2006 meant less new swimming pools and therefore less solar pool heating installations.

5. NUMBER OF INSTALLATIONS

Figure 8 shows that the number of solar installations has grown from 35,000 per year in 1998 to 72,000 per year in 2006. Over half of these installations are for solar pool heating. The Figure 7 and Table 3 count each installation and provide no information on the capacity installed for each technology. Since grid-connected photovoltaic installations are larger on average, the number of installations under represents the contribution of grid-connected photovoltaics.

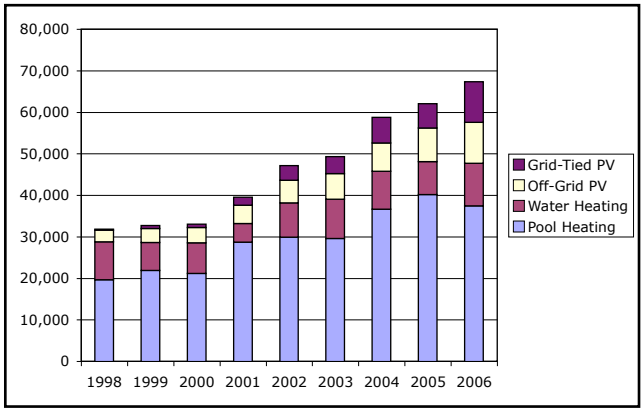


Fig. 8: Annual Solar Installations by Technology

Table 3 shows the cumulative solar installations by technology for 1998-2006. Since most grid-connected photovoltaic installations occurred during this period, that installation number is approximately the total number of grid-connected installations in the U.S. For the other technologies, significant installations occurred before 1998 and so the total number of installations would be much higher.

TABLE 3: CUMMULATIVE SOLAR INSTALLATIONS BY TECHNOLOGY, 1998-2006.

Solar Pool Heating	265,000
Solar Hot Water (and Space Heating)	73,000
Off-grid Photovoltaics	51,000
Grid-Connected Photovoltaics	33,000
Total	422,000

4. CONCLUSION

Solar installations for all solar technologies, except solar pool heating, grew rapidly in 2006. The long-term market trends for photovoltaics, solar thermal electric, solar hot water, and solar pool heating are distinct.

Photovoltaic installations grew 47% in 2006, with grid-connected installations concentrated in California. Preliminary data suggests hot water market grew at least 30% in 2006 and is concentrated in Hawaii and Puerto Rico. The pool heating market decreased 7% in 2006 and is concentrated in Florida and California. The first solar thermal electric installation in over a decade occurred in Arizona.

Measuring the number of installations, the pool heating market is the largest solar market, but the market share of photovoltaics is increasing each year due to financial incentives and other public policy initiatives.

The trends are likely to continue in 2007 with stable financial incentives and increasing product availability.

5. ACKNOWLEDGEMENTS

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6. REFERENCES

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