



Photovoltaic Solar Technology



Photovoltaic (PV) Technology – The Basics



- Directly creates electrical energy from sunlight (DC)
- No moving parts
- Lasts for 20+ years with minimal maintenance
- Uses direct and indirect insolation; works anywhere with light
- Does not store energy without a battery
- First commercialized in U.S. (Bell Labs) in the 1950's

How does PV technology work?

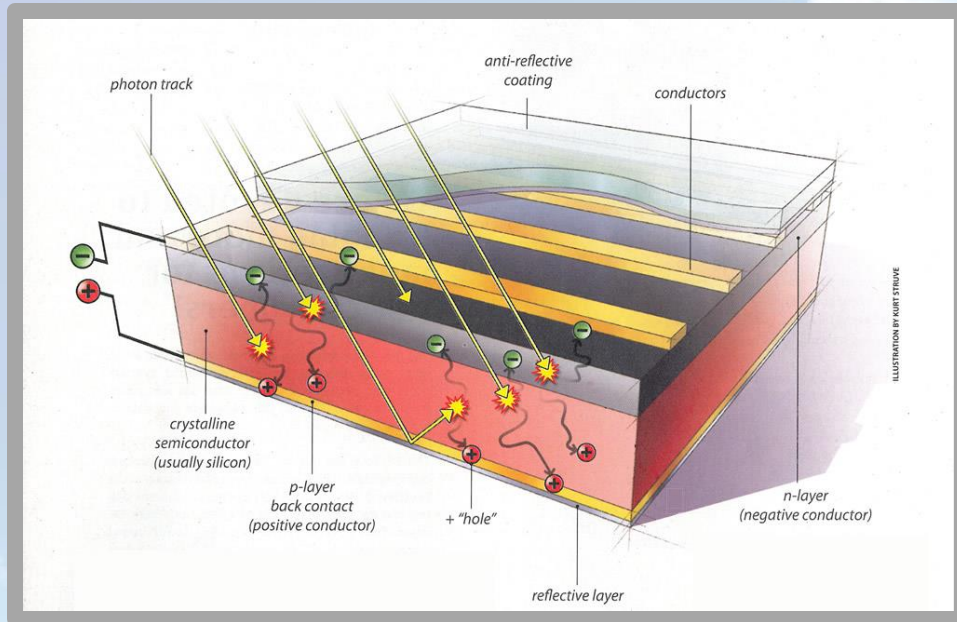


Diagram of a typical crystalline silicon solar cell. To make this type of cell, wafers of high-purity silicon are “doped” with various impurities and fused together. The resulting structure creates a pathway for electrical current within and between the solar cells.

- Photons strike and ionize the semiconductor material causing outer electrons to break free of their atomic bonds.
- Due to the semiconductor structure, the electrons are forced in one direction creating a flow of electrical current.
- Solar cells are not 100% efficient in part because some of the light spectrum is reflected, some is too weak to create electricity (infrared) and some (ultraviolet) creates heat energy instead of electricity.

Other Types of Photovoltaic Technology

In addition to crystalline silicon (c-Si), there are two other main types of PV technology



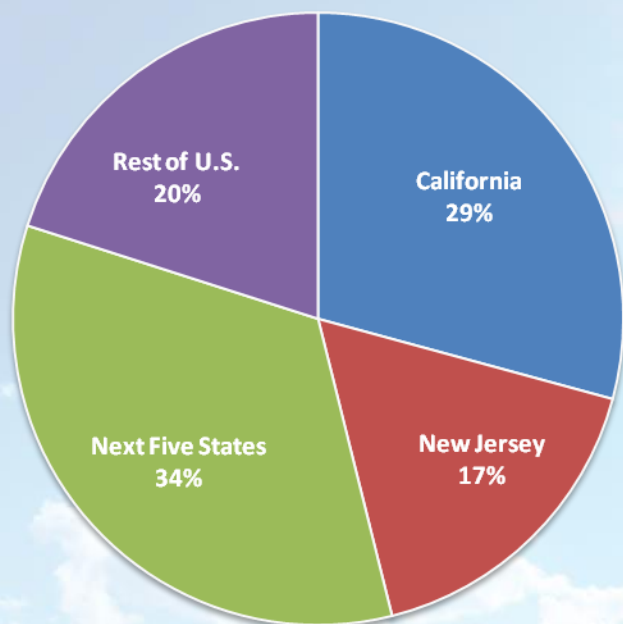
Thin-film PV is a fast-growing but small part of the commercial solar market. Many thin-film firms are start-ups developing experimental technologies. They are generally less efficient – but often cheaper – than c-Si modules.



In the United States, **concentrating PV** arrays are found primarily in the desert Southwest. They use lenses and mirrors to reflect concentrated solar energy onto high-efficiency cells. They require direct sunlight and tracking systems to be most effective.

Major Solar Markets in 2011

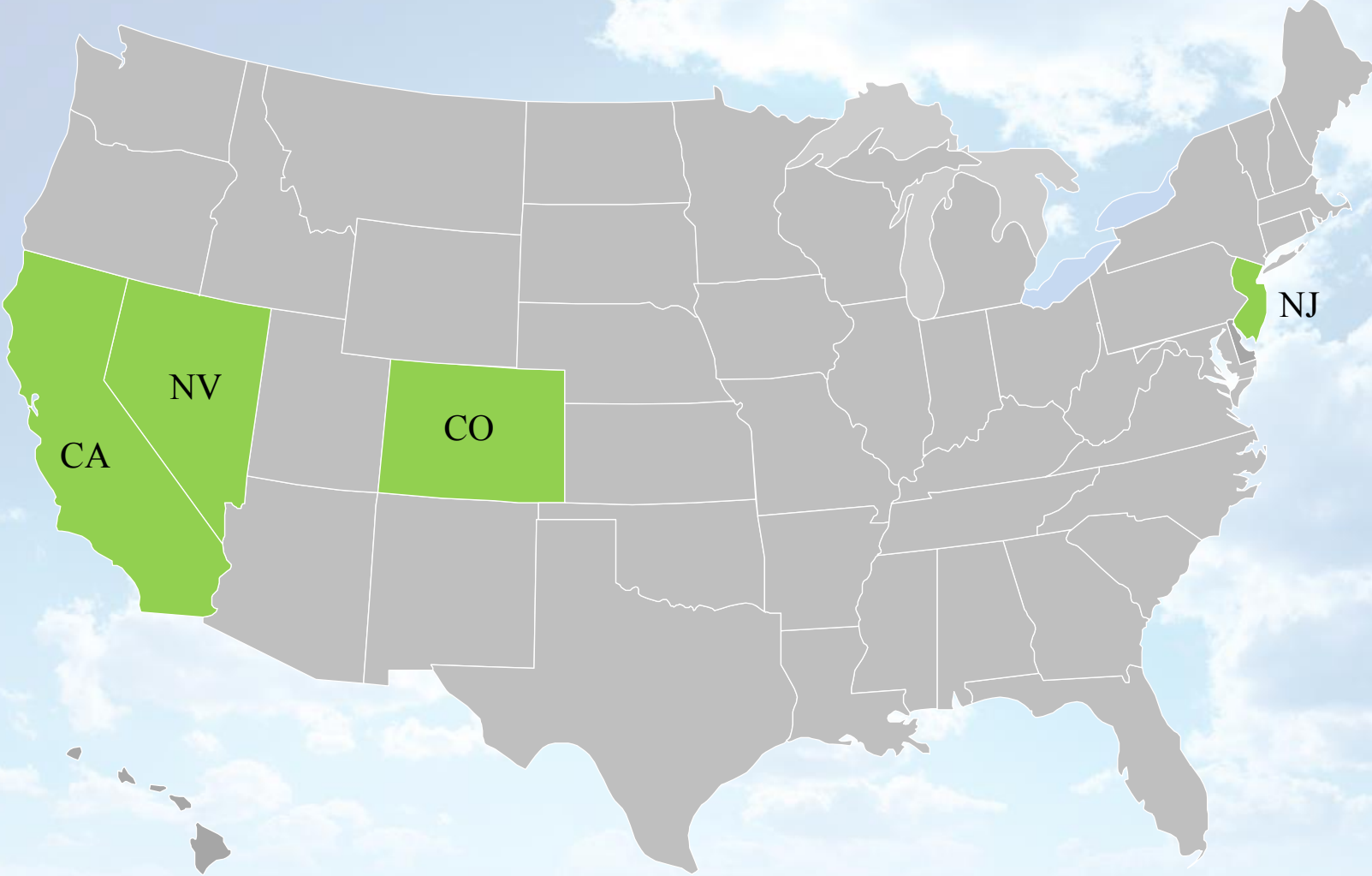
2011 PV Installations by Major Market



SEIA/GTM Research: *U.S. Solar Market Insight 2011 Year in Review*

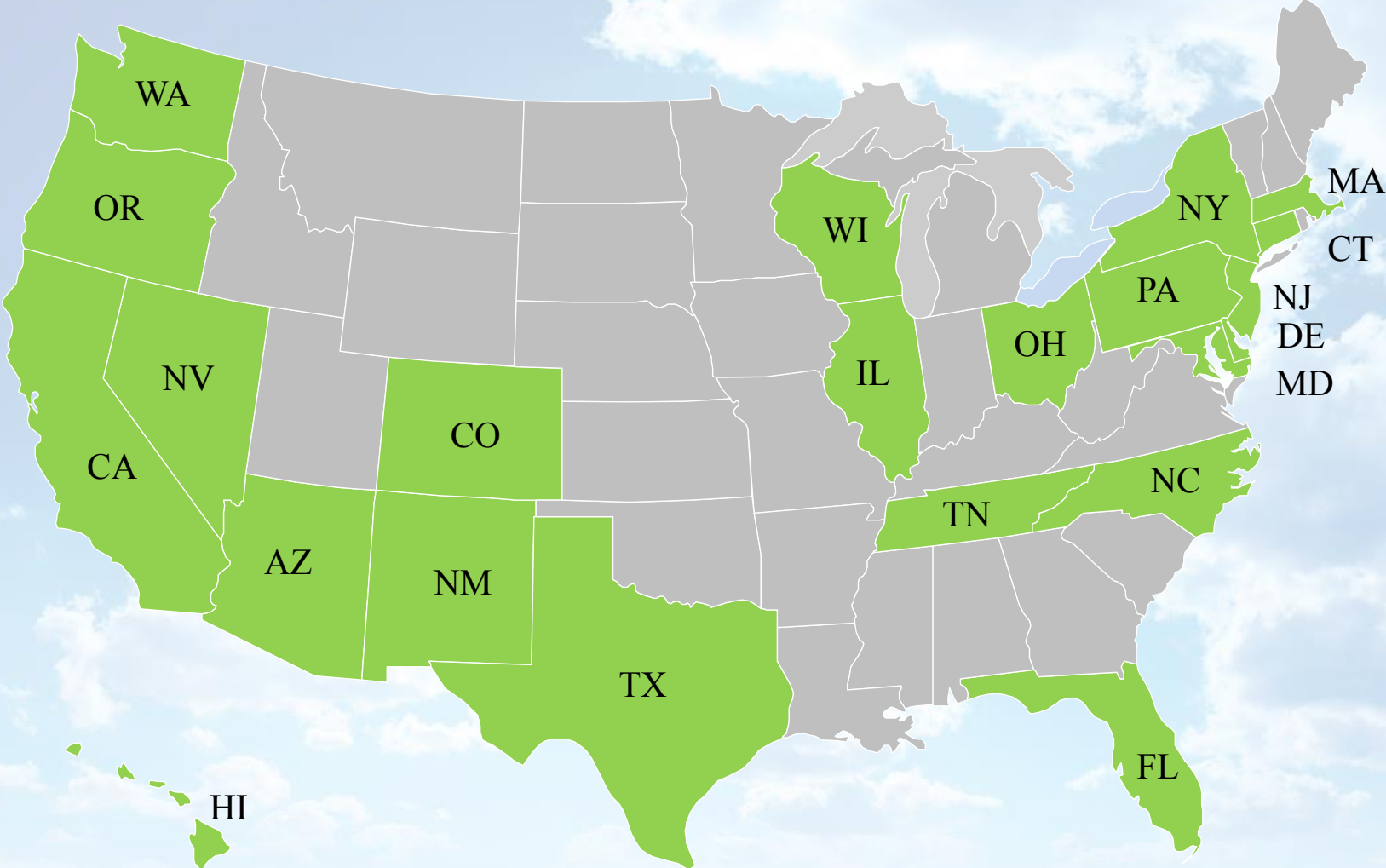
State	2011 Annual Installations(MW)	Cumulative Installations as of YE2011 (MW)	2011 Ranking
California	542.2	1,513.4	1
New Jersey	313.3	601.7	2
Arizona	273.2	383.2	3
New Mexico	115.8	160.9	4
Colorado	90.8	198.6	5
Pennsylvania	87.9	141.9	6
New York	59.9	114.4	7
North Carolina	54.8	97.2	8
Texas	47.1	77.7	9
Nevada	43.6	141.0	10

U.S. States With >10 MW of PV Installations, 2007



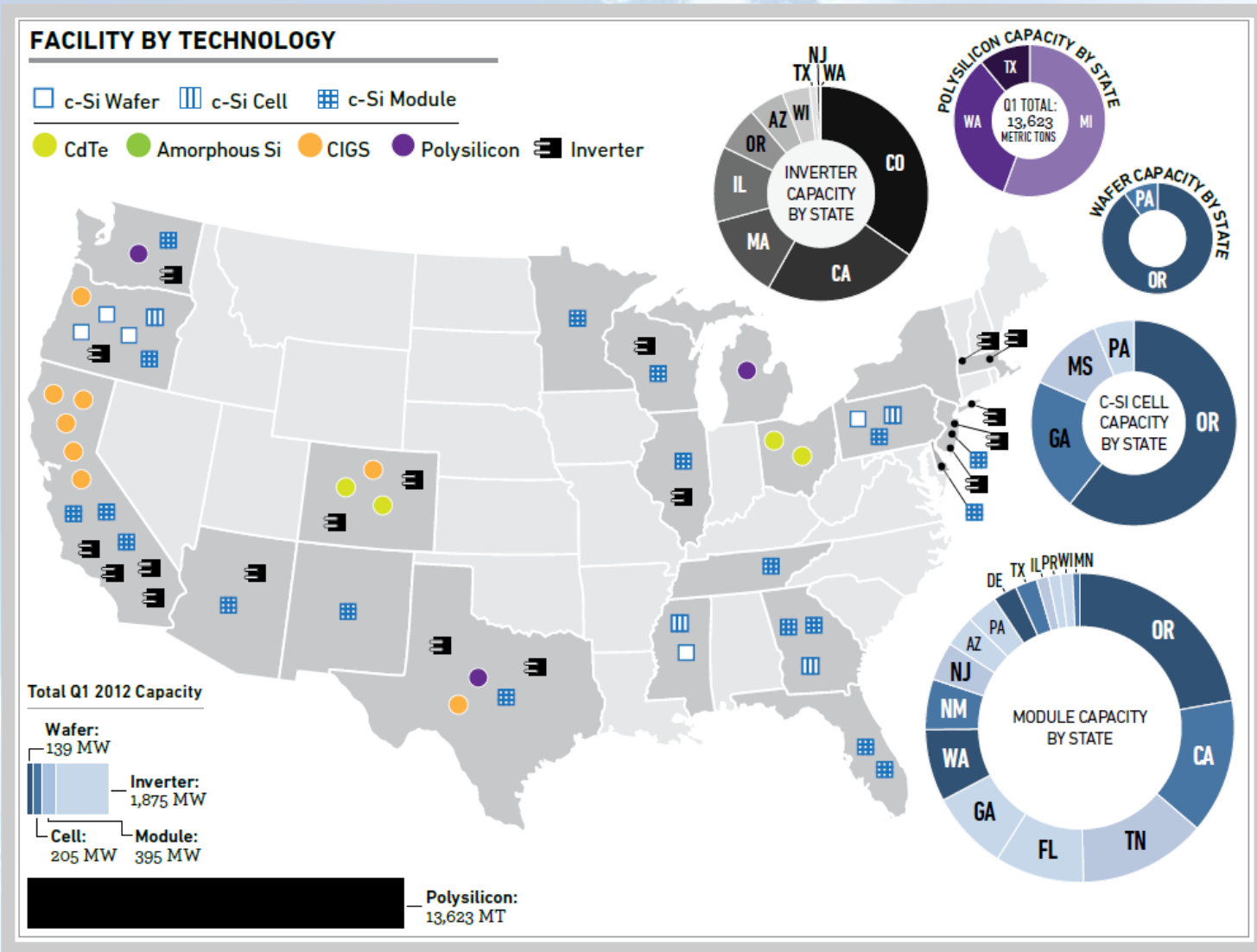
Source: SEIA/GTM Research: Solar Market Insight Q3 2011

U.S. States With >10 MW of PV Installations, 2011



Source: SEIA/GTM Research: Solar Market Insight, "2011 Year in Review"

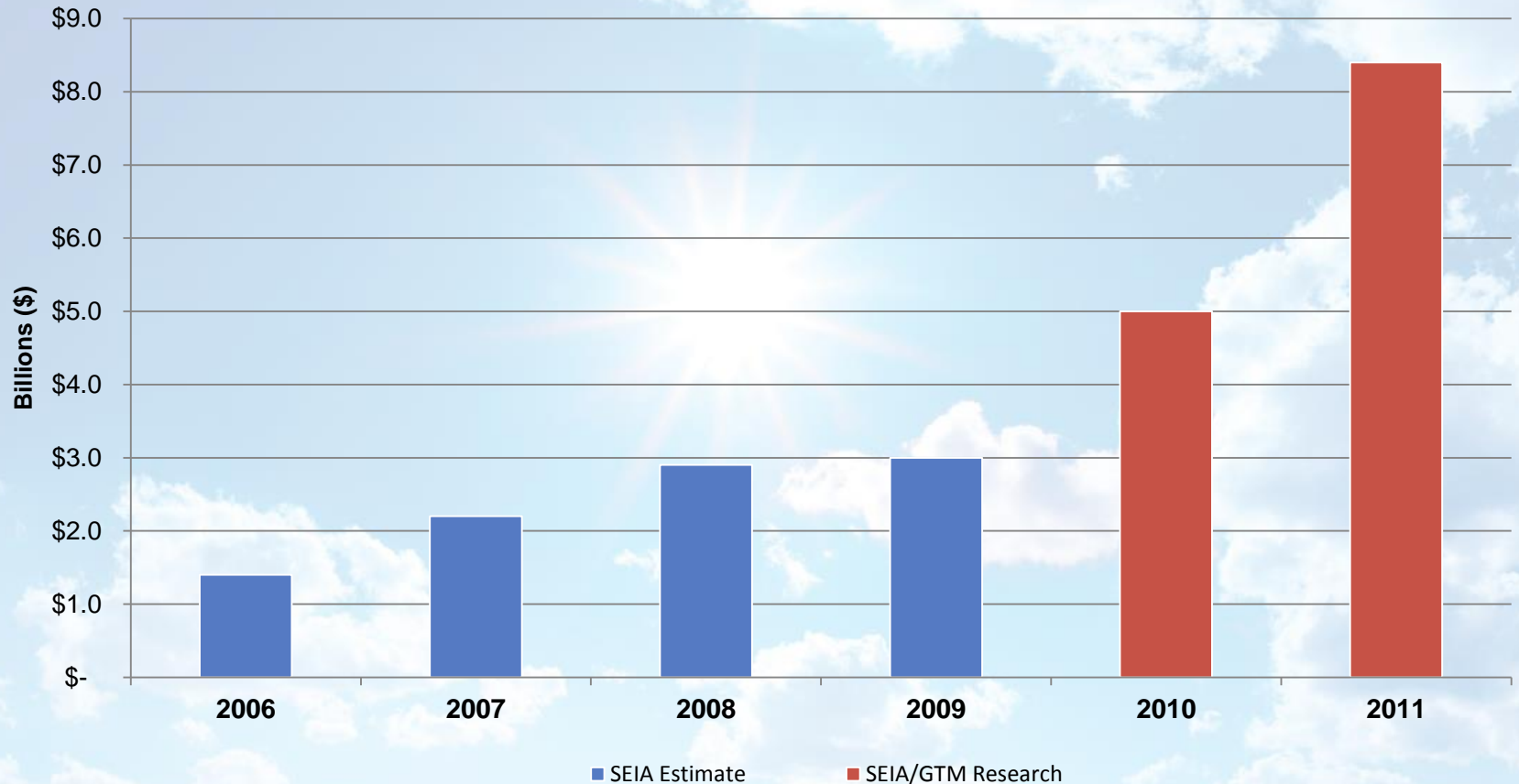
Solar Manufacturing Facilities in the U.S. 2012



Source: SEIA/GTM Research: Solar Market Insight 2012 Q1

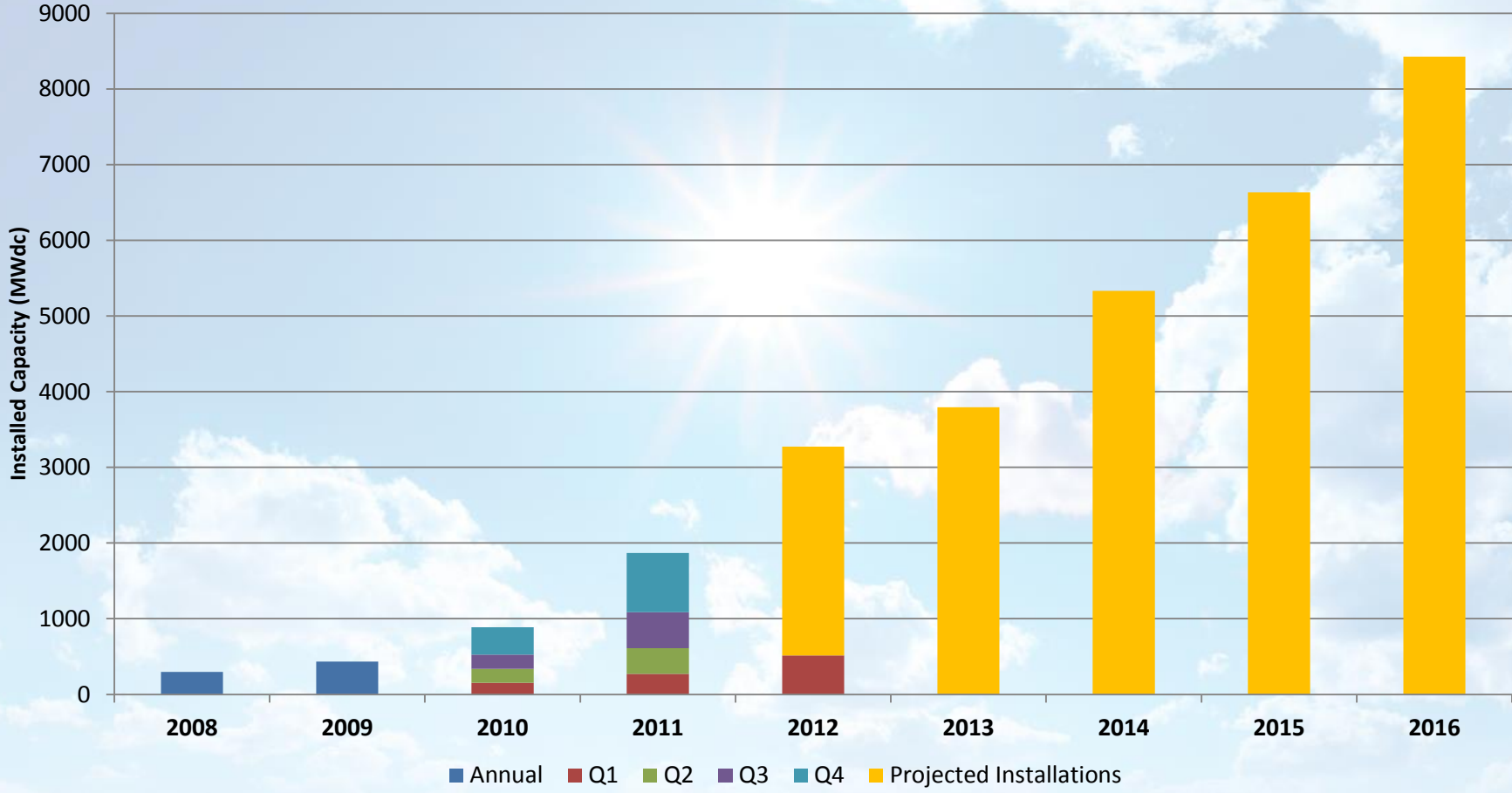
Continued Growth of U.S. PV Market

Value of PV Installations



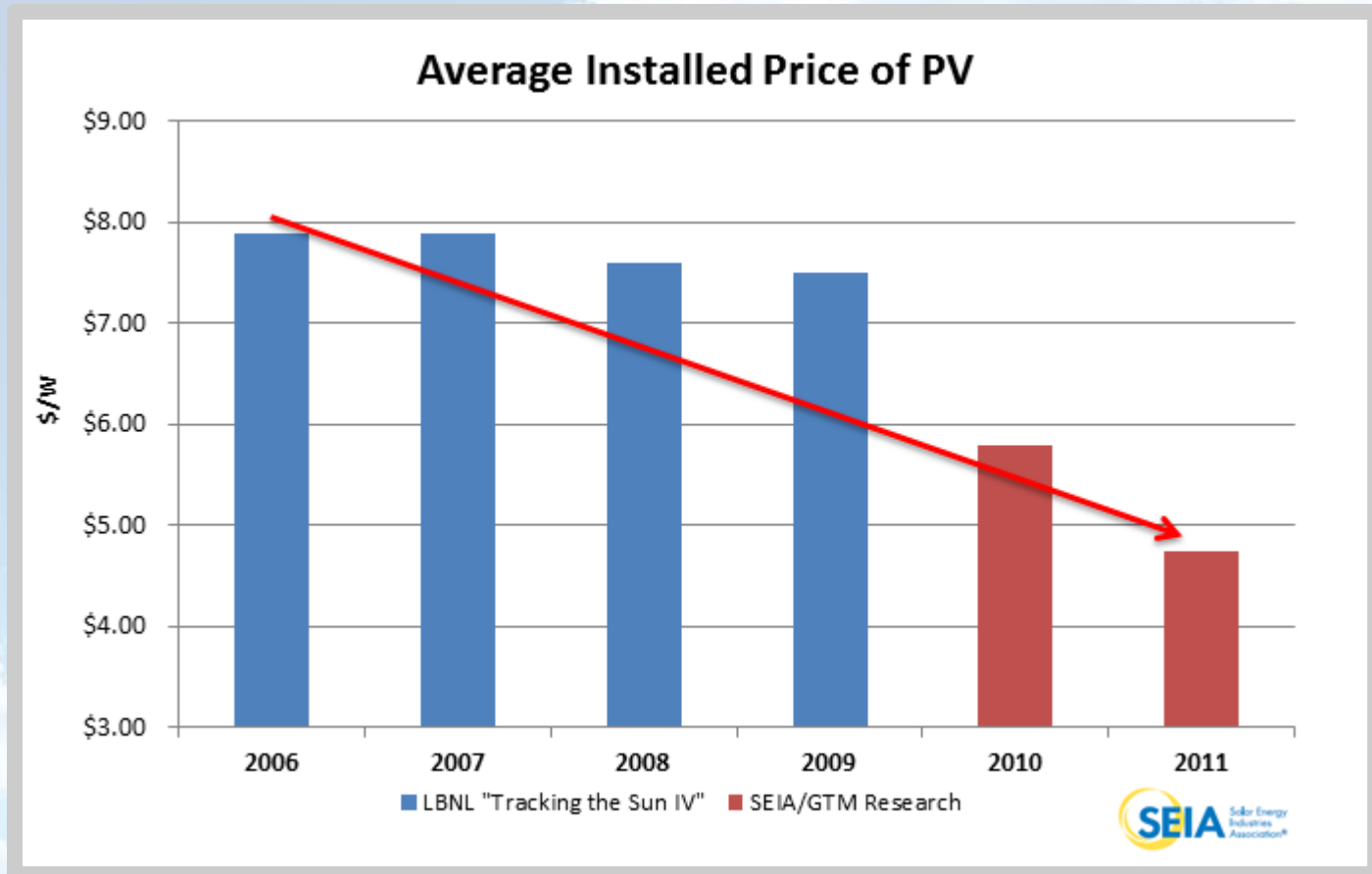
U.S. PV Demand Grew 109% in 2011

U.S. PV Installation Forecast



Source: SEIA/GTM Research: "Solar Market Insight Q1 2012"

Costs of Solar Continue to Decline



Photovoltaic Technology - Financing

To address the issue of up-front costs, solar integrators have developed a number of financing options for their customers.

- **Solar Lease** – Customer pays little or no money up-front and is not responsible for system monitoring or repair. Often immediately cash-flow positive.
- **Power-Purchase Agreement (PPA)** – Customer purchases only the electricity generated from the system.
- **Property-Assessed Clean Energy (PACE)** – Up-front cost is paid by a local government fund and repaid by homeowner through property taxes.
- **Solar Renewable Energy Certificate (SREC) Loan** – Utility company pays the bulk of the system cost and is repaid by customer through annual sale of SRECs.

Photovoltaic Technology - Financing

Table 5. Advantages and Disadvantages of Residential Financing Structures⁴³

Residential PV Matrix from Homeowners' Perspective	Purchase with Cash	Home Equity Loan	Solar Lease	Residential PPA SunRun Power Plan	Property Tax Model	PSE&G Solar REC Loan Program
Up-front cost to homeowner	36-70%	None/Low	0 - 20%	5-25%	None/Low	36%
Homeowner has maintenance responsibilities	Yes	Yes	Depends on program	No	Yes	Yes
Homeowner Pays for Inverter Replacement	Yes	Yes	Depends on program	No	Yes	Yes
Likely impact on future utility bills*	Lower	Lower	Lower	Lower**	Lower	Lower
Required cash payments (above utility bills)	No	Yes - loan payment	Yes - lease payment	Yes - electricity payment	Yes - property tax payment	No - although annual true-ups possible
Ownership of PV system in Year 1	Yes	Yes	No	No	Yes	Yes
Take residential federal tax credit	Yes	Yes	No	No	Yes***	Yes***

* Compared to buying 100% of the electricity from the local utility. This does not mean that other costs, such as a loan or lease payment will be 100% offset by retail utility bill savings.

** The third-party PPA ownership model assumes that retail electricity prices will exceed the PPA price. While likely, unless structured as a fixed discount to retail prices, it is not guaranteed.

*** Based on the proposed changes to the subsidized energy financing concept in the stimulus bill.

(Solar Photovoltaic Financing: Residential Sector Deployment; NREL, March 2009)

Photovoltaic Technology - Financing

*How much will it cost to install a solar array on my house?
What's my return-on-investment?*

- **Short answer:** I have no idea.
- **Longer answer:** it depends. There are a lot of factors that go into solar economics. In addition, it's worth considering that solar energy is a wealth creating investment, so up-front cost is only one component of the total value to the customer.
- **Longest answer OR "Here's what you need to know to get the answer"**
 - How much annual sunlight does your area receive? Does your rooftop face south? Is it free of shading?
 - Do you live in a major solar market? How many companies offer installations? What types of financing do they offer?
 - How much are you currently paying for electricity? How much do you use each month? Does your utility offer net energy metering?
 - What federal, state and local incentives are available?

Questions?

What different thin-film technologies are available and what are their applications?

How do solar customers deal with storing the energy from their systems?

What are the typical incentives available at the state and federal level?

What are the key national and local policies for creating solar markets?

How do specialized solar cells work, like those used in CPV or on satellites?

Questions?



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