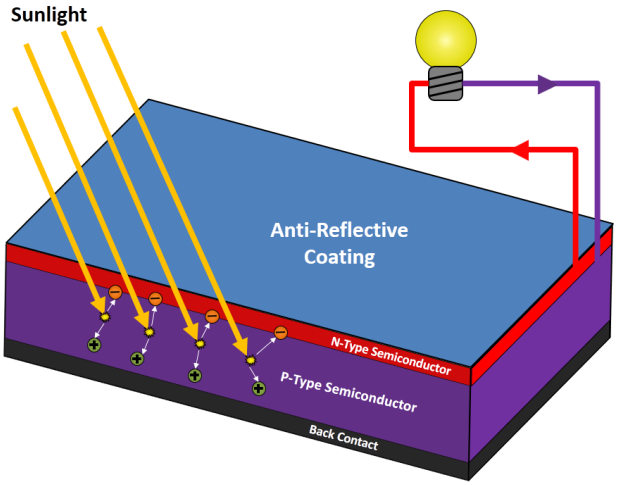
Solar Photovoltaic (PV) Energy

LAFAYETTE COLLEGE

Rick Cerretani
EGRS 352-01
cerretar@lafayette.edu



Basics of PV Power Generation

- Photons of sunlight passes through the anti-reflective coating and into the layer of (usually silicon) p-type semiconductor material.
- Photons of light "knock" electrons loose from the atoms of the p-type semiconductor, thus ionizing the atoms.
- The electrons are attracted to the n-type semiconductor, which is connected to metal plates or wires to conduct the resulting DC electric current.

Solar Resource

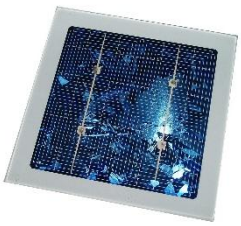
A region's *solar resource*, also known as the *insolation*, represents the average amount of radiative energy from the sun available to that region on any given day. Regions with a smaller solar resource than others suffer a disadvantage, as PV technology cannot generate as much power as it would in a region with a greater solar resource.

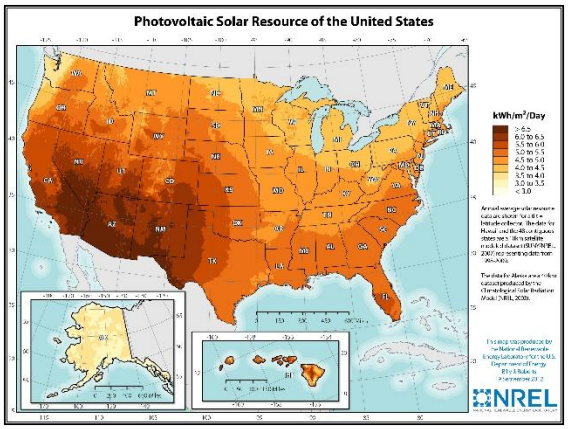
PV Cell Types

- **Monocrystalline Silicon**
  - Most efficient: 15-20%
  - Most expensive: $2-5 per watt
  - Cut into wafers from a single-crystal cylindrical ingot
  - Most common type
- **Polycrystalline Silicon**
  - Moderate efficiency: 13-16%
  - Less expensive & faster production
  - Molten silicon cast into ingots
- **Amorphous Silicon**
  - Least efficient: 8-10%
  - Inexpensive: $2-3 per watt
  - Thin: 2 µm versus 200-400 µm for crystalline silicon
- **Thin-Film Cell**
  - Inexpensive: $1-4 per watt
  - Efficient: 14-20%
  - Various types: copper indium diselenide, cadmium telluride, gallium arsenide

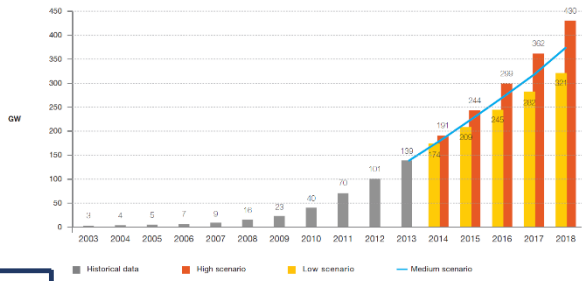
Key Numbers

- Current U.S. solar electric capacity: **>17,500 MW**
- New electric capacity installed in 2014: **36% solar**
- Average 2014 energy cost for PV in U.S.: **$2.71/W**
- Approximate total solar panel area needed to fulfill all energy demand in the U.S. **40,600 square miles**
- Approximate total land use required to fulfill U.S. energy demand using only PV: **81,200 square miles**





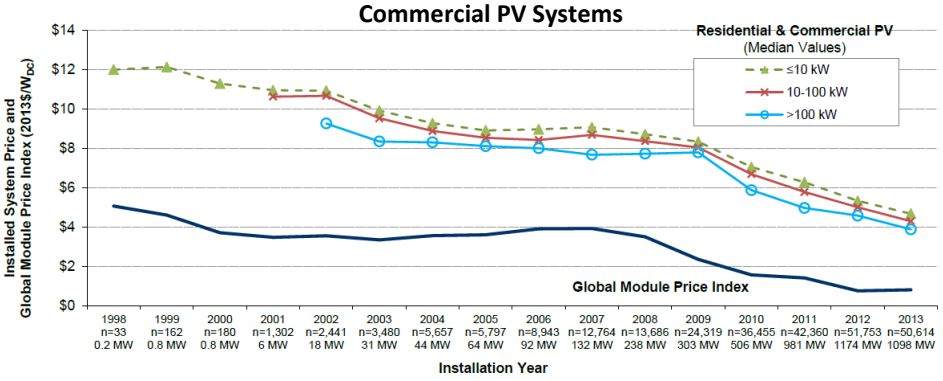
Global Cumulative PV Implementation



Pricing

One of the most significant problems facing the continued adoption of PV systems is their considerably high price relative to that of preexisting energy utilities. However, prices have been steadily declining over time, dropping by an average 6-8% annually since 1998. They are also expected to continue falling, with current price projections or the year 2020 being at roughly half the levels that were projected 5-10 years prior.

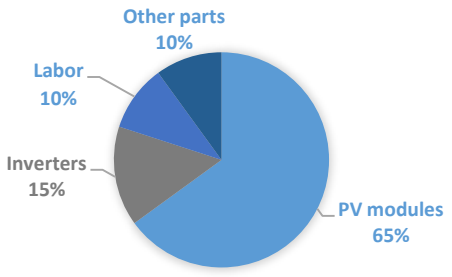
Median Reported Installed Prices of Residential & Commercial PV Systems



Global

The global market for solar PV is anticipated to continue to grow. Germany, China, Italy, Japan, and the U.S. are the current world leaders in solar PV adoption. In 2013, more than 10,000 MW of solar PV generation capacity was added in the EU.

Approximate Component Cost Distribution for PV Power Systems, 2006



Basics of PV Power Generation

Patel, Mukund R. *Wind and Solar Power Systems: Design, Analysis, and Operation*. 2nd ed. Boca Raton, FL: Taylor & Francis, 2006. Print.

"Photovoltaic (Solar Electric)." *SEIA | Solar Energy Industries Association*. Web. 18 Apr. 2015. <http://www.seia.org/policy/solar-technology/photovoltaic-solar-electric>.

Solar Resource

Information and figure:

"Solar Maps." *NREL: Dynamic Maps, GIS Data, and Analysis Tools*. 2 Feb. 2015. Web. 18 Apr. 2015. <http://www.nrel.gov/gis/solar.html>.

PV Cell Types

Patel, Mukund R. *Wind and Solar Power Systems: Design, Analysis, and Operation*. 2nd ed. Boca Raton, FL: Taylor & Francis, 2006. Print.

Key Numbers

Current U.S. solar capacity, capacity installed in 2014, and average 2014 PV cost:

"Solar Industry Facts and Figures." *SEIA | Solar Energy Industries Association*. 1 Dec. 2014. Web. 18 Apr. 2015. <http://www.seia.org/research-resources/solar-industry-data>.

Calculations based on assumptions:
- PV efficiency = 15%
- Insolation = 5 kWh/m^2/day
- U.S. energy consumption = 98.32 quadrillion Btu
- Land use factor = 2.0 units per unit area of PV

Global

Information and figure:

Global Market Outlook for Photovoltaics 2014-2018. Rep. N.p.: European Photovoltaic Industry Association, n.d. Web.

Pricing

Information and figure:

Feldman, David, and Galen Barbose. *Photovoltaic System Pricing Trends: Historical, Recent, and Near-Term Projections*. Issue brief no. PR-6A20-62558. U.S. Department of Energy, 22 Sept. 2014. Web. 19 Apr. 2015. <www.nrel.gov/docs/fy14osti/62558.pdf>.

Chart data from:

Patel, Mukund R. *Wind and Solar Power Systems: Design, Analysis, and Operation*. 2nd ed. Boca Raton, FL: Taylor & Francis, 2006. Print.