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Renewable Energy Fact Sheet

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Photovoltaics

Using semiconductor materials to convert sunlight into electricity

Key Facts

- Photovoltaic (PV) systems consist of panels coated with a thin layer of semiconducting material. The sunlight knocks electrons loose from the atoms of the semiconducting material, and as the electrons flow through the material, they produce electricity.
- Almost every region in the United States has sufficient solar resources for PV systems. On partly cloudy days, PV systems produce up to 80 percent of their potential electrical capacity, and on very overcast days, they can still produce about 25 percent.
- A 90-mile square PV generating station in an average solar location in the United States could produce enough electricity to meet the entire country's peak demand, according to the National Renewable Energy Laboratory.
- Current worldwide installed PV capacity is more than 2,000 megawatts (MW). The world PV market is growing at approximately 25 percent annually.

Photovoltaic Technology

- Photovoltaic cells, also known as solar cells, are small, electricity generating devices made of semiconducting materials. Individual solar cells have a capacity of 1 to 2 watts of power and range in size from smaller than a postage stamp to several inches across. These cells are mounted onto flat plate arrays of various sizes. This technology is established, and PV systems have been powering satellites for years.
- Some PV arrays are positioned to face south all the time, while others are mounted on devices that track the sun, which increases power production throughout the day.
- PV systems are sized as needed for specific locations and applications. Fields of solar arrays produce utility-scale power. Homeowners and businesses can add PV systems to augment their electricity supply. Homes must usually remain connected to the grid so they can buy power from the local utility when solar power is insufficient, although many solar homes have been built to operate off the grid. In areas with "net metering," homeowners can sell excess electricity to the utility. Small systems can also provide electricity in remote off-grid locations to power water pumps, for example.

Benefits

- *Ease of installation:* Small systems that produce less than 500 watts require only a few hours to install and weigh less than 150 pounds. Such systems require only occasional inspections and cleaning and can be placed in remote locations or on buildings.
- *Modularity:* Capacity can be increased on as as-needed basis.
- *Distributed power:* PV is a distributed power source, so it can reduce demands on transmission infrastructure and increase grid reliability.

- *Pollution prevention:* Solar energy does not generate greenhouse gases or other pollutants. Each kilowatt of PV-produced electricity annually offsets up to 217,000 pounds of carbon dioxide, 1,500 pounds of sulfur dioxide, and 830 pounds of nitrogen oxides, according to the National Renewable Energy Laboratory (NREL). The *energy* payback time for PV systems, the time required for the system to displace as much fossil energy as was required to manufacture it, ranges from 1 to 4 years, according to NREL. As most solar systems have life expectancies of 30 years, 87 percent to 97 percent of the electricity they generate is effectively emissions-free.
- *Jobs:* The construction of PV arrays and PV power generation currently provide more than 20,000 high technology jobs in the United States, and this workforce is projected to grow to 62,000 by 2015, according to the Solar Energy Industries Association.
- *Domestic energy security:* PV electricity is produced domestically, thereby helping to reduce energy security concerns associated with depending on foreign countries for oil and natural gas.

Cost

- Utility-scale PV electricity costs between $0.20 and $0.30 per kilowatt-hour (kWh). The costs of residential and small-scale PV electricity are more variable, but can be as low as $0.20 per kWh. The cost has dropped more than twenty-fold since the technology's development and continues to fall as technology improves.
- Although PV costs more than conventional utility-scale electricity on average, PV is the most cost effective energy option in some remote off-grid areas and in places with high peak electricity prices and PV incentives. The Santa Rita Jail in California, for example, installed PV cells with a capacity of 1.2 MW on the roofs of its buildings. The jail has reduced its peak power consumption by 30 percent, and in the first year of the project's operation (2002-2003), the jail avoided purchasing over 1.4 million kWh of electricity, primarily at peak times. This electricity was then available to other consumers, lowering the risk of brownouts. The jail saved over $425,000 in electricity costs in the first year alone. Over the 25 years of the PV system's operating life, the jail expects to realize a net savings of more than $15 million, assuming constant electricity prices.

Issues

- *Intermittent power:* Although PV cells only produce electricity during the day, they can provide electricity at night or on cloudy days when coupled with battery storage.
- *Financial risk:* While solar energy is free, upfront capital costs of PV are high. Acknowledging the risks of new technology development, the Department of Energy, the Electric Power Research Institute and several other organizations formed the Photovoltaics for Utility-Scale Applications project that operates three utility-scale PV systems. This project allows utilities to experiment with the technology with minimal financial risk.
- *Toxic byproducts:* Producing PV systems involves small amounts of toxic chemicals and creates small quantities of hazardous waste. Research into how to reduce the toxic chemicals and energy used in solar array production and how to recycle PV arrays is ongoing.

For More Information

American Solar Energy Society http://www.ases.org/
National Renewable Energy Laboratory http://www.nrel.gov/clean_energy/elec_pv.html
Solar Energy Industries Association http://www.seia.org/
DOE Office of Energy Efficiency and Renewable Energy http://www.eere.energy.gov/solar/photovoltaics.html

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