Overview

Photovoltaics is a technology in transition. Photovoltaic (PV) power has long been cost-competitive in a variety of off-grid applications; and as the cost of PV electricity continues to fall, this environmentally benign technology is becoming increasingly attractive to electric utility companies. In the United States, photovoltaics is currently making the move from primarily remote, stand-alone applications to utility grid support.

Acording to the Solar Energy Industries Association (SEIA), total grid-connected photovoltaic generating capacity in 1994 was about 18 MW, spread across 36 states. Although stand-alone applications are difficult to quantify because they are so widely dispersed, there are an estimated 25,000 homes in the United States powered exclusively by photovoltaics.

More than 850 U.S. companies are currently involved in the manufacture and sale of photovoltaic modules and system components. The industry brings in more than $300 million in revenues annually and employs 15,000 people — most of them in high-quality jobs, such as manufacturing, engineering, sales, installation, servicing, and maintenance.

International sales continue to drive the PV industry. The largest market for photovoltaics is in the developing world, where two billion people still do not have electricity in their homes. Photovoltaic systems are particularly well suited to this market because of their high reliability, their suitability for applications of almost any size, and the fact that they do not need costly transmission lines. Approximately 70% of U.S. photovoltaic manufacturing output is exported.

Sacramento Municipal Utility District/PIX02439

Through its PV Pioneers program, the Sacramento Municipal Utility District (SMUD) installs and operates grid-connected, rooftop PV systems on customers' homes. The program creates jobs in the utility's service area and reduces the need for SMUD to purchase electricity from other regions.

Success Stories

The United States leads the world in photovoltaic research and manufacturing, accounting for 43% of global PV module production in 1995. The growing international popularity of photovoltaics is creating an increasingly buoyant domestic PV industry, and U.S. manufacturers are scaling up their production facilities to take advantage of emerging markets. These expansions are creating skilled jobs in several states.

U.S. Manufacturers Lead the Way

Siemens Solar Industries (SSI), based in Camarillo, California, is the world's largest manufacturer of photovoltaic cells and modules. In 1995, the company shipped 17 MW of photovoltaic modules, representing half of U.S. production and 21% of total world production that year. To help meet growing worldwide demand, SSI completed a $3 million expansion of its facility in Vancouver, Washington, in February 1996. The expansion created 33 new jobs in the Vancouver area, and all work on the facility was awarded to local contractors, further contributing to the local economy. SSI employs a total of approximately 350 people at its facilities in California and Washington.

Solarex, the second largest PV manufacturer in the United States, has been in business for over 20 years. During the late 1970s and early 1980s, as oil prices rose, major oil companies began investing in renewable energy as a hedge against an uncertain future in fossil fuels. Amoco Corporation bought Solarex in 1983. Most of the oil

companies concentrated on developing their renewable energy for the long-term utility market; in other words, they were not very concerned with short-term profitability. Amoco, on the other hand, treated Solarex as part of the business from the very beginning, producing revenues from existing products at the same time as investing in technology development.

Today this strategy is paying off. In 1995, Solarex captured 27% of the U.S. market (12% of the global market), with total sales of $45 million. In January 1996, the company broke ground on a new wing at its manufacturing facility in Frederick, Maryland, which already employs 240 people.

"This dynamic expansion project by Solarex will provide the kind of high quality [jobs] that Maryland needs to continue building a prosperous, vibrant economy."

— James Brady, Secretary of the Maryland Department of Business and Economic Development (*Solar Industry Journal*, First Quarter, 1996)

Solarex is also building a $25 million manufacturing plant in James City, Virginia. The company was lured there by state incentives specifically designed to create jobs and strengthen the state's economy by attracting PV manufacturing companies to the area. The new plant will employ a total of approximately 80 people.

David Patryas Photography/PIX01545

U.S. manufacturers are expanding their output to meet the growing demand for PV systems. This creates skilled jobs at production facilities in several states, such as this thin-film plant in Golden, Colorado.

How It Works

Photovoltaics is the direct conversion of light ("photons") into electricity ("voltage").

The basic unit of a typical photovoltaic system is the PV cell, which is made of layers of semiconducting materials similar to those used in computer chips. When incoming photons of light strike atoms in the semiconductor material, some electrons are knocked loose, causing electricity to flow. The greater the intensity of the light, the more power is generated by the cell.

PV cells, which produce DC electricity, are usually connected together and enclosed in protective casings called modules. Photovoltaic systems can provide an independent, stand-alone power supply or can be connected to the electrical grid. In stand-alone applications, modules can be connected to inverters to supply AC electricity and to batteries to store electrical power for periods when the sun is not shining. Grid-connected systems both feed power into the grid and use the grid as a source of backup power.

Craig Miller Productions/PIX03500

The U.S. PV industry employs 15,000 people, most of them in high-quality jobs, including installation, servicing, and maintenance. This 340-kW system was installed on the roof of the aquatic center for the 1996 Summer Games in Atlanta, Georgia. It is the world's largest building-integrated, rooftop PV system.

Another PV manufacturer, Atlantis Solar Systems/Solar Building Systems, also took advantage of Virginia's incentives; Atlantis is constructing a production facility in Cape Charles that will create 25 jobs.

According to an August 1995 article in *The Newport News Daily Press*, "Virginia, whose economy once was rooted in tobacco, is leaving its plantation past behind and heralding its future in high technology." Virginia has increased its investments in science and math education at all levels, and is looking to attract industries that will provide high-paying jobs for its home-grown graduates in the fields of engineering, chemistry and science. "PV is exactly the kind of industry that Virginia wants to encourage," said Ann Broadwater of the Virginia Department of Development.

Other U.S. manufacturing companies have also been expanding their operations. Solec International, for example, the country's third largest PV manufacturer, more than doubled its workforce between 1993 and 1996. The company now employs 130 people.

And AstroPower, Inc., a tiny start-up venture 10 years ago, now has 145 employees and annual revenues exceeding $10 million, 80% of which are from exports.

Growing Utility Interest

According to the Utility PhotoVoltaic Group (UPVG), "UPVG's market evaluation work has shown that PV can make a contribution to every utility in every part of the country." UPVG is a group of more than 80 electric utilities formed in 1992 to investigate utility applications of photovoltaics. Today, 39 U.S. utilities are actively testing grid-connected photovoltaic systems, including California's Sacramento Municipal Utility District (SMUD), a UPVG member and, with 480,000 customers, the nation's fifth largest customer-owned utility.

More than half of SMUD's projected load requirements have been met with renewable-source electricity, such as the utility's PV Pioneers program, and energy efficiency programs. SMUD also operates the country's largest PV power plant, a 2-MW facility on the grounds of the utility's now-closed Rancho Seco nuclear power plant. These programs have created jobs within the utility's service area and mean that SMUD has to purchase less power from other regions.

"Our customers want more from us than just a good price; they want long-term reliability, a clean environment and local economic development. Solar can help us meet these needs."

— Don Osborn, SMUD solar program manager (*Solar Industry Journal*, Third Quarter, 1995)

A growing number of electric utilities are also becoming familiar with the advantages of photovoltaic power for remote applications. In 1994, Southern California Edison (SCE) started an off-grid PV program called Partnership with the Sun. John Bryson, SCE's chairman, says it is a win-win program: "Homeowners and businesses in remote locations get clean, quiet electricity. Independent contractors get jobs and construction projects. And Edison is able to serve new customers who otherwise have no dependable source of power."

Saving Money for Ranchers

Photovoltaics can be a winner for rural electric cooperatives. KC Electric Association, a rural electric cooperative in eastern Colorado, is saving its members money by providing them with photovoltaic power. The association serves 4000 square miles of prairie with an average of only two customers per mile of distribution line. Every year, winter storms knock out as many as 1000 utility poles and 38 miles of lines. With replacement costs of $10,000 per mile of line, the association has been spending up to $380,000 on maintenance every year.

The lines provide little revenue. About half of the association's customers use the electricity primarily to power small irrigation pumps. In 1990, KC Electric began using photovoltaics as a more practical and affordable alternative to replacing damaged distribution lines serving remote livestock wells or extending lines to new well sites. The cooperative can provide PV-powered water pumping at a cost of $1800 to $6000 per well — saving its members thousands of dollars when compared with the cost of providing grid electricity.

Roger Taylor, NREL/PIX01860

Worker installing a grid-independent, PV-powered street light.