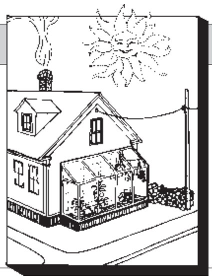

Photovoltaics Update

by Alex Wilson

Solar energy has lost some of its excitement and urgency with the loss of residential-solar tax credits and the dramatic drop in oil prices. Indeed, the solar-hot-water industry has all but disappeared in this country—at least temporarily.

Photovoltaics, on the other hand, has fared much better. Electricity prices are still increasing in much of the country, particularly in the Northeast. As PV costs drop, they become more and more cost-effective for remote applications. In general, photovoltaics is becoming a good long-term option for supplying electricity.

Unfortunately, early estimates of how soon PV prices would drop to affordable levels were overly optimistic. Also, the government has cut funding for photovoltaics along with all other renewable-energy technologies. Nonetheless, the technology is progressing rapidly, and the day when we can routinely design PV panels into our houses is drawing closer. In this column, I will bring you up to date on where the technology now stands.

They're, Cute, But What Do They Do?

PV cells are composed of a semiconductor material, such as silicon, whose electrical properties can be altered by slight additions of specific impurities. PV manufacturers form two different layers in one cell: one layer wants to give up electrons, and the other wants to absorb them. Where these layers meet, electrons flow from the side with a surplus to the side with an electron deficit. In so doing, a "barrier," with unequal charges on either side, is formed.

This barrier allows electrons to flow in only one direction—a sort of one-way valve. When sunlight strikes the cell, the photons excite the semiconductor material and cause electrons to be freed. The electrons move across the barrier and accumulate on the other side. By connecting a wire between the two sides of the cell, the surplus of electrons can flow back to the other side; this flow is the electricity we can tap.

It is a simple and elegant process—one that uses no fuel and has no moving parts (except for electrons). It is the only electrical generation process we use that does not require a mechanically rotating dynamo.

Photovoltaics Research

PV research is concentrating on using thinner and less expensive materials for the cells, improving the efficiency at which PV cells convert sunlight into electricity, and streamlining the manufacturing process to make more cells more quickly, at lower cost. The major silicon PV technologies are summarized in the Table.

A great deal of attention, both here and in Japan, is being focused on amorphous-silicon PV cells. Amorphous silicon is much cheaper than the crystalline silicon that has been used almost exclusively until recently. It offers the potential for spray-on or electrodeposition, with a continuous roll of flexible steel or plastic being processed into PV cells.

Chronar and Energy Conversion Devices, two fast-growing U.S. companies, are devoting their full attention to this technology, and Arco Solar, the world's largest PV manufacturer, expects to convert much of its output to amorphous silicon over the next several years.

Other thin-film PV technologies potentially offer far greater efficiency and more durability than amorphous silicon. Some of the most promising are copper indium diselenide, cadmium telluride, and gallium arsenide. About a dozen firms around the country are investigating these materials, often in layered cells. Laboratory efficiencies as high as 13 percent have been reported, compared to records of 19 percent for crystalline silicon and 11.5 percent for amorphous silicon.

Concentrating PV systems are another area abeing actively pursued. In these systems, efficiency is boosted by reflecting additional sunlight onto the cells. Reflectors cost much less than the cells to produce, so the cost per watt drops. Concentrating systems are often installed on tracking mechanisms that point them toward the sun throughout the day.

PV Applications

As researchers produce better PV cells at lower costs, the list of practical applications grows.

In the 1950s when practical PV cells were invented, they cost about $1,000 per *peak watt* (i.e., cells required to produce one watt of electricity in full sunlight). At that price, buying enough PV cells to light a 100-watt light bulb would cost $100,000.

Although $1,000/Wp sounds astronomical, it was, in fact, a bargain for the early satellites, which had no other dependable power source. The space program brought PV cells out of the laboratory and put them to use, and photovoltaics remains the most important power system for almost all of our orbiting satellites.

By the early Seventies, the cost had dropped tenfold to about $100/Wp. At that price, photovoltaics began to be cost-effective for certain limited, earthbound applications: mountaintop radio repeater stations, and corrosion protection for Arctic pipelines. (The alternative was diesel-powered generators with fuel brought in by helicopter—and, in some cases, mules—or batteries, which had to be lugged around for recharging.)

By the mid-Eighties, the cost had dropped another tenfold to about $10/Wp, and the price now varies between $5 and $10/Wp depending on quantity. At these prices, photovoltaics makes sense for hundreds of applications where utility power is not available.

The coast guard now uses photovoltaic power in thousands of navigational signal buoys. PV-powered electric fence chargers are used widely here and in New Zealand and Australia. Vacation homes and primary homes located more than half a mile from power lines can often be powered more cheaply with photovoltaics than with utility power. PV-powered motorist-aid call boxes are saving money for highway departments. Electronic products such as calculators can be built less expensively with PV power than with batteries.

Photovoltaics makes a lot of sense for providing power for remote applications. The economics compare favorably with diesel generators, even when the diesel doesn't have to be carried long distances. But the one application everyone is waiting for—PV utility power—is probably another five or ten years away.

Utility companies currently spend millions of dollars a year on research and demonstration projects to gain experience with photovoltaics, expecting the technology to become cost-effective by the late 1990s. New England Electric has a $1.3 million program under way to install 35 PV systems on houses and commercial buildings in Gardner, Mass., and to study their impact on the single feeder line the buildings are served by.

Bill Sherry, the manager of the project, believes that utility involvement with photovoltaics in the East will consist mainly of decentralized, grid-connected rooftop systems such as those in Gardner. Further west, where large areas of open land are available, centralized PV power plants may be a better option, eliminating the need for lots of small inverters and other equipment. Indeed, western utilities are spending millions of research dollars on such applications. Several centralized PV power plants, the largest of which is 6.7 megawatts, are operating in California, and several others are to be built soon.

Photovoltaics is not yet a household word, but builders should expect to begin seeing such systems on the houses they build in the not-too-distant future. I'll keep you posted on advances. ■

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Current PV Technology Summary

Cell Type	Efficiency	Advantages	Disadvantages
Single Crystal Silicon	10-13%	Well-established and tested technology Stable Relatively efficient	Uses a lot of expensive material Lots of waste in slicing wafers Costly to manufacture Round cells can't be spaced in modules efficiently
Polycrystal Silicon	10-12%	Well-established and tested technology Stable Relatively efficient Less expensive than single-crystal silicon Square cells make more efficient spacing	Uses a lot of expensive material Lots of waste in slicing wafers Fairly costly to manufacture Slightly less efficient than single-crystal silicon
Ribbon Silicon	10-12½%	Does not require slicing Less material waste than single crystal and polycrystal Potential for high-speed manufacturing Relatively efficient	Has not been scaled up to large-volume production Complex manufacturing process
Amorphous Silicon	4-8%	Very low material use Potential for highly automated and very rapid production Potential for very low cost	Pronounced degradation in power output (Staebler-Wronsky effect) Low efficiency

Table reprinted from "Photovoltaic Technology Update," by Alex Wilson, *Alternative Sources of Energy,* May 1986.