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Residential Photovoltaics

Building awareness and momentum for an alternative energy source

By Eileen M. Smith, M.Arch.

In 1992, I founded the Solar Development Cooperative to encourage timely mainstream deployment of quality building-integrated photovoltaics (BI-PV) supported by a reliable service industry in the United States and global marketplace. This article shares what I have discovered about the solar industry and will clarify the different types of solar energy, related technology and how systems can be architecturally integrated into homes.

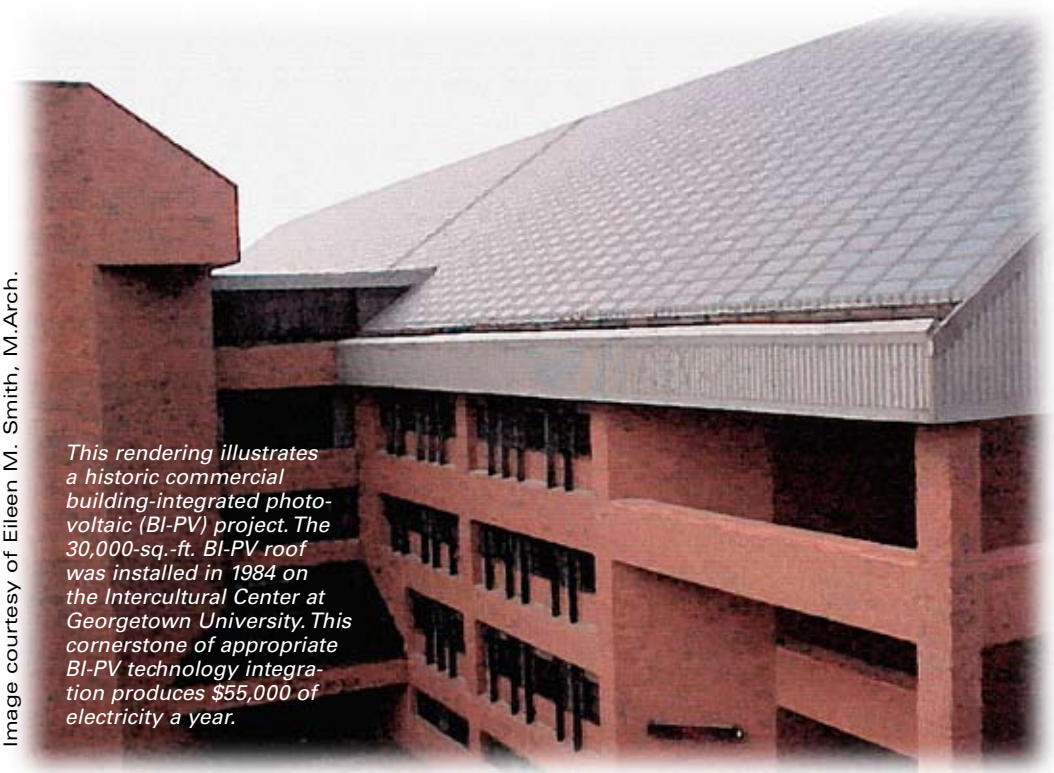

Image courtesy of Eileen M. Smith, M.Arch.

This rendering illustrates a historic commercial building-integrated photovoltaic (BI-PV) project. The 30,000-sq.-ft. BI-PV roof was installed in 1984 on the Intercultural Center at Georgetown University. This cornerstone of appropriate BI-PV technology integration produces $55,000 of electricity a year.

The question I have faced time and again from scientists to builders to homeowners is, "Why don't we use more solar energy?" During the 1970s Energy Crisis there was a strong attempt to transform the energy industry. Everyone celebrated Earth Day and became better-educated, but little happened. In fact, coal consumption in the United States doubled during the 20 prime years of Earth Day. In 1974, 99.5 percent of the electricity consumed by Americans was generated by fossil, nuclear and large hydro. By 1994, all other sources of electricity generation had only increased 0.1 to 0.6 percent. It is a complicated issue. We haven't figured out how to transition the energy industry.

Industry involvement

Why do Distributed Generation (DG) solar energy consumers and building professionals need to know about energy agencies? Clint Eastwood installed a solar system on his golf course, but the California Public Utilities Commission (CPUC), California Energy Commission (CEC) and Utilities did not provide the cash rebate and net metering incentives contracted for and promised by legislation. Most of us do not have the notoriety Mr. Eastwood does to call a meeting with the governor to demand payment. A man who bought a solar system after hearing one of my workshops two years ago is still waiting to be paid his cash rebate of $20,000 from the CEC. Building professionals and homeowners should educate themselves about how the energy industry works before they purchase a solar system.

Utilities and legislation are regulated through administrative proceedings via public hearings facilitated by state energy agencies. Organizations, individuals, groups and political constituencies can get involved in these proceedings to impact this massive vacuum of commerce.

Documents can now be filed using e-mail, and energy agency proceedings can be monitored on the Internet. Consumers organized via Neighborhood Energy Watch Solution Groups, or NEWS Groups, have the ability to provide an infusion of mass direct official consumer intervention to successfully monitor and redirect energy commerce. NEWS Groups will naturally educate homeowners while reducing the likelihood of inappropriate administration of legislation. These groups empower consumer support groups to assist BI-PV DG designers and owners.

Sun + BI-PV = Electricity

Solar renewable energy provides reliable, autonomous, fuel-free electricity. The rewards of facilitating this technology translate to convenience, health, aesthetics, safety, climate control and national security. You may be as confused as I was about the different types of solar energy and their applications within the building envelope. To clarify, let me introduce what I call My Three Suns:

Passive Solar Energy uses the light and heat of the sun through architectural elements like windows, daylights and vented air stone storage systems.

Solar Thermal Energy heats water for pools, hot water heaters and/or steam generators.

Active Solar Energy or **Photovoltaics** is the technology focus in this article. Light generates electricity using silicon semiconductors made from sand similar to computer electronic boards. There are no moving parts, no water, no noise, and most importantly, there is no pollution. The manufacturing process of most photovoltaic modules produces similar amounts of hazardous waste as photographic film development. The process of producing PV is less energy-intensive than the process of manufacturing a laptop computer. Photovoltaic-grade silicon is 900 percent cheaper to produce than computer-grade silicon. However, none is being produced in the world at this time. Since 1984, three oil companies have owned 95 percent of the PV manufacturing worldwide. According to *Sun & Wind Energy 2003*, Sharp PV production jumped from 71 MWp in 2001 to 123 MWp in 2002. In 2002, BP Solar produced 71.5 MWp, Kyocera 60 MWp and Shell Solar 55 MWp trailed by Sanyo, Astropower and RWE Schott Solar at around 30 MWp.

Crystalline PV includes monocrystalline and polycrystalline modules. It is made from refined sand that is melted and poured into molds to create silicon blocks or ribbons. These ribbons are either square or round, the width of a CD. A wire or laser saw is used to slice thin wafers, or solar cells. The solar cells are arranged onto modules and linked with silver or copper serving as conductors for the electricity they generate from the sun. The modules are durable and produce 10 to 20 watts per sq. ft. They perform best in climates where they cool at night. Polycrystalline modules have 20- to 30-year warranties and 30- to 50-year life cycles. When we achieve 50-year limited warranties, BI-PV will be competitive with the best roofing materials.

Thin Film is made by machine and produces a roll or shingle of photovoltaics. Thin Film photovoltaics generate around 8 to 10 watts per sq. ft. and can be cut into different shapes. This PV thrives in the heat but degrades faster over time. It usually has a 20-year warranty.

Dendritic Web is a combination of the best characteristics. It produces at 10 to 20 watts per sq. ft. like crystalline but is also flexible like Thin Film. As far as I know, government approvals and certification are still pending.

Installation of PV arrays

The primary goals of any type of installation should be safety, aesthetics and proper orientation of the array to assure the maximum exploitation of the photovoltaic surface. Design and installation standards are only beginning to respond to the rapidly growing market of PV consumers. PV demand is growing at 30 percent per year. The goal is to lead the market away from the add-on engineering afterthought appearance of many solar array installations toward aesthetic integration as an architectural element. The following are the five basic types of solar array installations, and I recommend only the last two.

Nonarchitectural Mounting or Installation: Field Arrays and Roof Rack Mount. The Field Array in Hesperia, Calif. was installed by Arco Solar in 1988. It was the first 1 MWp PV system in the world. President and Hillary Clinton installed a field array on the White House lawn each Christmas they lived there to light the

The history of photovoltaics

Eileen M. Smith's book *ElectriCity Beyond the Curve of Deregulation Featuring Neighborhood Energy Watch Solution Groups and the Ethos of Commerce* shares the author's observation of the progress of building-integrated photovoltaics (BI-PV) since 1975 with original papers on solar electricity she has presented at international conferences, including the American Power Conference. From 1998 to 2003, she was active in California's joint agency Rulemaking on the Utility Distribution Company's Role in Distributed Generation (DG). Rulemaking R.98-12-015 and R.99-10-025 were facilitated by the California Public Utilities Commission (CPUC) with associated dockets in the California Energy Commission (CEC) of 99-DIST-GEN(1) and 99-DIST-GEN(2).

ElectriCity shares the history of photovoltaics including the 1984 installation of the 30,000-sq.-ft. BI-PV roof on the Intercultural Center at Georgetown University. She presents her strategy for industry transformation via consumers organized in Neighborhood Energy Watch Solution Groups (NEWS Groups).

Christmas tree. Rack Mount PV is installed upon poles bolted to the roof usually anchored by sheet metal. I would not recommend Field Array or Rack Mount for design/build projects unless they are integrated flat or are aesthetically integrated into the structure. Not only do they look bad, but these incomplete mountings result in faster degradation of the components.

Building-Integrated Photovoltaics (BI-PV) Mounting and Installation. A photovoltaic system is made up of several components. The most important is the photovoltaic device, generator or array carrying a 20- to 30-year warranty. The wiring system includes an inverter, conduit, meters, monitors and the utility grid. Where one chooses to have the option of independence in a power outage or where they are not located near the utility grid, a battery back-up system along with other grid-independent technology must also be installed. With the volatility of the energy industry today, I recommend at least a 12-hour battery backup system for every solar system installation.

Direct Mount is only recommended where it is adhered to the primary roofing material in a manufacturing process like Sunslates or United Solar's batten-seam and standing-seam roofs incorporating Thin Film on metal roofing. Photovoltaics directly adhered to the roofing surface at the site creates numerous installation considerations most installers and roofers don't have the time or expertise to address. GM and Arco Solar developed prototypes of Direct Mount technology in the 1980s, but they are not widely used. There is potential for applying the photovoltaic effect directly to ceramic tile, but that would be best accomplished in the manufacturing process.

Stand-off Mount is where the solar array roof is laid on framing supports a few inches above the weatherized roofing material. It provides numerous benefits including increased weatherization, natural venting, access for easier removal and repair of photovoltaic modules and wiring.

Integral Mount is where the roof is designed at proper orientation for solar modules installed on rafters as original roofing material. Crystalline photovoltaics are generally used for this type of integration. Tempered glass, in 3/16-in. thickness, is used as structural element and top "cover plate" for nearly all photovoltaic modules strong enough to serve as the building's primary roofing material. Modules withstand 125-mph positive and negative wind-loading without damage or leakage.

The Georgetown University Intercultural Center roof (pictured on page 20) is an example of BI-PV combining Stand-off and Integral Mounting techniques. The structure is built to naturally exploit the 300-KWp solar array. The installation is laid on a frame a few inches above the weatherized sealed roofing surface. The primary complaint about this solar demonstration is that it needs increased ventilation and easier access to modules. Access should be designed into the system for troubleshooting, repair and cleaning. Sprinklers could be installed to clean a residential BI-PV system. The Georgetown solar system has generated an average of $55,000 of electricity a year since 1984. It has healthy output and is expected to last another 20 to 30 years. There is some degradation of the framing system. Titanium is an ideal framing system for BI-PV because it is lightweight, it does not degrade like other metals, and it is architecturally aesthetic. ✦

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Related links

University of New South Wales, Centre for PV engineering
www.pv.unsw.edu.au/bepv

Million Solar Roofs Program
www.eere.energy.gov/femp/millionroofs/ms-ovw.html

National Renewable Energy Laboratory (NREL)
www.nrel.gov

National Center for Phovoltaics (NCPV)
www.nrel.gov/ncpv

Federal Energy Regulatory Commission (FERC)
www.ferc.gov

California Public Utilities Commission (CPUC)
www.cpuc.ca.gov

California Energy Commission (CEC)
www.energy.ca.gov

Solar Energy Industries Association (SEIA)
www.seia.org

Neighborhood Energy Watch Solution Groups (NEWS Groups)
www.geocities.com/electricitynewsgroups