

A History of Photovoltaics

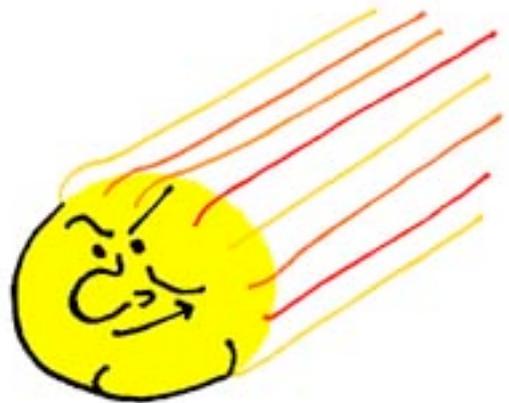
By John Perlin

1876 - PHOTOELECTRIC DREAMS

When William Grylls Adams and his student, Richard Evans Day, discovered that an electrical current could be started in selenium solely by exposing it to light, they felt confident that they had discovered something completely new. Werner von Siemens, a contemporary whose reputation in the field of electricity ranked him alongside Thomas Edison, called the discovery "scientifically of the most far-reaching importance." This pioneering work portended quantum mechanics long before most chemists and physicist had accepted the reality of atoms. Although selenium solar cells failed to convert enough sunlight to power electrical equipment, they proved that a solid material could change light into electricity without heat or without moving parts.

1953 - THE DREAM BECOMES REAL

In spring 1953, while researching silicon for its possible applications in electronics, Gerald Pearson, an empirical physicist at Bell Laboratories, inadvertently made a solar cell that was far more efficient than solar cells made from selenium. Two other Bell scientists - Daryl Chapin and Calvin Fuller - refined Pearson's discovery came up with the first solar cell capable of converting enough of the sun's energy into power to run everyday electrical equipment. Reporting the Bell discovery, The New York Times praised it as "the beginning of a new era, leading eventually to the realization of harnessing the almost limitless energy of the sun for the uses of civilization.



1956 Searching for Applications

Although technical progress of silicon solar cells continued at breakneck speed - doubling their efficiency in eighteen months - commercial success eluded the Bell solar cell. A one-watt cell cost almost \$300 per watt in 1956 while a commercial power plant cost 50 cents a watt to build at that time. The only demand for silicon solar cells came from radio and toy manufacturers to power miniature ships in wading pools, propellers of model DC-4's, and beach radios. With solar cells running only playthings, Daryl Chapin could not help but wonder, "What to do with our new baby?"

Late 1950s - Saved by the Space Race

While efforts to commercialize the silicon solar cell faltered, the Army and Air Force saw the device as the ideal power source for a top-secret project - earth-orbiting satellites. But when the Navy was awarded the task of launching America's first satellite, it rejected solar cells as an untried technology and decided to use chemical batteries as the power source for its Vanguard satellite. The late Dr. Hans Ziegler, probably the world's foremost expert in satellite instrumentation in the late 1950s, strongly differed with the Navy. He argued that conventional batteries would run out of power in days, silencing millions of dollar worth of electronic equipment. In contrast, solar cells could power a satellite for years. Through an unrelenting crusade led by Dr. Ziegler to get the Navy to change its mind, the Navy finally relented and as a compromise, put a dual power system of chemical batteries and silicon solar cells on the Vanguard. Just as Ziegler predicted, the batteries failed after a week or so, but the silicon solar cells kept the Vanguard communicating with Earth for years.

OUT OF THIS WORLD



Early 1960s - Bringing Solar Cells Down to Earth

Despite solar cells' success in powering both American and Soviet satellites during the 1950s and early 1960s, many at NASA doubted the technology's ability to power its more ambitious space ventures. The agency viewed solar cells as merely a stopgap measure until nuclear power systems became available. But solar engineers proved the skeptics wrong. They met the increasing power demands by designing ever larger and more powerful solar cell arrays. Nuclear energy, in contrast, never powered more than a handful of satellites. Hence, since the late 1960s, solar cells have become the accepted power source for the world's satellites. The increasing demand for solar cells in space opened an increasing and relatively large business for those manufacturing solar cells. Even more significantly, our past, present and future application of space would have been impossible if not for solar cells. The telecommunication revolution would never have gotten off the ground if not for solar powered satellites. Unbeknown to most, solar energy has played a crucial role in society's technological progress over the past forty years.

Early 1970s - The First Mass Earth Market

While the use of solar cells in space flourished during the 1960s and early 1970s, down on Earth electricity from the sun seemed as distant as ever. Cost was never a factor for space cells. Manufacturers worried more about size, efficiency and durability: the cost of the launch, and the continuing operation of equipment once in space far outweighed the price of power in space applications. But on Earth, the primary criteria is price per kilowatt hour. Solar-cell technology proved too expensive for terrestrial use until the early 1970s when Dr. Elliot Berman, with financial help from Exxon Corporation, designed a significantly less costly solar cell by using a poorer grade of silicon and packaging the cells with cheaper materials. Bringing the price down from \$100 a watt to \$20 per watt, solar cells could now compete in situations where people needed electricity distant from power lines. Off-shore oil rigs, for example, required warning lights and horns to prevent ships from running into them but had no power other than toxic, cumbersome, short-lived batteries. Compared to their installation, maintenance and replacement, solar modules proved a bargain. Many gas and oil fields on land but far away from power lines needed small amounts of electricity to combat corrosion in well heads and piping. Once again, electricity from the sun saved the day. Major purchases of solar modules by the gas and oil industry gave the fledgling terrestrial solar cell industry the needed capital to persevere.

1970s - Captain Lomer's Saga

It cost the Coast Guard more money to install, maintain and replace the non rechargeable batteries that powered its buoys than the buoys themselves. A brave Coast Guard officer, then Lieutenant Commander Lloyd Lomer, who had training in optics and physics, believed that their replacement by solar modules could save taxpayers millions of dollars and do the job better. But his commander refused to listen. Exasperated by such stonewalling, Lomer finally appealed to higher authorities and got the nod to solarize the Coast Guard's navigational aids. President Ronald Reagan commended Lomer for "saving a substantial amount of the taxpayer's money through your initiative and managerial effectiveness as project manager for the conversion of aids to navigation from battery to solar photovoltaic power." Thanks to Lomer's persistence, not only does the U.S. Coast Guard rely almost entirely on solar power for all of its buoys and light houses but so do all the other Coast Guards throughout the world.

1974 - Working on the Railroad

When the Southern Railway put in solar modules to power warning lights at a railroad crossing near Rex, Georgia, the railroad had so little confidence that the cells would work that they also connected the lights to a utility line for back up. But that winter, ice build up on the wires caused them to fall, and the only electricity in Rex, Georgia came from the solar array. Around the same time, novel telecommunication systems such as microwave repeaters had made telephone and power poles that followed the tracks obsolete. and many railroad lines wanted to remove these poles to save on maintenance. To avoid train accidents, the railroads still needed a few watts here and there to power signaling and shunting equipment along their lines. Word spread about the Southern's success with solar, leading many lines in the United States and throughout the world to choose the sun to run on site their track safety devices rather than waste huge sums to bring in distant centrally-generated electricity.

Late 1970s - Long Distance for Everyone

In the early 1970s, the Australian government mandated Telecom Australia, the quasi-public agency in charge of the nation's telecommunications, to provide every citizen, no matter how remotely situated, with the same high-quality telephone and television service that those living in urban areas took for granted. To accomplish the mandate, Telecom Australia searched for an reliable stand-alone power source to run rural telephones and microwave repeater stations. Generators and wind machines did not pass muster. Fortunately, solar cells had come down in price to put them in the running as well. Putting them through a vigorous testing program, Telecom Australia came up with a module design that would only need periodic servicing checks despite the harsh conditions of the Australian outback. Thirteen solar-powered repeaters went up in 1978, each situated twenty-five miles apart. They worked so well that Telecom Australia put up seventy more - the longest network consisting of forty three repeaters spanning fifteen hundred miles. The Australian experience helped make, by 1985, solar modules the power system of choice for remote telecommunications.

1970s - Father Verspieren Preaches the Solar Gospel

Dominique Campana, a graduate student in Paris in the 1970s, came up with the idea of applying solar cells to pump water. French physicist Jean Roger translated her concept into a working prototype on the island of Corsica. People from all over the world concerned about supplying healthy water to those where no power existed came to see the solar-run pump. Among the visitors was Father Verspieren - a French priest whom the Malian government put in charge to tap the deep aquifers that run underneath the sands of Mali to save the country then suffering from the worst drought of the twentieth century. After viewing the Corsican installation, Verspieren saw the sun as the solution, not the problem. Starting in the late 1970s, Verspieren initiated a solar water pumping program that has become the template for success in the developing world. Fewer than ten pumps powered by solar cells existed in the world when Father Verspieren installed his first in Mali. Now, tens of thousands power pumps on every continent. As one expert stated, "Thank you, Father Verspieren that today we have lots of solar pumps everywhere and for showing the international community that solar cells are an excellent power source for the people of Africa and the rest of the developing world

1980s - Electrifying the Unelectrified

From the 1960s through the 1980s, experts planned to power rural parts of the developing world - where the majority live - according to the Western model: build centralized generating plants and by networks of wires transmit the electricity to consumers. But constructing such networks has proven too costly, leaving billions of rural people without electricity. These people have had to rely on costly and inadequate ad hoc solutions to light their homes and power their appliances such as kerosene lamps, automobile batteries and generators. In many cases, solar cells have provided to those living far away from electrical lines the means to obtain higher quality lighting and more reliable power. Since 1983, half of the households in the outlying islands of Tahiti have relied on solar-generated power. More rural Kenyans use electricity from the sun than that offered by the national utility. At least one hundred thousand families in Mexico, Central America and the West Indies run their lights, television sets, and radios with solar electricity. These successes has led the World Energy Council, the international organization of utilities, to recognize, "Solar cells for use at individual houses are a very important development that warrants particular attention as they are ideal for low-power rural applications.

1980s - Solarizing the Electrified

When governments of developing countries began to fund solar energy programs in the mid-1970s and early 1980s, they favored large-scale, centralized solar-cell plants. Since engineers can tailor solar electric modules to any particular electrical need at the site of use, many came to realize that solar cells could allow each building to become its own electrical power plant by placing them on the roof. This would eliminate much of the capital costs inherent in constructing a centralized power plant such as buying land, putting up transmission lines, laying foundations and support structures and so on. Swiss engineer Marcus Real proved the economic advantages of the micro approach by selling 333 rooftop solar systems to homeowners in Zurich, Switzerland. After the success at Zurich, no one talks about centralized solar-cell plants anymore. Instead, governments are developing financial incentives to encourage homeowners to place modules on their rooftops. Architects and builders can use solar-cell material to build with, becoming facades, roofing, walls and windows. This eliminates a lot of duplication and extra work. For such reasons, Architectural Record lauds this approach as "a

cost-effective energy option that architects should routinely consider.

1990s - Better Cells, Cheaper Cells

As the price of solar cells has dropped over the years, they have become the least expensive power source for small-scale electrical demands located away from utility lines. Solar cells have also proven a cheaper source of electricity whenever people have to excavate to lay utility lines underground. Solar cells have therefore saved taxpayers millions in powering emergency call boxes along highways. When a new bus shelter goes up, cities have discovered that it costs less to install solar cells to keep it lit at night than to dig up pavement for the placement of power lines. For the same reason, many municipalities or the highway departments choose solar cells to run street lamps or warning lights. However, solar electricity still costs more to generate than power from existing overhead utility lines. Many believe that current production methods - growing silicon into cylinders or casting them as ingots and then cutting them into very small pieces - cost too much to ever bring down the price to compete with centrally-generated electricity. To dramatically bring down their price, solar cell companies have invested a lot of money to somehow either grow the silicon into a shape that eliminates most of the slicing or merely deposit solar cell material onto an inexpensive but rigid support structure such as ceramic, glass, plastic, or steel.

The Silent Revolution Continues...

The solar-cell industry has grown dramatically over the last twenty years, increasing output 200 fold in this time period. Today, those needing power in remote areas no longer regard solar cells as an alternative source of energy but consider them the most effective solution. Institutions like the World Bank now believe that solar cells "have an important and growing part to play in providing electrical services to the developing world." In less developed countries, where over half of the population must travel over two hours just to make a phone call, the United Nations today sees solar cells offering these people "for the first time a real practical possibility of reliable telecommunications for general use. Opportunities for solar cells in the developed world continue to grow as well. Solar cells produce electricity than highly polluting diesel generators. The National Parks Service and Defense Department have begun to replace their generators with solar cells. No longer on the highways or roads do portable generators power portable signs warning motorists of lane closures or other important news. Solar cells have replaced them. As the increasing demand for electricity starts to clog the world's power lines, like traffic jams on our freeways, solar cells strategically built on or into homes and buildings can provide the much needed electricity without further burdening the old electrical routes. Or at times, like on a hot August afternoon, when the electrical highways have emptied, mini-electrical plants consisting of solar modules can refill transmission lines to prevent brownouts and blackouts. The skyrocketing price of oil and natural gas and their dwindling supplies as world demand continues to grow will force the world to use more and more electricity generated by the sun. The change from fossil fuels to solar cells will also help clean up our polluted skies and keep a lid on global warming. As Science magazine wrote more than twenty years ago, "If there is a dream solar technology, it is solar cells, a space-age electronic marvel at once the most sophisticated solar technology and the simplest, most environmentally benign source of electricity yet conceived.

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