Gradium Solar Cells: Now Less Is More

*By Barbara M. Wolcott**

For every lunar landing, Mars explorer or Galileo space probe there is a corollary benefit on terra firma, from instant communication to clean power generation. It is also worth recognizing that one singular scientific advance has had a major part in the benefits of space explorations: Mighty mite solar cells that in space take a licking and just keep on ticking.

Solar cell technology has an important role in the National Aeronautics and Space Administration's Performance Plan for 1999 and beyond, where they pledge a "faster, better, cheaper" approach to reduce spacecraft development time and costs. That same technology has a growing place in the commercial market here on the ground with flat plate banks of cells providing primary power for households and backup power for the communication business.

However, until recently solar power has had an image problem. Not only is it believed to be expensive compared with available electricity from traditional sources, the panels are troublesome to set and in some cases, ugly. In thirty-nine states across the country, condominium associations have banned solar panels from their buildings in spite of the growing need for clean power. Enter the new generation: Solar power is now beautiful and affordable, especially in view of dramatic changes in utility company billing systems.

In northern California, the Sacramento Municipal Utility District (SMUD) is already on board because of explosive population growth in its area. SMUD is the smallest utility in California, but the fifth largest publicly owned electric utility in the United States in terms of customers served. SMUD has had to address both distribution and production issues that do not face other utilities because older companies already have poles widely installed. Power generation costs are about half that of putting in transmission lines, and looking at a cost of running new lines in the neighborhood of $1 million a mile—and running power to an industrial site significantly more—SMUD looked seriously at alternative power to reduce capital costs. They polled their customers to ask if they were interested in green energy. The answer was emphatically yes, and in 1993, SMUD embarked on a solar roof program called the PV Pioneer Program.

SMUD installs PV roofing on volunteer customers' homes, retains ownership and maintenance of the solar system and participants pay the same as their average electric bill plus a small surcharge. Four hundred fifty homes already have the solar roofs and another 100 will be installed each year for the next five years. There are more volunteers for the roof installations than can be accommodated immediately.

The program has been so successful that SMUD has embarked on a second phase of the project where homeowners may purchase the systems outright. Until recently the cost of an individual home installation in the open market has been about $18,000, but SMUD customers can purchase a complete system, including net metering, for $4,460 on a ten year contract at 9.5 percent, or with their own financial resources. Just over half the actual cost is subsidized by SMUD.

SMUD has a history of using alternative energy and has solar cells running new power substations, in addition to maintaining the ten year old PV power plant at Rancho Seco. The roof-top power plants are enabling the utility to put off the construction of additional power plants, as well as help meet power demand at peak hours of 11 am to 2 pm which are the same hours the PV roofs are producing excess power.

The new solar technology is so promising that British Petroleum has committed significant production volume to the cells. With manufacturing plants in six countries, including one in Fairfield, California, BP is the world leader in affordable solar technology. The cost of solar cells is now one-seventh of what they were in 1980 due to improved manufacturing methods and increased market demand. BP Solar expects sales will increase to $1 billion in the next decade. This movement is only a few years old in the United States, but with very aggressive marketing for the last 15 years in other countries, it is much more commonly used in Europe and Japan.

The bulky, unsightly panels are gone and in their place are sleek roofing tiles, not unlike slate or asphalt, into which solar cell crystals are hermetically sealed. The new PV cells used in roofing material are made from amorphous silicon, which is melted, then poured onto a substrate and let to solidify just like a window pane, instead of growing the crystals, then slicing them as has been the case with earlier versions. Crystals in older cell technology are oriented in the same direction to be active when exposed to sunlight, but the far less costly amorphous silicon has microscopic orientations in many directions. A large percentage of them are not used at all, so the cell is scanned during manufacture to identify which ones are not oriented usefully and then blown away with a laser. The result is similar to a piece of Swiss cheese, with microscopic holes, making the wafer look transparent at a distance, but a solid when viewed up close.

In the roofing tile, each cell is connected with fine metal ribbons, attached to a one foot by two foot concrete/fiber backplate that is sprayed with metal to create a conductive surface. The result is a roof tile that is approximately the same thickness as conventional asphalt roofing. The tempered glass tiles have been documented to withstand temperatures ranging from minus 23° to 166° Fahrenheit, and winds in excess of 125 mph. The modules are classed as A roofing material in Los Angeles County, California and Dade County, Florida which means that the material is the best, of the longest lasting quality. PV power stands head and shoulders above other energy producers, especially in comparison to facilities like Diablo Canyon. PV energy is extremely simple and clean, has no moving parts, needs no support facilities, and it has no toxic by-products to conflict with the environment. Basically, you take a cell and expose it to sunlight. The only environmental impact is in the manufacture, which is minimal.

SMUD produces PV energy in banks of cells on covers for parking areas, and in a region that commonly has summer temperatures in triple digits, that is a public relations coup. In a few short years, SMUD has become the largest distributor of PV generated power in the world.

As encouraging as this news is to solar power enthusiasts, solar cells are poised to take another giant leap forward, and LightPath Technology's Gradium lenses will be in the vanguard.

---

*Barbara M. Wolcott is an independent, freelance writer specializing in technology, people and travel located in San Luis Obispo, CA.

Two years ago, the U.S. Air Force Space Vehicles Directorate called for research bids for advanced photovoltaic cells that were ultimately developed and delivered by LightPath Technology. LightPath had been researching the photovoltaic concentrator lens system with a fifty percent increase in power and a major decrease in size for about twelve years. LightPath's optical lens products have wide ranging potential uses from imaging and laser optics with its ability to bend light and separate colors, to dividing multiple wavelengths for fiber optics WDM (wavelength division multiplexing) applications. The unique glass can be pre-programmed like a microchip to make the glass bend and curve light to accomplish certain effects with light.

For space technology, the solar concentrators provide much higher functionality because they produce power even when not pointed exactly at the sun. If the sun hits the cell at 10° off the perpendicular, it is able to bring the light into the glass and funnel it down to the photovoltaic cell. Even 2° makes a substantial difference for the present flat plate cells now in use, and the new technology allows satellite manufacturers to relax tolerances to meet the sun perpendicularly for continuous power—a major improvement that saves hydrazine fuel onboard used to redirect satellites toward the sun.

LightPath's Gradium lenses are able to reduce the satellite module weight by 50 percent and the square footage of the panels by 20 percent, which results in decreased launch costs or increased room for payloads. The lenses also allow the launch of more powerful data transmitters which in turn reduces the size and cost of Earth stations. With space power not dependent on exact perpendicular status with the sun, the amount of hydrazine fuel in satellites will be better utilized to prolong the life of the satellite itself.

The Deep Space 1 mission, launched on October 24 of last year is the first test of the solar cell concentrators, but of more interest to the earth-bound, LightPath is working to adapt the technology to solar arrays for use on the ground or on roofs. At present the cost is significantly higher for the new solar power arrays, but as commercial deployment increases, the corresponding costs will fall.

Lead-free Gradium glass is unique in that it is the only material that can direct light internally, collect and concentrate energy, and separate wave-lengths for high-speed data. The technology has the capability to reduce effective costs ten times or more for satellite systems without a reduction in PV power production. Their efficiency rate is 30-32 percent in light to energy ratios, compared with 17-24 percent with non-Gradium concentrators.

The Gradium concentrators could have an enormous impact on communications for telephone, video, television and cable transmission. At present, there are about 250 Geostationary (GEO) and about 100 Low Earth Orbit (LEO) satellites operating in orbit. By 1999 those numbers will climb to 300 and 340, respectively. By 2005, it is expected that 1,600 satellites will be orbiting Earth.

Following the extraordinarily successful Phase 2 test of Gradium solar concentrators at the Air Force Research Lab in Albuquerque, Air Force officials were impressed enough to help LightPath make a rapid technology transfer to the commercial satellite market. Gradium is giving solar cell technology a giant leap forward to compete in the open market for a share of the power industry. Future advances are likely to push the technology ahead of any other source of power generation.

In California power companies have two years to retire their uncapitalized debts in the wake of sweeping reform. After that time, all indications point to significant rate increases despite the competitive nature of power purchase, transmission and delivery. It may be that only the owners of roof tile solar power systems are smiling at that prospect. Chances are that few of them will fully appreciate that their personal solar power production is a reality because photovoltaic solar cells have been, and will continue to be, the workhorses of space exploration.

1999 Directory

The 1999 Membership Directory will be published early in May. Members are urged to ensure that the information Headquarters has in its database is up-to-date.

Directory Information Forms have been mailed to all affiliate leaders with instructions to forward them to all members for updating. If affiliate members have not received these forms they should contact their affiliate leader promptly.

Direct members receive Directory Information Forms with their annual dues renewal notice.

Directory Information Forms must be received by the end of March to have the information included in the May Directory. Changes in member information may be sent to Headquarters at any time.

Conference Proceedings
21st IAEE International Conference
Quebec, Canada May 13-16, 1998

The Proceedings from the 21st International Conference of the IAEE held in Quebec, Canada, are now available from IAEE Headquarters. Entitled *Experimenting with Freer Markets: Lessons from the Last 20 Years and Prospects for the Future*, the proceedings are available to members for $89.95 and to nonmembers for $99.95 (includes postage). Payment must be made in U.S. dollars with checks drawn on U.S. banks. To order copies, please complete the form below and mail together with your check to: Order Department, IAEE Headquarters, 28790 Chagrin Blvd., Suite 350 Cleveland, OH 44122, USA

Name _____

Address _____

City, State, Mail Code and Country _____

Please send me ____ copies @ $89.95 each (member rate) $99.95 each (nonmember rate).

Total enclosed $_____ Check must be in U.S. dollars and drawn on a U.S. bank, payable to IAEE.