

New, Cost-Competitive Solar Plants for Electric Utilities

Challenge

The price of photovoltaic solar panels fell rapidly from about \$30 per Watt in 1975 to about \$5 per Watt a decade later. However, the production cost of a standard solar panel for the most part leveled off for a number of years at just under \$5 per Watt, remaining too costly for most large, utility-scale installations. With the advent of new solar concentrator systems, it became possible to replace expensive solar cells with inexpensive plastic lenses that focus sunlight onto small cells. This technological advance enabled lower panel manufacturing costs, improved cell performance, and increased utility-scale solar system efficiencies.

In the 1980s, the U.S. Department of Energy supported innovative research at the National Renewable Energy Laboratory that led to the development of multijunction solar cells with the world's highest conversion efficiencies—up to 50% higher than the highest silicon solar cell efficiencies. By the late 1980s, the Electric Power Research Institute (EPRI) had developed a high-concentration photovoltaic (HCPV) system which they believed to be a promising option for utility-scale solar power plants. However, one technical challenge they faced was the rapid degradation of solar cells under the intense ultraviolet radiation in concentrated sunlight.

Innovating Solutions

In 1989, staff at the newly-formed Amonix tackled the solar cell degradation problem. Within a year, they had stabilized the cell and started working with EPRI to develop the remaining system, including the lens, structure, and tracking system. With DOE EERE SBIR funding, Amonix redesigned the photovoltaic cell unit and integrated the cell, circuit board, and heat sink into a single cell receiver plate for economical, large-scale production. The company also redesigned the rest of the system for improved manufacturability using funding from EPRI, DOE, and private sources. The result: the Amonix MegaModule®.

Although Amonix holds the world record for silicon solar cell efficiency at 27.6%, the world record for multijunction cells is now 50% higher. Amonix has been able to increase MegaModule® performance by 50% by replacing its production silicon cells with production multijunction cells having efficiencies over 37%. Today's commercial and defense satellites use multijunction solar cells with conversion efficiencies above 35% (the record is over 41%). Performance in space is critical and multijunction solar cells have demonstrated unbeatable performance. By bringing these multijunction solar cells “down to earth” and incorporating them into the MegaModule® design, Amonix has significantly improved MegaModule® efficiency—further reducing the cost of utility-scale solar electricity.

The MegaModule® sections are manufactured in a plant and easily trucked to the installation site (the photo depicts the 7700 system with 7 MegaModules® on each pedestal). In 2001, Amonix was awarded a patent for their method of making the cell receiver plate. Since then, Amonix has worked with electric utilities throughout the southwestern U.S. to develop and test six generations of this system, which has allowed the company to resolve remaining technical problems and produce an efficient, reliable system.

Amonix began producing the improved MegaModule® in 1998 and has already installed 28 systems in the U.S., with a combined peak power capacity of 700 kW. Since 2006, Guascor Fotón has installed over 400 hundred of these systems in Spain, where market incentives provided the opportunity for cost-effective utility power plant projects. Amonix found Guascor Fotón's experience to be invaluable for identifying how best to deploy MegaModule® systems on a large scale and help make the most of future market opportunities.



DOE Small Business Innovation Research (SBIR) support enabled Amonix to develop its 7700 system, which drastically reduces the requirement for costly solar cells by using Fresnel lenses to concentrate sunlight 500 times onto small, highly efficient photovoltaic cells. This reduces the cell area so that expensive solar cell materials can be replaced with inexpensive plastic lenses.

Amonix Inc. (Torrance, CA), founded in 1989, develops and manufactures high concentration photovoltaic (HCPV) systems and high-performance silicon solar cells. In 1994, the company won *R&D Magazine's* R&D 100 award for silicon solar cell performance with record conversion efficiency. Around the same time, Amonix also developed the large MegaModule® platform suitable for use with all high performance solar cells. Since the early 1990's, Amonix has developed and tested six successive generations of MegaModules® and in 2005 the company licensed this technology to Guascor Fotón, which built a 10 MW/year manufacturing plant and has installed over 12 MW of MegaModule® systems in Spain.

www.amonix.com

A case study from the U.S. Department of Energy's Office of Energy Efficiency and Renewable Energy SBIR program, providing competitive grants for scientific excellence and technological innovation to advance critical American priorities and build a strong national economy – one small business at a time.

Solar Plants for Electric Utilities

In 2009, Amonix is introducing the newest generation of its high concentration photovoltaic product to the utility market. The Amonix 7700 is the seventh generation MegaModule[®] system and combines decades of advances in MegaModule[®] design and technology, combined with the world's highest efficiency multijunction solar cells. DOE funding through the Solar America Initiative (SAI) is also supporting development of this powerful combination. Amonix won an SAI award in 2007 for its proposal to reduce the cost of the MegaModule[®] structure, improve product reliability in actual operating conditions, build a MegaModule[®] manufacturing plant in the U.S., and reduce the cost of solar electricity to meet national goals (measured as the levelized cost of electricity) of 6 cents per kilowatt hour by 2015. Amonix is on track to achieve these objectives.

Amonix received DOE SBIR Phase I & II funding in 2000-2001 for two related projects.

- The first was to develop a tightly packed array of cells for use with a parabolic mirror concentrating system. However, Amonix ultimately discovered it required far more cell cooling than the more efficient MegaModule[®].
- The second was to integrate the MegaModule[®] unit with an electrolyzer to create an efficient, cost-effective system for producing hydrogen. The project results emphasized the most effective lever for reducing the cost of solar hydrogen production was higher solar cell efficiency.

SBIR Impacts

Projected Benefits of Amonix MegaModule[®] HCPV Systems: 2009 to 2020

Estimates assuming a 2008 base of 8750 kW installed and 200 kW installed per year from 2009 to 2020¹

Energy²	Energy generation	323 MWh
Environmental³	Cumulative NO _x emissions avoided	314 tons
	Cumulative SO _x emissions avoided	850 tons
	Cumulative CO ₂ emissions avoided	215,000 tons

Innovation

The Amonix MegaModule[®]:

- Reduces system cost, potentially below \$3 per Watt
- Reduces levelized cost of energy to meet DOE Solar America Initiative cost goals for U.S. utilities
- Uses high-efficiency multijunction photovoltaic cells to achieve AC system efficiency of over 25%
- Does not require water because it is passively air-cooled
- Has a small footprint, reducing land-use requirements
- Yields energy paybacks in less than one year

In addition, long-term field experiences have shown improved system durability and reliability, easy scale-up for any size installation, plus reduced field assembly labor due to the modular design.

Company Success

For Amonix, SBIR support enabled them to both develop a platform suitable for any high performance solar cell, and to design for economical manufacture and assembly with sustainable operational reliability.

Amonix has been successful in the marketplace, in part due to business planning and networking with potential commercial partners enabled under the Phase III program. As a technology-driven engineering company, Amonix has also benefited from SBIR evaluation of its efforts to commercialize its technology.

Amonix' partnership with Guascor Fotón in Spain has been key to rapid commercialization. Although the U.S. market is less subsidized, the outlook is positive as Amonix anticipates domestic sales of \$500 million in 2010. With 70% of the concentrating photovoltaic (CPV) market, Amonix has more CPV technology installed in the world than any other company.

Amonix has grown from a staff of 15 in 2006 to a staff of 44 in 2009.

¹ It is assumed that the estimated installed systems will run full-time, which is not under the control of Amonix.

² Energy generation based on Amonix "rule of thumb": approximately 145,000 kWh for a 53kW(ac) system, depending upon the location where the system is installed (Amonix website).

³ Environmental data calculated using EPA National Average Emissions.

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