

# CPV sector finally taking off?

The concentrator photovoltaics (CPV) industry has a lot to be excited about in 2011. This year marks the first time that CPV developers have seen projects larger than several megawatts financed and approved, thanks to prices becoming more competitive with PV in certain locations. And this year could mark the beginning of the CPV build-out. Total global CPV installations are expected to surpass 1 GW per year by 2015, says a research report.

**T**wo thousand eleven will probably one day be known as the year CPV took off, with numerous projects starting to deliver power around the world, new manufacturing facilities, and major contracts signed with utilities for larger projects. At least, there's some evidence about it. This year, NextEra Energy Resources started delivering power to El Paso Electric in New Mexico from its 5 MW CPV facility using 84 Amonix 60 kW CPV power generation units. This is the largest CPV facility in North America, matching the size of SolFocus's CPV plant already in operation in Portugal.

But these smaller facilities will quickly be surpassed by larger projects. Cogentrix is now developing a 30 MW CPV project with Amonix modules in Southern Colorado called the Alamosa Solar Generating Project. When completed in 2012, it will be the largest CPV project in the world. But it is very likely that it won't hold that title for long. French-German Soitec has plans to install a 150 MW CPV power project for San Diego Gas & Electric in California by 2015. Soitec will support the facility with a 200 MW capacity factory in the San Diego area designed to manufacture CPV systems.

Big projects are on the way, but for now, 5 MW and smaller projects – plus test projects – are all the industry has seen financed and constructed. "The CPV industry has always promised a lot and delivered very little, until 2011," says Nancy Hartsoch, Vice Presi-

dent of Marketing for SolFocus in California. CPV developers have about 170 projects under development worldwide, most of which are in the US, with 331 MW of power under construction, says a Greentech Media Research report. In the second quarter of 2011 alone, US CPV installations totaled 9 MW. SolFocus's product is operating today in Arizona, Colorado, California, Hawaii, Italy, Portugal, Greece, Spain, Australia, South Africa, and Malaysia.

While these figures do not seem to be high – considering that the accumulated global solar installed PV capacity currently is an estimated 60 to 70 GW – they represent a big step for the CPV industry, which had only installed 28 MW worldwide before 2011. Now, with over 5,500 MW of CPV projects with signed power purchase agreements and nearly US\$ 4 billion in federal financing secured in the US, the industry is set to expand in the next several years. "Even with the most aggressive PV cost-reduction roadmaps, CPV should always be the winning technology in markets where it works," says Guy Blanchard, Senior Vice President of Sales and Corporate Development at Amonix in California. "Our job as an industry is to demonstrate that in the coming years," he says.

## How and where it works

In spite of the technology being around since the 1970s, CPV is only now starting to get developed on

Isofotón's most recent installation, which is in Gormud, China

Photo: Isofotón

a larger scale because it's starting to be economically viable in certain markets. Because the technology works by concentrating sunlight onto a relatively small solar cell, it works best in the sunniest places. "The magnification factor can reach up to several hundred times, allowing a relatively small solar PV cell to generate a lot of electricity," says Paul Robusto, PV Business Development Manager at Intertek Testing Services in California.

The technological breakthrough for the CPV industry came a few years ago when the semiconductor industry developed the triple junction solar cell. The technology has been around a long time, but it was only once solar cells became more efficient that CPV projects became economically feasible, says Nancy Hartsoch of SolFocus. "After the development of the multi-junction solar cell, CPV became economically viable."

Multi-junction solar cells contain several p-n junctions that are each tuned to absorb a different wavelength of light, such as UV, infrared, and visible light. Single-junction solar cells used in traditional crystalline silicon PV panels cannot absorb as much solar energy and have a theoretical limit of 34 % efficiency. "By absorbing more light wavelengths, multi-junction cells improve the theoretical efficiency limit to 47 percent," says Russ Kanjorski, Vice President of Business Development at Semprius, Inc. in North Carolina. Currently the best single-junction cells have reached 25 % efficiency in the lab while CPV multi-junction cells have reached 42 %.

One of the biggest challenges for the PV industry is the high capital cost per kilowatt-hour (kWh). CPV technology according to its supporters helps reduce the capital cost per kWh by minimizing the amount of semiconductor material needed in each solar module. Some new CPV solar cells are so small that they

use only a fraction of the expensive semiconductor material needed by crystalline silicon cells. "Semprius uses a micro-transfer printing technology that allows the company to make the smallest solar cells in the industry: 600 microns by 600 microns," says Kanjorski.

## CPV works where the sun is bright

Because the triple junction solar cells are so small and they require solar energy from the entire light spectrum, they work best in sunny locations with a high direct normal irradiance (DNI) factor, of 1,800 kW per square metre or higher, says Robusto. "CPV works in regions with a lot of sun, like Spain, Italy, North and South Africa, Australia, the Middle East, parts of Latin America and Asia, and the US Southwest."

In order to work best in these sunny locations, CPV modules must be set on dual-axis trackers, which face and track the sun throughout the day. "CPV needs to be facing directly at the sun because it requires direct light, not diffuse light like crystalline PV panels," says Kanjorski. By tracking the sun, CPV plants start producing high amounts of energy throughout the whole day. "Rather than a typical curve with PV that tapers off in the morning and the late afternoon, CPV operates at maximum potential all hours while the sun is out," says Kanjorski. Tracking greatly increases the output of the system. For example, in a test facility in California, Intertek reported producing 5.5 kW per day on a fixed panel and about 10 kW per day with tracking, says Robusto.

This late-afternoon high-energy output is one of the main reasons that utilities are now starting to become more interested in CPV, says Blanchard. "Utilities want energy diversity, and CPV has a higher energy density in the afternoon when demand is usual-



Having realised the 30 MW solar power plant for Xcel Energy in Alamosa, Colorado, US manufacturer Amonix will be the CPV market leader with a market share of more than 80 % (total market volume worldwide to reach above 60 MW at the turn of the year).



In the second quarter of 2011 Amonix realised this plant with 36 pedestals, 2 MW, at the University of Arizona Science and Technology Park.

Photos (2): Amonix



**Emcore's G3-1090X CPV module certified by Intertek with the ETL mark**

Photo: Intertek

ly at peak." PV technology drops off as the sun drops lower in the sky, just as utilities have to meet peak demand, usually from 4 pm to 8 pm. "Right now the energy coming from CPV plants may be a bit more expensive, but it delivers higher value energy."

Contributing to meet peak demand especially in sunbelt states with widespread use of air conditioning, CPV technology according to its advocates is more easily scalable than PV and concentrating solar thermal power (CSP) technologies. Scaling up PV requires a lot of land, which is often located far away from where the energy is needed. "With CPV, we can have 5 to 100 MW plants that can be placed near where utilities already have transmission capacity and distribution lines," says Hartsoch. CPV panels produce more power per panel so they require less land and fewer materials. As CPV gets scaled-up it gets more cost-competitive with PV.

In addition to using less land than PV, CPV panels according to Hartsoch get the efficiency benefits of concentrating solar energy without needing to be enormous, like CSP plants. This technology, which also concentrates the sun's energy, only makes economic sense if power plants are really big – several hundreds of MW. Like a large PV plant, this requires a lot of land, which is expensive. By using less land, CPV projects do not face the same common environmental permitting problems as large CSP facilities. Because the panels are off the ground and move throughout the day on trackers, permanent shading or large ground-mounted systems do not disturb local wildlife, Hartsoch argues. And smaller power plants do not harm local wildlife nearly as much.



Semprius from Durham, North Carolina, has developed gallium arsenide-based cells that are 300 times smaller than standard cells. According to the company, “optics concentrate 1,000 suns onto the high-efficiency solar cells, which only cover 0.1 % of the module area”. Currently, Semprius is building a pilot production plant in Henderson, NC. Venture capital has come from Siemens, who has a 16 % stake in the start-up company.

Photo: Semprius

“In addition to easy scaling for CPV systems, CPV technology is more cost-effective than PV in sunny locations because it actually works better at high temperatures instead of losing efficiency like PV”, adds Robusto. Triple junction solar cells operate at 96 % efficiency at 40° C, he says. Polysilicon only works at 80 % efficiency at higher temperatures.

Naturally, with such high temperatures, cells have to be cooled. “One of the drawbacks of CPV is the heat generated,” states Rick Stansley, Co-Director of the University of Toledo’s Wright Center for PV Innovation and Commercialization in Ohio. “CPV systems have a higher operating cost because of cooling. Different CPV systems have different mechanisms for cooling; some use a coolant while some use water,” he says.

### Innovation to reduce costs

With so many aspects of the technology different from conventional crystalline PV panels, the only way to compare the two technologies with each other is to look at the levelised cost of electricity (LCOE), or the cost per kWh that makes the project work. LCOE includes everything that goes into a solar project, from the cost of materials, installation costs, operation and maintenance costs, up to the financial return on

**Sunflower single module tracker made by Energy Innovations from San Diego, California. The company emphasizes that these CPV modules can be installed on fields, rooftops or carports.**

Photo: Sunflower



the investment. It is a balancing game, says Stansley. For example, tracking systems on CPV projects add about 35 % to the cost of the overall module itself, he says. “But it becomes about twice as efficient.” Every project has its own unique variables that have to be tweaked in order to make projects work.

In locations where the technology works well – sunny, utility-scale applications – CPV is already becoming cost-competitive. CPV will be cheaper than PV in these markets sometime between 2015 and 2020, assuming the CPV industry will achieve a 30 % reduction in total installed cost, says a Greentech Media Research report. 30 % cost reductions are likely because one of the biggest benefits of CPV technology over conventional crystalline silicon PV panels is a greater potential for efficiency improvements, says Hartsoch. “CPV has a steeper cost reduction path than other technologies,” she says. Technology and balance of systems (BOS) innovations are key to the long-term growth of the industry.

Considering that the market potential for CPV is so big and there are relatively few players, there is a lot of room for new technological breakthroughs and new companies. Three CPV developers, Amonix, Soitec (Concentrix Solar), and SolFocus, account for 96 % of global projects in operation, construction or development, says a Greentech Media Research report called “Concentrating Photovoltaics 2011: Technology, Costs and Markets”. There is lots of room for innovation.

Many companies are working on creating new ways to increase cell efficiency, says Kanjorski. “People in the industry are discussing getting to 50 percent cell efficiency in the next ten years,” he says. Right now, the best cells, triple junction cells, operate at 41.6 % in the lab. These cells are considerably more expensive to produce, and therefore require concentration ratios of greater than 400 times to be economically competitive, says Kanjorski. The CPV industry is moving away from lower-concentration technologies because it isn’t possible to recapture all the money spent on tracking and optics with only small amounts of concentration. Therefore, most CPV companies today are shooting for innovative breakthroughs with new cells and high concentration ratios, says Kanjorski.

For example, Semprius has its own cell design that uses a micro-transferring printing technology that allows them to reuse the substrate. The cells are also 300 times smaller than the standard industry cells, which results in fewer defects, better quality, and less heat, says Stansley.

Apart from solar cells, some companies are focusing on using different, cheaper concentrating materials. Some systems use plastic because it is cheaper and lighter, says Robusto. But normally, CPV companies are interested in using the most reliable material, which is glass. “Glass stands up to thermal variations and humidity better and will withstand the elements better.” Most high-concentration CPV companies are using glass in their optical system to concentrate sunlight today.

Some CPV companies are trying to open the technology to other markets. For example, Energy Innovations from California offers a 300 kW compact carport-mounted CPV system, based on so called Sunflower's single module tracker technology. The company headquartered in San Diego points out that their system can be installed anywhere, on the field, on rooftops or carports. Thus, carports in high DNI areas could potentially be a big market as consumers purchase more electric vehicles.

## Bankability

Innovations are critical for bringing costs down, but too many new innovations can hurt the bankability of CPV projects because investors do not understand the risks of new technologies. "We want innovation, but at the same time our customers rely on guarantees that we can provide in order to be comfortable giving us capital," says Blanchard. "We have to get innovation into the product while having the bankability that clients value."

But proving a new technology takes time. The only way CPV companies can prove the technology works, is to actually show how it works and provide guarantees and warranties. "Third-party verification companies, like Intertek, are critical for giving CPV companies the credibility they need in order to find finances", notes Robusto.

In order to push for innovations but still maintain some bankability, SolFocus uses different solar cells from different companies. "We use two established solar cell companies and three innovators," explains Hartsoch. Thus, the company isn't locked into one cell supplier and has a diversity of technology and performance options that allow it to install projects in more diverse locations. SolFocus has been making CPV systems based on multi-junction cells for six years now and has 8 MW operating in the field. "We can say finally, yes, our commercial plants are operating at 100 percent planned capacity or better, so this makes bankability much easier for us," says Hartsoch.

Companies that can guarantee their technology are starting to see investors enter the market. Semprius has raised US\$ 20 million from venture capital funds from investors including Siemens Venture Capital, Arch Venture Partners, Applied Ventures, Illinois Ventures, Intersouth Partners, In-Q-Tel, and GVC. "We feel it is very important for the CPV industry as a whole to take its technology to market with a partner like Siemens, with credibility and engineering experience," says Kanjorski. Big players like Siemens will help convince customers that the performance is guaranteed, he says. The funding Semprius has raised will go to establish a 5 MW pilot plant expandable to 35 MW.

With funding entering the market, the CPV industry has a lot to look forward to over the next several years. But there is still a lot of work – i.e. reduction of costs – to be done before CPV may become a major segment of the solar industry.

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