# CONCENTRATION CUTS COSTS

**Concentrating photovoltaics is booming. Energy suppliers and venture capital companies are investing heavily in this young technology. Using this fresh capital, manufacturers can finally exploit to the full the great potential capacity of light-bundling solar modules.**

Written by Sascha Rentzing

A rare news item—in its fourth financing round, Solaria of the U S collected more money than it expected. A developer of concentrator solar power systems, it had already announced the closing of that round in May 2010, when the kitty reached $45 million. But further investors then pressed for a share, so the company extended the investment phase until August. The operation paid off, for over the summer Solaria bagged a total of $65 million.

"We will use the capital to accelerate production," says Solaria CEO Dan Shugar. Greater output will certainly be required, for this California firm's light-bundling modules, which require tracking systems, are very much in demand. Energy supplier Enxco, for example, a subsidiary of the French EDF group located in San Diego and also an investor in Solaria, plans on expanding its solar farms in the US and Canada with the concentrators. The two parties made a five-year supply agreement to that purpose in August.

Investors are attracted by the prospect of cheap solar power. "With an efficiency of 14%, we are eye-to-eye with normal standard modules, but thanks to the savings in semiconductor material, we can produce at 15%–30% lower cost," says Philipp Kunze, Managing Director of Solaria Germany. To get that result, Solaria saws normal monocrystalline silicon cells into strips two millimetres wide and rearranges them with the same space in-between. "That way we need only half as much silicon, so we can produce two cells out of one," says Kunze. In the gaps, Solaria places V-shaped plastic light guides that bundle the light onto the silicon strips at double intensity. The modules are then fitted to trackers so they track the sun precisely.

Sawing up finished components and combining them into new cells again sounds weird, but Kunze explains that this approach saves money because the cost of plastic and additional process steps is less than that of conventional cells. The use of trackers also pays off, he says, because they help to increase energy efficiency per unit area and, thus, reduce installation costs.

## Plastic replaces expensive silicon

This technique promises some relief from expensive photovoltaics (PV). Many firms are searching desperately for ways of saving on cost, and they know the existing technologies will probably be hitting their limits soon. Crystalline cells cannot be made ever more cheaply, because manufacturing the silicon and further processing the wafers is energy-intensive and laborious. Thin-film modules are already suffering problems now because of their limited capacity (new energy 4/2010). Systems that bundle light to increase its energy density for electricity production practically have unlimited development potential. Cheap optics can replace expensive absorber material, while the efficiency of multiple cells—the core component of high-concentration systems—is still capable of being markedly boosted. "This lets us look forward to dramatic price reductions," says Arnulf Jäger-Waldau of the European Commission's Joint Research Centre.

Energy suppliers and venture capital companies keen to invest are, therefore, queuing up at suppliers. US utilities are showing the most interest. 2010 could be a breakthrough year for the solar concentrator technology. At peak times, electricity consumers in California have to pay almost half a dollar per kilowatt-hour, but solar farms can already produce electricity more cheaply.

Growing demand is increasing the number of new entrants tremendously worldwide.

"Around 50 companies now sell concentrating PV, 60% of them founded in the last five years," says Jäger-Waldau. Greater electricity yield means most developers are putting their money on a high concentration of 100 or more suns (see chart).

The Italian market promises a further boost, for a dedicated feed-in tariff ("Con-to Energia") for concentrator photovoltaics (CPY) was recently introduced. Depending on array size, up to 200 megawatts (MW) of CPV can be funded at EUR 28 to 37 cents per kilowatt-hour. This technology, still a niche phenomenon, is a hot favorite of analysts because it could cut the cost of producing electricity from the current 26 cents to eight cents as early as 2015.

Concentrix Solar of Freiburg, taken over in late 2009 by French semiconductor supplier Soitec, is among the leading suppliers of such high-concentration PV systems. It makes modules in which Fresnel lenses focus light 500-fold on tiny stacked cells with an efficiency of up to 38%. "In countries with high insolation, this technology works 10%– 20% more economically than conventional solar power systems," says Concentrix CEO Hansjörg-Lerchen muller.

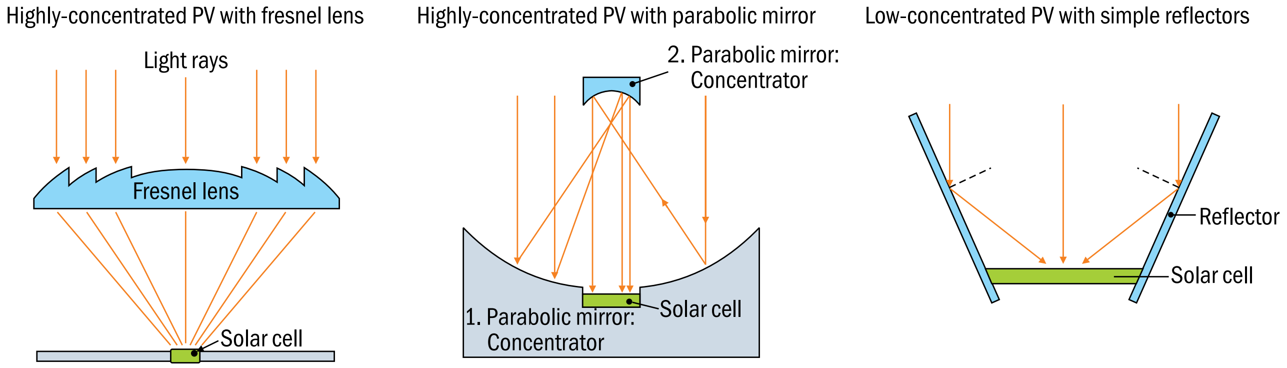
Production is laborious, however, for getting each lens to focus precisely on its target cell requires the two components to be aligned with each other with millimetre precision. Concentrix can use cells smaller than a fingernail and can even afford to incorporate expensive multiple cells consisting of three absorber films stacked on top of each other. Since the lenses only work under direct insolation, they are fitted to trackers.

High system efficiencies justify the effort, however. Lerchenmuller says that under a southern sun, the technology converts 25% of incident light into electricity almost twice as much as common modules.

And the next innovation can already be foreseen, for parent company Soitec is developing a manufacturing process in which five different semiconducting connections between materials of the main chemical groups III and V—such as aluminium, gallium and indium—can be stacked on top of each other. Until now, it has only been possible to manufacture stacked cells made from three absorber films. The result is said to be an immediate 45%–50% increase in the efficiency of the multiple cells and a 35% increase in system efficiency. "The process could be industrially usable in three years," says Andreas Bett, head of the materials, solar cells and technology department at the Fraunhofer Institute for Solar Energy Systems in Freiburg.

Concentrix reckons that the new "super cell" will provide good market opportunities. EU market watcher Jager-Waldau estimates that the current 50 to 100 MW of concentrator capacity installed worldwide could rise to 2000 MW by 2015. "We want a big slice of this cake," says Lerchenmuller. The firm has joined the Desertec Industry Initiative as an associated partner to smooth the way for power station projects in the Near East and North Africa. The Freiburgers already have a foothold in the US and are building a concentrator power plant with a one-megawatt

## Three types of light concentration




Concentrator photovoltaic is an alternative approach to reducing the cost of generating electricity from solar power. This technique reduces the requirement for expensive semiconductor material by bundling the light with an inexpensive optical concentrator. A small cell positioned at the focal point of the bundled light transforms the highly concentrated beam efficiently. Concentration factors now range from 2–1000. Low-concentration systems normally use simple optics, such as plastic light guides that bundle the light with doubled intensity onto a monocrystalline silicon cell. They can save up to 50% in semiconductor material. In medium and high-concentration systems, complex optics such as Fresnel lenses or parabolic mirrors bundle the light onto a multiple cell consisting of a stack of several semiconductors. The higher the concentration, the smaller the cell can be.

capacity for the Chevron oil group in New Mexico. Among Concentrix's fiercest competitors for the much sought-after desert locations are US firms Amonix and Solfocus. Amonix shares the efficiency record with Concentrix, for its systems transform 25% of light into electricity. The biggest concentrator project yet, at 59 megawatts, has now been implemented in Taiwan. The competitor there, Arima Eco, likewise relies on Fresnel technology, and uses a III-V cell with an efficiency of 36%. Solar Systems of Australia and Solfocus of California are also working with 500-fold concentration, but their system solutions trap the light with parabolic mirrors rather than lenses. They bundle solar radiation onto a stacked multiple cell positioned close to the focal point.

## The energy of 1000 suns

Isofoton of Spain, Morgan Solar of Canada and Daido Steel of Japan plan to face future competition with an even higher concentration of 1000 suns. Like Concentrix, Daido uses multiple cells made by Azurspace Solar of Heilbronn, but packs them behind two lenses that concentrate the light — a Fresnel lens and a second lens — to achieve an even greater energy density. So far, says Daido, its systems only have an efficiency of 22%–23% and cost 5 per watt of installed capacity, including biaxial trackers. But Daido Steel is banking on quick progress, and a representative of the firm stated at the Valencia PV conference that improvements in its production methods would lower the system price to 3–4 per watt, the level of conventional flat plate modules, as early as 2011.

He said the firm also plans to reduce the cost of producing electricity dramatically in the coming years by boosting efficiency by more than 10%.

Morgan Solar of Canada also promises to offer a technology that, in sunny regions, will produce electricity up to 70% more cheaply than present-day standard modules. The key to greater affordability, says the firm's head Eric Morgan, is the use of inexpensive light-guide optics. A specially shaped acrylic plate five millimetres thick collects the light and directs it at a secondary glass lens inside the component. The convex glass receives the light at 50 times the sun's intensity, concentrates it to an intensity of 1000 suns, and directs it vertically onto a solar cell underneath. This technique exploits the optical phenomenon of total internal reflection, in which a light beam meeting the bounding surface of a lens at a precisely defined angle is reflected in it instead of passing through. When technically mature, such systems are expected to achieve an efficiency of 25%–30%. Morgan Solar's approach has convinced such investors as the Spanish energy group Iberdrola and the California Energy Commission, which have so far invested $11.5 million in the firm. Most of the money is going into the construction of a plant in California with 35 MW of capacity, where series production is to begin in late 2011.

Although most other firms are also developing systems with complex optics and high concentration, experts still see market opportunities for low-level concentrator systems as well. "The competition is tough," says Joachim Luther, a solar specialist who once headed the Fraunhofer Institute for Solar Energy Systems in Freiburg. Only Solaria can demonstrate progress worth mentioning, however. Despite strong competition, the firm thinks it's on the right track. "Our technology works even without direct sunlight," says Kunze. Solaria modules could, thus, be installed in regions like Germany. There are, moreover, many possibilities for optimization. Solaria's developers plan to fit future light collectors with plastics that concentrate the light not just twofold but threefold. Another option is to position the output connections of the silicon cells at the back, so they do not cast shadows. But first, however, Solaria has to achieve series production.

This article is reproduced from
*New Energy* magazine, October 2010, No 5