Cutting Costs in Photovoltaics

Efficiency gains for photovoltaics may still be captured in the upstream stages of the value chain, such as in glass manufacturing.

Photo courtesy of F-Solar.

Although the costs for solar power have come down considerably, photovoltaics (PVs) are still unable to compete with conventional energy sources. Cell and module production have already been rationalized substantially. Companies now need to focus on innovations in raw materials and components.

Analysts agree: After two years of consolidation, the global PV market is picking up again. The market research company NPD Solarbuzz expects global demand for PVs to reach between 45-55 GW this year, up from 37 GW in 2013. Experts expect strong growth in Asia, as well as in North and South America. This means that alongside the established markets in Europe, new regions will soon emerge on the PV landscape.

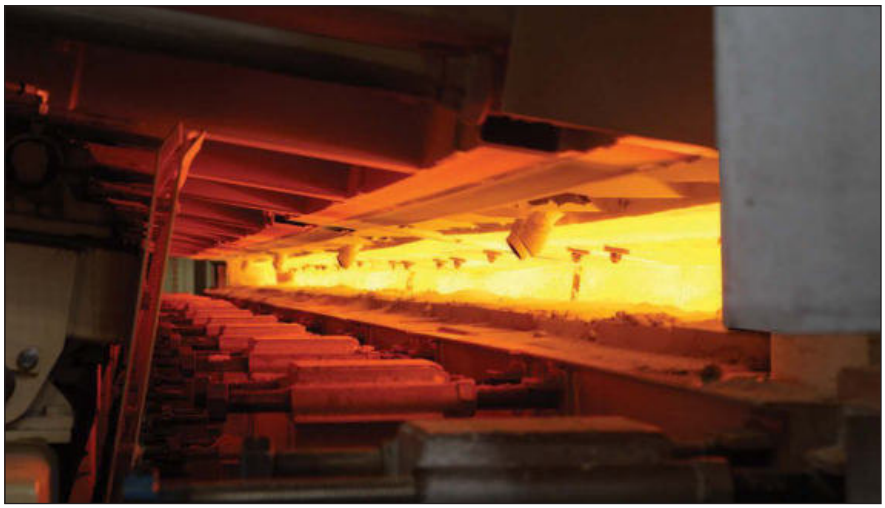
Markets are driven by solar power feed-in-tariffs designed in line with Germany's Renewable Energies Act. About 60 countries have now introduced this type of subsidy; at the same time, PV systems are becoming more affordable each day. According to the trade portal pvXchange, prices for an average turnkey system with crystalline modules from Germany dropped by about 25% to around $2,056.65 per KW.

This price decrease can be attributed to the intense competition in the PV industry. In China, in particular, solar energy component factories have been rapidly emerging over the past few years due to state subsidies. "In China, this is encouraged by the state," said Frank Haugwitz, business consultant and China expert. "Chinese manufacturers wish to dominate this promising future market at any cost." The oversupply of solar modules is forcing producers to offer drastic discounts.

Surveying the Market

Bidding wars are starting to affect the European solar industry. According to current data provided by the German Statistical Office, over half of the 10,200 jobs at German module producers have been lost since 2012. For the first time in almost four years, employment has fallen below the 5,000 threshold. On the other hand, PV now boasts comparable power generation costs with conventional power plants due to this shift in pricing; in some very sunny regions, solar power is already competitive. In the southwest region of the U.S., large solar power plants can produce one kilowatt-hour (kWh) for as little as $0.11—almost as inexpensive as gas and coal-fired power plants.

To cut costs even further, however, the solar industry will need to exert major efforts. "In cell and module production, the savings to be expected will



The production of solar glass is energy intensive and relatively expensive, so companies use every "setting screw" to cut costs. ***(Photo courtesy of F-Solar.)***

Solar glass not only protects the shimmering blue solar cells against detrimental influences, but also helps catch as much sunlight as possible. ***(Photo courtesy of Solarworld.)***

not be as dramatic as over the past two years," said Florian Wessendorf, general manager of the Association for Photovoltaic Components in the German Engineering Industry Federation (VDMA), who explained that technical innovations have already been largely implemented.

But the industry has other cost-cutting options. One approach is the so-called balance-of-system costs. In PV, these costs describe the total amount incurred for components and services required for installing fully operational solar systems at a site, excluding module costs. This includes costs for inverter, substructure, wiring or mains connection. At present, these items account for roughly one-third of the total cost of a solar project.

Glass as a Cost-Cutting Tool

Some efficiency gains may still be captured in the upstream stages of the value chain, such as in glass manufacturing. According to data by Heiko Hessenkemper, professor of glass and enamel technology at the Technical University (TU) of Freiberg, Germany, cover and carrier glass currently cost about $109.69 per kWh of module output. This means glass accounts for at least 10% of the present module prices of $822.66 to $1,096.88 per kWh. Hessenkemper believes that this proportion can be cut by two-thirds to about $41.13 per KWh by relatively simple means.

"There are materials that can be easily separated from the gaseous phase and deposited on the glass," explained Hessenkemper. "These increase the strength of glass while reducing reflections at the same time."

This simple method of surface modification, which does not even require any process changes to glass manufacturing, means the thermal pre-stressing that has been required for glass toughening until now is not necessary. The hardening process that gives glass sheets the characteristics of elastic, yet resistant bodies may protect the sensitive solar cells against weather impact for many years. However, the process is both energy- and cost-intensive: The sheets are first heated to over 1,112°F and then quickly cooled off, starting with the surface, thereby transferring them into a state of residual stress.

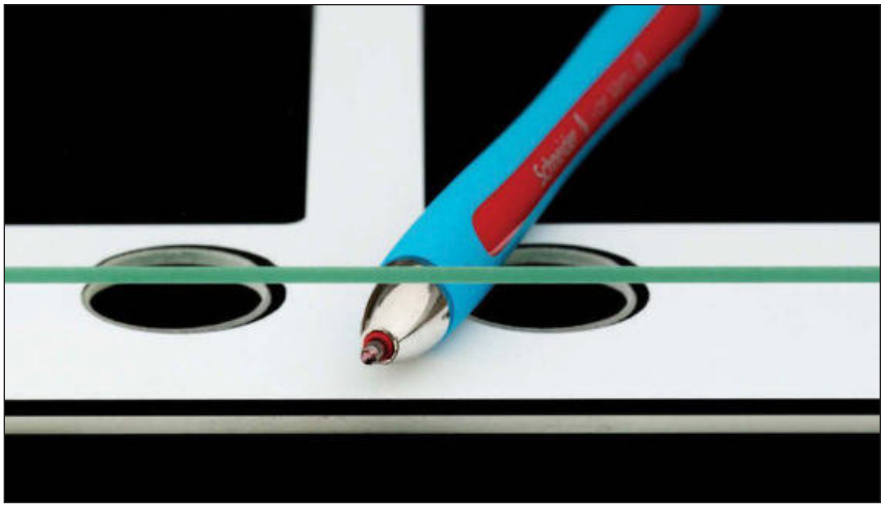
According to Hessenkemper, although gaseous phase separation is already fit for commercial use and currently being tested primarily by Asian glass producers, the technical approach pursued by the Friedrich-Alexander University (FAU) in Erlangen-Nürnberg, Germany, and its project partners are still in the research stage. Scientists are working on types of smart solar glass that adjust the sunlight to the spectral sensitivity of solar cells with the help of fluorescent materials. As a result, the power yield of the cells can be improved, and power generation costs can be reduced.

Smart Solar Glass

For years, scientists have been aware of a method to expand the spectral area of solar cells through "luminescence down-shifting." Those parts of sunlight that solar cells find difficult to absorb can be converted into wavelength spectrums where the cells work very efficiently. The FAU project is specifically geared to converting high-energy, ultraviolet and blue light into low-energy, green and red light by means of an ultra-thin fluorescent layer.

According to FAU Project Manager Miroslaw Batentschuk, it is not necessary to change the established manufacturing technologies for solar glass overall: only parts of the coating need to be modified. Initial project results are

Solarworld "wraps" its solar cells in two glass sheets so the sensitive "light catchers" are better protected and last longer. *(Photo courtesy of Solarworld.)*



Thin yet extremely stable, today's solar glass is only 0.2 cm thick, saving material costs and making glass-glass module production possible. These come with a robust glass sheet rather than a backsheet. *(Photo courtesy of F-Solar.)*

promising. "With thin-film solar cells based on copper, indium, gallium and selenium, we have achieved efficiency improvements of up to 5%," he said.

Until such novel technologies as smart solar glass can be used on a commercial scale, the industry will implement more obvious innovations. For instance, since last year, in a joint venture with Interpane and the Dutch company Scheuten, the German solar glass manufacturer F-Solar has offered float glass that is half the thickness of conventional solar glass (0.2 cm). "The reduced material input brings down the price," said F-Solar CEO Thomas Keyser. "Furthermore, module manufacturers benefit from these thinner glass sheets for new products, such as glass-glass modules."

In this type of module, one glass sheet replaces the otherwise usual backsheet. This protects the embedded solar cells against compression and tensile forces, making them less susceptible to cell breakage. In additon, moisture can no longer penetrate modules as easily and damage the sensitive cells. Module service life increases, modules produce more power, and cost per KWh decreases.

Glass-Glass Modules

Since 2013, the solar producer Solarworld has offered glass-glass modules by the name of Sunmodule Protect. By company accounts, while these modules are as light as customary glass-backsheet modules of the same dimensions, despite the additional glass sheet, they age considerably more slowly. The modules reportedly work for 30 rather than 25 years and lose less than 0.35% yield per year.

In general, producers today count on an annual degradation of 0.7%. Solarworld is therefore considering further upgrades to the technical features of its new glass-glass modules. At present, they still consist of conventional solar cells from multi-crystalline silicon. In the future, highly efficient passivated emitter rear cells (PERC) with efficiencies of over 20% could be used instead—another of Solarworld's new developments. To achieve this high efficiency, the cell rear is provided with additional coatings that reduce both electrical and optical losses.

Another approach to increasing the efficiency of solar modules is offered by so-called anti-reflex layers on the front of the glass. Most of these are single-layer, nano-porous structures from silicon oxide. They reduce the reflection of the incoming light and increase the light transmission of the glass. Since more light hits the solar cells, this additional energy increases the total efficiency of the modules by 2-3%.

By its own account, machine producer Bürkle from southern Germany offers solar glass suppliers a particularly efficient coating process. In contrast to the frequently used spray coating, Bürkle's e.a.sy-Coater roller application machines are said to apply especially homogeneous fluid films of just 0.0005-0.0015 cm thickness to the glass. According to Bürkle's product manager, Oliver Meisriemel, this process is ideal for avoiding material waste and achieving a defined layer thickness. "Layer thickness variations are easy to identify through color deviations," he said. "With our roller coater, a technically and visually perfect surface can be achieved."

Learning Opportunities

At glasstec 2014, which will be held October 21-24 in Düsseldorf, Germany, machine manufacturers will present their latest manufacturing technologies for solar glass production. Innovations for solar glass and solar modules will also be the focus of the "solar meets glass" Congress at the upcoming event. Here, experts from the solar and glass industries will get together from October 20-21 to exchange ideas on the progress made in glass and module manufacturing, as well as in materials and costs. Experts hope for a close alliance between the two sectors.

"Glass still holds great innovative potential and one the PV industry has by no means fully tapped into yet," said Hessenkemper.

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