



WILL SOLAR TECHNOLOGY REMAIN A HOT ISSUE EVEN WITH A GLOBAL ECONOMIC CRISIS AT HAND? PHOTOVOLTAIC EXPERTS WEIGH IN ON THE TECHNOLOGY, OPPORTUNITIES, AND FUTURE OF SOLAR TECHNOLOGIES.

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SOLAR'S BRIGHT FUTURE

Growing demand for clean energy sources, lower manufacturing costs, and more-advanced PV (photovoltaic) technology has in recent years driven the rapid expansion of solar-cell- and PV-array manufacturing. Even with a challenging global economy, industry experts say that PV technology will remain hot as the industry ramps up to meet growing ecologically savvy consumer and commercial demand for alternative-energy technologies, with growth rates already surpassing those of the semiconductor industry.

Just how big is the demand for solar power? Market-research company Gartner Inc reports that with the global market for electricity growing rapidly, there is significant growth on the horizon—from 17 PW (petawatt) hours in 2005 to a forecast 21 PW hours in 2010

and as many as 33 PW hours in 2030. From 2005 to 2010 alone, demand for electricity should increase 21%, outpacing population growth at 6%; 400-GW (gigawatt)-scale power plants, mainly based on fossil fuels and nuclear power, will meet this need.

If estimates hold up, by 2030, 2000-GW-scale power plants will be necessary to meet new electricity demand, and a potential need will arise to replace a large number of obsolete power plants. Demand on this scale, coupled with industrial and consumer demand and the desire to be free of foreign-fuel sources, has opened up significant opportunities for the PV market, Gartner says.

Some analysts believe that the solar-energy industry will be much larger than the semiconductor industry. “It could take 10, 15, or 20 years, but there’s no doubt that it is so vital, so important, and so critical that this is a technology that is here to stay,” says Alain S Harrus, a partner at Crosslink Capital and a 25-year semiconductor-industry veteran.

“With the financial crisis we’ve had in the [last few months], valuation of pub-

lic companies has collapsed, and that [situation has] been reflected on the private side, as well," he notes. However, the economic slowdown has not stopped the amount of work going on in the PV industry and the number of new companies still trying to raise money. "A lot of these private companies have funding for ... six, nine, [or] 12 months to two years, and, therefore, they just keep doing what they are doing because the market ultimately is there to make electricity at a cost competitive with fossil fuels," Harrus points out.

Paula Mints, principal analyst for Navigant Consulting's PV-services program and associate director of Navigant's energy practice, agrees that solar will continue to maintain the excitement it has garnered as of late. However, she says, the market is first going to soften, for the obvious reason: the economy. "People are drawing back on larger projects because credit is tight," she says.

Equal to that pressure, Mints says, is the cap Spain recently put on its feed-in tariff, a popular program in Europe. Given that Europe contains more than 70% of the global solar market, this blow was significant. "Spain has been growing

AT A GLANCE

Analysts expect a need for 2000-GW (gigawatt)-scale power plants by 2030.

Wafer-based crystalline silicon has historically dominated the PV (photovoltaic) market and holds a 90% share.

Most utilities see PV technology as experimental.

Crystalline-silicon-based PVs attract users, such as residences and urban solar farms, with limited-space footprints and a need for maximum electricity output.

enormously, a lot of product was shipped into Spain, and now it has nowhere to go," she notes.

As such, Mints is revising her solar-photovoltaics forecast downward for the next two years but still expects 25% growth for 2009, down from almost 60% growth in 2008, based on solar shipments of 5 GW to the first point of sale in 2008—not a bad growth rate compared with the semiconductor-industry figures.

Echoing Mints and Harrus, Jim Hines,

research director for semiconductor and solar at Gartner, agrees that the outlook for the solar industry remains strong relative to other sectors of the economy. "This is an area where we expect to continue to see some pretty good growth rates," he says, a sentiment that October's Solar Power conference in San Diego reflected. "Talking to people on the show floor, there was a lot of optimism, and [the] outlook is strong for 2008 and 2009," he notes. Most module suppliers, especially the thin-film, PV suppliers, report strong demand.

Gartner expects crystalline-silicon-based PVs to remain the core of the market, reaching 13 GW sold by 2012, thanks to both the large installed base of manufacturers and the fact that the technology has a higher efficiency rate than its thin-film counterpart. It attracts users, such as residential installations and urban solar farms, with limited-footprint applications and a need for maximum electricity output.

Meanwhile, thin-film-PV technology imparts a strong opportunity with the potential to sell more than 4.5 GW by 2012, given its low-cost potential in overcoming the lower energy-conver-

REACHING GRID PARITY

Perhaps the burning question in regard to solar power is when this form of energy will reach grid parity—with a cost equal to that of conventional, fossil fuel-based electricity.

Alain S Harrus (photo), a partner at Crosslink Capital, points out that there is not one answer that applies to the entire world. In California at 3 pm, a residential customer in a certain pricing "tier" is below grid parity—45 cents or more, whereas solar is at about 20 cents, he says. Comparatively, in the Pacific Northwest, where hydroelectric power generation is about 5 cents per kilowatt hour, solar doesn't make as much sense.

It is currently about three times more expensive to generate electricity with PV (photovoltaic) technology than with fossil fuels. But strong efforts to reduce costs in crystalline

PV and thin-film PV could allow grid parity to occur between 2012 and 2015.

However, the grid-parity argument is invalid to some experts, including Andrew Skumanich, PhD, founder of SolarVision Consulting. Grid parity is an artificial notion, he warns.



"You're comparing solar panels to your wall plug for the toaster, and the problem is that, when you buy solar panels, you are buying hardware that is going to generate electricity," he says. "But you have to write a check for \$20,000 or \$30,000 for a typical house. ... Even if you lower the cost to ... maybe \$15,000, you're still paying only 10 or 15 cents a kilowatt hour out of the plug."

Skumanich cautions against rationalizing that, over the life of the house, you're paying 10 cents per kilowatt hour, which is the same as the grid: "You can't lose sight of the fact that you said, 'over the life of the house.' That's pretty major. When you are writing the checks for the month, do you want to write a check for \$15,000 for something that is not going to pay back for 10 or 15 years?"

sion efficiency for installations without space constraints, such as rural systems. A limiting factor to the growth rate of thin-film-PV technology is the time it takes to reach high-volume production and obtain product certification before utilities integrate the technology into their power mix, Gartner reports.

Hines also notes that the feed-in tariff cap in Spain has caused inventory to build up, also affecting price; the industry is addressing the problem, which doesn't appear to be long-term. On the other hand, market researchers at iSuppli Corp expect prices for polysilicon to create PV cells to drop in 2009 and the following years because of imbalances in the solar-supply chain (Reference 1).

RACE FOR EFFICIENCY

Wafer-based crystalline silicon, which comprises monocrystalline and polycrystalline, has historically dominated the PV market and holds a 90% market share. The remaining 10% of the PV market currently comprises thin-film-solar technology, including cadmium telluride, amorphous silicon, and copper indium gallium diselenide.

Cadmium telluride is currently leading in thin-film-PV applications because it is the only thin-film-PV technology in volume production. First Solar leads the way with its 0.5-GW manufacturing capability. The peak efficiency for cadmium telluride is 16.5%, with an average efficiency of 11%. There are also concerns about the recycling of toxic cadmium.

Silicon-based thin-film PV includes two fundamentally different cell structures, according to Gartner's Hines. One employs amorphous silicon, which has relatively low efficiencies of 6 to 7% and is the material most companies are starting with to ramp up production. The other silicon-based thin-film-PV technology is tandem junction, which combines amorphous silicon and a microcrystalline-silicon layer. Applied Materials and Oerlikon are the major vendors in this segment. Tandem junction is in the early stages of qualification but is not yet in high-volume production. Currently, its low efficiency rates restrict its



use to installations with low land cost, limiting residential use, but make it a strong contender for solar farms. "When customers of Applied and Oerlikon are able to move that technology into production and begin manufacturing panels based on tandem junction, they expect to get efficiencies around 10%, which should be competitive with cadmium telluride," Hines says.

Copper-indium-gallium-diselenide-PV technology is a bit of a wild card, he points out, because it has demonstrated efficiencies as high as almost 20%, according to a study at the National Renewable Energy Laboratory. But lab tests differ from real-world tests. "The challenge with [the material] will be [determining whether it can] really deliver that level of efficiency in a production-worthy process on panels that are robust enough to survive a 25-year expected lifetime in the field," says Hines.

"It's going to be a race between the silicon-based and cadmium-telluride-based thin-film technologies to see which will get the lowest cost per watt. Clearly, First Solar has an advantage and a pretty substantial head start [with its] cadmium-telluride approach," he says.

Still, industry participants widely agree that there is room in the market for both thin-film- and crystalline-silicon-PV technologies to coexist and serve different market segments. "Crystalline silicon [can] deliver higher power densities, which is an advantage in installations where you're trying to maximize the power output from a given

amount of area, [such as] a residential rooftop or even on some commercial rooftops," says Hines. "It really depends on how you are trying to maximize power output or minimize cost. For that reason, crystalline silicon will not go away. There is a lot of work being done to reduce cost on the crystalline side through using less silicon material and thinner wafers."

With thin-film technology, it's a somewhat different story, he asserts. "There's a lot of innovation going on, and it is really too early to pick the winners. First Solar has a very strong first-mover advantage with its technology, so it is really

up to the new guys to deliver a compelling advantage that will enable them to take share away." Hines warns that a silicon-panel producer that can drive lower costs through better economies of scale or a copper-indium-gallium-diselenide design with significantly higher efficiency would disrupt the market.

SOLAR-GROWTH DRIVERS

From a technology point of view, the PV industry is moving along at a fast clip, but the size of the industry is actually a growth inhibitor. The fact that PV technology represents such a small part of global energy demand causes most utilities to look at it as an experimental program. Gartner estimates that total global-PV sales will reach almost 4 GW this year.

Cathy Boone, senior director of global marketing and government relations in Applied Materials' solar-business group, notes that, even though solar technology has been around for a while, manufacturers have never been able to produce it on a scale that would allow it to solve the world's energy problem. "Right now, solar produces 0.01% of all of the world's energy," she says. The international energy agencies say that, every year, we'll need to add about 120 to 130 GW of new generating capacity, with a gigawatt being enough power for San Francisco. So, add about 120 San Franciscos' worth a year."

According to Navigant's Mints, incentives are the only factors that drive



demand in solar unless it is off-grid. “The Spanish market is a case in point,” she explains. “[Spain] put a cap on [its] market, and now the whole world shrinks because of that [decision]. These are really expensive programs that are very difficult to design. They have to be designed to stimulate a market [but] also be controllable and economically viable because someone has to pay for it. Essentially, where there are incentives, there will tend to be a market. This [situation] is a little offset right now because of the economy, but I don’t think anyone believes the recession will go on forever. ... Once there is a recovery, the proper incentives will be in place to drive demand.”

Gartner’s Hines agrees that government subsidies drive demand for this product. Therefore, growth depends on the ability of governments to support investments in solar projects through these subsidies in whatever form they take: feed-in tariffs, as in Germany and Spain, or other incentives that exist in the United States. It appears that the subsidies are intact for now, he says, but if the economic situation worsens or stays bad for a longer time, governments might have no choice but to pull them back.

Another concern of equal importance is the availability of financing for large solar projects. Even though interest rates are low, the tightening credit situation could affect those projects. In fact, Ap-

plied Materials confirmed in its fourth-quarter fiscal results in November that solar projects are seeing delays because customers are having difficulty getting funding (**Reference 2**).

But Applied officials remain optimistic. “We see a lot of opportunities in the solar market, and a couple of things drive that [opportunity],” says Boone. “First, government incentives still are quite strong for solar. The United States finally [passed] the extension of the ITC [incentive tax credit], and, for the first time, that tax credit is now available to residential homeowners without a cap—that means any size system.” The \$2000 cap limited who could take advantage of it, she explains. “And we certainly don’t want to be in a position where ... only people at a higher-income category can afford to get solar.”

Second, Boone adds, Applied sees the ability of utility companies to take advantage of the ITC for the first time as a groundbreaking opportunity. “When we look into the future, we see a very clear divide in the solar market: the residential-rooftop and small commercial-space-constrained installation, dominated by the wafer-based crystalline-silicon products that are very high in efficiency but a little bit more costly. That is a market that we see growing in both the United States and Europe.”

The company is also seeing the rise of what it believes is going to be the

“transformative heart of solar’s answer to the energy equation,” as Boone explains, which is utility-scale solar. “Allowing utilities to capture tax credits for solar-generation facilities is going to unleash a lot of demand here in the United States. We have a lot of sun in the United States. Germany, the largest solar market in the world, gets as much sun as Maine, and that’s not a very sunny place. We see growth in places like California, the Southwest, and the Southeast,” she notes, pointing to Florida as an example. Last year the state passed a new RPS (renewable portfolio standard) that essentially is going to require its utilities to get a certain amount of generation from renewable portfolios.

SOLAR OPPORTUNITIES

Solar is set to continue to grow at a rate that many in the semiconductor industry have noticed, even with high residential costs and the arguments against “grid parity”—when solar’s cost equals that of conventional electricity (see sidebar “Reaching grid parity”). Fortunately, semiconductor companies can play a part in the solar industry in power management, balance of inverters, microcontrollers, test systems, and automation.

The semiconductor industry has made a dent in solar, as Crosslink Capital’s Harrus observes. “A good majority of the solar start-ups in Silicon Valley are staffed by semiconductor people—on the process side, on the equipment side, on the management side—and the core technology comes out of universities or national laboratories. There are dozens of examples of this [trend].” He believes people are realizing that the semiconductor industry is not what it used to be and are moving to the solar side.

Semiconductor companies that have made inroads in the solar market include Applied Materials, National Semiconductor, Linear Technology, and Analog Devices. Also, OEMs, such as Advanced Energy, have adapted their technology to fit solar factories. And, because part of solar installation is the power management, Advanced Energy, Analog Devices, and National Semiconductor are fitting in well; power control and power management are jobs the semiconductor industry knows how to do.

Gartner’s Hines points out that there is more synergy between FPD (flat-pan-

el-display) manufacturing and thin-film-solar-panel manufacturing than between the traditional semiconductor market and solar. Sharp, for example, one of the largest FPD manufacturers, is also the No. 2 solar-cell manufacturer, after Q-Cells, and just announced a major thrust into thin-film-PV technology. Hines believes there will be similar moves to come, citing Samsung and LG as examples.

POWER CONTROL AND POWER MANAGEMENT ARE JOBS THE SEMICONDUCTOR INDUSTRY KNOWS HOW TO DO.

In addition to opportunities for device makers, Hines notes, there is room in the solar market for some—but not all—semiconductor-manufacturing equipment and technologies. “Just because solar is silicon-based does not mean it represents an opportunity for every equipment company,” he says. “If you look at the crystalline-silicon-PV-manufacturing flow, there are diffusion furnaces, deposition of nanoreflective coatings, [and other factors]. And, while there are some similarities, there are far fewer processing steps, and there is really no need for advanced lithography. The metallization is far less critical. They are using screen printing and silver paste.” Still, he notes, as the industry evolves, there is a great opportunity to learn from the semiconductor industry about how to improve the manufacturing efficiencies within the PV market. He suggests looking at opportunities in process control, metrology, inspection, and automation technology.

On the thin-film side, the big crossover is from FPD manufacturing. Applied Materials and Oerlikon are leveraging capabilities that they developed in this area.

On the downside, the transition from semiconductor to solar is not always sunny. Although solar and semiconductors are fundamentally about silicon and technology, the similarities end there, says Andrew Skumanich, PhD, founder of SolarVision Consulting. For chips and

semiconductors, "You're trying to build more and more complexity in and make it more and more functional," he says. "You can charge for that." With solar, "Absolutely everything is about lowering the cost and not necessarily increasing the complexity," he says. "What you talk about is a metric: dollars per watt." It may be difficult for a semiconductor company to adjust its focus from improving functions to reducing costs and improving productivity.

SUCCEEDING IN SOLAR

A semiconductor company can theoretically make the transition to becoming a successful player in the solar industry, Skumanich says. "But if [it goes in thinking], 'Well, we've got hotshots in technology, and what's solar but another way of making a diode?' then, [it's] going to have problems, because, ... even though [the company] might have a good approach, it doesn't make the overall cost go down, and it won't fit into the market," he cautions.

Crosslink's Harrus points out that, to achieve success in the solar industry, "the technology is less than 25% important; 80% is excellence in low-cost manufacturing because electricity is a commodity."

"When we're making chips—with the exception of memory, which is a commodity—there is a whole value chain, and you're pricing to value. You can have great gross margins on chips that are valuable, but electricity is a commodity. We don't care when we throw the switch on where the electrons come from; we want to pay the least possible amount," he says, noting that the solar market differs from the conventional chip industry, in which the quality of your phone, for example, depends on the quality of the chips inside.

"We are at the stage where technology sometimes is very interesting, but nobody cares," says Harrus. People understand that, if you can't manufacture something in high volume, it is a waste of time. **EDN**

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