



Business

is exciting

OptiSolar is currently constructing a large commercial-scale amorphous silicon solar thin-film project in Sarnia, Ontario. Photo: OptiSolar

If there's one word solar industry members use to describe the state of the thin-film business today in the USA, it's "exciting".

First of all, Sempra Generation, a subsidiary of Sempra Energy, in December completed a 10 MW thin-film plant in Nevada – which is the largest thin-film installation in North America today. The company says it believes the project – which uses thin film manufactured by First Solar of Arizona – produces the least expensive solar energy in the world. Pacific Gas & Electric (PG&E) of California has signed a 20-year contract for the output of the plant. What's more, even bigger plants are on the horizon. For example, OptiSolar, based in California, has proposed the 550 MW Topaz Solar Farm project in California, which would use relatively low-cost, thin-film PV panels, according to the company. PG&E has signed a contract to purchase the output of the plant, which would begin power delivery in 2011 and be fully operational by 2013.

Growing market share

Thin-film technologies, which reduce the amount of light-absorbing material used to manufacture a solar cell, are grabbing up some of the market shares formerly taken by the conventional crystalline silicon panels. Because thin-film photovoltaics can produce electricity at lower prices than crystalline silicon and don't use much of the shortage-plagued silicon, they're gaining in popularity and are seen as more attractive under certain circumstances. Because they're less efficient, they're more appealing when there's enough land available to build larger plants. However, where land or roof space is scarce, the higher-efficiency crystalline will be cheaper, notes Jerry Caldwell, senior project engineer for Recurrent Energy in California. "This is a very exciting time for the thin-film sector with as much financial backing as it's gotten in the last few years. There



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is a plethora of new companies coming out with new variations on an assortment of technologies", he says.

Thin-film technology has benefited in recent years from the research and development that's gone into flat-screen televisions, says Tom M. Djokovich, President and Chief Executive Officer of XsunX, an Oregon-based company that plans to build and operate a thin-film manufacturing plant with more than 100 MW of manufacturing capacity. "The same manufacturing techniques you use to make flat panel TVs you use to make different layers of amorphous silicon solar cells", he explains. "All this technology we developed to make bigger TVs can also make bigger, cheaper amorphous silicon solar cells."

In general thin film has a number of advantages over other solar technologies, says Michael Fritsch, President and Chief Operating Officer of Confoe, Inc. in Texas, which improves operational performance, factory output, and supply chain management for renewable energy companies. Thin-film PV modules have the lowest manufacturing cost today and show the best potential for improving costs throughout the value chain, he notes. These technologies use fewer materials and aren't affected by the current silicon supply shortage. They also are better suited to building-integrated PV systems. Says Alan Bernheimer, Vice President of Corporate Communications for OptiSolar, "Doing thin film on a large scale is really what has begun to make it effective."

Some say that thin-film's market share will eventually catch up to crystalline silicon's. Thin film represented about 10 % of the PV market in 2008 and is expected to increase to 28 % in 2012, mentions Fritsch.

Best choice in some cases

"Thin film will lower the cost of solar power in some applications – especially large-scale arrays sited in warm climates", says Paul Wormser, Senior Director of Engineering and Product Development, Sharp Solar Energy Solutions Group. "There's a tremendous amount of anticipation about thin film because we've been striving for genuine grid parity, and thin film moves us toward that goal", he adds. Helping move the industry toward the low-cost goal is the 10 MW Sempra plant. Sempra Energy Spokesman Art Larson says the company believes its 10 MW El Dorado Energy Solar project produces the cheapest solar energy in the world. The low cost is not only due to the thin film advantage; it's due also to the fact that the plant was built in an area where there is already an existing natural gas fired plant. "The infrastructure was there for connection to the grid. That's a crucial component of building renewable or any power", he explains. A number of factors gave rise to the construction of the largest, lowest-cost solar facility in North America, he adds. "Obviously public policy and concerns about climate change have all played a role", he says, adding that Renewable Portfolio Standards (RPS) – especially in California and the Southwest – help boost the market for thin-film solar and other types of renewable energy.

In constructing the plant, cost was not the only concern of manufacturer First Solar, says Lisa Krueger, First Solar's Vice President of Sustainable Development. The company's thin film has the lowest carbon footprint and the shortest energy payback of PV technologies. "Obviously, having cost-effective solar technology is a great way to affect climate change. We also embrace product life-cycle management", she states. The company has developed recycling technology to recover semiconductor material, she says. "We purify and compound it for use in new modules. We recover glass and the semiconductor material."

Thin-film: a threesome

Sempra's El Dorado Solar Project utilizes one of three types of thin-film technology – cadmium telluride. First Solar is able to use the technology to achieve an average manufacturing cost per watt lower than crystalline silicon's, says Fritsch. Cadmium telluride technologies have produced panels with efficiencies in the 6 % to 10 % range, with a record efficiency of 16.5 %, he says. But cadmium telluride carries some environmental concerns so manufacturers must implement recycle and reclaim programmes.

The most well-developed of the three thin-film technologies is amorphous silicon. One of amorphous silicon's advantages: it doesn't use any hard-to-find or difficult compounds, says Bernheimer. "It uses 1 % of silicon polycrystalline and doesn't use any metal", he adds. It's also possible to replicate amorphous silicon on different

substrates, including steel and glass, says Georgina Benedetti, a research analyst in the energy and power systems division of Frost & Sullivan, a consulting firm with offices all over the world. **Amorphous silicon technology has produced production panels with efficiencies in the 5 % to 10 % range and a record efficiency of 13 %, mentions Fritsch.**

A third type of thin-film technology is copper indium gallium selenide (CIGS). CIGS may hold the most promise for low-cost manufacturing, says Fritsch. "The major players use electronic printing processes to create the solar cells. This gives the potential for very low cost/high-throughput manufacturing which does not require high vacuum or high temperature (meaning relatively low capital costs for equipment)", he says. This technology is also well suited for producing building-integrated PV – where the PV panel is part of the building material itself. CIGS technology has produced production panels with efficiencies in the 10 % to 14 % range and a record efficiency of 19.9 %, he says. The US Department of Energy's National Renewable Energy Laboratory (NREL) recently created a thin-film CIGS solar cell that reached 19.9 % efficiency in testing at the lab, according to NREL. "This is the very first 20 % efficiency solar thin-film ever made", says Miguel



Largest thin-film PV modules in the industry, Gen 8.5 by Signet Solar, on display at Intersolar conference 2008, Germany.

Photos (2): Signet

Contreras, group leader for the NREL CIGS group. "This efficiency is very comparable now with the efficiency of the most common solar cell - the polycrystalline solar cell, with 20.3 % efficiency."

Cost per watt matters

The 550 MW plant planned by OptiSolar would employ the more widely used amorphous silicon technology. "This involves a lot less silicon than a polycrystalline solar cell and is what has been around a lot longer. We only use 1 % of the amount of silicon",



Start of production of the Gen 8.5, Signet Solar's technology which lowers the cost of photovoltaic modules by combining proven silicon thin-film technology with very large area manufacturing and an industry standard equipment set.



Solar lens manufactured by 3M used to concentrate solar radiation

Photos (2): 3M

says Bernheimer. "We put a thin film of silicon on the back of a piece of glass, which we turn into solar cells. It is a lot less expensive to manufacture because there's less silicon and manufacturing is cheaper. The film is a lot like a silicon chip. We just deposit the thin film on glass." And thin film offers another advantage over crystalline solar cells, he adds. "Crystalline solar cells have a harder time following the sun and you need trackers. With thin film, you don't need to track because it works at different angles." He notes, however, that because thin film is less efficient, more land is required. "Cost per watt is really what matters at the end of the day."

Another amorphous silicon user is Sharp, which has announced that it will introduce "next-generation" thin-film solar cells in the US market in the near future. The cells will feature efficiency and longevity. "With its thin-film solar product, Sharp will be capable of handling multi-megawatt, large-scale utility projects that are best served by a thin-film solar solution, and the company is already working with prospective US customers in preparation for these large-scale deployments", the company says in a press release. Sharp's Wormser says that the development of technology allowing for more than one layer of thin film made this type of thin film worthy of commercial-

izing on a large scale. What Sharp does is build a sandwich, he explains. "The first piece of bread is glass; the peanut butter and jelly is thin film and the next piece is a weather barrier." "With the thin film of today, the efficiency is way up and the stability is terrific. You want to maximize the economic situation and technical situation of how many layers. We build two layers now." Sharp will be building three layer thin film in the future, he says. The different layers capture different portions of the light spectrum, allowing for more light to be captured from the sun, he explains. Sharp's two-layer technology consists of two very thin film layers of silicon. One is amorphous and the other is microcrystalline silicon, says Wormser. The additional layers also make the thin-film cells last longer, he says. "The thin film of old was mostly one layer, amorphous, low performing. There were some companies that used multiple layers of thin-film amorphous silicon. It had better performance but was not competitive with crystalline. Now that there is a technological and manufacturing ability to create microcrystalline layers, you get the best of both worlds. You get the best use of materials because it's so thin. You get the ease of manufacturing and pretty good efficiency and stability that you get from crystalline. It's the idea of marrying amorphous silicon with microcrystalline."

Another sandwich solution

XsunX also uses the two-layer approach, says Djokovich. "We create sandwiches of different solar cells, each tuned to capture a certain spectrum of sunlight", he says. "The top will be tuned to capture reds and blues, and the lower cell will be tuned to capture more of the green spectrum." The company is building a factory in Oregon that is expected to start production in 2009.

Like many of the thin-film companies, Oerlikon Solar also seeks to take advantage of the low cost of thin film. But rather than producing modules, the company sells customers a complete manufacturing system that allows them to make modules and enter the market quickly, says Christopher O'Brien, Head of Market Development for North America. "Our core competency is optimizing manufacturing equipment. We develop a standard tool set that a number of customers can use to get into the market quickly. It's a faster way to grow our business than to make panels ourselves", he says. "We don't buy the glass or gases and don't hire workers. The factors that we can control, we do guarantee", he says. Oerlikon guarantees customers the efficiency of the modules and the throughput of the plant. For single-layer modules, it guarantees an efficiency of 7%. Most single-junction thin film has an efficiency of 5.5% or 6%, he adds. The cost of the electricity produced by Oerlikon systems, he says, is about half the cost of conventional crystalline silicon. The estimated production cost using the system is about US\$ 1.20 per watt, he explains. That's similar to the cost of electricity produced by First Solar which announced in February

that it has cut production costs to 98 cents per watt. "Expect the cost to decrease to under US\$ 1 per watt or as low as 70 cents per watt in the future", O'Brien says. The goal is to see energy generated on Oerlikon's equipment drop enough so that it's at or below the conventional cost of power, he states.

Cost-competitiveness is near

And that time is only a few years away, says Bernheimer. "We are already cost-competitive with other renewable energies. We are just a few years away from being cost-effective with fossil fuel plants. These solar plants have a lifetime of 20 to 30 years, so they will be cost competitive within their lifetime with fossil fuels. This is why PG&E is signing on

Solar panel from 3M




with projects like this", he says. Low cost is indeed what prompts PG&E to sign contracts with renewable energy developers, says PG&E Spokeswoman Jennifer Zerwer. California's RPS calls for the company to ensure 20 % of its power comes from renewable sources by 2010. The Sempra plant is PG&E's first project in photovoltaics to come online. "The advantage of thin film: it's an attractive technology. Like other solar, it's available when we need it most during peak energy demands on hot summer days. It's modular in nature and easy to set up", Zerwer says. **But there's yet another reason the thin film market is growing – and it's not about silicon shortages, suggests Fritsch. "I think the more compelling driver is that there are a lot of different ways to 'skin the thin-film cat.' There are a**


lot of different technology approaches that could pay off big. You also have the migration of talent from semiconductor to PV, which puts a lot of engineer brainpower and prowess on the thin-film technology side of things", he says.

Industry sources expect that they'll soon see more incentives – and more technological developments – that will help boost the market even further. Right now the industry is seeing a downturn related to the US recession. "We're in a short blip now because of the credit crunch", says Djokovich. But with the Obama administration, that's expected to change. "With the Obama administration, all we see right now is optimism", he states. "The realities are, if they do what they claim they're going to do – build a new energy economy – wind and solar will be an important part of that. And that's a good thing." Says Tracy Anderson, Business Director of 3M's Renewable Energy Division, which provides thin film and resins for PV: "It's an exciting time. If projections hold true, we will all be very busy."

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