C&EN
CHEMICAL & ENGINEERING NEWS

OCTOBER 20, 2008 | VOLUME 86, NUMBER 42 | PP. 40-45

U.S. Solar Energy Heats Up

Infusion of tax breaks and venture capital may jolt underutilized energy source to prominence

Jeff Johnson

THE SOLAR INDUSTRY received a powerful boost two weeks ago, when Congress passed and President George W. Bush signed a $700 billion bailout package for financial markets. Married to the financial rescue bill were energy-related tax incentives for coal, hydrogen, wind, oil shale, solar, and more.

SEIA

Sun Catcher Acciona Energy's 64-MW concentrating solar power plant in Nevada, the first such U.S. plant to go on-line since 1990, is one of the world's largest.

The solar provisions expand in dollars and extend in years the current tax breaks that would have expired by year's end. The solar incentives now last for eight more years and allow businesses, residents, and utilities to deduct from their federal tax bills 30% of the cost of a solar energy system. Previously, utilities could not directly get the federal break, and benefits for homeowners who wanted rooftop solar panels were capped at $2,000 for a system likely to cost $25,000 to $35,000.

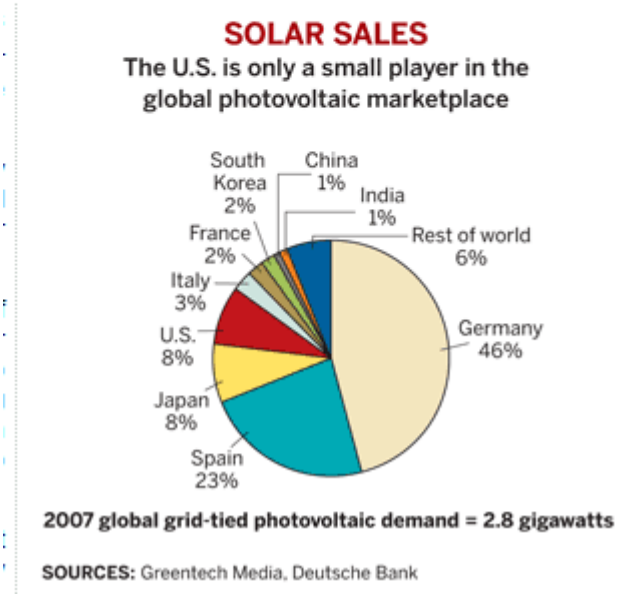
"This is the most significant federal policy ever enacted for the solar industry," stated the Solar Energy Industries Association (SEIA), as the bill became law. In total, the federal solar tax benefits run to around $2 billion over eight years, according to analyses by the congressional Joint Committee on Taxation. They make up only a small part of the $110 billion tax package legislators tacked on to the financial bailout package. Still, $2 billion is a big jump for solar, and it comes at a time when the U.S. solar industry is already experiencing 45% annual growth.

But 45% of almost nothing is very little. The U.S. is a small player in global solar energy. In 2007, the world used about 2.8 gigawatts of solar electricity. Some 46% was consumed in Germany, Spain came next with 23%, and the U.S. and Japan were tied for third, using about 8% each. As a proportion of consumption, however, the U.S. share was much smaller than Japan's because the U.S. consumes four times more electricity than Japan.

Eight years of subsidies is enough time to change the status quo and make solar energy competitive on a watt-by-watt basis with traditional fossil fuels, particularly coal, says Monique Hanis, SEIA's communications director.

For decades, the U.S. solar industry has been on the cusp of a great wave, but so far it has remained an insignificant energy source in this country, providing only one-eighth of 1% of the nation's electricity. The U.S. has a solar electricity capacity of 920 MW that is tied to the electricity grid. Of that, 500 MW is photovoltaic electricity and 420 MW is utility-scale concentrating solar power. Another 2,260 MW of captured solar energy runs equipment such as calculators and road signs, heats water for swimming pools, or has other domestic and industrial uses. But a single coal-fired power plant can produce 500 MW and run hour after hour; photovoltaic systems put out juice for only six or so hours on a typical day.

"Once Solar Reaches Grid Parity In Price With Other Electricity Generators, There Will Be Virtually Limitless Growth Potential."



However, conditions in today's energy world are in flux, and change breeds disruption and upsets old patterns. The days of a coal-based energy economy may be numbered, with competition rising from alternative sources such as solar energy.

Coal, the mainstay of U.S. energy, provides half the nation's electricity. It also produces some 35% of U.S. carbon dioxide emissions, the leading human-generated greenhouse gas. Although Congress has been unwilling to pass legislation limiting CO_2 emissions, environmental and community groups have blocked construction of all but a few new coal-fired power plants. Even utilities themselves are increasingly worried about future dependence on coal in a carbon-constrained world.

FLEDGLING PROJECTS to capture and sequester CO_2 from coal-fired utilities are getting started, but they are decades away. And it remains unclear whether they will work at commercial scale or prove too expensive and make coal uncompetitive with other sources of electricity.

So the race is on for new energy sources to meet the world's future electricity needs, and a host of players—wind, solar, coal with carbon capture and sequestration, geothermal, natural gas, and a new generation of nuclear plants—are all vying with sharp elbows to get to the front of the pack.

Optimistic studies funded by the solar industry estimate that some 28 GW of new solar electricity—equivalent to the electricity output of 28 nuclear power plants—will be produced by 2016 because of the tax extension. According to more realistic assessments, however, some 27 utility-scale projects, totaling 5,400 MW, are in various stages of development. These had been put on hold over fears the tax credits would expire, Hanis says, but are now likely to resume. She calls the tax package a "game changer" for solar energy.

Today, large companies are selling solar products, Hanis says, singling out Dow Corning, DuPont, IBM, Intel, and Applied Materials. "These are big savvy companies with a track record in manufacturing. They now have eight years of stable tax policy during which they can plan and run three-, five-, eight-year-long projects."

Homeowners also will be encouraged, Hanis says, knowing they can knock 30% off the cost of a rooftop solar unit or save even more if they live in states that offer their own solar tax incentives. Some 26 states set renewable energy targets with various incentives to encourage installation of renewable energy sources.

These subsidies are a significant change from the past, when U.S. subsidies were meager compared with those of Japan, Germany, and Spain. Spain and Germany both offer feed-in tariffs that allow producers who use solar energy to sell electricity to utilities at highly inflated prices. The price works out to around 60 cents per kWh, several times higher than the normal retail price of electricity in those countries and a money-maker for the producer.

Along with cutting national CO_2 emissions, the solar subsidies have enabled a domestic solar industry to develop in Germany, Spain, and Japan. Japan ended its subsidy and its rate of domestic solar installations has remained flat, but its industry continues to expand to other parts of the world. Germany and Spain are trimming back the size of the tariff but still have an active industry. The expanded U.S. subsidy is all the more important to solar energy's growth in the U.S. and internationally, says Paul D. Maycock, president of Photovoltaic Energy Systems, a solar consulting firm he created in 1981.

"The world solar market is 80% driven by subsidies," he says. Maycock began working on solar for the federal government in the Ford Administration and has worked on solar energy for longer than the Department of Energy has existed. Over the past few years, he has spent 90% of his time advising anxious financiers by analyzing a flood of proposals from new solar start-up companies trying to raise money to enter this potentially lucrative marketplace.

"We are starting to see a 'solar Silicon Valley,' " Maycock says, "with breakthroughs of the week. Some of the headlines are ridiculous, but some look absolutely great. Still, it remains to be seen if they can pull it off and get their first round of financing."

Applied Materials
Major Module Applied Materials' thin-film solar panels are several times larger than most photovoltaic panels, measuring more than 7 feet on a side and producing 350 to 500 W.

However, he says, the energy and economic environments are changing in ways that will help solar. He predicts a charge for CO_2 emissions is on the horizon, which, coupled with coal's rising prices, will make it tougher for coal to compete.

Coal's leading competitors—nuclear energy and natural gas—are not without problems, however. Nuclear power faces escalating construction costs, lengthy construction times, and huge initial investments—plus radioactive waste. Natural gas is a good complementary fuel to satisfy peak electricity needs at midday, when demand is highest. But its cost continues to rise, driven by electricity and industry use, particularly as a feedstock for chemical companies.

Solar technology, on the other hand, boasts zero fuel costs, modular construction, low maintenance, and high output in midday, when electricity cost is also highest, Maycock says. Furthermore, he and others believe the retail price of electricity generated by solar technologies is approaching that of natural gas. In light of all that solar energy has to offer, Maycock says, "it could be an incredible time for solar."

Larry Kazmerski agrees. He has been in the solar business for more than 30 years and is now director of the National Center for Photovoltaics at the Department of Energy's National Renewable Energy Laboratory. "Last year, I did a search and came up with about $320 million in venture capital investments in thin-film photovoltaic solar technologies in the U.S. alone. That level is over twice what the U.S. government annually puts into its solar R&D program, the Solar America Initiative," Kazmerski notes. "What has happened is that 10 years ago the federal government was the bank for this industry. But now the government can leverage its money to support particular projects and companies. Funding has just switched around."

Kazmerski is a proponent of thin film, one of several photovoltaic technologies. Unlike traditional solar technology using polysilicon wafers, thin-film technology uses silicon or other photoelectric materials that have been deposited on glass or other substrates. Thin film is less efficient in producing electricity from the sun (around 8%) than polysilicon wafers (14%), but it uses less silicon and other materials, is cheaper to make, and lends itself to automated manufacturing (C&EN, July 14, page 11). Traditional silicon-wafer solar panels are used in 90% of photovoltaic technology worldwide.

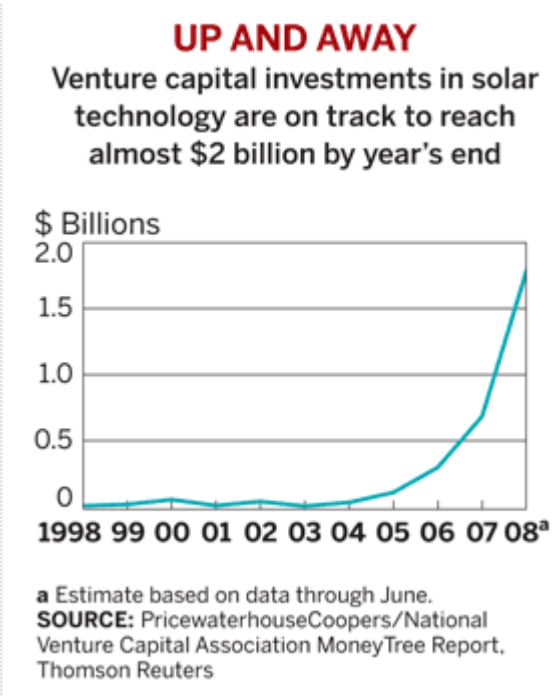
THIN-FILM solar-panel technology was once considered futuristic fantasy, Kazmerski says, but use of thin-film solar panels is growing in the U.S. and now accounts for 30% of the U.S. market, leading to the cheapest solar products on the market.

Kazmerski notes that several companies—First Solar, Applied Materials, and Oerlikon—are making the world's most inexpensive solar modules by using thin-film technology. Equipment manufacturers, rather than materials scientists, have become leading technology developers, he says.

These manufacturers have devised highly automated facilities, he says, where glass flows in one end of a factory and thin-film solar panels come out the other.

For example, Applied Materials, in California, and Oerlikon, a Swiss company, make fully automated turnkey production facilities that manufacture thin-film solar modules and sell the assembly line to manufacturers. Pointing to Applied Materials' background in semiconductors and flat-plate-panel manufacturing, Kazmerski says, "Engineers who know processing and manufacturing have combined with people who know photovoltaics, and they are now driving down the costs."

Jim Cushing, product management director of thin-film products at Applied Materials, explains, "We are always looking for new markets." Applied Materials has produced the world's largest photovoltaic thin-film plate—5.7 m^2 in size with an output of 350 to 500 W, several times larger in both dimension and output than any other module. "We leveraged our capability in semiconductors to the flat-plate liquid-crystal display industry, and then we saw the technology was very similar to technology used in solar. We had the ability to deposit material on large glass, but the challenge was that the rest of the industry wasn't depositing on that large a glass and the equipment didn't exist," Cushing notes.



The company developed a production line for large solar modules; adapted field installation equipment for them; and sold the package to companies interested in making, selling, and installing the panels. Cushing says they have contracts in five countries, worth $3 billion, to develop production lines capable of producing 1.5 GW annually. None of the facilities are in the U.S. yet, Cushing says.

Meanwhile, new solar investments by venture capitalists are on track to reach a record $1.6 billion by the end of the year, according to John S. Taylor, vice president for research with the National Venture Capital Association, a trade association. The growth has been huge, he says, compared with $108 million in 2005. Taylor stresses the importance of venture capital in providing seed money and a lively competitive environment for new product development.

Venture capital investors include Google.org, which to date has put about $45 million in a mix of energy technologies, including geothermal, wind, and plug-in vehicles, as well as solar, according to Dan W. Reicher, director of Climate & Energy Initiatives for the organization. Google's goal is to produce 1 GW of renewable electricity capacity that is cheaper than coal. In the solar arena the company has invested in utility-scale solar thermal companies BrightSource Energy and eSolar Inc.

Google is mostly interested in large-scale solar technologies, Reicher says. "We are also in partnership with General Electric and are looking at getting the grid ready to receive solar and other renewable energy in large-scale applications.

"In the late '70s, there was a major push in solar. Some progress was made and then scaled back, but in the past several years, there has been a real resurgence

in interest propelled by energy security, climate change, and economics," he points out. "The resource is vast and inexhaustible, technology is coming along, and prices are coming down, but solar remains small and we have a long way to go."

SOLAR ENERGY'S FUTURE, he predicts, may be slowed as the global financial crisis deepens and less money is available from traditional investors—banks, financial institutions, and pension funds. However, like other venture capitalists C&EN interviewed, Reicher believes venture capital funding will remain a big player for solar start-ups.

"Clean energy, including solar, is one of the more promising economic areas right now, and I think it will be an important area to bet on in terms of rebuilding the economy," Reicher says.

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"Energy is the most fundamental problem of the 21st century," says Ira Ehrenpreis, general partner at Technology Partners, a clean-technology investment firm with some $750 million under its management. He adds, however, that solar is likely to be just one of many clean energy sources.

Once solar technology reaches "grid parity" in price with other electricity generators, however, "there will be virtually limitless growth potential," Ehrenpreis says. "We are targeting companies with novel technologies that ultimately lead to lower cost per watt than current traditional generation sources," he says, stressing that the company has invested in a diverse portfolio of clean energy sources.

OTHER CLEAN-TECHNOLOGY capital firms have invested in technologies to improve the electrical grid and recycle expensive silicon used to make solar cells. At the same time, they are investing in companies that complement or replace currently operating coal-fired utilities, such as SkyFuel, Ausra, and eSolar. These companies are developing utility-scale solar thermal concentrators that can be built adjacent to coal-fired power plants, producing steam to run the coal plants' turbines and generators, and using the plants' grid connections.

The solar collectors could replace or supplement coal at coal-fired utilities. A spokeswoman with SkyFuel says seven large western utilities are interested in the product.

Trevor Loy, general partner in the venture capital firm Flywheel Ventures, which has funded SkyFuel, notes that clean industries like solar are ripe for "gigantic leaps from innovation." Traditional energy industries have been around for 100 years and require huge investments to modify, Loy notes. Consequently, they are beyond the funding abilities of venture capital.

Photovoltaic Energy Systems' Maycock, ever the optimist, predicts solar will achieve grid parity and be comparable in price with other electricity sources by 2012 or 2013. "We need the subsidy to carry us for the next four years," Maycock says.

"Grid parity doesn't mean cheap solar electricity everywhere," he notes. "Rather, it will be in parts of the country where electricity is relatively expensive and the sun shines often."

Maycock thinks 15% of total electricity would be the solar industry's highest contribution to the U.S. energy economy, but he notes that it has a long way to go to reach that amount.

"We are at one-eighth of 1% now, and even growing at 50% compounded annually, we might get to 4% in 10 years. But my God, we'd all be trillionaires," Maycock says with a laugh. "I think utilities will balk when they have to supply backup power when the sun doesn't shine."

Chemical & Engineering News
ISSN 0009-2347