



**About: Joyce Laird** has an extensive background writing about the electronics industry; semiconductor development, R&D, wafer/foundry/IP and device integration into high density circuit designs.

# SunShot takes aim at PV costs

**Part two:** With its *SunShot* program, the US Department of Energy (DoE) is trying to lead the world in research dedicated to slashing PV costs.

**O**N 4 February U.S. Secretary of Energy Steven Chu introduced the *SunShot* program, which is now the cover program for the *Dollar-per-Watt* (US\$1/W) initiative (see *Mar/Apr 2011, pp 52*). Chu hopes the *SunShot* program will help restore innovation and reestablish US leadership in the solar industry: “We effectively want to bring down the cost of large-scale installations to a dollar-per-watt, which would correspond roughly to about 6 cents per kilowatt hour for general electricity.”

As part of the *SunShot* initiative, Chu highlighted the Government’s substantial investment in the development of the next generation of solar technology. This investment would focus on strengthening the supply chain for solar photovoltaics (PV), he said, including support for materials and tools suppliers, as well as new manufacturing processes.

Finally, funding will also continue for the incubator program designed to support projects that will help commercialise promising new solar technologies. So, in the U.S., it is clear that a lot is going on in PV research.

“Right now solar requires help – incentives and subsidies. But if we can reach the goal of eliminating all of this and reach the cost of a fully installed system that is at the US\$1/W level, that means you’re

generating at a cost comparable or lower than any other method of generating electricity. That’s what we are getting at. We want it to be the low cost alternative without subsidy. With the DoE help to manufacturers, research laboratories, universities, this is achievable. Once that happens, it opens the floodgates to companies in the solar field.”

Jen Stutsman, DoE Officer of Public Affairs works hand in hand with the Director of the US\$1/W program, Dr Ramamoorthy Ramesh, and Secretary Chu. Her focus is in handling how to best communicate the goals of the program.

She says, “if you look at the total clean energy initiatives underway at the Department, beyond *SunShot*, you’ll see that the DoE is looking at the big picture, advancing a broad portfolio of technologies to reduce our dependence on fossil fuels and transition to clean energy resources, including solar, wind, nuclear, biomass, offshore wind, and energy efficiency.

“The *SunShot* program is focused on solar specifically because Secretary Chu has looked at this in great detail and believes the U.S. has both the technological know-how and entrepreneurial spirit to make

“We have both the technological know-how and entrepreneurial spirit to make cost-competitive solar energy a reality by the end of the decade”  
Jen Stutsman, DoE

## A Perspective to Consider

In the opinion of Dr James Winebrake of the **Rochester Institute of Technology (RIT)** all Government subsidies, including the *SunShot* program, are instrumental in moving renewable energy forward. But he believes the focus should be expanded somewhat.

“The benefits[...]of using renewable power are considerable as it relates to reduced greenhouse gases, pollutants and dependency on foreign oil,” he says. “However, in my opinion, subsidies that are aimed at PV and other types of electricity production technologies need to be coupled with subsidies that promote electric vehicles. The transportation sector is the most important area to get under control from an energy security and greenhouse gas standpoint.”

He goes on to say that statistically, over two thirds of U.S. oil consumption alone is used in the transportation sector, not in the electricity sector. Only approximately 2% of US electrical generation consumes foreign oil or petroleum.

“What would really be useful and interesting would be if the Government coupled subsidies for PV and other renewable power generation sources with those for electric vehicles. For instance incentives for utilities to install PV simultaneously, marrying an incentive to the public for the purchase of electric vehicles. Then the utilities would be providing clean, renewable PV power to run the incentive-purchased consumer

transportation. Then you would really start to see the benefit of PV as an energy security venue,” he says.

Winebrake notes that the economic PV return on investment is largely based on where systems are installed geographically. The economics differ as to whether PV could be more effective – for example a PV system in Southern Europe vs. a PV system in Northern Europe. “It will be interesting as to how the subsidies play out regarding regional and geographic initiatives for PV technologies,” he says.

He also believes that education is another issue that has fallen to the back burner in recent years. Energy production, storage, transmission and use of a smart grid to use electricity efficiently are all technologies needed.

“There needs to be a resurgence in the power engineering area and there needs to be an investment in... colleges and universities to bring back the interest in power engineering degrees, and courses of study to train the next generation of professions who can work on reinvigorating and refurbishing our dying electrical grid system. That is a key area where Government[s] should really be investing; in engineering students.”

He concludes that if the PV market starts to really boom in the U.S. and elsewhere because of things like *SunShot*, that will stimulate the market and make it more financially attractive to the new generation of electrical engineers who will carry this goal forward.

cost-competitive solar energy a reality by the end of the decade.”

### Talking to the experts about reducing cost

Many *SunShot* workshops are continuing and participants come from every area of the solar chain. Opinions vary depending on what the focus of each company is, but the overall enthusiasm of working toward a singular goal is something that runs through the meetings.

**SunPower** (CA, U.S.) has been working with DoE for more than 25 years. Julie Blunden, EVP for Public Policy & Corporate Communications, says that because of SunPower’s vertical integration, the company sees a great opportunity in joining hands within the workshops in the DoE *SunShot*/dollar-per-watt program. “We go all the way from ingot growing and wafering on a joint venture basis to installation at the larger scale and service of installed systems. Therefore,

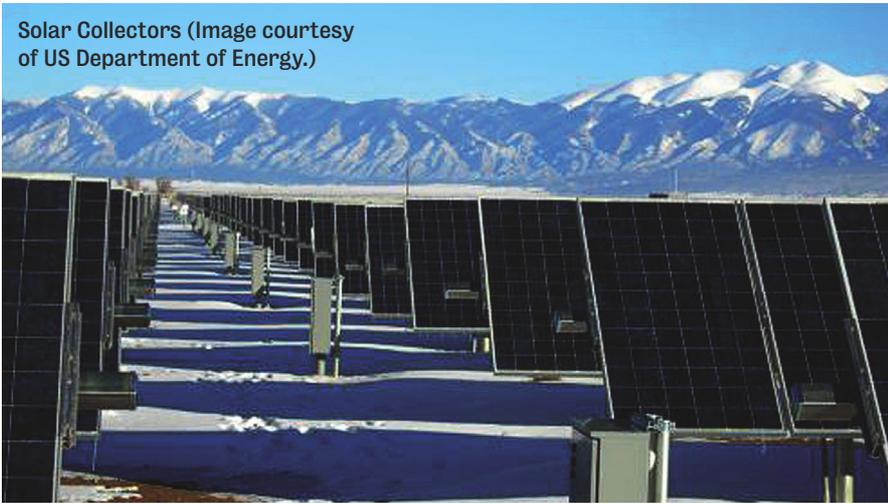
we have a very comprehensive understanding of the system in depth. In the solar community we span most of the supply chain to commercial sales and service ourselves. We have a unique perspective of how valuable a complete handshake across the entire value chain is to bring down solar costs.”

Blunden believes that the goal is definitely possible if the real focus is less on the dollar-per-watt and is simply focused on making solar competitive with the existing fossil fuel fleet. “If you can get down into the mid-cents per kilowatt hour, that puts you into the game,” she says.

SunPower has added to that area with innovations developed with the help of DoE funding, such as the *SunPower T5 Solar Roof Tile* which **Southern California Edison (SCE)** is using in rooftop solar systems. “It is revolutionary in that it has a single unit that essentially gets rid of the aluminum, and turns a laminate into an entire system - through the framing of the laminate in a polymer that essentially fits into the next system on either side, like Lego. Therefore, instead of making a frame and then a racking system, we have collapsed those two things into a single item with a longer shelf-life and less than half the installation cost,” Blunden says.

Mark Petri, technology development director in the *Energy Engineering and Systems Analysis Directorate* at **Argonne National Laboratory**, represents Argonne at DoE workshops. Petri coordinates the entire laboratory’s portfolio of alternative energy and efficiency, and power grid work, which gives him a bird’s-eye perspective of many issues. “The two things that struck me about the solar energy workshop were the very close collaboration DoE was having with **EERE** [DoE’s office of **Energy Efficiency and Renewable Energy**], and the enthusiasm from the participants. This told me that both agencies were serious about the goals,” Petri says. “In the current workshop participants were looking at what is on the table today. There are silicon cells. How can we reduce the cost of those today? A big part of the cost is the actual material itself. The efficiencies are not really the issue. If you can get 20% efficiency you are probably doing

Solar Collectors (Image courtesy of US Department of Energy.)



Research facility at Dow Solar Solutions (Image courtesy of Dow Corning, Dow Solar Solutions.)



pretty good. But you need to reduce the material cost. Once the goal of a dollar-per-watt was on the table, the focus immediately turned from how do I make my solar cells more effective to how can I reduce silicon waste.

“One of the things I found interesting was there was a debate on

thin-film vs. glass-encased rigid panels, and it was an interesting perspective from the balance of plant people. As a scientist I think thin-film is kind of cool because it can be used in so many different applications, but for actual bulk power, the engineers and the installation experts said that

thin-film did not hold any advantage over standard mounted silicon. I found that interesting,” he says. “They said that the flexible PVs don’t necessarily lend themselves to being any better on roof mounted systems. In particular because of wind loads. The weight of the glass encased systems actually added safety to the installation. That was a perspective I never had before.”

Eric Peeters, Vice President, **Dow Corning Solar Business** (Midland, MI, U.S.) says that they enthusiastically support the goal to reduce cost without the need of subsidies. “Dow Corning’s entire solar portfolio is built around the goal of bringing material-based solutions to the photovoltaic supply chain to help our customers successfully reduce the cost of solar energy,” he says. “While clearly, solar needs Government subsidies today, the goal should be to get to the point where that is no longer needed as quickly as possible.”

Dow Corning holds a technology agnostic portfolio that addresses all areas of PV technology. “We know that we need to look at innovating all technologies,” Peeters says. For example, Dow Corning, and its Hemlock Semiconductor Group joint ventures, has invested over US\$5 billion in solar materials, manufacturing capacity and technology development in the last five years. By 2015, Dow Corning says the joint ventures will have increased polysilicon manufacturing capacity by up to 10 times over a 10-year span. Additionally, Dow Corning is constructing a plant in Hemlock, MI, to manufacture monosilane gas – a key material used to manufacture thin-film solar cells.

Peeters sees solar energy as a phenomenal economic opportunity also because the true growth of the solar market means jobs around the world. “Jobs are a huge part of the solar industry. This also stimulates new engineers and scientists in schools and universities. Like the solar chain, it is also a plus to both the overall educational and economic chain.”

Jamie Hahn, Managing Director of **Solis Partners Inc** (NJ, U.S.) takes a financial slant on the whole PV perspective as a growth focus for the market. “As a developer and systems integrator, I can tell you that the

**“Once the goal of a dollar-per-watt was on the table, the focus immediately turned from how do I make my solar cells more effective to how can I reduce silicon waste”**  
**Mark Petri, Argonne National Laboratory**

Sun in, electricity out.

If only everything in the future  
could be so predictable.



## INCREDIBLY STABLE FORECAST.

Solar modules from SCHOTT Solar have what it takes for long-term attractive revenues: high performance stability\*, the quality of a renowned German technology company and experience in solar technology since 1958.

More information at  
[schottsolar.com/solar-yield](http://schottsolar.com/solar-yield)



SCHOTT  
solar

\* In a long-term study conducted by the Fraunhofer-Institute the SCHOTT Solar modules still achieved over 90% of their original performance even after 25 years.

*whatever the future holds.*



SunPower solar system  
(Image courtesy of  
SunPower Corporation.)



Jeff Elam (Chemist)  
and Anil Mane (Materials Scientist), working  
on the scale up of ALD  
for PV (Image courtesy  
of Argonne National  
Laboratory.)

## “It’s good to have lofty goals, but you have to have your feet on the ground” Jamie Hahn, Solis Partners

industry as a whole has made great strides in renewables since the first silicon solar cell from **Bell Labs** in 1954, but they have been very small, incremental improvements. Today the average solar module efficiency ratings are between 14% and 16% and there is still a very long way to go. It’s good to have lofty goals, but you have to have your feet on the ground,” he says.

Hahn believes that New Jersey is in a good place and has done a good job in stimulating the market, creating a broad variety of job growth. “There are bumps in the road and we know there will be more in the future, but at least

we are on the road and moving forward. The state made a decision back in 2007 that the traditional rebate system did not work. It has proven not to be a sustainable model due to the fact that the rebate funds allocated in any given energy year tended to become depleted quicker and quicker, which created a start-and-stop mentality in the marketplace.

“This uncertainty creates more risk and limits the amount of capital coming into the market. So spreading it across a 15-year, production-based incentive program that is supported by the load-serving entities (LSEs)

provides a much more sustainable program. The increased certainty lowers risk which in turn lowers the return requirement on the capital. By bringing in more competitive capital, there is more capital competing for jobs and ultimately, that lowers the cost of installed solar. Many states are looking to New Jersey as a potential model to follow,” he says.

Peter Rive, is the Co-Founder and COO of **SolarCity** (CA, U.S.).

Rive was a participant in the first workshop held on the US\$1/W program in 2010, and plans to be a consistent participant, mainly to keep a balanced perspective and making sure the system integrator’s voice is clearly heard. “I think the overall goal here is to focus the whole industry on a goal and to bring all areas of the industry together with DoE, so that the DoE can then focus on policies that can help get us there,” he says.

As a business, SolarCity looks at PV from a holistic point of view. “It’s not what technology to use, it is which is the most cost-effective and gives the best results for the project. We work with everything. It has to be the best technology at the best price and best efficiency for the specific installation and area. We work with thin-film, silicon, micro inverters...anything that works,” Rive says.

When asked about the SunShot program goal of US\$1/W installed system by 2017, Rive says that from a utility perspective, this may be achievable, but from the commercial and residential point of view, a more realistic goal of even US\$3/Wh without incentives would be a great boost to the industry as a whole. “If you reduce the cost of capital and increase demand and can sell solar at 18 cents a kilowatt hour without incentives, the industry would grow dramatically. It would be amazing,” he says.

### The lab level going strong

Argonne National Laboratory currently has several projects being funded out of umbrella programs at DoE under the *Solar Energy Technology Program (SETP)*. While still in the realm of the dollar-per-watt program, these fall into the area of long-term research. Key to the PV projects is the atomic



Solis installation in New Jersey (Image courtesy of Solis Partners, Inc.)

layer deposition (ALD) technologies research program, which is associated with two studies: Growing PV using copper sulfide ( $\text{Cu}_2\text{S}$ ) and nanostructured transparent conductors (TCs). Dr Seth Darling is a scientist and solar energy strategy leader at Argonne. The programs each have their own principal investigators: Dr Jeff Elam for the TCs and Dr Alex Martinson for the  $\text{Cu}_2\text{S}$ .

“These are part of the next-generation PV program. The reason we are using copper sulphide is that it is an abundant material. There is a lot of copper and sulphur out there, unlike formulas based on indium or tellurium, which are limited materials,” Darling explains. “Traditional methods of making copper sulphides for photovoltaics don’t work very well. By using ALD we can create a nanoscale, interdigitated structure by depositing the copper sulphide material onto nanoscale interdigitated substrates. That allows us to enhance performance. We basically take these materials that normally don’t perform very well when they are in a traditional film, and get better performance out of them.”

Also based on ALD technology is a new form of transparent conductors. “You need one of your electrodes to be transparent to let the light in, but the reason we want to use ALD is we believe a lot of these next-generation

PV technologies are going to be nanostructured,” Darling says. “You need a way to deposit the transparent conductors onto these highly three dimensional, nanostructured architectures such as with the copper sulphide. ALD is the ideal method because it can deposit conformally over convoluted, three dimensional structures easily.”

Darling adds that an additional advantage is that using ALD provides a beautiful conformal coating that covers all the surfaces uniformly, using very little material. “You normally need a thick transparent conductor layer to ensure you don’t have any holes. But with ALD, you can grow a very thin layer without any holes and therefore use much less material,” he says.

Even with conventional technology, ALD offers a cost reduction. Indium tin oxide is the classic transparent conductor layer in PV, however Indium is expensive because it is a rare material. Using ALD, you can use less of it and get the same performance. “You can minimise the amount you’re using and also minimise how far the charges have to go to get to the electrode with the newest nanostructured designs, so you get better performance that way as well. The biggest key however is that you need to be able to deposit on these next generation nanostructures and traditional deposition just can’t do that.

Even if you wanted to, you just can’t do it. ALD can do both. It can save cost on today’s technology and also penetrate deeply into nanostructures.”

These projects are only about a year and a half into development and per Darling, they are past the small test pieces. They’ve demonstrated that transparent conductors can be deposited onto substrates that are quite large – 12 x 12 inches.

### Addressing the bottom line

Blunden puts it pretty succinctly when she says, “the reality is that within the 2017 time frame, what we will be talking about is solar becoming the new number one and number two energy resource in the United States. I emphasise the word *new*. Are we going to turn off the entire coal fleet and replace it with solar power between 2014 and 2017? No. We may do a quarter or a third of the coal fleet due to EPA regulations, but that’s going to be over a period of 2014 through 2020.

“The real question is how do we get from today’s prices with roadmaps to a number that is in the 10 cent range and how many more people will start using solar because the systems will cost so much less over the lifetime of the system. It will be easier, more in reach for all residential, schools, businesses, public buildings and utilities. In reality, the changes will have some improvement in efficiency, but we are only talking about going from 20% to 22.5%. The real cost-saving is the full system, not the efficiency of the modules,” she adds.

Leading scientists tend to agree that the ultimate answer will be a handshake across technologies in some form. Perhaps a totally new paradigm shift that will bring about a previously unknown form of solar system. Only time will tell.

e: [Joyce.Laird@REF.contributor.com](mailto:Joyce.Laird@REF.contributor.com)

*This article is the second in the Dollar-per-watt series (the first article, PV’s falling costs, appeared in the March/April 2011 issue, p. 52). The next article will focus on the BOS area and all of its complexities, including LCOE over the lifetime of an installed system. NB: Articles first published in **Renewable Energy Focus U.S.** magazine.*

“The real question is how do we get from today’s prices with roadmaps to a number that is in the 10 cent range”  
Julie Blunden, SunPower