



About: Based in California, **Joyce Laird** has been writing for a wide range of industrial magazines for over a decade. Her extensive background in the semiconductor industry created a perfect transition to covering developments in photovoltaics.

Cover story

The Biggest Challenge

In the final installation on the **Department of Energy's (DoE) SunShot-US\$1/W** program, the biggest challenge of them all, the balance of system (BOS), is addressed.

BOS FALLS into two main divisions; the hard costs for installation materials and labor; and the soft costs, which can truly add up fast: Financing, permitting, inspections, specialized paperwork for regional and national incentives, etc.

When DoE went looking for the right person to head up the new *Solar Energy Technology Program*, Secretary of Energy Steven Chu wanted somebody with a semiconductor background but also somebody who was not integral to any of the inside markets in the solar system chain. Someone with the knowledge, but without a vested interest in an area, who could look at the whole picture with an open mind. He found what he was looking for in Dr Ramamoorthy Ramesh, Resident Professor at **UC Berkley**.

Online: renewableenergyfocususa.com

Wired for Solar

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<http://tinyurl.com/3z9mbxn>

PV innovations: Solar thin-film technology update

<http://tinyurl.com/3fvw46r>

Solar Powered Carrots in California

<http://tinyurl.com/3rjlkry>

High Concentrating PV Project Loan Guarantee

<http://tinyurl.com/3atvl8g>

An AREVA installed CSP system. (Courtesy of AREVA Solar.)



“In name, I am the lead on the *Initiative*. But in reality, a large pool of people throughout DoE, the national labs, academia and industry are all working with this program. We are working together toward a single goal – just from different directions,” Ramesh says. “Our goal for SunShot is to get solar down to about 6 cents a kilowatt hour without subsidies, making it cost competitive with other forms of electricity.

“On the soft BOS side, permitting needs to be greatly improved and streamlined nationwide,” Ramesh adds. “We want as many areas involved in these workshops as possible so we can draw on the very best of all ideas from all perspectives.”

Beyond the basics of the installed solar photovoltaic (PV) cost, Ramesh says that they will also be focusing on the levelized cost of energy (LCOE) and distributed power, and how to approach the issue of developing a more modern, smart grid with potential for power storage. Of all the areas, Ramesh says that the BOS is probably the most difficult problem to deal with because it is hard to pinpoint clearly.

“In our workshops, our goal is to define all these qualities. Where are

they? What leads to the cost? What can be done to reduce the cost? We are providing a framework where people who don’t normally interface, can come together.”

Within the BOS workshops, a big part is how to address the issue of every state and every utility having individual paperwork. Some installers have said that this can be 50% and more of the total installation cost. Ramesh says that DoE is trying to work to streamline the permitting processes and take advantage of information technology systems that could significantly reduce costs for cities and counties that manage local permitting.

Opinions from the Commercial Sector

Eric Peeters, Vice President, **Dow Corning Solar Business** notes that the BOS cost in the US is strikingly higher than in Europe. “The reason for this is not necessarily the complexity of permits and paperwork. Much has a lot to do with economies of scale. However, the industry in general whether in Europe or the US, has not focused enough on the innovations that are possible on the BOS side. This is the next big area to tackle,” he says.

To bridge the gap with academia, Dow Corning and the **University of Toledo** signed a memorandum of understanding (MoU) to engage in collaborative discussions on solar PV research and development efforts to help reduce the cost of solar energy to

make it a viable and economically competitive energy option globally.

The University of Toledo is well known for thin-film technology, while Dow Corning in partnership with **Hemlock Semiconductor**, is known to be one of the leading suppliers of crystalline silicon materials. It’s an immediate handshake. “We are taking a total value chain approach with this research center from raw feedstock to installation, while also looking for the best innovations across all areas, including those not yet developed,” Peeters says.

Peter Rive, Co-Founder and COO of **Solar City**, notes that the capital component also needs to be considered within the *SunShot* program. “What is driving the cost of capital? That is something that is very interesting to discuss with the DoE because it is something they may actually have more control over rather than the technology side,” he says. “But more than anything else, I think the key point for me is the entire program needs to refocus on the dollar per kilowatt hour number, not the dollar-a-watt.”

Like many others, Rive also brings up the soft costs such as a need for standardizing permitting: “Permitting cost and paperwork is definitely something that can be controlled by a government organization,” he says. “The hard costs, modules, electronics and so forth are dominating the conversation right now because they are easy to see, easy to describe, easy to define where cost

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**Dr Ramamoorthy Ramesh,
 UC Berkley**

issues stand. The soft costs tend to fall into the background. We participate to make sure they have an equal voice. We need to keep the DoE informed so they understand the issues.”

Jamie Hahn, Managing Director of **Solis Partners Inc**, agrees that for lowering the overall cost of the BOS, standardization of permitting is one of the first things the Government should focus on if they want to really reduce the cost of an installation nationwide.

“We’ve seen minor advancements that reduce labor time to install, but the paperwork trail has not changed. Innovations in the area of actual installation will help and will come from system component manufacturers, but streamlining the paperwork and

permitting is something the Government can actually control itself,” Hahn says.

Headquartered in Charlotte, NC, **Providence Solar LLC** is a developer and independent power producer. The company finds sites and brings the investors in. Then they source the capital and negotiate with the power companies. “We build the sites and get the interconnection agreements and then we operate them. We are mostly in North Carolina because there are good tax credits and the Carolinas are very energy friendly,” CEO Tom Kepper says.

He notes that some costs fall outside of the control of project management, such as the paperwork side and the

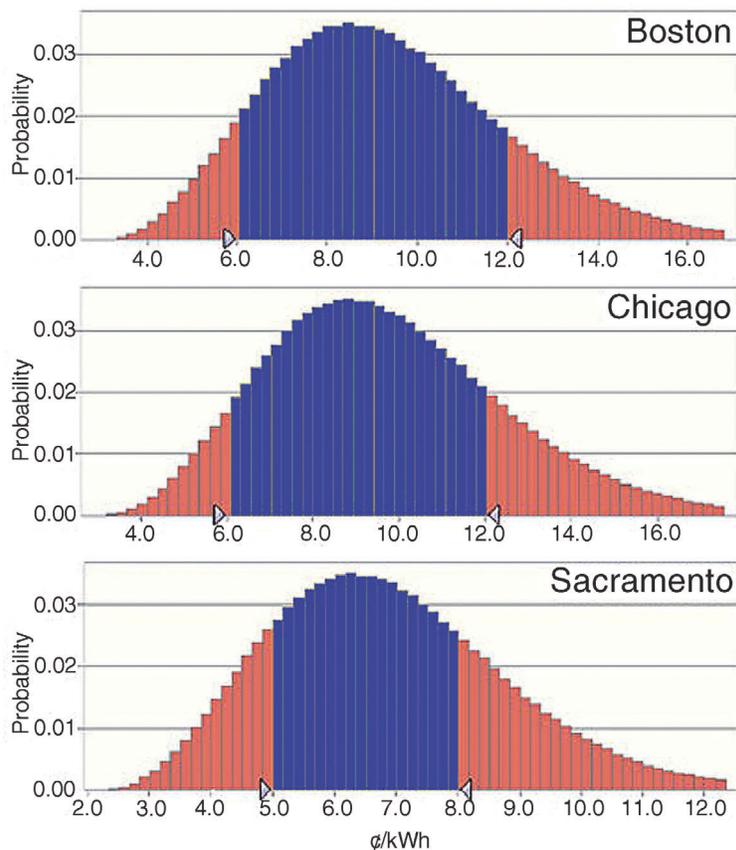
professional fees that must be met to finalize any major installment project. There are also commodities such as copper wiring and aluminum for racking. “This is where the consolidation of installation devices into actual solar panels or panels that eliminate racking entirely are looking like very good options,” he says.

Based in Brooklyn, NY, and with offices throughout New Jersey, **Solar Rainbow Services LLC** manages every aspect of project execution - from site acquisition, to engineering and long-term maintenance.

“We have strategically teamed up with renowned PV designers and engineers, warranty certified roofers, financial institutions as well as energy utilities in order to assist clients with the confidence and opportunity to go green,” Solar Bawabeh, CEO and Co-Founder says. He agrees with Kepper, that when discussing BOS components, much of the material needed for a PV system can’t easily be cost-controlled. But as far as permitting is concerned, it depends on the state. “New Jersey has been very aggressive in accommodating the solar industry. They see how much we, as an industry, have done in creating jobs and helping the economy so they have basically streamlined the paperwork process,” he says.

Bawabeh believes that DoE needs to step up and define a national uniform process. “What is really needed today to get more of these systems installed, is developing a good financeable model. There is no accepted financial model for solar based solely on the systems output. If funds can be readily found from banks, investment firms or Wall Street, more installations will take place and, all prices will automatically start decreasing rapidly for all installations everywhere,” he predicts.

Michael Miskovsky, President of **Zep Solar**, has participated in a number of the conferences within the SunShot program. “It hasn’t escaped notice that the BOS issues of the program all mirror our business plan,” he says. “As a



To be effective LCOE must take a full approach to all costs. Illustration from Royal Society of Chemistry: S.B. Darling et al., “Assumptions and the levelized cost of energy for photovoltaics,” *Energy Environ. Sci.* (in press). DOI: 10.1039/c0ee00698j. (Courtesy of Argonne National Laboratory.)

Solar Initiative Goes Beyond PV

With global headquarters in France, **AREVA** is well known as a giant in the nuclear area, and is also a leader in solutions for all types of CO₂-free power generation. **AREVA Solar**, based in Mountain View, CA, operates in the United States, India, and Australia. Areva has been involved in many of the DoE SunShot programs.

“We are working very closely with the DoE to understand what they need and what they have available in terms of support. AREVA has been in the renewables business for almost five years now,” Jayesh Goyal, Vice President, North American Sales at AREVA Solar says. “We entered the solar business about a year ago with the acquisition of **Ausra**.”

Goyal explains that the solar area they are involved in is concentrated solar power (CSP) using *Compact Linear Fresnel Reflector (CLFR)* technology.

Unlike concentrating PV (CPV) or standard PV systems, CSP provides

some thermal inertia, so it can still generate power during short periods when the sun is not available, making it easier to integrate with the electric grid.

For the immediate future, AREVA Solar is concentrating on projects at the utility or industrial level. But Goyal says that AREVA is keeping all options open regarding other technologies. “We are focused right now on solar thermal, but we certainly have not ruled out any of the other solar technologies. I think that is one of the benefits we bring to the industry in terms of our ability to backstop these projects and make them bankable because of our years of experience with utilities. Financers see AREVA as a credible entity standing behind these projects. Certainly we are planning to play a big role in the industry. Companies like AREVA that have solid industry knowledge are going to be the ones that add direction to the DoE programs.”

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company we are on a mission to drive down BOS cost.”

Zep Solar, offers a patented auto-grounding, drop-in mounting solution that, according to Miskovsky, can save over US\$0.50/W in installation time and material waste. “Our hardware is designed to mate with solar modules manufactured with the *Zep Groove*, a specialized slot in the PV frame that

enables the rapid coupling and automatic grounding of solar modules. The Zep System requires no rails, making it easier to ship, warehouse and install,” he says.

Zep Solar licenses its groove design technology directly to major global module manufacturers. **Canadian Solar’s NewEdge** modules come with the Zep Groove. “**Trina Solar** will be

using our design on a line of modules they call *TrinaMount*. This will come out in the second half of 2011,” Miskovsky says. “The system allows system owners to cut installation costs up to 50% and installation time up to 75%.”

The Science Behind LCOE

Whenever you start talking about a cost-based strategy like SunShot, you have to have a proper handle on the true costs. Dr Seth B. Darling, scientist at **Argonne National Laboratory**, says that the problem with cost-per-watt is that it is talking about the initial capital costs of the system and then vendor specified performance data. “The vendor says you’re going to get 15% efficiency. But, that’s going to depend on your geographic location,” he says. “You also don’t know exactly how much sunshine your system will see, what the maintenance costs will be, and so on. LCOE is the better metric. It accounts for both lifetime cost and lifetime energy production. That is the true comparison between different PV technologies and really between any type of energy production/delivery technology, regardless of what it is.”

However, per Darling, traditional LCOE calculations take singular values to do their equations. Although a start, it’s not enough. “Sunlight varies in any given location. You can’t just use one specific value because it can’t be said with certainty that this is what the sunlight is going to be, day after day, year after year, over a 30 year period. That goes for all the inputs in the calculation. You can’t say for certain what the insolation will be, what the cell efficiency will be, what the degradation rate will be. For financing, what the discount rate is going to be over the lifetime of the system,” Darling says.

What Argonne did was capture those uncertainties by instead of plugging in just one number, built a distribution of values based on the best available data. “We looked back at the distribution of sunlight over the past 30 years in several locations, and did some statistics on that and came up



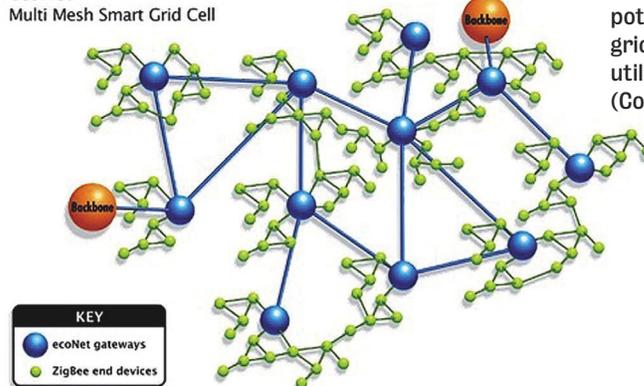
The NexGrid system provides computer interface for the consumer. (Courtesy of NexGrid.)

with an informed probability distribution of that value –what the sunlight might be like in the coming 30 years.”

“If you do that for all the areas that go into an LCOE calculation, you come out with what is called a *Monte Carlo* simulation; which is a standard mathematical technique. This pulls data from all of those distributions according to their probabilities in a random way and simulates random pulls a million times. By doing this from all input distributions, you wind up with an LCOE that is also a probability distribution. Instead of claiming the LCOE will be US\$0.15/kWh, the LCOE will be between US\$0.08/kWh and US\$0.22/kWh with some defined certainty using all the combined probabilities. It is a way to capture the cost uncertainties when it comes to photovoltaics.”

By giving a low and a high, the new LCOE calculation basically provides confidence in the calculated projection. “We can say with 90% confidence that this is what the costs will be. It is much

ecoNet
Multi Mesh Smart Grid Cell



An illustration of the potential using a smart grid interface between utility and customer. (Courtesy of NexGrid.)

more informative to all the stakeholders: Regulators, investors, technologists. Everyone involved in the game now has much deeper information as to what the true costs are and to also pinpoint any areas where the uncertainties are and tighten those up,” Darling says.

Darling notes that in doing this program they learned that there was not a lot of good data in the Midwest to base these calculations on. “To do a real LCOE calculation, you need that information to plug in, so we are forming what we call the **Midwest Photovoltaics Analysis Facility (MPAF)**. Initially, it will be one facility, but we want to have multiple sites where we will collect real world performance data from a wide variety of commercial PV module technologies. Crystalline silicon, polysilicon, amorphous silicon, CdTe, CIGS and so forth using multiple panels of each one.

“We will be collecting real world solar panel data along with ultra local meteorological data so there will be a weather station right there that collects the temperature, sunlight, humidity and

so forth. By collecting real performance data and meteorological data for that specific location, we get correlation data for instance between the amount of sunlight and the conversion efficiency for these specific technologies.”

Understanding the Smart Grid

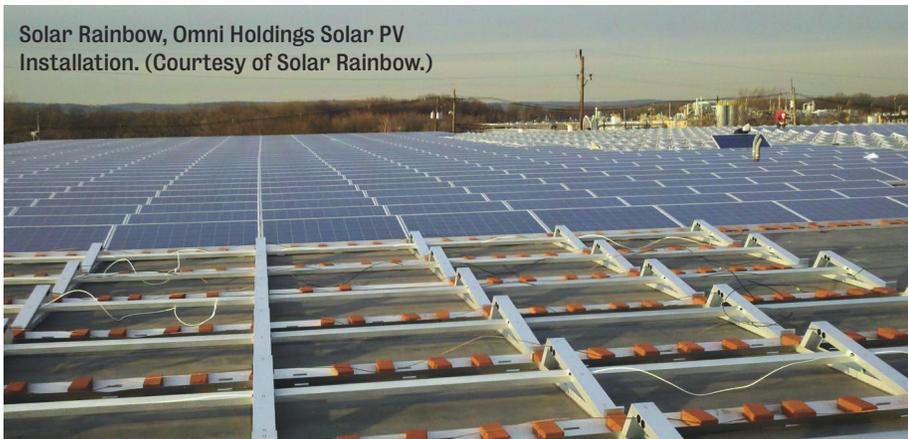
Power storage, transmission and distribution are the combined holy grail of all renewable energy generation. Once there is a good solution for storing the power for future distribution and use on demand, that will be the time of true renewable revolution.

If any company knows about the benefits of a true smart grid, **NexGrid** is the source. This Virginia company has been dedicated to pushing the standards that will support the development of a national, and potentially global, smart grid system for over two years. It isn’t just talk. They currently have 7 utility customers onboard using their technology.

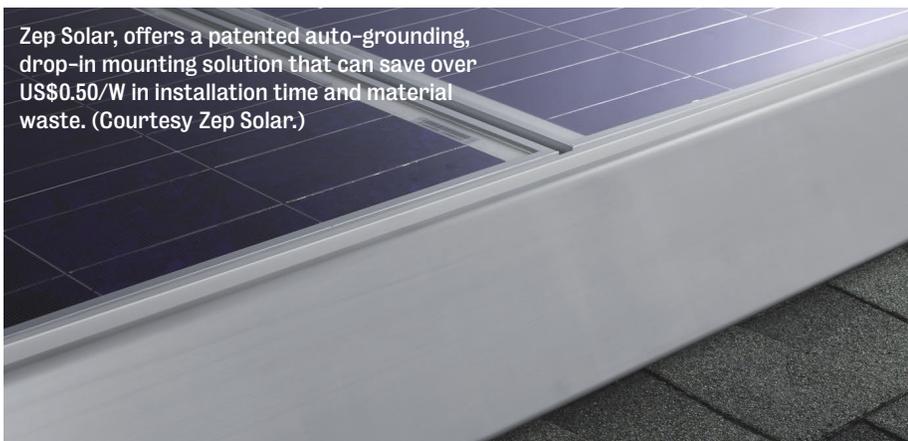
“We go for pure standards. We didn’t want to get involved in any proprietary services for networking that would lock in any utilities to using any particular vendor,” John Espey, Chief Operations Officer says. “We work on the distribution side. What we are trying to accomplish with the smart grid is to make it be like the internet. It grew out of standards, telecommunications equipment and easy-to-use software so people could access it through an intuitive web browser. We are working on the distribution side of the smart grid

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Argonne National Laboratory

Solar Rainbow, Omni Holdings Solar PV Installation. (Courtesy of Solar Rainbow.)



Zep Solar, offers a patented auto-grounding, drop-in mounting solution that can save over US\$0.50/W in installation time and material waste. (Courtesy Zep Solar.)



“Cisco recently said they believe that they will sell two or three times as much gear for the smart grid than they did for the internet as a whole. That’s how big they think this market can be for them.”

John Espey, NexGrid

to enable customers and utilities to get better transparency as to what is going on within that distribution grid,” Espey says.

Espey explains that the only way this can happen is through standards. “It’s the same as with the internet. To be plug and play, internet standards were developed around things like JavaScript, HTML, Ethernet, TCP/IP,

HTTP that work in the background. This is how we are approaching this idea of a smart grid.”

Both **GE** and **Whirlpool** have announced plans that they will be embedding a wireless *ZigBee* communications into every single appliance. When NexGrid installs a system, they currently put a ZigBee chip inside of the meter to allow real time

communications from the meter. “Once you have that, it gets really powerful because both the utility and the customer can not only see overall power usage but they can pinpoint it down to each appliance and device in the home or business.”

To be truly effective, storage and transmission issues are also technologies that need to be developed as part of a smart grid. And having that capability nationwide, would also level out the cost of energy by allowing areas in need to draw from areas with surplus.

“When you get smart meters and real time communications usage networks, you can make better systems. You can control your distribution systems in real time. Part of that would be with storage with routing across states. It would allow intelligent real time decisions. At that point, decisions can be automated, based on real time demand knowledge and pre-programmed thresholds. Again it gets back to the standards. You need solid sets of universal standards so multiple smart grids can communicate efficiently in real time.

“**Cisco** recently said they believe that they will sell two or three times as much gear for the smart grid than they did for the internet as a whole. That’s how big they think this market can be for them. It’s changing a mindset and the forward looking utility companies are making the change,” Espey concludes.

Recap

The major issues affecting BOS are: Reducing the amount of parts needed on the hard cost side, getting the Government to streamline the soft cost side, and utilizing an effective LCOE algorithm so the true installed lifetime cost can be known. Finally, without an updated grid that can handle efficient energy storage, transmission and distribution nationwide, as much as 30% of energy generated by clean technology will go to waste, again translating into financial losses. Each has its own separate challenge, but the bottom line is the same for all – saving money.

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