Solar Poised for Explosive Growth

By Andrew Beebe, Chief Commercial Officer, Suntech America

The United States has potential to become the world's largest market for solar power over the next five years. This growth, however, will depend on three key factors: better panels, better PV plant construction and a better understanding of PV's value proposition.

When I got into the solar industry in 2002, photovoltaics (PV) had a reputation as being an expensive, green window-dressing for liberal yuppies. If that ever were true, it's not anymore. Today, in sunny regions such as the desert southwest, solar projects can deliver clean electricity for less than $0.10/kWh, without government subsidies. And PV generates power when grid operators need it most.

Although all electrons are made equal, an electron generated between 12 p.m. and 6 p.m. is worth a lot more than an electron generated between 12 a.m. and 6 a.m. Just ask the Electricity Reliability Council of Texas (ERCOT), which operates one of the world's largest power grids. This past summer they experienced record peak power demands, raising the spectrum of rolling blackouts and asked electricity consumers to conserve electricity from 3 to 7 p.m.

Power supply challenges are not limited to peak power shortages. The glaring risk for utilities is not the volatility of solar or other renewables, but the long-term volatility of coal and gas prices and their ability to meet growing power demands in a reliable and cost-effective manner. Global power demand will likely triple this century, driven largely by fresh appetites from throughout Asia and Africa. Realistically, finite fossil fuel supplies will not be able to match growing demand and it's all but certain that fuel prices will rise and fluctuate under supply constraints.

Solar technology serves as a reliable hedge against rising fossil fuel prices, as utilities can lock-in a solar power rate today for at least 25 years. That won't change as long as sunlight remains free. Solar projects also have the added benefit of creating about seven times more jobs than fossil fuel power plants, particularly valuable in this challenging macroeconomic environment. That partly explains why solar is one of the fastest-growing industries in the U.S., employing nearly 100,000 professionals and creating thousands of new jobs each year.

Although solar offers a competitive value proposition in today's market, there's still room for improvement and that will be necessary for solar to become the leading source of power generation in the U.S. The price of solar electricity has declined on average by about 15 percent each year over the past 20 years, even faster in 2011. That trend must continue over the next few years so that the industry can compete in the open market against all sources of traditional generation.

Although electricity is a commodity, the solutions used to generate electricity are not. In the current highly-competitive market environment, several superior solar technology providers are emerging from the pack. According to a report from IMS research, the top 10 global solar module manufacturers gained 10 percent market share over the last year, a healthy sign of a maturing industry. The market is rewarding bankable suppliers of high-quality, low-cost PV products. In other words, customers are choosing the products that will deliver the lowest possible levelized cost of solar electricity for consumers. The market is working like it should. To remain competitive, leading panel manufacturers must continue to improve the performance of their products by roughly 10 percent a year while reducing the costs by just as much or more.

In addition to competition in PV module manufacturing, we're also seeing greater competition in power plant construction, which, along with other balance-of-systems costs, typically accounts for more than half of the costs of solar electricity. As the solar industry uncovers unprecedented, long-term market opportunities, established engineering, procurement and construction contractors are getting interested and bringing decades of experience building carbon-based power plants to the table. That's an exciting validation for the industry.

Each year in the U.S. we're seeing the construction of multi-hundred megawatt solar projects and estimates for 2012 foresee more utility-scale PV solar installations in the U.S. than residential or commercial solar projects combined. By 2015, we're anticipating roughly 5 to 6 GW of total annual installations in the U.S. of which 70 to 80 percent will be utility-scale projects. Healthy competition is improving the economics of large-scale power plant construction, ultimately driving down the price of solar electricity for utilities and ratepayers.

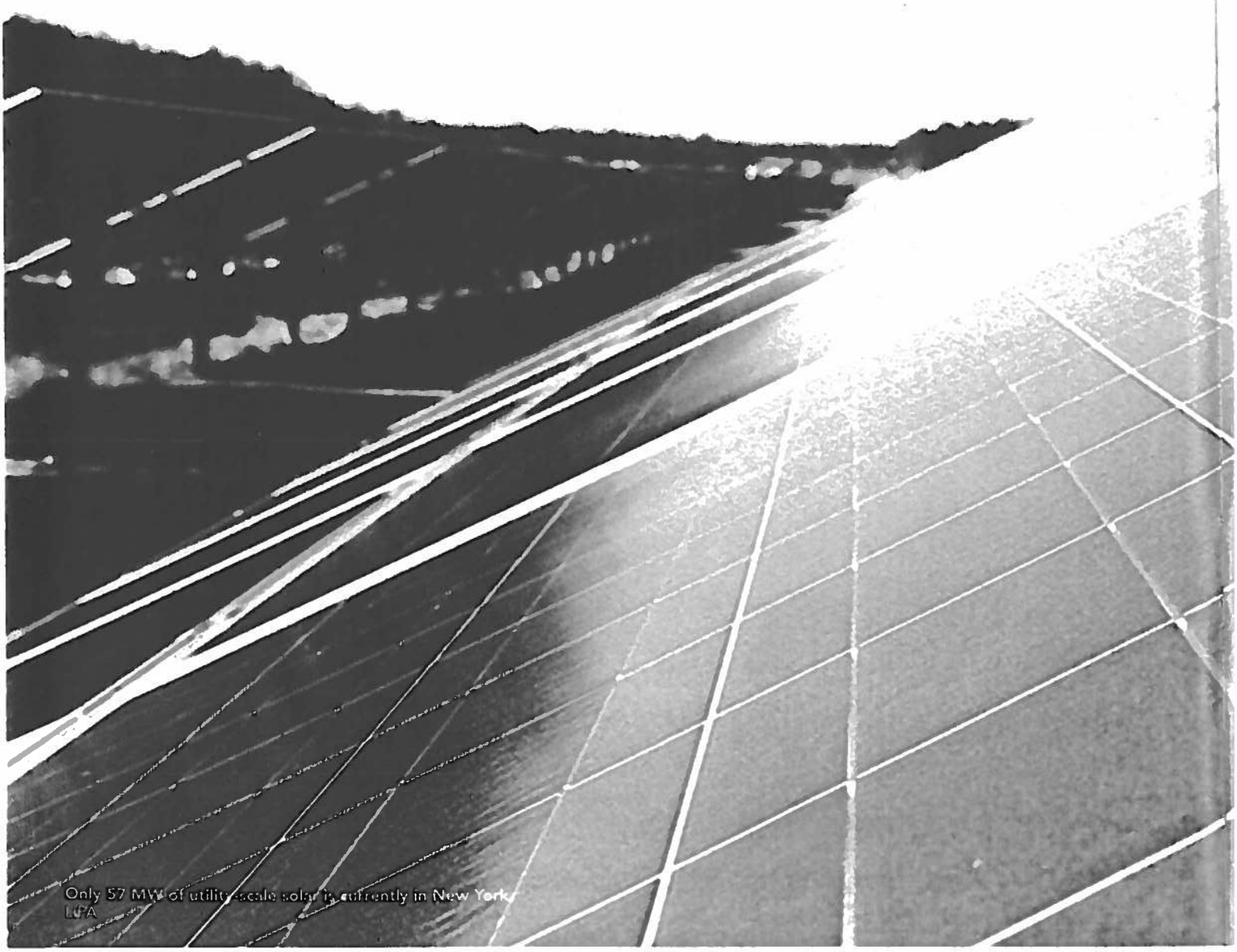
In the long term, achieving a 100 percent renewable portfolio will require a mix of renewable generation assets as well as advanced smart grid and storage technologies. We're not ready for that just yet, but, with continued technology improvements, it's certainly possible. Right now, in this transitional period, solar perfectly complements existing grid assets to meet peak power demands in a very cost-effective manner.

Solar technology is still the future, but it's also ready today. pe

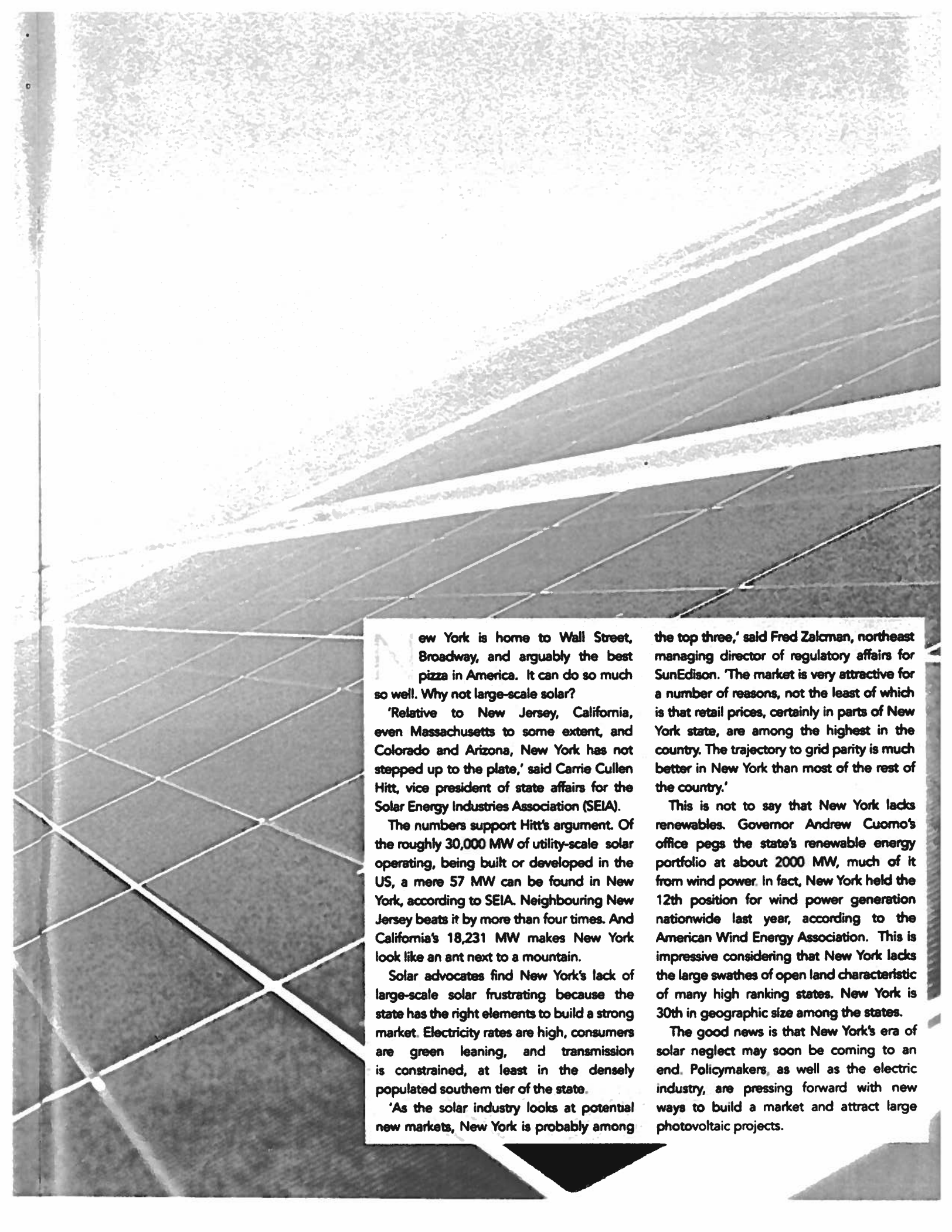
SOLAR IN NEW YORK

Strategy to make solar shine

New York is behind, so far, on large-scale solar development. California's 18,231 MW makes New York look like an ant next to a mountain. But as the solar industry looks to develop new US markets, New York is among the top three contenders. Elisa Wood finds out why.



Only 57 MW of utility-scale solar is currently in New York
LPA



New York is home to Wall Street, Broadway, and arguably the best pizza in America. It can do so much so well. Why not large-scale solar?

'Relative to New Jersey, California, even Massachusetts to some extent, and Colorado and Arizona, New York has not stepped up to the plate,' said Carrie Cullen Hitt, vice president of state affairs for the Solar Energy Industries Association (SEIA).

The numbers support Hitt's argument. Of the roughly 30,000 MW of utility-scale solar operating, being built or developed in the US, a mere 57 MW can be found in New York, according to SEIA. Neighbouring New Jersey beats it by more than four times. And California's 18,231 MW makes New York look like an ant next to a mountain.

Solar advocates find New York's lack of large-scale solar frustrating because the state has the right elements to build a strong market. Electricity rates are high, consumers are green leaning, and transmission is constrained, at least in the densely populated southern tier of the state.

'As the solar industry looks at potential new markets, New York is probably among the top three,' said Fred Zalcman, northeast managing director of regulatory affairs for SunEdison. 'The market is very attractive for a number of reasons, not the least of which is that retail prices, certainly in parts of New York state, are among the highest in the country. The trajectory to grid parity is much better in New York than most of the rest of the country.'

This is not to say that New York lacks renewables. Governor Andrew Cuomo's office pegs the state's renewable energy portfolio at about 2000 MW, much of it from wind power. In fact, New York held the 12th position for wind power generation nationwide last year, according to the American Wind Energy Association. This is impressive considering that New York lacks the large swathes of open land characteristic of many high ranking states. New York is 30th in geographic size among the states.

The good news is that New York's era of solar neglect may soon be coming to an end. Policymakers, as well as the electric industry, are pressing forward with new ways to build a market and attract large photovoltaic projects.

SOLAR TIMES FOUR

The change begins at the top. In Cuomo's 2012 annual state-of-the-state address in January, he launched the NY-Sun Initiative. Its goal? To quadruple solar by 2013, with much of the growth from large-scale solar.

'Over the decades, we have aggressively developed our hydroelectric resources and are making great progress in tapping our land-based wind resources. Now it is time to focus more attention on exploiting our solar potential,' he told lawmakers in the speech.

To that end, Cuomo proposed competitive bidding to attract large-scale solar projects. The New York State Energy and Research Development Authority, a quasi-government agency known more commonly as NYSERDA, has set out a plan to realise Cuomo's goal, which the authority says could bring 269 MW of solar to the state from 2012–2015, and 110 MW some time after. NYSERDA calls the plan 'aggressive but achievable'.

To meet the new goal, NYSERDA has asked the state Public Service Commission for US$54 million per year over four years, a doubling of its solar budget. About 75% of the money, or $39 million a year, would go towards large-scale solar.

The solar industry is praising Cuomo's effort, but also acknowledges its shortcomings. While Cuomo's programme speeds up solar development for the short term, it does little beyond four years. To attract industry investment, the state must provide a more consistent policy for long-term growth, say solar advocates. To that end, they have been pushing for a solar feed-in tariff (FiT), solar renewable energy credits (SRECs), or other methods to move the industry beyond developing hundreds of megawatts of solar into thousands of megawatts.

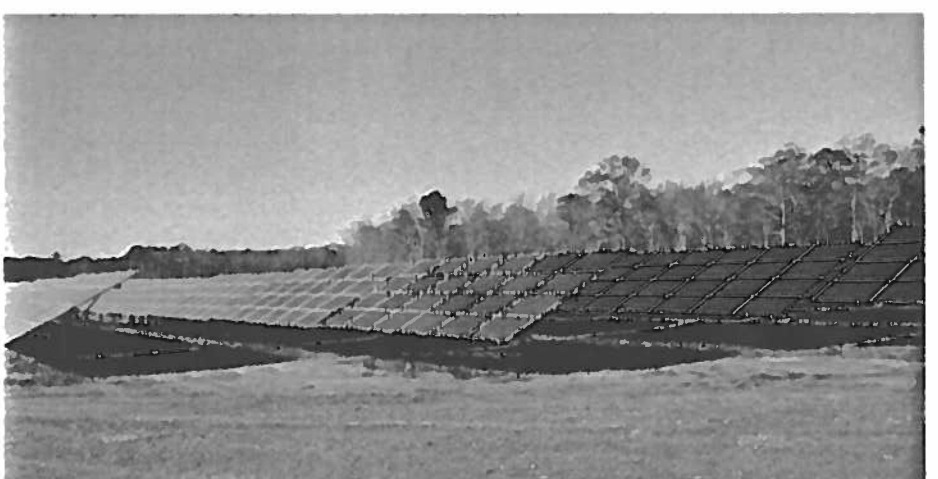
But that means winning support within New York's tumultuous and often distracted legislature. Last year, advocates carefully nurtured a solar bill that would have fostered development of 2500–5000 MW of solar. But it never became law; legislators turned to other issues, including the state budget, and the solar plan was put on the backburner for further study by NYSERDA.

In January, NYSERDA responded with a report that looked at the impact of developing 5000 MW of solar by 2025. The results were somewhat inconclusive because of the difficulty predicting how quickly solar costs will drop and what the future holds for federal tax incentives. Assuming solar costs could be anywhere from $1.4 million to $4.3 million per installed MW by 2025, ratepayers would pay a low of $300 million to a high of $9 billion.

The low-cost scenario produced a net benefit for ratepayers; the high case a net cost. For example, New York would create 700 jobs if solar prices fall to the low end, but lose 2500 jobs at the high end. At the same time, 5000 MW of solar would lead to environmental benefits: a 4% reduction in fossil fuel use, a 3% drop in carbon dioxide emissions, a 4% drop in nitrogen oxides, a 10% drop in sulphur dioxide and 3% drop in mercury. To reach such an ambitious goal, the state needs to pursue solar with a policy that is 'both flexible and responsive', said NYERSDA. Such a policy would include the kind of metering, sales tax exemptions and interconnection standards that drive down solar costs.

'Even with this range of cost uncertainty, given the many potential benefits that PV has to offer and the long-term potential for lower-cost PV technology, New York State should support continued investment in the steady and measured growth and deployment of PV as part of a sound and balanced renewable energy policy,' said NYSERDA.

Cuomo also is opening up new opportunity for big solar projects through his new 'Energy Highway' initiative to upgrade the state's ageing infrastructure. As part of the initiative, his office issued a formal solicitation in April 2012 seeking ideas from developers, utilities and others about how to fix various energy problems. One of the problems is how to attract more utility-scale renewable energy to New York, so that it reaches its target of getting 30% of its electricity from renewable energy by 2015 and more beyond that. A special task force plans to review the submissions and propose an Energy Highway strategy this summer. The state hopes to draw $2 billion in private investment.



Solar installations continue to rise despite tariff cuts.
Environmental Way

LONG ISLAND AS LEADER

NYSERDA isn't the only public entity working to bring more solar to New York. Two other authorities manage and deliver large amounts of electricity in the state: The Long Island Power Authority (LIPA) and the New York Power Authority (NYPA).

Both are focusing strongly on solar. In fact, LIPA is New York's star when it comes to large-scale development. With 1.1 million customers, LIPA is a large municipal utility, and has the second-highest revenue among US municipal electric utilities. LIPA also has fostered more large-scale solar – 50 MW – than any other New York utility (see sidebar opposite). And it has plans for even more.

Why has LIPA developed so much more large-scale solar than any other utility in the state? First, its electricity rates are among the highest, creating a smaller gap between grid and solar prices than is found in other parts of the state. Second, as a municipal utility it operates with a nimbleness not possible for investor-owned utilities that are subject to greater state regulation and oversight.

'Politically, it is easier for LIPA. They govern themselves, like any municipal utility. They have a more streamlined process,' said Hitt. LIPA is able to avoid a problem that has held up solar development in New York: co-ordination among many players. 'It isn't easy getting all of the players around the table,' she said.

Moreover, Long Island has weather fit

for PV. 'It is an obvious resource – we have sunny days most days of the year here,' said Michael Hervey, LIPA's CEO.

Now, LIPA plans to continue advancing solar by introducing the state's first feed-in tariff (FiT). 'Governor Cuomo's announcement of quadrupling of solar in New York State fits well with our plan,' said Hervey. 'Our energy plan calls for the next 50 MW block of solar. What we've decided to do is not go out for a request for proposals, but introduce a feed-in tariff.'

Details of the FiT were being worked out this spring, with LIPA scheduling a vote of its board on the plan in May, as *REW* goes to press. The FiT marks a diversion from the utility's initial approach to securing large-scale solar. In the past, LIPA issued a solicitation, chose winning developers and projects, and then signed long-term power purchase agreements with them. The long-term commitments from a credit-worthy utility helped the projects secure financing.

LIPA expects the FiT to lead to even more large-scale solar on the island. 'The FiT and fast-track interconnection standards will open up quite a bit of opportunity for commercial rooftop, commercial parking lots, landfills – places that are several acres in size. We're making it simpler for developers to provide us with solar in that size tranche,' said Hervey.

SOLAR MAP

Meanwhile, the New York Power Authority, the largest state-owned power organisation in the US and operator of several hydroelectric facilities, has launched a programme to drive down solar costs. Called the NY-Sun Solar Market Acceleration Programme, or Solar MAP, the $30 million, five-year programme will focus on PV research, training and demonstration projects.

'The NY-Sun Solar Market Acceleration Programme is designed to target and reduce solar development costs to spur New York's technology leadership in this important renewable energy market,' said Gil C. Quiniones, NYPA's president and chief executive officer.

NYPA will seek studies on reducing costs for solar equipment, including racks, inverters, monitoring devices and modules. The aim is to demonstrate new technology, system-integration strategies, cost reductions and safety. NYPA will also explore soft-cost reduction strategies to standardise permitting and streamline grid integration.

Separately, the authority has used its low-cost hydropower to help solar manufacturing in the state. NYPA granted hydropower allocations to Globe Specialty Metals when the company reopened and expanded by $60 million in western New York in order to manufacture silicon for solar power systems. NYPA also allocated hydropower to Precision Electro Minerals, in western New York, which manufactures fused silica for solar-panel grade silicon and other industrial products.

On a less optimistic note, NYPA closed a solicitation in spring 2012 without making an award for 100 MW of PV. Issued in 2010, the solicitation sought private developers who would own and operate solar systems at public facilities. The solicitation failed for several reasons, according to NYPA, including public facilities' reluctance to sign long-term leases and a realisation that the programme would do little to increase local manufacturing since most of the equipment purchased would come from outside the state.

Meanwhile, legislation to set a state goal of developing between 2.5 GW and 5 GW of solar was again pending at the time of writing. And again its fate was uncertain as lawmakers instead focused on other issues, trying to finish up their work before the session's culmination in late June.

Industry observers are carefully watching New York because the stakes, they say, go beyond the state and could have repercussions for the larger Northeast, a region that is a prize for solar developers because of its large electricity demand and high prices. 'In the aggregate when you look at the Northeast, it is shaping up to be a very sizeable, very robust market,' said Zalcman. 'New York has 35,000 MW peak. So it is a very big and diverse energy market and tends to be a regional leader. As goes New York, so goes much of the rest of the region.'

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A SOLAR ISLAND APART

While much of New York has been slow to develop large-scale solar Long Island is an exception. At the state's southern border off of New York City the island is home to the East Coast's largest solar array, the 32 MW Long Island Solar Farm.

The project emerged from a solicitation issued by the Long Island Power Authority (LIPA), which resulted in two separate awards, one to BP Solar and the other to enXco, an affiliate of EDF Energies Nouvelles. BP pursued the solar farm, while enXco built a 17 MW carport, solar project. In both cases, LIPA bought the capacity, energy and associated renewable energy credits.

BP built the solar farm at the Brookhaven National Laboratory solar farm in conjunction with the US Department of Energy (DOE), installing 164,312 crystalline solar photovoltaic modules within the smallest footprint of an array of its size in the nation. Owned in part by Met Life, the project began delivering power in November 2011, and won *Renewable Energy World*'s Readers Choice Award in 2012.

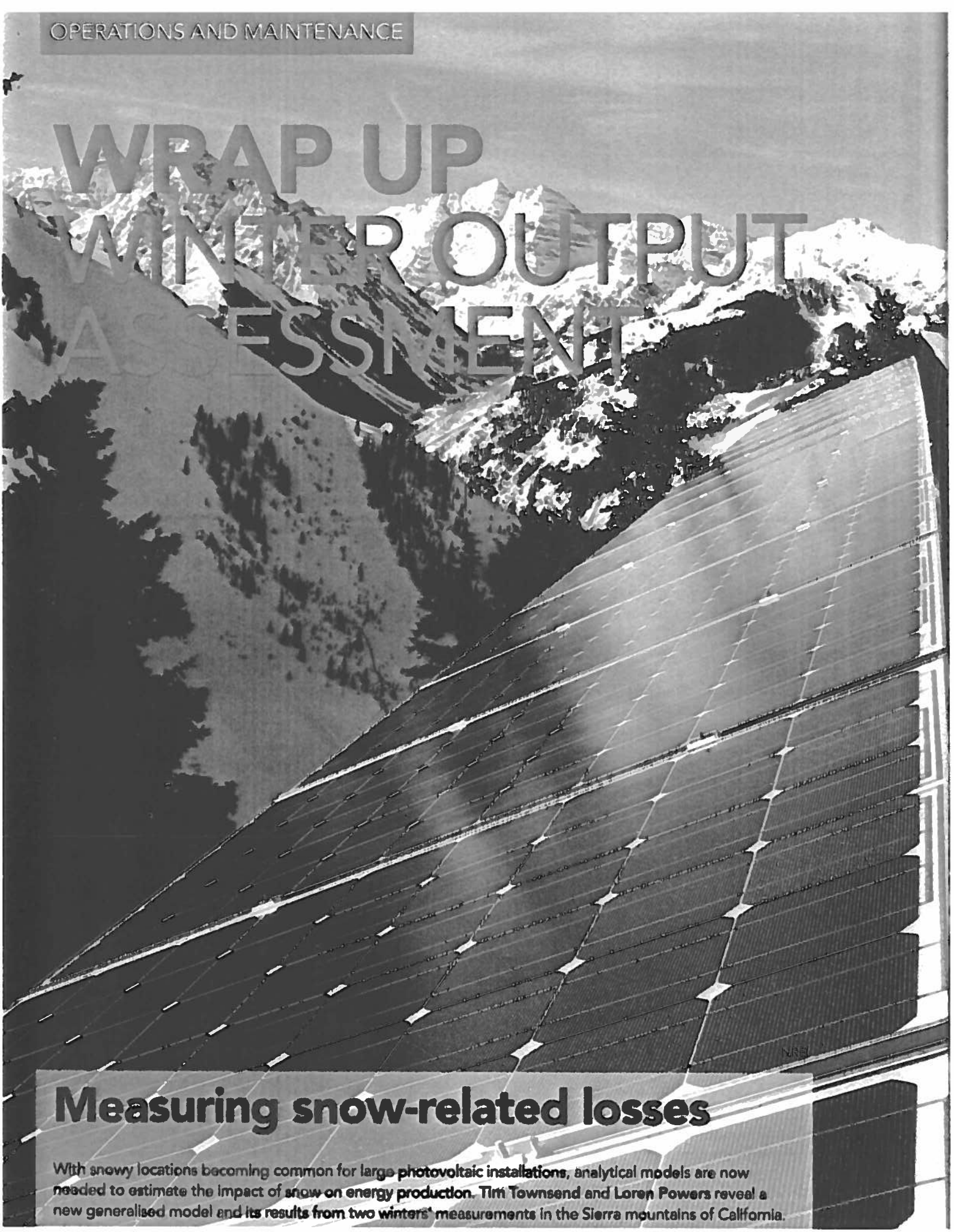
The solar farm is also being used by Brookhaven to study the hour-by-hour or even minute-by-minute microclimate effects of solar in the Northeast, an effort expected to further our understanding of grid reliability and integration of intermittent resources. The DOE facility employees more than 3000 scientists, engineers and staff, and hosts about 4000 guest researchers annually.

LIPA estimates it will pay $298 million for power from the solar farm (including interconnection costs) under its 20-year power purchase agreement, amounting to about 60 cents/month for the typical residential customer. LIPA officials envision the solar power providing price stability over the years to offset fossil fuel volatility.

Meanwhile, the enXco carport project, known as the Eastern Long Island Solar Project, remained under construction in the spring 2012 on 18 ha. enXco, which diversified from wind to add solar to its business in 2008, is installing 60,000 Suntech grid-connected modules largely in car parking lots on government-owned property. Seven sites will host the panels, and collect lease revenue.

'It is a great use of what is otherwise a parking lot to produce power,' said Hervey. Both the enXco Solar Carport and BP Solar Farm show the advantages of public-private partnerships to develop solar, said Hervey.

WRAP UP WINTER OUTPUT ASSESSMENT



Measuring snow-related losses

With snowy locations becoming common for large photovoltaic installations, analytical models are now needed to estimate the impact of snow on energy production. Tim Townsend and Loren Powers reveal a new generalised model and its results from two winters' measurements in the Sierra mountains of California.

Historically, PV modules installed in snowy climates have been part of small, off-grid arrays mounted at very steep tilt angles. This is done both to shed snow quickly and to maximise winter output. Unfortunately, this concedes too much annual energy to be a good design strategy for larger contemporary systems.

Today's snowy climate PV systems tend to be installed at angles shallow enough to make them prone to snow loss, and as large-scale PV installations become more widespread in snowy locations analytical models are needed to estimate the impact of snow on energy production.

Both weather and array design factors influence the amount of snow loss. Weather factors include the quantity and quality (moisture content) of the snow, the recurrence pattern of storms, and the post-storm pattern of temperature, irradiation, wind speed, wind direction, and relative humidity. Array design factors essentially boil down to orientation (fixed or tracking, tilt, azimuth, and tracker rotation limits) and the surrounding geometry (open rack or building-integrated). Building features can also either help (e.g. melt) or hinder (e.g. dam up or drift) natural snow shedding.

Nonetheless, a generalised monthly snow loss model is introduced here which, despite some limitations, appears to deliver good-quality, unbiased monthly loss estimates which can now be used as inputs to the simulation programs PV investors rely on for decision-making.

LAKE TAHOE TEST BED

BEW Engineering, Inc – a DNV company – set up three pairs of 175 W_p poly-silicon Mitsubishi model PV-UD175MF5 PV modules at fixed tilt angles of 0°, 24° and 39° on south-facing racks in Truckee, California, at the beginning of the 2009–2010 winter. The module pairs are spaced far enough apart to prevent row shading, even on the winter solstice.

Near Lake Tahoe, the station's latitude is 39° and its elevation is 5900 feet (1800 metres). The site receives an annual average of 200 inches (5 metres) of snow.

One module of each pair is manually cleaned and thermostatically heated. The three un-cleaned modules are allowed to shed or accumulate snow naturally and are bordered with two feet (0.6 metres) of similar material to minimise edge effects.

A datalogger saves hourly records of irradiance for the three tilt angles, short-circuit current and temperature for each module, along with air temperature and relative humidity. Meanwhile, an hourly webcam shot records snow depth and assists with quality checks. A second source of data is a 125 kW_p Truckee Sanitary District (TSD) system located two miles (3.2 km) south of the BEW station and sitting at the same elevation.

For BEW's rig, snow losses are gauged as the difference in monthly amp-hours between the clean and uncleaned modules. For the TSD system, snow losses are gauged as the difference in measured energy and predicted energy for an always-cleaned array.

The TSD system faces south at a fixed 35° tilt, similar to one of the paired sets of BEW's test modules. The lowest edge of the 17 foot (5 metre) long rows are six feet (2 metres) above ground. While the District does not manually clean this array, they do regularly plough snow from between the rows to prevent snow from piling up. This maintenance practice proved to be especially valuable because snow is not removed from the array, yet ground interference does not occur. It is as if the array is very high above ground. Indeed, ground interference at the BEW site has resulted in twice the annual energy loss as the TSD site.

CALCULATE WINTER LOSSES

Depending on tilt angle, wintertime energy losses of 40%–60% and annual energy losses from 12%–18% were noted in the first year of operation, though data from the TSD system were not included. The first winter was statistically very normal. The lost energy due to snow buildup in the seven-month winter season ranged from as little as 25% for the 39° tilt to as much as 42% for the flat orientation. The seasonal results project to losses in annual output of 12%, 15%, and 18% for the 39°, 24°, and 0° tilts, respectively.

While these results were hugely significant for this location, no attempt was made to project how the Truckee results would translate to other, less snowy locations based on the first year of measurements. The model development and fitting task was completed after the second year of measurements, after which BEW's generalised model was tuned enough to be provisionally applied to other locations. The current form of the model is:

'A generalised monthly snow loss model can be used by PV investors for decision-making'

Snow loss, % =
$C_1 * Se' * \cos^2(T) * GIT * RH / T_{AIR}^2 / POA^{0.67}$

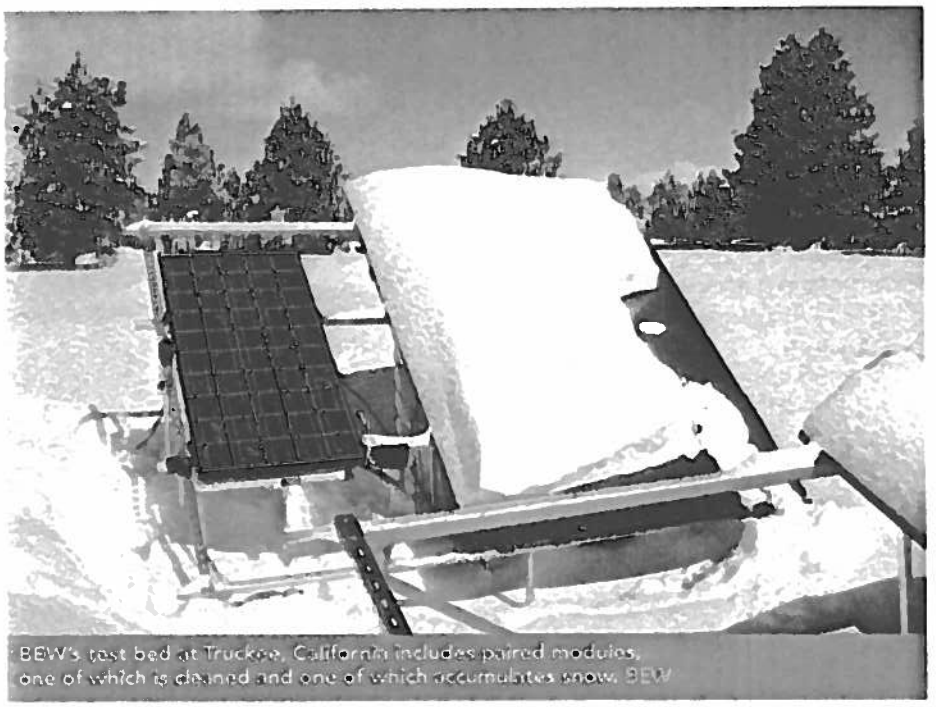
Where:
C_1 is a fitted coefficient, 5.7×10^4
Se' is the 6-week rolling average effective snowfall in inches, with
Se = S (monthly snow, inches)*0.5*[1+1/N], where N is the number of snow events per month
GIT = ground interference term, defined in detail below
RH = average monthly relative humidity, %
TAIR = average monthly air temperature, C
POA = monthly plane of array insolation, kWh/m^2

The GIT is further defined as:
GIT = $1-C_2/\exp(\gamma)$; C2 is fitted from data as 0.5; γ is the dimensionless ratio of snow received divided by snow dissipated, such that whenever the amount of snow received exceeds the ability of the array geometry to deposit it on the ground, shadow-like interference will quickly reduce array output by a factor of 2 to 1. BEW defines γ as:
$R * \cos(T) * Se' * 2 * \tan(P) / (H^2 - Se'^2)$

Where:
R is the row plane of array dimension, inches
T is the tilt angle, degrees
P is the stabilised snow pile angle, nominally assumed to be 40 degrees
H is the drop height, inches
And Se', effective rolling-average snowfall, inches as defined above

For one of the US's snowiest urban areas, it was observed that annual losses of 12%–18% may be expected in a typical year for fixed tilt arrays mounted at tilt angles ranging from 39° to 0° (flat). However, monthly losses may be substantially higher; an entire month's output was lost for a shallow tilt angle unit when several feet of snow fell, for example.

On a rolling annual basis, the snow losses have averaged 6% for the TSD system, 13% for the 39° BEW module, 17% for the



BEW's test bed at Truckee, California includes paired modules, one of which is cleaned and one of which accumulates snow. BEW

24° BEW module, and 26% for the flat 0° BEW module. However, the principal use of this information is not necessarily to point out how much potential generation is sacrificed in a very snowy location, but to serve as a baseline for validating proposed snow loss models.

DEVELOPING A LOSSES MODEL

Key variables affecting generation might be supposed to include snowfall quantity, climate and weather factors such as temperature, radiation, relative humidity, wind speed/direction, and snow moisture content. Additional influences include array geometry such as tilt angle, row slant length and distance to ground as well as ground interference effects.

An equation that relates monthly energy loss to monthly snowfall in inches was developed with units of percentage loss per inch of snow. The final equation accounts for ground interference, air temperature, plane of array insolation and relative humidity. Terms such as wind and snow moisture content were not available in this test.

A promising simple annual snow loss relationship was posed, which suggests annual energy loss may be estimated as the product of a 0.1%/inch snow loss, multiplied by a tilt angle adjustment factor.

There is a clear relationship between tilt angle and energy loss, though the relationship will be influenced by other factors. However, the study only evaluated fixed-tilt configurations, and although tracking systems can be evaluated to some degree by the model, in practice the dynamic movement and vibration of tracking systems is likely to lessen the effect of snow even more than predicted.

The most encouraging findings are that the study shows annual energy predictions can be essentially unbiased when accounting for snow, and that the errors are well within the normal level attainable with simulation programs in general. Furthermore, these results can be obtained using measurements widely available in long-term climate databases, coupled with array-specific design geometries. Better estimates are possible if exact array geometry information is available to characterise ground interference effects. Indeed, the effect of ground interference is significant and was observed to have roughly a two-fold effect on typical snow loss for the specific array geometry used at the test station.

APPLYING A GENERAL MODEL

The Lake Tahoe area is not a prominent solar market, though the Truckee Sanitary District installed an array in 2009 and there are several other commercial PV installations in the region. However, well-established commercial solar markets (together with average annual snowfall) include Denver, 60 inches (152 cm); Milwaukee, 47 inches (119 cm); Boston/New England, 43+ inches (109+ cm); Detroit (and Ontario Canada), 42 inches (107 cm); Chicago, 38 inches (97 cm); and the Mid-Atlantic region with 20–30 inches (51–76 cm). Taking Philadelphia, Detroit and Denver, each city is at about the same latitude, roughly 40°, but their average annual snowfall varies smoothly from 20–60 inches (0.5–1.0 metres)/year, all well short of Truckee's normal total.

Each system is assumed to be south-facing, at a tilt angle equal to latitude minus 15°, with ground interference characteristic of common modules 2 metres long in portrait mode, mounted six inches (15 cm) above the roof.

Inputs needed to generate these estimates were readily obtained from the National Renewable Energy Laboratory's (NREL) solar radiation database and Wikipedia's climate data for each city. In addition to two fixed coefficients, the data needed to run the model are factors including site latitude, array geometry (tilt, row slant length, and height above ground), monthly snowfall and the number of snow events per month, average air temperature, plane of array insolation, and average relative humidity. The monthly loss estimates which result can be used directly as inputs to popular PV simulation programs such as PVSyst.

BEW is now concluding its third season of measurements at Truckee and plans to present its updated findings at the Solar Power International conference in Orlando, Florida this autumn. With such large amounts of money tied to performance, quantitative means of addressing snow loss risk are sorely needed. As this is the first published analytical model for snow loss estimation, the impact of applying it in this emerging market is potentially very large. The goal is to improve snow loss modelling and thereby improve the bankability of projects in snowy locations.

Tim Townsend and Loren Powers are engineers at BEW Engineering, San Ramon, California. BEW is now part of DNV KEMA Energy & Sustainability.

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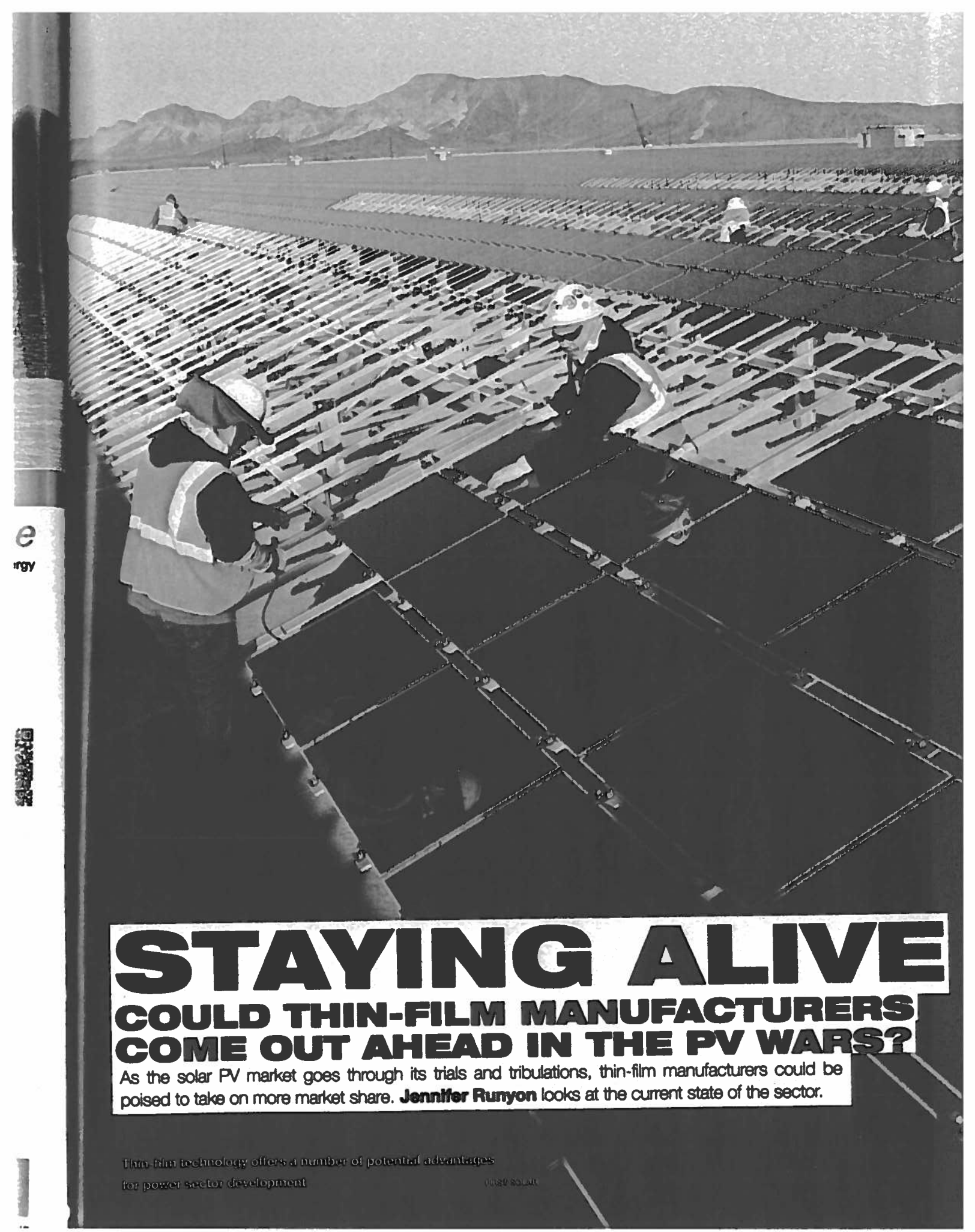

STAYING ALIVE

COULD THIN-FILM MANUFACTURERS COME OUT AHEAD IN THE PV WARS?

As the solar PV market goes through its trials and tribulations, thin-film manufacturers could be poised to take on more market share. **Jennifer Runyon** looks at the current state of the sector.

Thin film technology offers a number of potential advantages for power sector development

FIRST SOLAR

In the solar electricity market, consolidation and contraction are the buzzwords of the day. Today, all solar PV manufacturers face an over-supplied and underfunded PV market. The oversupply and drop in subsidy across Europe and the US has forced crystalline silicon manufacturers to sell panels below manufacturing costs. As the weeks tick by, major manufacturers, one after another, are announcing bankruptcies or plans for a major scaling back of their operations. Thin-film solar panel manufacturers have not been able to stay out of the fray, with many struggling to keep up.

MJ Shiao, author of *THIN FILM 2012–2016: Technologies, Markets and Strategies for Survival*, argues that thin-film may be dying, but it isn't dead yet. He points out that venture capital investment continues in the sector and key players have large expansion plans.

THIN FILM ADVANTAGES OVER CRYSTALLINE PV

Crystalline PV has the cost advantage now with slightly more efficient panels selling for right around US$1/W. SolarBuzz's March 2012 report shows mono-crystalline silicon PV panel price at $1.10/W and multi-crystalline silicon PV panels selling for $1.06/W.

But thin-film works better in diffuse-light conditions and in hot environments, which means that in certain sun-drenched areas of the world, thin-film turns out to have a lower levelised cost of energy (LCOE) – the final cost to produce a kilowatt-hour of solar power. So while a crystalline silicon PV panel may have a higher efficiency, meaning that it can convert more sunlight to power when the sun is shining, that same crystalline panel will produce energy for a shorter amount of time during the course of the day. And that same panel will experience greater degradation of power in hot environments than the thin-film panel, according to experts.

Couple thin-film's lower LCOE in hot environments with the fact that the solar market is shifting towards more remote, unsubsidised markets that already experience high electricity prices, and it is clear that thin-film could take on more market share in the future.

KEY PLAYERS IN THE INDUSTRY

Thin-film solar panels are created through three different manufacturing techniques that use different core components: amorphous silicon (a-Si), cadmium telluride (CdTe), or copper indium gallium diselenide/copper indium sulfur/selenide (CIGS/CIS).

The only small silver lining to the cloud that is very low solar power panel costs, according to Chris O'Brien, head of market development at Oerlikon Solar is that low module prices are driving increased demand for solar power in general.

With Oerlikon recently acquired by Tokyo Electron (TEL), O'Brien points to markets in the Middle East, Africa and India as areas where there is a growing interest in solar PV. Whereas PV projects in those regions used to be in the sub-megawatt range, he says they are now coming in in the multi-megawatt range. This is a trend that many in the industry expect to continue.

O'Brien also notes that pricing will remain low and that only those manufacturers that can innovate enough to bring down costs will be able to compete.

'All solar bids in California are coming in the range of $.09/kWh. I think what that reflects is not just the current low prices but an expectation that the price will continue to go down. In that case the RAM [renewable auction mechanism] was for deliveries in 2016.'

Oerlikon, which manufactures the equipment to build amorphous silicon (a-Si) thin-film module manufacturing plants, has seen a drop in equipment upgrades so far in 2012. 'Most estimates are that the investment this year will be down by more than 50% compared to last year,' O'Brien said.

O'Brien explained that in 2010 and 2011 manufacturers expanded aggressively, at what have turned out to be unsustainable rates. He called it a manufacturing equipment bubble. 'A number of aspiring manufacturers wanted to copy the success of the 2009 emerging market leaders in China, like Suntech, Trina, Yingli,' he said. Those tier 1 manufacturers successfully expanded to 2 GW of manufacturing capacity in 2009, he said, resulting in a glut of panels on the market. Today, many of those manufacturers which aggressively expanded are now left sorely in debt, stuck with equipment that might not be sellable in the near future.

'I expect there might be some buyer's remorse,' O'Brien observed.

Oerlikon is waiting for the next manufacturing equipment investment cycle to begin and O'Brien expects that to happen by the end of 2012. 'I think the market is catching up to the investment that was made in 2010, 2011,' he said.

'What will be different for the next investment cycle,' he continued, 'is that the cost requirement will be much lower.' O'Brien said he expects that manufacturers will need to diversify in order to stay afloat, which might mean that some crystalline silicon manufacturers will differentiate their lines.

'I don't expect that PV module prices will increase,' he said. 'The next investment cycle will be shaped by what technologies can provide a sustainable business model at PV module prices that are at or below today's prices.'

O'Brien said that Oerlikon can deliver a 140 MW manufacturing line that will produce 10.8% efficient panels at $0.50/W as long as it is running at full capacity. He looks forward to working with Tokyo Electron (TEL) to further improve the line after the early March announcment that it was being sold to TEL, a leading semiconductor equipment supplier from Japan.

a-Si thin-film manufacturers producing panels with Oerlikon equipment include Astronergy, Auria, Baoding Tianwei, Bosch Solar Energy, Gadir Solar, HelioSphera, Inventux Technologies AG, Schott Solar, Pramac and Sun Well Solar. In addition to these players, Sharp Solar has an a-Si thin-film line.

FIRST SOLAR – CADMIUM TELLURIDE (CDTE) THIN-FILM

First Solar has robust plans for the future, according to David Erhart, marketing communications manager. Erhart explained that it is First Solar's thin-film technology that 'takes a simple piece of glass and turns it into a complete solar module in less than two and a half hours' that has fuelled the company's success so far.

To date, the company has more than 5 GW of modules installed worldwide and was the first company to break the $1/W cost barrier. It currently manufactures its panels at a cost of less than $0.75/W and the company won't stop there, according to Erhart. A recently announced restructuring of First Solar should bring the company's average manufacturing to $0.70–$0.72/W in 2012, below prior expectations of $0.74/W. In 2013 the company estimates average module manufacturing costs will range from $0.60–$0.64/W.

Erhart said First Solar is the current world-record holder for CdTe PV cell efficiency at 17.3% and PV module efficiency at 14.4%, NREL-verified numbers. The company plans to take those efficiencies to scale. 'We expect to take cadmium telluride thin-film solar technology to levels that it has never been before,' he said.

In addition to manufacturing, First Solar has become active in building and operating utility-scale power plants. It boasts the 'largest pipeline in the industry with more than 2.7 GW of solar PV plants under construction or in development with PPA,' Erhart said.

He pointed to three US projects – the 290 MW Agua Caliente, the 550 MW Topaz Solar Farm and the 550 MW Desert Sunlight projects – as examples of some of the power plants that First Solar is developing, which also happen to be among the largest PV power plants under development in the world.

First Solar has now set its sights on the developing world, in line with many other solar power players.

While acknowledging that markets can shift on a dime, Erhart said: 'Regardless of where the existing markets go, we want to invest in what we call long-term sustainable markets.' This view evidently makes a lot of sense when put in context and considering the on-again, off-again subsidies that are in place in Europe and which have really dominated market development.

'We don't want to wake up every day dependent on these subsidies,' said Erhart, explaining why the company is interested in more stable and attractive markets such as 'markets that have a need for electricity, that have high irradiance, and have high costs of electricity,' he said.

First Solar's CFO Mark Widmar echoed this view on market development, telling *REW*: 'Over the next couple of years, we also intend to make progress in sustainable markets'.

First Solar modules use '98% less semi-conductor material than the semi-conductor materials required for traditional crystalline silicon manufacturing processes,' said Erhart. That has meant that the company has had a significant cost advantage over the years, although GTM Research's MJ Shaio points out that the cost-advantage window is closing. 'Scores of thin-film silicon manufacturers, drawn by the pied piper of propped poly prices, suddenly saw utilisation rates collapse and their low-efficiency, very low-cost product turn into a very low-efficiency, average-cost product, evaporating any competitive advantage they might once have had,' he said in his thin-film report.

In terms of competition, Erhart sees the 'usual suspects' as First Solar's main rivals in the space. These are the crystalline solar PV module makers.

However, he explained that it is not always just other solar companies that First Solar is in competition with. 'When you are going into these emerging markets to help them with their dire energy needs, you are not necessarily competing with other solar panel manufacturers, you are competing with other forms of energy,' Erhart said. 'In Saudi Arabia, for example, we are competing primarily with diesel which they would rather sell as gasoline or petrochemicals than burn for their own domestic electricity.'

First Solar has a lot to be proud of as well, according to Erhart. He said that the company has the lowest balance of systems (BOS) costs in the industry; an award-winning safety record; and the fastest installation velocity in the industry.

Other existing CdTe thin-film firms have not had quite the success that First Solar has had so far. Abound Solar recently announced plans to layoff 180 employees while it builds its next-generation higher-efficiency module. GE, which acquired PrimeStar Solar last year, said it would be building a 400 MW CdTe factory in Aurora, Colorado. The facility is under construction is expected to begin producing panels this year.

SOLAR FRONTIER, CIS THIN-FILM DEVELOPER

With the exception of GE's more recent entrance into the thin-film market, Solar Frontier is the only major thin-film player that has a huge parent company. Showa Shell Sekiyu KK owns Solar Frontier and having such a wealthy parent company leaves little doubt that Solar Frontier will be able to make strides in the solar power industry.

'So far, it's a good year for us,' said Greg Ashley, the company's COO for the Americas. 'Even though global prices have stayed low, they pretty much stabilised over the past few months,' he continued.

Solar Frontier manufactures copper indium selenium (CIS) solar panels and has a 1 GW factory in Japan and several smaller facilities in other areas of the world.

Ashely said that CIS has a few advantages over CdTe and a-Si panels. 'Our measured performance ratio is still higher than CadTel [CdTe],' he said. 'I think the fact that we've stayed with a very strong framed module, whereas most of the other thin-film folks have gone to frameless, or stayed with frameless gives us some installation/design flexibility that they don't have,' he explained. 'And our modules are slightly larger so the combination of the frame and the larger size, we typically have lower BOS and are easier to handle.'

Thin-film manufacturers suddenly saw their low-efficiency, very low-cost product turn into a low-efficiency, average-cost product

The company has its eyes set on Japan. 'Demand for us in Japan is exploding [as the country is] getting ready for the new feed-in tariff (FIT),' he said. Japan's FIT is set to go live 1 July 2012.

Nonetheless, Ashley also echoed the market shifts taking place. He said, for Solar Frontier, the US holds great potential. In addition, the company is doing business in the Caribbean, and is pursuing business in Hawaii and Latin America.

But Japan is where it really plans to grow: 'Japan is probably a bigger, faster, easier growth market for us… but in the long run, it's all the sun belt countries, the developing countries,' he said.

With Shell as a parent company, Solar Frontier doesn't have a lot of trouble penetrating new markets due to its long history in the global energy markets said Ashley. 'We've got a very strong presence in a very large historical network of relationships both with the private and public sector,' he noted.

He said the company is 'granted some preferential access to the right types of opportunities with the right types of companies, with the right types of partners' in the emerging markets across the globe. For example, 'we have EPC partners with some of the larger players in India… same thing in Thailand and Malaysia and other parts of the world'.

To date, however, Solar Frontier is working on smaller projects than its rival First Solar. Ashley said that for now, even its utility-scale projects are in the 1–2 MW range – except, of course, for the 130 MW Catalina solar project, in Kern County, California, USA.

Like Oerlikon's O'Brien and First Solar's Erhart, Ashley believes that PV module manufacturing pricing will remain in the $1/W range but 'in this race to get to installed cost of $1/W, I think we are very far off from that,' he added.

Ashley said that the solar industry's biggest problem right now is the excess inventory that has built up, a problem that he thinks could be resolved by the country that manufactured a lot of it: China. 'The market in China itself will have a big influence,' he said. Ashley thinks China will begin soon to stimulate its own internal demand and that will reduce the impact that oversupply is having on the market.

Other CIGS players include MiaSole, Avancis, Global Solar, Nanosolar, Sotecture and Solibro, owned by Q-Cells, which filed for bankruptcy in April, leaving the fate of Solibro up in the air.

Ashley remains incredibly optimistic about thin-film. He believes that 'thin-film is competitive with crystalline even at the lowest prices' and 'not just our technology… there's going to be more thin-film manufacturers and it's good that there are and it's good that the existing ones continue to grow and thrive,' he said. 'I'm very hopeful for all my competitors, as well as my own company.'

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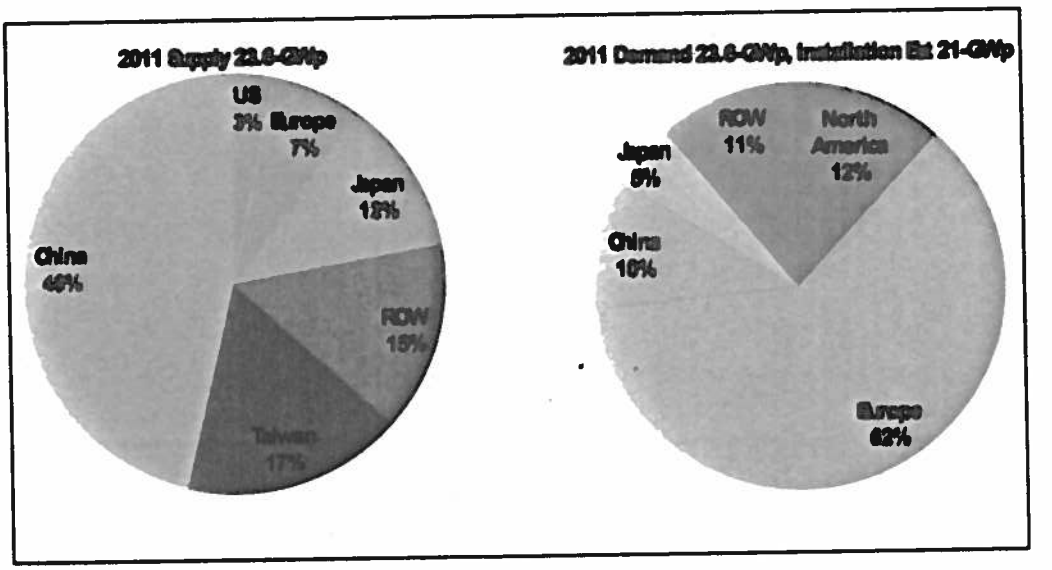
PV OUTLOOK DARKENS ON 2012 'MARKET CORRECTION'

After surging for four years, the PV industry must now face a widely expected downswing, according to the latest report from Navigant.

'Along with this growth have come low margins, losses and failures,' says the report's principal author Paula Mints. 'We've been waiting for a correction for a while – and we now face a two-year correction at least.'

Mints believes the industry will experience some pain as it confronts its failure to plan for inevitable challenges.



2011 supply and demand shares

NAVIGANT

A CHALLENGE AHEAD

Mints furnishes a quote from the economist Kenneth Boulding to sum up the challenge: 'Anyone who thinks that exponential growth can go on forever in a finite world is either a madman or an economist'.

The seventh annual report from Navigant, entitled *Photovoltaic Manufacturer Shipments, Capacity & Competitive Analysis 2011/2012*, provides an analysis of the PV industry's current situation along with a five-year forecast of technology shipments to 2016.

Compared with other recent analyses for the PV sector, Mints' view could appear overly conservative. Her work is based on 'classic market research principles' and focuses on analysing PV technology whether shipped as a module or a cell from the manufacturer to the first point of sale in the market.

Mints notes that there is significant outsourcing in the PV industry, and that this leads to overstating shipments by counting the same capacity twice: once as a sale by a branded supplier and secondly as a sale by the OEM supplier to which the branded supplier has outsourced production.

'Even Chinese companies outsource 5%–25% of what they report,' she says. 'Many times companies include outsourced production as their own, which makes the industry look much more successful than it is.'

Among the unfortunate outcomes of such over-reporting is that governments have based their policies on a misleadingly rosy scenario of low prices and high shipments, she adds.

In her forecast for the sector, she also highlights a flaw in widespread assumptions of a steady increase in the cost of conventional energy. The emergence of shale gas scuppers the expectation that fossil fuel costs wil steadily climb while solar power costs fall.

'The biggest problem is the low price of gas – the best attribute of solar is that it provides a hedge against the volatility of fossil fuels,' she says. 'Isn't high quality and clean energy better than being the cheapest game in town?'

SOLAR IN 2011

In the meantime, though, the sector already has enough challenges to overcome. Among the most disturbing is that around the globe – but especially in solar's heartland in Europe – incentives are now on the slide.

'The current correction might have been avoided had manufacturers, demand-side participants and investors paid attention to the one salient fact about incentives: incentives

TOP 10 MANUFACTURERS

RANK	2011 EST	MWP	TECHNOLOGY	REGION
1	Suntech	1991.2	c-Si	China
2	First Solar	1900.8	CdTe	ROW/Europe/US
3	JA Solar	1690.0	c-Si	China
4	Yingli	1467.0	c-Si	China
5	Gintech	1400.0	c-Si	Taiwan
6	Trina	1283.5	c-Si	China
7	Motech	1040.0	c-Si	Taiwan
8	Canadian Solar	992.3	c-Si/a-Si	China
9	Sharp Solar	895.0	c-Si	Japan
10	Jinko Solar	856.5	c-Si	China
	% total	57%		
	Estimated total shipments	23579.3		

are designed to decrease over time as demand is stimulated,' says Mints.

A 'rush to the bottom' in bidding on power purchase agreements (PPAs) adds to the industry's headache. In Mints' view, prices bid for PV systems in markets such as India are impractical.

'Bidding on power purchase agreements and tenders is too low and many projects are likely to be renegotiated,' she says. 'The alternative to renegotiation may be bankrupt systems or systems that will not be built.'

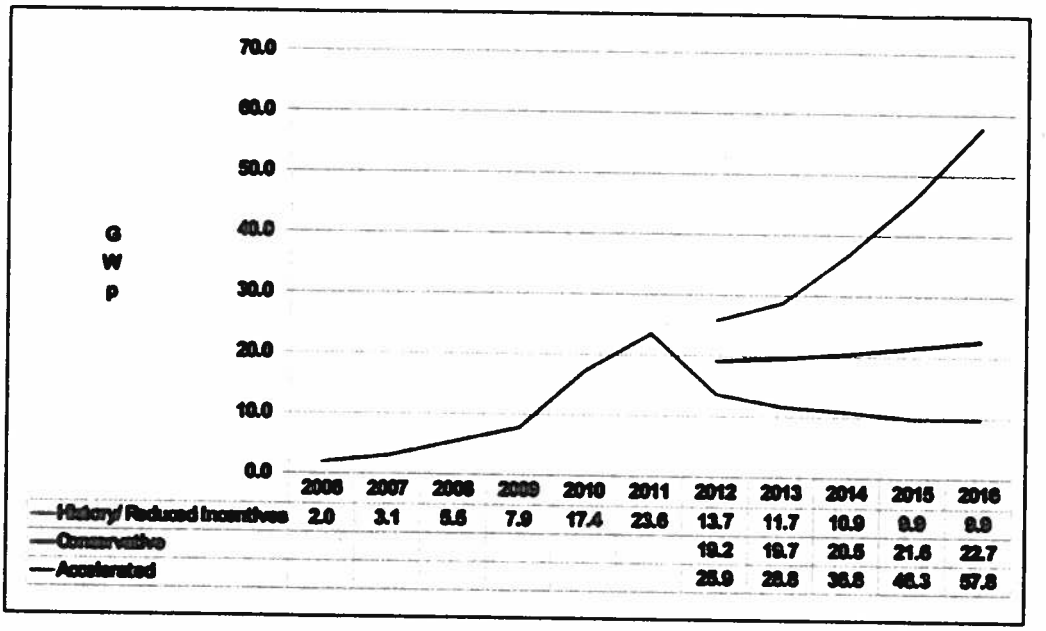
At the same time, PV technology is also being held at artificially low prices by high levels of inventory, high levels of manufacturing capacity, rumours of low prices and, again, lowering of incentive rates. 'Prices are too low – they're being held down by 4–5 GW of inventory,' says Mints. Reselling this inventory not only deflates prices but fuels expectations of further drops in price. Over 2011, while shipments of technology to the first buyer surged 35%, revenue only nudged up 4%.

Solar industrial capacity has also shadowed the trend in incentives and prices by slipping by 10 percentage points to 67% in 2011, according to Navigant's figures. This skid is forecast to continue in 2012, with capacity edging back further to 66%.

Over 2011, Navigant's analysis puts global shipments at 23.6 GW. For this year, Navigant provides three guide figures. Under a 'reduced incentives' scenarios, shipments plunge to 13.7 GW. The 'conservative' forecast is for 19.2 GW. An 'accelerated' outlook gives a total of 25.9 GW.

But as companies are now losing money on every megawatt, the lower figures are the ones Mints hopes for. 'Even under the conservative forecast, companies are still mostly losing money,' she says. 'I fear we may hit my accelerated forecast of 25.9 GW in 2012, which would mean that we've probably got a three-year correction.'

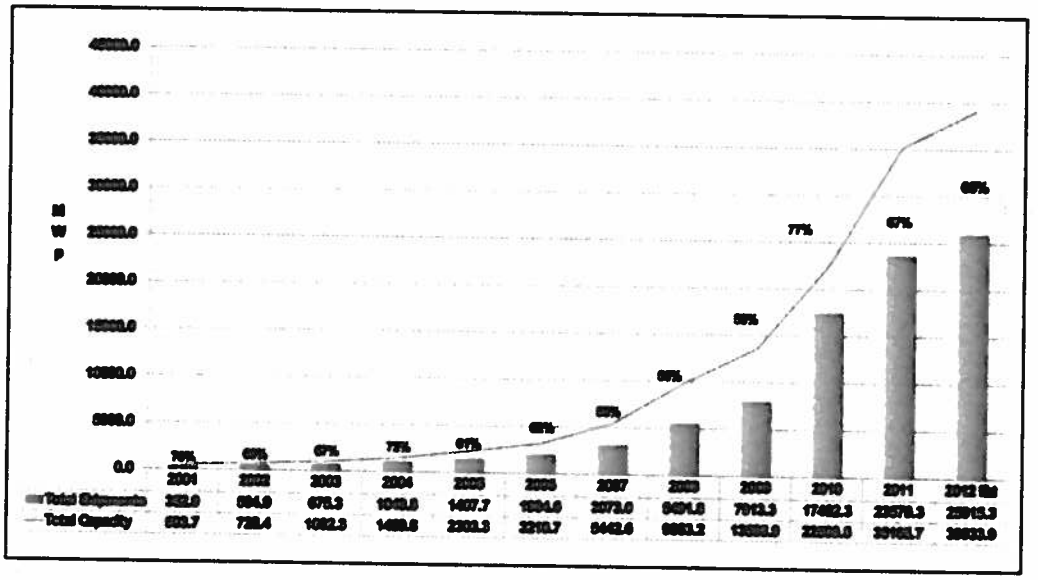
Navigant plots the average selling price for solar modules as continuing to edge down to US$1.31/Wp in 2012, a drop from $1.37 in 2011 and $1.48 in 2010. Although many look to China to mop up demand as European markets wilt, Mints is sceptical. 'China is starting to lower its incentives,' she says. 'I, and others like me, had felt it would be difficult for China to support both exports and its domestic market.'



	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
History/ Reduced Incentives	2.0	3.1	5.6	7.9	17.4	23.6	13.7	11.7	10.9	9.9	9.9
Conservative							19.2	19.7	20.5	21.6	22.7
Accelerated							25.9	28.8	36.8	46.3	57.8

Three scenarios for total shipments from 2012

NAVIGANT



PV industry capacity for 2001 to 2012

NAVIGANT

Mapping of regional demand and supply shares reveals that last year China contributed a whopping 46% of supply while providing only 10% of demand. 'We need to slow down,' is Mints' perspective on the PV industry's best path forward.

THE ROAD TO RECOVERY

But Mints finds grounds for hope amid the PV sector's woes. 'The industry will emerge leaner from this correction with the business and financial models necessary to move it to a low-incentive environment,' she says.

In particular, the industry will have to improve very quickly in terms of balance of systems as well as system design and installation, she argues. 'That includes large fields,' she says. 'We need to discover new ways to design fields – for example, to collect different spectrums of light. We need new business models. However, with complexity comes cost.'

Neither vertical integration nor enhanced dependence on Chinese manufacturing will get PV on a more sustainable track, Mints argues. Rather than a 'big bang', a series of refinements in technology will bring the sector out of the correction.

In Europe, she sees the complexity of the current system, and the expense this adds, as another hurdle to be removed from the sector's path.

In sum, the solar sector should rediscover its roots as an industry as it returns to an environment without substantial subsidies.

'I'm expecting accelerated learning,' she says.

Piers Evans

For more information on *Photovoltaic Manufacturer Shipments, Capacity & Competitive Analysis 2011/2012* visit www.navigant.com

The DEAL

Vermont's Solar Deal: One Small State Makes a Big Solar Impact

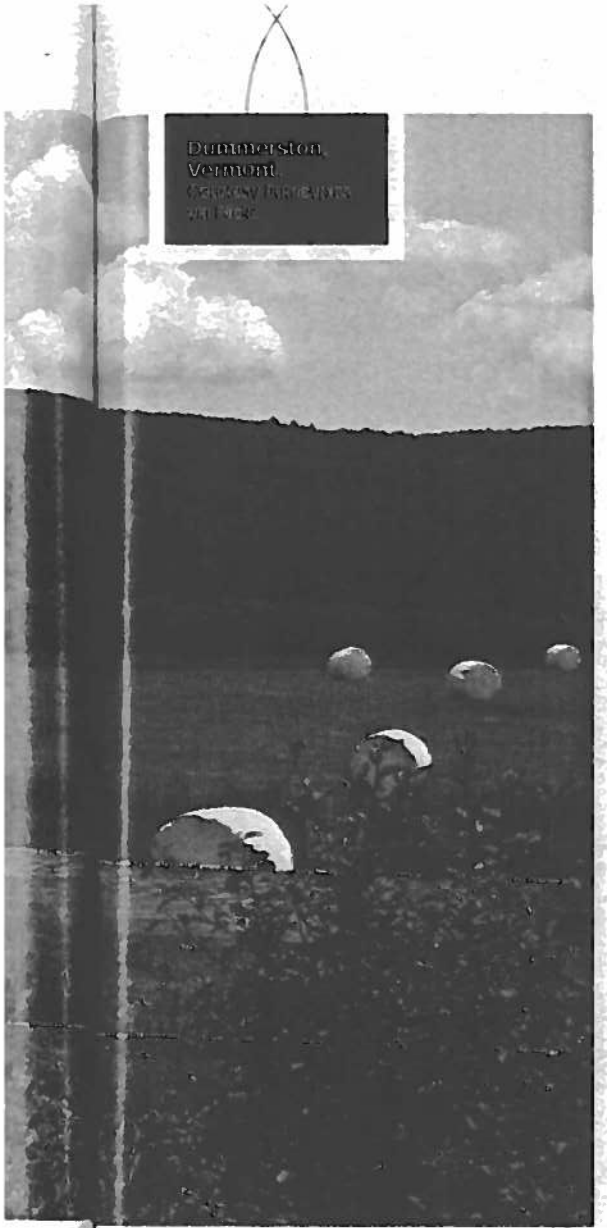
Vermont has enacted a simple solar registration process that abolishes permitting, cuts time and has brought renewed vigor to solar power in the state.

Meg Cichon,
Associate Editor

So, you want to put solar on your roof. You're part of the 94 percent of Americans who think it's important for the nation to develop solar energy, as evidenced by the SCHOTT Solar Barometer, a nationally representative survey conducted by independent polling firm Kelton Research. You call several companies for quotes, and come to find out — a residential solar system is a bit more than you can afford, and your excitement to join the solar cause is diminished.

This may be an all-to-common situation for many in the U.S., which is why the U.S. Department of Energy (DOE) established the SunShot Initiative. The program hopes to reduce the cost of solar installations 75 percent by 2020. Its ultimate goal is to make solar a more attractive and cost-competitive form of energy for those looking to go solar. According to Ramamoorthy Ramesh, the manager of the SunShot program, solar should be as easy to install on your house as buying a set of tires for your car — who wouldn't agree with that?

With this initiative in mind, Vermont legislators enacted a groundbreaking bill that streamlines the installation



process for small-scale solar — including the elimination of time-consuming and expensive permitting. So, how much does the bill actually reduce the cost of solar?

It Costs How Much?

Estimating the true cost of a residential system can be difficult to pin down. According to John Farrell of Energy Self-Reliant States, the installed cost for residential solar was $6.40 in 2011, which means that the installation costs of a typical 3-kW system would be about $19,000.

"Even if we pick one of these, it's difficult to compare apples to apples, because grid electricity is priced in dollars per kilowatt-hour of electricity, not dollars per watt. Enter 'levelized cost,' or the cost of a solar PV array averaged over a number of years of production," explains Farrell. "For example, a 1-kW solar array installed in Minneapolis for $6.40 per watt costs $6,400. Over 25 years, we can expect that system to produce about 30,000 kilowatt-hours (kWh), so the 'simple levelized cost' is $6,400 divided by 30,000, or about $0.21 per kWh."

So what does permitting contribute to these costs? Aside from time, a recent report produced by SunRun estimated that permitting adds roughly $2,500 to the cost of an average residential installation. The report went on to speculate that streamlined permitting could make solar affordable for 50 percent of American homes. Experts at the SunShot initiative agree — they estimate that 40 to 50 percent of costs come down to "soft" costs like permitting, zoning, metering, financing and arranging a grid connection. According to a SunShot release, "That means consumers are now paying more to generate electricity from rooftop systems — an average of 18 cents a kilowatt-hour, according to the Department of Energy's calculations — than they would for conventional energy purchased from a local utility."

Addressing the Issue

In Vermont, legislators set out to establish a streamlined registration process and trash the headache-inducing permitting procedures. "There is a fiscal and environmental urgency for Vermont to move off fossil fuels and toward sustainable sources of power," said Vermont Gov. Peter Shumlin in a statement.

The new law states that utilities must approve systems 5-kW and smaller within 10 days of receiving a registration form and certificate of compliance with grid connection requirements. Before the law was enacted, solar applicants would need to receive a certificate of public good (CPG) from the Vermont Public Service Board, which would then determine if the project met environmental standards, was reliable and of economic benefit. In all, it was a 30-day process. If the project raised concern, it was to be resolved through a public hearing.

"It should be a national priority to cut unnecessary red tape and costly permitting for small renewables. Cutting out unnecessary costs will help us both meet our urgent energy needs and make domestic solar more competitive," said David Blittersdorf, president and CEO of Vermont-based AllEarth Renewables in a statement. "We've had the Department of Energy, U.S. Senate offices, state governments, and local installers all calling to ask about how we took this simple, common sense step."

The new law states that utilities must approve systems 5-kW and smaller within 10 days of receiving a registration form and certificate of compliance with grid connection requirements.

The bill also included other beneficial measures to move renewable energy adoption along. For example, it requires Efficiency Vermont and the Department of Public Service to create incentives for biomass heating systems, enhance the PACE (Property Assessed Clean Energy) Program that allows homeowners to lease clean energy over time while reducing upfront costs, and expands utility energy efficiency measures.

Small Steps Toward Grid Parity

Many hope that this innovative legislation will spread throughout the country to stabilize and reduce the cost of solar. The SunShot Initiative hopes that laws like Vermont's, and its own solar initiatives, will bring the cost of solar-generated electricity down to 6 cents per kWh by 2020. According to the Initiative, this price point will hopefully create solar adoption that will add up to 18 percent of the country's electricity generation by 2030.

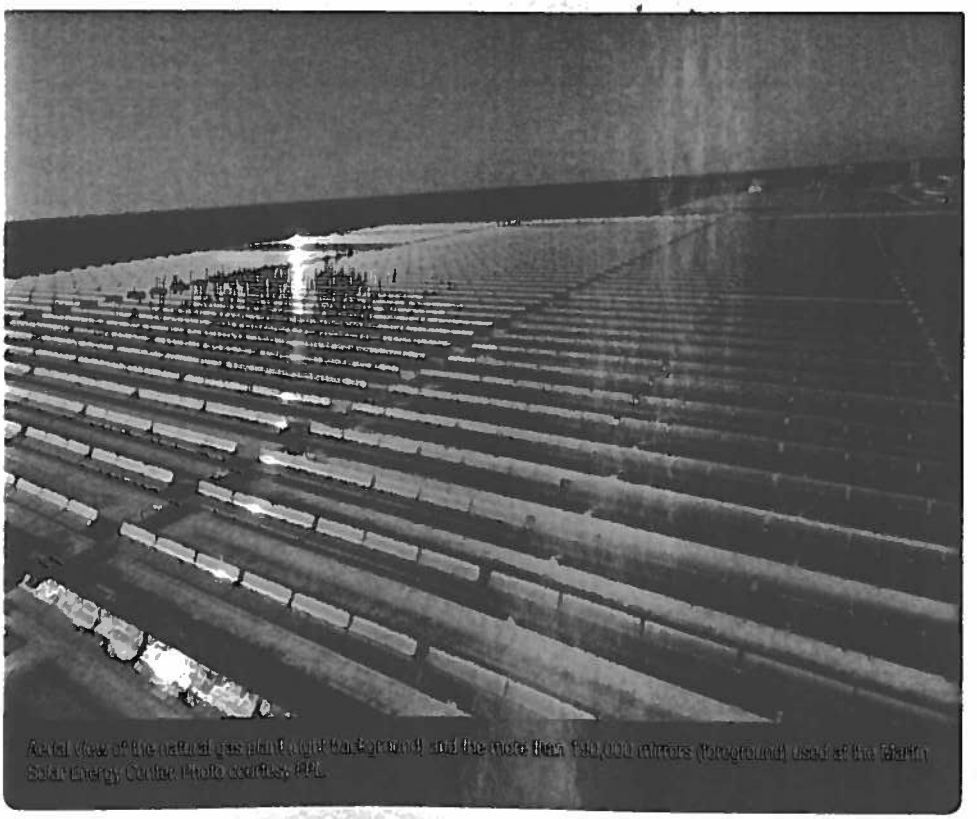
According to Dr. Ramesh, it's all about reducing soft costs, "And as you have more deployment, you have more innovation, and this will invariably bring down hardware costs."

Martin Solar: Harnessing the Power of the Sunshine State

By Brian Wheeler, Associate Editor

In September 2010, the Martin Next Generation Solar Energy Center generated its first solar-powered steam and has been providing heat to reduce a nearby combined cycle power plant's fossil fuel consumption ever since. The Florida Power and Light-owned and operated solar thermal power plant is among the world's first hybrid solar plants to connect to an existing power plant.

Construction began in 2009. With 1,000 workers on-site, the 75 MW solar plant was completed for $400 million, about $75 million under budget. The solar field is on 500 acres of the 11,000-acre site, which includes the 3,600 MW Martin combined cycle power plant. Located near Indiantown, Fla., the solar plant is made up of more than 190,000 parabolic mirrors that concentrate the sun's thermal energy onto 53 linear miles of heat collection elements that contain heat transfer fluid known as Dowtherm A. The fluid heats up to nearly 740 F and is pumped through heat exchangers to produce steam from feed water supplied by the existing plant. The steam is then sent to existing Nooter-Erikson combined-cycle heat recovery steam generators (HRSG's) and is further superheated to final steam turbine inlet conditions.



Aerial view of the natural gas plant (right background) and the more than 190,000 mirrors (foreground) used at the Martin Solar Energy Center. Photo courtesy FPL.

The solar field has been integrated with a pre-existing 1,150 MW combined-cycle natural gas fired plant at the Martin site equipped with four GE 7FA combustion turbines. Gary Kowalczyk, plant manager for both the Martin solar and fossil facilities, said the HRSG's at the 4x1 combined cycle plant are equipped with duct burners that can generate 100 additional megawatts of steam to a Toshiba steam turbine. Solar thermal is now displacing the need to fire the less efficient natural gas-fired duct burners.

"The steam (produced by the solar field) offsets the natural gas afterburners so it is also a fuel savings for the customer and very efficient," he said.

When the solar field is operating at full capacity, the plant achieves a 500 Btu/kWh heat rate reduction, which Kowalczyk called a "positive environmental aspect."

One concern for FPL when tying-in to the existing fossil plant was to maintain HRSG drum level control without upsetting generation on the existing unit. Once the solar plant began generating steam, plant engineers tuning the

system found the control challenge very manageable.

"There were some valve issues initially, but the startup process of supplying solar generated steam to the units for the first time went remarkably well," said Bruce Kullman, lead plant engineer.

"Solar generation is not new to us, but this is the first-of-its-kind tied-in to an existing plant."

Kullman said the project team responsible for getting the plant commercially operational benefited from the experience from other solar power plants the company owns and operates. NextEra Energy Services, of which FPL is a subsidy, operates one of the largest solar power facilities in the world. The Solar Electric Generating Systems (SEGS) plant in California's Mojave Desert is made up of nine solar plants that generate roughly 354 MW. And there are two other solar photovoltaic sites in Florida that are also operational.

"Solar generation is not new to us, but this is the first-of-its-kind tied-in to an existing plant," said Kowalczyk.

Even with the challenge of harnessing the sun's energy through cloud cover and rainy days, Kowalczyk said the plant has achieved full capacity on numerous occasions. He said the hybrid solar concept can be used at other existing fossil units.

Over its lifetime, the Martin Next Generation Solar Energy Center is expected to save FPL customers an estimated $178 million in fuel costs and prevent the release of 2.75 million tons of greenhouse gases. It will do that by reducing fossil-fuel usage by some 41 billion cubic feet of natural gas and 600,000 barrels of oil. The 75 MW facility is also the United States' largest solar thermal plant outside of California and is expected to generate about 155,000 MWh annually. pe