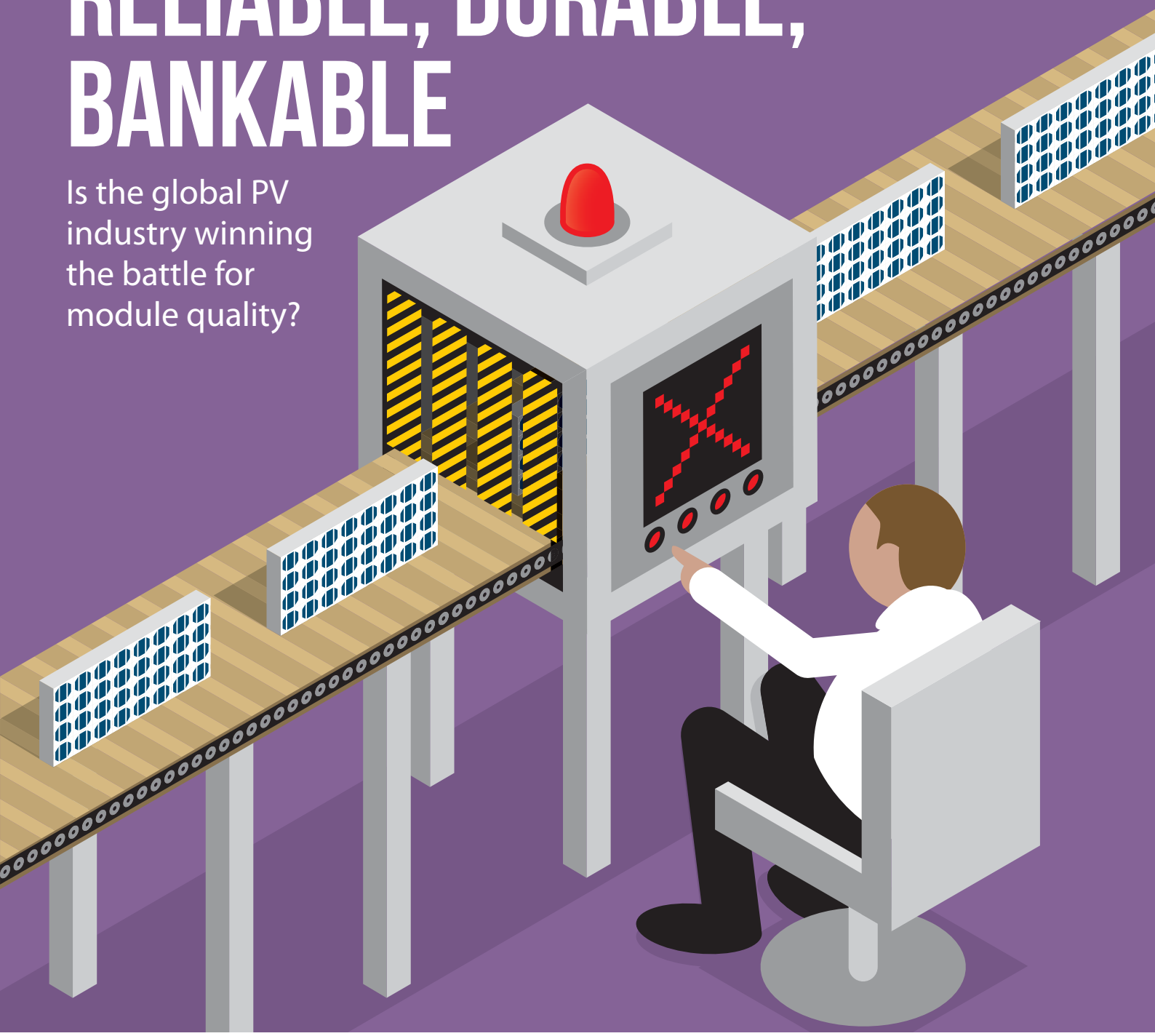
PV TECH POWER

Volume 01 | PV POWER PLANT TECHNOLOGY AND BUSINESS | October 2014

RELIABLE, DURABLE, BANKABLE

Is the global PV industry winning the battle for module quality?



SUNPOWER & SOLARCITY

Why the US PV giants are taking a lead in storage

FIXED VS TRACKER

JA Solar on which mounting system works best

FIRST SOLAR

Next-generation utility-scale PV power plants

SLOW-BURN USA

How America's steady approach to PV is reaping dividends

Solar Power International 2014

Las Vegas, USA
Oct.20-23, 2014
Booth1054

JA SOLAR
www.jasolar.com

Harvest the Sunshine

Premium Cells, Premium Modules

JA Solar Holdings Co., Ltd.
NO.36, Jiang Chang San Road, ZhaBei, Shanghai 200436, China
Tel: +86 (21) 6095 5888 / 6095 5999 Fax: +86 (21) 6095 5858 / 6095 5959 Email: sales@jasolar.com; market@jasolar.com

POWER PVTECH

Published by
Solar Media Ltd.
5 Prescot Street
London E1 8PA, UK
Tel: +44 (0) 207 871 0122
www.pv-tech.org

Publisher:
David Owen

Editorial
Head of content:
Ben Willis
Deputy head of content:
John Parnell
Contributors:
Mark Osborne, Andy Colthorpe, Lucy Woods, Colin Marrs, Leonard Dickinson

Design & production
Design and production manager:
Sarah-Jane Lee
Production:
Daniel Brown
Tina Davidian

Advertising
Sales director:
David Evans
Account managers:
Graham Davie, Lili Zhu

Printed by
Buxton Press Ltd., Derbyshire

Brands of Solar Media:

Photovoltaics International
Solar Business Focus United Kingdom
PV TECH
SOLAR POWER PORTAL
PV TECH PRO
MANUFACTURING THE SOLAR FUTURE
SOLAR ENERGY
Next Energy news
PV TECH STORAGE

Cover infographic by Leonard Dickinson

Introduction

PV deployment continues to grow at a remarkable rate. In just under 15 years it has gone from being a niche player, with a little over 1GW installed worldwide, to almost 140GW last year – more than a 10,000% increase. The technology's onward march looks set to continue well into the future, albeit at a slightly more measured pace, with estimates forecasting as much as 430GW worldwide by 2018.

With that continued expansion comes a pressing need to improve practices in the physical building of PV power plants. As upstream manufacturers have squeezed out cost in recent years, so those involved in the other end of the business must now take up the challenge of aggressively decreasing balance of system (BOS) costs – those non-module elements that now account for some 60-70% of an average system price tag. Only through continued innovation in technology and processes can the industry continue to drive down the levelised cost of producing solar power and ensure its future in the energy mix.

On the hardware front, savings in elements such as inverters, cabling and mounting equipment are a key part of the equation. Meanwhile, so-called 'soft costs' arising from aspects such as permitting, financing and labour also present opportunities for cuts. In the US, under the banner of the Department of Energy's SunShot initiative, the National Renewable Energy Laboratory last year published a roadmap charting a path towards a goal of slashing soft costs to US$0.65/W in residential systems and US$0.44/W in commercial systems by 2020.

PV Tech Power has been created in recognition of the many challenges the industry faces in achieving these aims. The title is an evolution of the *Photovoltaics International* technology journal, which has been at the forefront of documenting cost-per-watt reductions in PV manufacturing for the last seven years, and PV Tech, the leading dedicated online source of industry news and analysis. The publication combines cutting-edge technology papers from leading industry experts with analysis of business-critical trends and issues in a comprehensive resource aimed at all those concerned with maximising return on investment from large PV power plants.

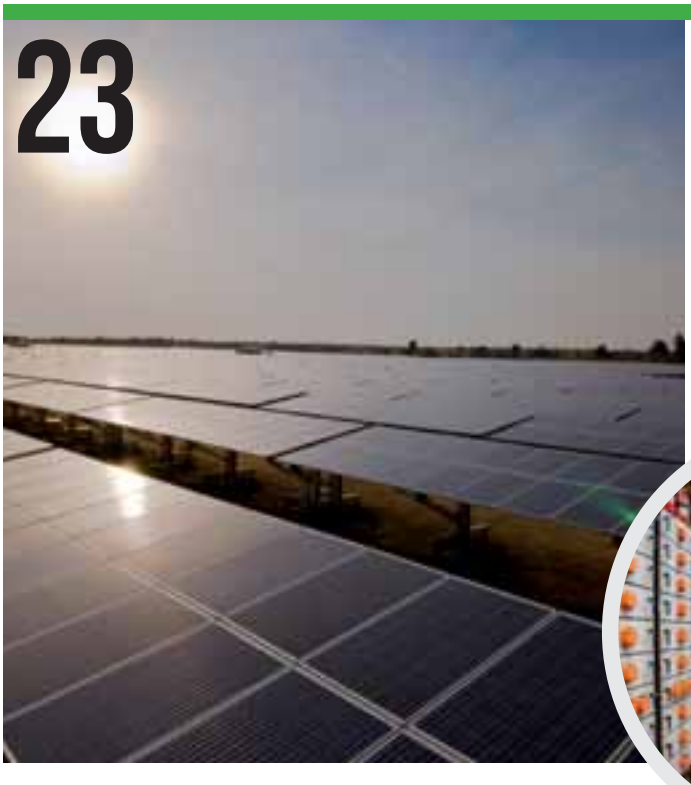
In this debut issue we explore the all-important question of module quality (p.29). Long-term module performance is fundamental to the overall profitability of solar systems, but we ask whether the current regime for ensuring quality is fit for purpose at a time of massive competition and growth. Leading manufacturers **Hanwha Q CELLS**, **ReneSola** and **Wuxi Suntech** offer insights into how they are staying ahead of the pack on quality.

On p.50, **First Solar** gives a detailed under-the-bonnet account of its new generation of high-voltage utility-scale PV power plants and the opportunities they offer for slashing BOS costs. Meanwhile, engineers from **JA Solar** compare the performance of fixed tilt versus single- and double-axis tracker mounting systems (p.61) and draw some surprising conclusions.

With an exclusive interview with **SunPower** chief executive Tom Werner on his hopes for energy storage (p.68) and **Black & Veatch's** exploration of methods for assessing a PV system's likely returns (p.74) also in the line up, we hope you find *PV Tech Power* an indispensible source of information.

Ben Willis
Head of content

Contents



AMERICAS

Share flotation

Vivint's US$370 million IPO

In its forthcoming Initial Public Offering (IPO), US residential installer Vivint Solar is targeting as much as US$370 million. Having gained approval to list on the New York Stock Exchange, the company is planning to sell 20.6 million shares out of a registered 23.69 million, between US$16 and US$18 each. Investor Blackstone will maintain control of the majority of remaining stock after the flotation. Another big player in US residential leasing, Sunrun, recently announced a major plan to add 800 new employees across the country and open or expand its operations in four states. The top ten solar installers in the US have over half of the national market share, according to figures released by GTM Research.

Vivint Solar is hoping to raise as much as US$370 million from its IPO. *Source: Vivint Solar*

Unsubsidised PV

Texas' first merchant PV plant connected for First Solar

In a relatively new industry like solar, 'milestone' can be an overused term. However, the connection of the first 18MW phase of First Solar's Barilla PV plant in Texas could arguably lay claim to that accolade, as it is the first plant in the state to operate without a power purchase agreement. The 'merchant' PV power plant in Pecos Country, west Texas, will instead sell electricity on Texas' ERCOT grid spot market. Unsubsidised merchant power projects are becoming more common in countries where solar offers a viable alternative to costly fossil fuel-generated power, such as Chile, but are largely untested in the US.

Brazil

Brazil holds auctions in push for 3.5GW of solar

As *PV Tech Power* was going to print, Brazil was preparing to hold an energy auction for all sources to compete for national tenders. A later round will include a solar-only category. With a general election taking place in October, it's tricky to tell what the future will hold for Brazil. Nonetheless, EPE, an energy research organisation affiliated with the government's renewables ministry released a plan for energy for the next 10 years, which included 3.5GW of solar. The plan says renewables' contribution to the country's energy mix is to stay at around 42% until 2023 and will account for 11.5% of all newly installed capacity in 2023.

Utilities

Duke Energy's US$500 million solar commitment

Often painted – rightly or wrongly – as the bad guys when it comes to the US PV industry, utilities are nonetheless starting to get wise to the appeal of solar. At any rate, one of them, Duke Energy, committed US$500 million in mid-September to PV. This will include building three utility-scale projects in North Carolina totalling 128MW. Assuming approval from the North Carolina Utilities Commission, construction is to start at the beginning of 2015, creating 750 local jobs. North Carolina's Solar Energy Association said the announcement "has promising implications for solar development," in the state. It also follows a wave of other announcements for North Carolina, including Apple's plan to build a 17.5MW solar farm.

DATA WATCH

1.5GW

Surge in Central America PV installations up to 2018 to be led by Honduras, according to new analysis by IHS.

US government

US government departments promote solar

US energy secretary Ernest Moniz, is in his own words, "very bullish" on the prospects for solar. His Department of Energy was joined in late September by the Department of Agriculture in holding that estimation, as US$68 million of funding was announced for 540 renewable energy projects including 240 solar projects. In addition President Obama recently announced a plan to put US military veterans through community college-type solar training facilities as part of a goal to add 50,000 new PV installers in the US by 2020. The Solar Instructor Training Network will conduct a new pilot job training programme for 400 veterans at a time at up to three military bases.

Finance

Google joins SunEdison's yield co backers

SunEdison's 'yield co' spinoff, TerraForm attracted headlines as search engine monolith Google decided to put US$145 million in equity finance into one of its projects in Kern County, California. Regulus PV power plant will make up to 10% of TerraForm's 808MW project portfolio using 248,000 SunEdison modules. Power will be sold through a PPA to Southern California Edison. TerraForm got started this summer after lengthy speculation and also connected two 50MW projects in the UK in September. Additionally, in August parent company SunEdison got more high profile backing when it secured US$160 million from Barclays and Citi banks for distributed generation projects in the US.

Chile

Chile's potential starts to be realised

Chile's potential as a solar industry 'sweet spot' has been touted for some time. This year however, projects finally started to get underway in volumes, including the approval by the Chilean environmental authority of a colossal 698MW project, split across 11 sub-projects. A week later the agency, SEA also approved two plants totalling 392MW capacity. Meanwhile big foreign players like SunEdison and Yingli Green have recently stepped up their presence in the country, with Yingli opening an office in Santiago and SunEdison striking up a deal for a 70MW project at a copper mine.

Manufacturing

SolarCity's own 'gigafab' gets underway

Following the acquisition of module manufacturer Silevo in June and the announcement that Tesla's 'Gigafactory' will be in Nevada, SolarCity broke ground on its own gigawatt-scale module factory in late September. The facility will manufacture modules together with Silevo and the start of construction was marked with a ceremony attended by New York governor Andrew Cuomo. The establishment of the factory is part of a plan to move upstream and realise a stated aim of achieving a "breakthrough" in the cost of solar power. Meanwhile, Suniva started construction on its second manufacturing plant in the US, a 200MW factory in Michigan that is expected to provide 350 jobs.

See page 68 for a feature on recent moves into energy storage from SolarCity and SunPower Corporation

Uruguay

Uruguay takes first bite of PV plan

Uruguay got a national plan to procure 200MW of solar kicked off with its first deal, as state utility, UTE, agreed to buy power from a 50MW PV power plant in July. The news was followed by a number of other big steps taken. Spanish firm Fotowatio Renewable Ventures (FRV) signed for US$70 million in funds from Norway's largest bank, DNB Group later

The power of solar is exponentially better.

And we're bringing that power to Las Vegas for

Solar Power International 2014.

And then some.

SPI '14 will unleash the power of

- the industry's most innovative products and technologies
- most inspiring speakers, experts, and thought-leaders
- and most engaging networking events and opportunities.

To exhibit or sponsor at SPI is to impact your bottom line exponentially.

www.solarpowerinternational.com.

Solar Power International • October 20-23, 2014 • Las Vegas Convention Center • Las Vegas, Nevada

SOLAR POWER INTERNATIONAL 14

POWERED BY:

40 YEARS SEIA Solar Energy Industries Association®

SEPA solar electric power association

WINNERS & LOSERS

PV

According to official data from the US Energy Information Administration (EIA), US utility-scale solar installations in the first half of 2014 defied a general downward trend across all generation types to surge by nearly 70% year on year. Meanwhile a study from the Department of Energy and Lawrence Berkeley National Laboratory found that solar prices in the US in 2013 fell by a further 15% year on year. The good news is tempered by the looming spectre of the 2017 cut in the federal Investment Tax Credit (ITC) rate from 30% to 10%, which according to research firm GTM, could result in the "collapse" of utility-scale solar in the US.

Source: SunPower Corporation

CSP

Although a final decision is not expected until mid-October, the future of CSP in the US seemed to be on an uncertain course as the developers of a 500MW project in the California desert formally withdrew the project's application. Despite a suggestion from the California Energy Commission (CEC) that altered plans could be considered, developers Abengoa and Brightsource made a submission to the CEC to abandon the plans entirely. So far only one CSP tower project, Ivanpah, has been completed in California. A report from Lux Research in February predicted that concentrating solar power (CSP) is set to shrink during the next four years but could make a recovery at the end of the decade.

Source: Brightsource

that month to reach financial close on a 65MW PV plant. Meanwhile, Local developer, Tecnova Renovables and global renewable energy developer, Sky Solar will build a 50MW crystalline silicon PV module factory in the west of the country.

MIDDLE EAST & AFRICA

Power Africa

World Bank pledges US$5 billion for Africa projects

The World Bank has pledged US$5 billion in technical and financial assistance for energy projects in Ethiopia, Ghana, Kenya, Liberia, Nigeria and Tanzania. The move, partnered with US President Barack Obama's Power Africa Initiative, was made in order to provide power for 600 million people on the continent that have little to no access to electricity. The financial development institution will provide direct financing, investment guarantees, and advisory services for project preparation. A 20 year loan worth €23 million (US$29.5 million) has also been agreed by the European Investment Bank (EIB) to support a 30MW solar development in Ouagadougou, the capital of Burkina Faso. The development is to serve as a reference point for future solar investments in the region.

Ghana

First phase of Ghana's 200MW PV plan underway

Authorities in northern Ghana signed a deal in summer to press ahead with the 40MW first phase of what will eventually be 200MW of solar capacity in the region. The Savannah Accelerated Development Authority (SADA) has finalised an agreement with DCH Solargiga, a subsidiary of China's Solargiga, to build the plant near Tamale, the principal town of Ghana's Northern Region. SADA will contribute 10% equity to the US$117 million-dollar project and DCH Solargiga the remainder. The company is expected to source investment from bodies such as the World Bank's International Finance Corporation. Upon completion the 40MW project will feed power into Ghana's national grid.

Cancelled tender

Jordan's cancelled 400MW tender for solar and wind

In early August, Jordan's Ministry of Energy and Mineral Resources cancelled a procurement round for four 100MW renewable energy projects. The process was open to wind and solar developments but a statement on the ministry's website confirmed that the process had been cancelled. Energy minister Mohammad Hamed was quoted in the *Jordan Times* blaming grid costs for the cancellation. The minister confirmed however that existing contract awards for renewable energy projects will not be affected with the grid ready to accept the new additions. The news emerged shortly after First Solar announced a deal, with a power purchase agreement already in place, to perform EPC duties on a 52MW PV project in the country.

Pipeline

Middle East and Africa's 12.3GW of projects

The Middle East and Africa's PV markets have a pipeline of 12.3GW, according to recent reports by analysis firm NPD Solarbuzz. Tracking projects in seven Middle Eastern countries and 29 countries in Africa, Solarbuzz said 95% are ground mounted. The Middle East in particular has suffered a number of solar false starts with progress in Saudi Arabia often touted, but yet to deliver significant projects. Africa's pipeline has reached 11GW, while the Middle East's stands at a comparatively humble 1.3GW. Meanwhile, Bloomberg New Energy Finance issued a prediction that investments of US$5.9 billion will be made this year in renewable (geothermal, solar and wind) energy in Sub-Saharan Africa alone.

Taxes

Pakistan industry warns of solar tax danger

Financial laws that came into force in July left containers full of imported solar equipment reportedly stranded at ports in Pakistan. The nation's Financial Act implemented a tax of over 30% on imported solar modules, which apparently led to an estimated 70 containers of solar panels becoming stranded at the port of Karachi. Due to the country's energy crisis, solar products had previously been tax exempted. At the time, Usman Ahmad, director at Karachi-based solar system wholesaler, Nizam Energy, said the tax was "a very shocking and unexpected decision from the government" that was "bringing the entire local industry to a standstill".

Local content

South Africa attracting big names

Some big announcements came out of South Africa's growing PV industry which continues to attract major international companies. German inverter maker SMA opened a manufacturing facility in Cape Town. In addition to producing SMA's Sunny Central inverter range the factory will enable the company to comply with local content requirements specified under South Africa's REIPPP renewable energy programme. In July, it was revealed that the South Africa subsidiary of Suntech is also pondering local manufacturing, having already secured 100MW of panel sales to projects in the country's REIPP tenders. JA Solar and Powerway, through a joint venture, also opened a module facility in the country this summer. South Africa is looking to install 3.725GW of renewable energy capacity by 2030.

SMA's opening of a factory in South Africa will allow the company to comply with local content rules. *Source: SMA*

EUROPE

Germany

First Solar looks for slice of Germany's rumoured 600MW tender

US thin-film manufacturer and developer First Solar will compete for a share of the 600MW large-scale tender that Germany is said to be preparing. Christopher Burghardt, First Solar's vice president of business development for Europe revealed details of the tender to *PV Tech* and said it would look to secure contracts as part of the competitive bidding process for solar farms up to 25MW in size.

UK

Finance agreed for Shunfeng's proposed 900MW pipeline

Wuxi Suntech's parent company Shunfeng and its partner Greenfield Solar International have signed a deal with German firm youmex to finance a proposed 900MW PV project pipeline in the UK. *PV Tech* reported in early May that the Shunfeng-Greenfield partnership hopes to build 900MW of UK solar projects by the end of 2015. The two companies are seeking to build the solar farms exclusively using panels by Chinese manufacturer Wuxi Suntech, which has been owned by Shunfeng Photovoltaic since April.

Legal

UK solar firms take government to court, again

Some of the UK's largest solar farm developers are taking the government to court for its early closure of the Renewable Obligation scheme to PV projects over 5MW. From April next year projects above that size will have to use the new contracts for difference (CfD) scheme that will see solar compete for capacity with onshore wind. It is the third legal challenge by in the industry in as many years. Unscheduled cuts to the rooftop feed-in tariff were deemed illegal by courts and a £132 million damages claim is under negotiation.

IPO

Scatec Solar plans US$200 million IPO

Norwegian developer and EPC firm Scatec Solar announced an IPO with estimated share prices valuing the company at US$199-200 million.

The company will be listed on the Oslo stock exchange with the initial placement planned for 2 October. The company said shares offered at the new price were oversubscribed.

Scatec Solar said it was targeting 750MW of PV capacity by 2016.

The 75MW Kakbult PV power plant in South Africa. Scatec Solar has been making inroads in Africa and hopes the continent can help drive its growth. *Source: Scatec Solar*

Retail

IKEA to expand into eight new markets

Furniture retailer IKEA will expand its in-store solar sales into eight new markets. The company is partnered with Hanergy for an all-in solar service in the UK. Hanergy will now work with IKEA in The Netherlands and Switzerland. Another six countries will follow over the next 18 months although IKEA has not revealed details on these or confirmed which PV firms will be involved in delivering the service.

Trade case

EU won't pursue Solarworld's claims of breaches

The EU confirmed to *PV Tech* that it would not be following up on the evidence given to it by Solarworld that alleged to prove there had been routine breaches of the price undertaking with Chinese manufacturers. EU ProSun, the Solarworld-led organisation behind the trade complaints said there was "good reason" to now begin an anti-circumvention case against Chinese manufacturers, without confirming that work on this was underway.

ASIA-PACIFIC

China

Shunfeng Photovoltaic grabs cash and pipelines

Shunfeng Photovoltaic secured a US$3.25 billion line of credit in August. Shortly after the company acquired European project developer SAG Solarstrom and confirmed it would base its European HQ at Solarstrom's German base. It continued its downstream activity with a 250MW deal at a mixed-use agricultural site. In less positive news, the company suspended its shares while it clarified Chinese press reports of a dispute with an EPC. Shares resumed trading and the company said it the issue would be dealt with in the courts.

EPCs

TBEA megadeals not enough to unseat First Solar as world's largest EPC

TBEA Oasis did not unseat First Solar as the world's largest EPC firm despite a number of big wins in its domestic Chinese market. TBEA secured around 1.3GW of contracts over the summer including a 1GW deal in Inner Mongolia that is scheduled to begin in May 2015. The latest IHS rankings, revealed in August, showed that the American thin-film giant had held on to its position despite earlier predictions that it was set to lose out.

China

Hareon bags more than a 1GW of projects

PV manufacturer and project developer Hareon has secured a number of large project wins. The largest, signed in late July, will see it build up to 6.2GW up till 2017 in a joint venture with Swiss firm ILB Helios. The projects are spread throughout Europe, Middle East and Africa with more than half in Turkey. In a busy few months for Hareon it also agreed

Japan

Japan rips up approvals for nearly 2GW of unbuilt projects

Japan's Ministry of Economy, Trade and Industry (METI) cancelled 1.82GW of unbuilt projects. The figure, which was confirmed to *PV Tech*, includes projects approved for the lucrative 2012 feed-in tariff rate.

It had been suggested previously that some developers could be sitting on the permits while the cost of PV equipment fell offering better returns on investment. METI said it would not reveal the names of developers involved.

Earlier in the year the ministry gave companies an August deadline to complete the necessary paperwork that moved projects into the construction phase.

Too many Japanese developers were reportedly leaving projects unbuilt while equipment costs fell. *Source: Solar Frontier*

a 1GW ground mount and rooftop deal with real estate firm Jiangshan Yongtai Investment Holdings. The company has agreed project deals worth almost 9GW since the start of July this year however, it was unclear if some of its Turkish pipeline was being double-counted.

Price watch

Philippines minister hails solar as it undercuts fossil fuels

Rooftop solar is cheaper than coal in the Philippines, according to the country's secretary of energy, Carlos Jericho Petilla. Electricity from a coal plant cost up to PHP12.00 (US$0.28) when distribution charges are added. Rooftop solar costs PHP9.00 per kWh (US$0.21) for generation and has no costs for distribution or transmission, said Petilla. Developers juwi, nv vogt and Conergy all announced new ground-mounted projects in the country over the summer as the Philippines' PV push continued.

Australia

Solar project falls as Australian government turns back on renewables

Australia's solar progress took a blow when an independent inquiry into the future of the country's renewable energy target (RET) suggested a scale-back or complete closure to additional projects. Prime Minister Tony Abbott reportedly intervened personally to ensure the report left the option of completely scrapping the policy on the table. Shortly after the news, CPV firm Solix announced it was suspending financial agreements it had secured for a 100MW project citing uncertainty over the RET's future.

Market

China added 3.3GW in first half of 2014

China installed 3.3GW of solar generating capacity in the first half of 2014, according to statistics released by the government. The country traditionally has a busier second half of the year, however the slow pace in the first six months did prompt a series of policy changes from Beijing to stimulate the market. In early September further policy changes were announced by the National Energy Administration (NEA) in an attempt to kick-start the rooftop market as it asked local authorities to identify potential large-offtakers and boost subsidy support. China had capped support at 8GW for distributed generation and 6GW for large-scale solar capacity at the beginning of the year but appears to be falling short.

DATA WATCH

17GW

The total Asia Pacific solar end demand in the second half of the year, according to market research firm NPD Solarbuzz.

ON PAGE 23

For a more in-depth analysis of the latest developments in India's dynamic fledgling solar market, see the feature on page 23.

TIMELINE

The development of the India trade case since new Prime Minister Modi was elected

- 01 MAY
- 05
- 10
- 15

16 MAY
Modi wins election and puts access to energy high on his priority list

- 20
- 25

23 MAY
Indian Ministry of Commerce recommends anti-dumping duties with the ministry of finance to make the final decision in August

- 01 JUN
- 05
- 10
- 15
- 20
- 25

23 JUNE
Two ministers in Modi's new cabinet call for their colleagues in finance to reject the recommended duties

- 01 JUL
- 05
- 10

10 JULY
Modi releases his first budget. It's scrutinised by those looking for an indication of his stance on dumping but includes only a few tax breaks

- 15
- 20
- 25
- 01 AUG
- 05

5 AUGUST
India's chamber of commerce estimates that anti-dumping duties would add 18-75% to the cost of a solar project

- 10
- 15
- 20
- 26 AUG

22 AUGUST
Deadline for a decision from the ministry of finance passes with no announcement meaning duties cannot be invoked

26 AUGUST
Minister for power, coal, new and renewable energy, Shri Piyush Goyal tells domestic manufacturers to run at full capacity and says the entire industry will be "fully supported"

TATA POWER SOLAR
ENABLING SOLAR EVERYWHERE

TATA

25 YEARS OF INNOVATION, QUALITY AND RELIABILITY

SUPERIOR ENERGY YIELD

AR coated glass | High fill factor cells and modules | TUV and UL certified PID free modules | Enhanced low light performance

ROBUST DESIGN

Optimized edge clearance | Withstands high snow and wind loads | Anodized aluminium frame

HIGH PERFORMANCE

Tested beyond IEC/UL standard | High reliability under extreme weather conditions | Electroluminescence tested for micro–cracks

RELIABLE WARRANTY

25 year linear power warranty in line with industry best practices | Warranty claims of less than 0.07% over two decades

PART OF INDIA'S MOST TRUSTED BUSINESS GROUP WITH A LEGACY OF 146 YEARS

25	200	180	600
year linear warranty on modules	MW module manufacturing capacity	MW cell manufacturing capacity	MW of modules shipped globally

TATA POWER SOLAR SYSTEMS LIMITED

Contact: +91 82855 41082 | Email: modules@tatapowersolar.com | Website: www.tatapowersolar.com

Slow-burn US begins to catch fire

US Focus | The US has steadily developed what is now among the world's leading solar markets. John Parnell explores how its conservative approach has allowed it to build a solid industry that will now prepare it for challenges that lie ahead

You may not immediately think of the land that brought us monster trucks, one gallon sodas and Las Vegas as an advocate of the conservative slow and steady approach to life.

The 'Hollywood' approach to developing a solar market is arguably the all-in, generous feed-in tariff (FiT) route taken in Europe. While establishing such measures at a federal level in the US would be near enough a political impossibility, no state has chosen to take that approach either.

California will almost certainly end the year with more than 8GW of installed capacity, just shy of half all of that in the US. But there is no sign of the violent boom and bust cycles that have categorised the development of solar in Europe's major markets.

"The US market deliberately played a 'slow and steady wins the race strategy,'" says Jigar Shah, founder of SunEdison and clean energy evangelist.

The end result is that Shah believes the US will be the largest source of end-demand for solar in the world in 2016.

"I believe that very strongly. Once that occurs I think that the reality of the global politics is that most emerging markets would rather copy the US than Europe," he claims.

"Our goal in the US was not to artificially inflate solar through FiTs but to gently educate the banking sector on why they should be investing in solar. That process probably took five years longer than the FiT strategy but my sense is that today we're seeing the product of this broad education that we were able to accomplish in the US."

Massaging this financial interest has been the gentle demand created by Renewable Portfolio Standards (RPS) that many states adopted to ensure a portion of their electricity came from clean energy sources. Nevada's 25% goal by 2020 included a stipulation that 6% of its power would come from solar. Oregon, Maryland and Colorado also included more modest sub-targets for solar.

"There's one big transition taking place in the utility-scale market and that's the transition from a totally RPS dominated demand landscape to one that is a lot more diverse," says Shayle Kann, senior vice president of GTM Research. "Historically, the reason California and to a lesser extent Arizona, Colorado, Nevada and New Mexico have dominated the utility market is because they had an RPS that mandated utilities to procure renewables and in some cases solar."

"What has changed now is that power purchase agreement (PPA) prices for utility-scale have got low enough that solar can compete in a variety of different geographic and conceptual locations without needing the extra boost of the RPS. FirstWind signed over 400MW of contracts recently in Utah, which has no RPS to speak of. We've counted up over 3GW of utility-scale solar contracts signed in the last 12 months outside of the RPS standards."

Michael Barker, senior analyst at market research firm NPD Solarbuzz, agrees that the favourable economics are feeding the growth seen in the US market.

"Solar is competing with natural gas and this is opening a large swathe of the country that has not traditionally been strong in terms of PV deployment," he says. "Solar in the utility segment is being driven by strong project economics. PV power plants are being seen as strong long-term investments and that is leading to a lot more funding coming into the industry and investors looking to invest in or purchase these large-scale developments – especially those projects that are able to agree long-term PPAs."

With more capital investment, there is more growth, and Shah's observation about the importance of educating investors bears out.

Redrawing the map

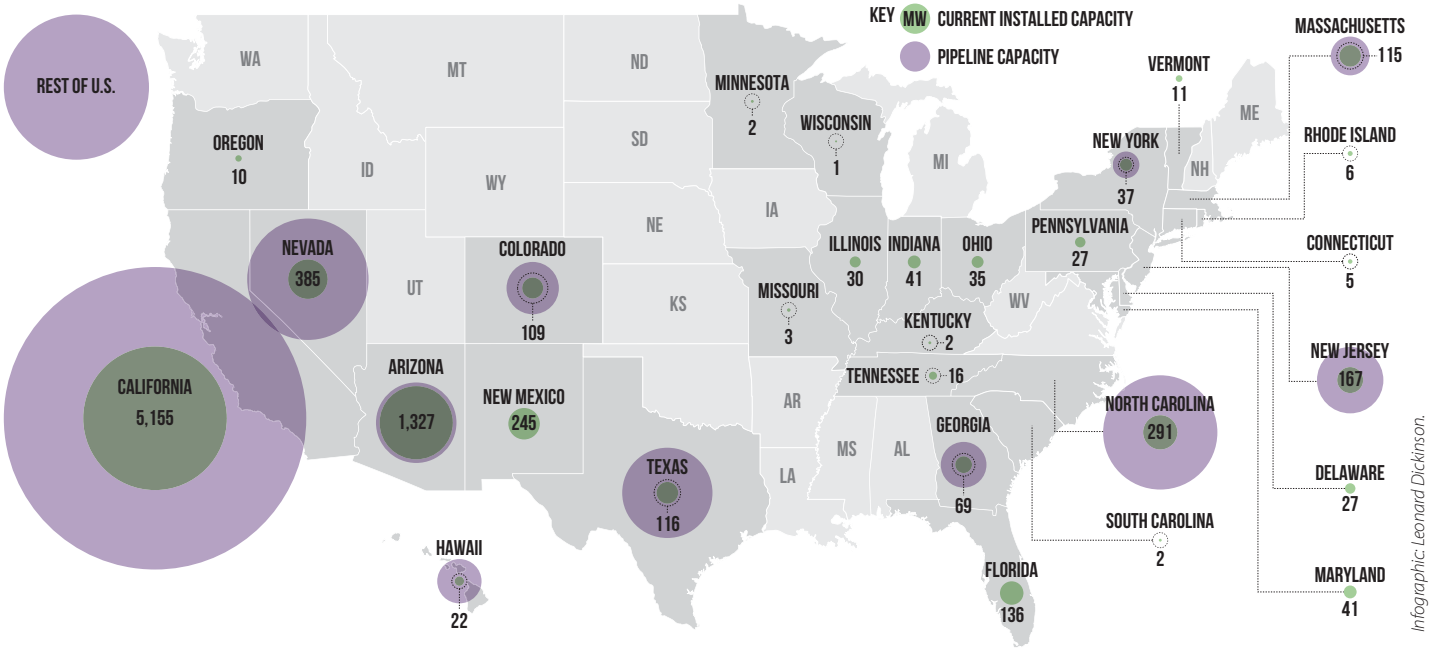
With new drivers behind the industry, the distribution of projects is also set to change. The infographic overleaf compares installed capacities with current project pipelines. Some have ambitions far beyond their

The world's biggest market by 2016?

Analysts respond to Jigar Shah's prediction that the US will be the largest source of end demand for solar in 2016:

Adam James, GTM Research
We do expect the US to be the largest global market in 2016, exceeding China by a razor-thin margin. There are two aspects of this 2016 story that are indicative of the broader market. First, the global market is still very concentrated in a few key countries, with the US and China accounting for over 50% of the market in 2016. Second, the global market is still highly policy-dependent, as those top two markets are being primarily driven by incentives; in the US by developers installing projects ahead of the ITC deadline, and in China from the feed-in-tariffs driving the utility-scale and large commercial and industrial market.

Ash Sharma, IHS
In terms of annual (DC) installations we predict the US will install around 9.5GW in 2016, second place behind China. Of course China has the ability to surprise and change rapidly, but all indications are that government policy and support will only accelerate deployment in China rather than slow it. As such, I find it hard to see the US displacing China in 2016. In 2016 we predict a spike in demand, as developers rush to complete projects before the ITC falls to 10%. This is likely to cause a significant fall in US installations in 2017 (we expect by as much as 33%) and would see the US fall behind Japan and further behind China



Infographic: Leonard Dickinson.

The infographic shows the operating capacities of major projects in key states in the US taken from latest available SEIA data at the time of publication. The larger circle shows that state's PV pipeline for ground-mount projects as of September 2014, according to the NPD Solarbuzz US Deal Tracker. This includes projects in pre-planning, planning or construction. Once RPS driven markets in the west are now meeting new competition from states in the east and south east as project economics stack up favourably. Despite the healthy geographic pipeline spread, California remains largest market by some distance.

current generation capacity, some markets appear tapped out. For now.

California is way out in front but where is the solar potential in the US?

"Well Texas is a large state so you will always get large numbers out of Texas. It's the same with North Carolina," says Shah. "But I think you'll also get high penetration in Iowa, Utah and places like Georgia. Which I think is critical: it's not just about large numbers and flashy press; it's about whether utilities start viewing solar as a systemic way of managing the grid."

Barker believes that the state-by-state policies in the US protect it to an extent from the bust cycles seen in many European countries. The RPS may be redundant in one state, but here are plenty others knocking at the door.

"The US is punching below its weight but it's growing at a good clip and it's growing steadily. There is no one US market, there are 50 plus the federal policy, so it's less susceptible to policy shock," says Barker.

Tony Dorazio, president and CEO of Texas-based solar developer and manufacturer OCI Power, has the kind of desirable 25-year PPA in place for the 400MW San Antonio project. He tells *PV Tech Power* why he'll continue to hedge that potential risk by working in multiple markets.

"I won't put all my eggs in the Texan basket. I'm looking at states that are potentially starting to come up, south-eastern states, which have decent irradiation. I will continue to build out Texas and on top of that contracted PPA we also have some manufacturing. We make panels, trackers…so I'd love an all-in-Texas product to sell here. But if Arizona, New Mexico and California come up, as an IPP I will go there in a minute," says Dorazio.

OCI has also opened an N-type cell plant since *PV Tech Power* spoke to Dorazio.

Taxing troubles

The most likely policy shock on the horizon for US solar is the cut in the Investment Tax Credit (ITC) from 30% to 10%, which will kick in at the end of 2016.

GTM's Kann has forecast dire consequences in the aftermath of the cut.

"That's going to be really hard. The ITC reduction is going to have the biggest immediate impact on the utility-scale sector. What we are going to see is a huge boom in installations getting completed in 2016 and then a complete collapse in 2017. There is almost no utility-scale solar being planned to come online in 2017," he says.

"In fact some of the developers that are signing PPAs that start in 2018 or 2019 are still planning on constructing the projects in 2016 but then having a variety of ways through which they can bridge those few difficult years [before the PPA begins]."

Building a project before a PPA contract starts paying out secures the ITC but leaves projects without an income stream. Canny developers have found more than one way around this.

"There's two main ways. The first is what is called a merchant nose, so it's a merchant project selling wholesale power on the spot market for a few years until the PPA kicks in. The other option is a bridge PPA which is a short PPA that might last only a few years with a different utility and at a different rate before the full PPA begins," explains Kann.

Solarbuzz's Barker believes that with the ITC cut known about well in advance, the industry will find ways to cut costs and offset the impact. OCI's Dorazio agrees.

"It's pretty simple. It's one of the reasons why we started to vertically integrate, to manage the cost of the value chain and to become as efficient and as cost-competitive as possible," he says.

Another approach is to diversify. "You have to look at going international," Dorazio says. "You can go to areas with high prices for electricity, emerging countries that not only need power but need a stable grid and will pay a premium for it while you also continue to drive their costs down. It's about diversity. Anyone in this industry knows that I think."

He says OCI is casting its net far afield looking at "a lot of Asia, Africa and South America, anywhere where you compete with diesel generation, weak grids and no power".

Feeding the fire

Regardless of the source of demand, another key factor in making the economic case for solar is the availability of finance.

The maturity of the market has offered

Jigar on…

Yield cos

When you think about the US model, what we're doing is saying how to correctly price the risk of very small projects. Most people like the EIB, know how to underwrite billion dollar projects in Africa and India and other places, but they have a hard time underwriting 1,000 US$1 million projects. That's what we have proven in the US. We've figured that through a yield co you can create a portfolio of those 1,000 US$1 million projects.

The yield co has already been done in London as well and I think we'll see yield cos going public in Singapore and Mumbai and other stock markets around the world. There's certainly no lack of ability to replicate the model, the question is can you feed the beast? Once the US is the largest market in the world, people will have the confidence that you can find the projects to make this market work. You can't sustain the costs of structuring this model unless you have enough projects to invest in.

The future US market

Texas is a large state so you will always get large numbers out of Texas. It's the same with North Carolina. But I think you'll also get high penetration in Iowa, Utah and places like Georgia. Which I think is critical, its not just about large numbers and flashy press. It's about whether utilities start viewing solar as a systemic way of managing the grid.

Utilities

Education is sometimes overrated. Jealousy is sometimes underrated. It's better to make someone jealous of you than to educate them. A lot of utilities in the US and around the world are jealous of our industry and that's causing some of them to try and join us and copy us which is wonderful news. It's a milestone for the industry.

The day is always darkest before the dawn. Right before you win, is when people are at their most vitriolic against you. The fact people are so animated about solar now gives me hope that we are actually winning.

President Obama's climate plans

All these things are valuable. Whether it's the International Energy Agency saying renewables are critical for meeting climate change goals or the UN saying renewable energy is essential to reduce costs in emerging markets. The more reasons we have the better. It's like that Ghandi quote: 'First they ignore you, then they ridicule you, then they fight you, and then you win.'

The ITC cut

I think the UK has led in this area. When the UK was faced with this existential threat of the FiT being cut nearly 50% it delayed it a year through the courts and then it responded within a year after that. The US market has two and a half years to figure out how to meet this target. The same is true in Germany and India. Many markets that have had these cuts in incentives have found that the solar industry was able to figure out how to make do in the new environment.

Trade

There has to be a global conversation about what it means to be fair in this space. The good thing about solar is that there is not that much profit in the manufacturing part of the business. I don't actually think China is getting such a good deal by exporting this stuff around the world. It does get the jobs. They're not that high paying jobs and I'm not sure they would all move to the US if there was a fair regime.

That said I don't think it is incumbent on the US to lead a conversation on how we create a framework so the private sector understands what rules we're operating under.

Technology

There's still a tremendous amount of technology innovation still to be deployed and there is a lot of optimism that solar will continue to go down in cost for the next six year. Its important to note that in the coal, gas and nuclear industry, they are all looking at inflation. None of them are looking at cost reduction.

new routes to finance for the major residential installers and the utility-scale developers alike. For the latter, yield cos have offered another string to the bow. Betting the farm on this as a source of solar salvation could be premature.

Shah points out that while yield cos could well emerge in a number of developing solar markets, the one problem with a yield co is that you need to ensure you continue to have sufficient projects

"There's certainly no lack of ability to replicate the model, the question is can you feed the beast? You can't sustain the costs of structuring this model unless you have enough projects to invest in," he says.

So would Dorazio's OCI look to follow in the footsteps of NRG Energy and fellow developer SunEdison and launch a yield co?

"We're a relatively new company and we don't have the megawatt base right now to push off the revenues we need to be a yield co, but we have the growth story. It's too early for us. We're not ready for it so we're not studying it. We'll look at it again in two years," he says.

Dorazio explains that as well as sitting on a large volume of projects you also need to show you have the ability to continue to add to 50-100MW to that every year. He describes yield cos as "a bit of a craze" and expects the appetite for them to spike then wane.

"I think there will be more. I just don't know how many more. A lot of companies are even trying to create themselves as yield cos…they are almost becoming a financial instrument more than being backed by real, technical, asset-based companies," he says.

"I think some of the yield cos out already will falter. They won't be able to keep up with the growth and that will sour investors on the yield co. They will start to look harder at the company and the growth of the company to see if they have the track record to pull that off. We'll see that in the next two years," he predicts, adding that he also expects smaller companies to then choose to shun yield cos because of the cost of running them. For this reason, Dorazio expects most to take "a conservative" approach to yield cos.

The future of US solar again looks to be founded on the slow and steady approach.

Tempering the yield co "craze" into just another sustainable source of financing for developers would show admirable restraint – the same restraint that has typified the slow and steady growth of solar in the US thus far. If the sector keeps going this slow and steady, it might just race ahead to the top of the tree and fulfil Jigar Shah's 2016 prediction. ■

Author

John Parnell is deputy head of content at Solar Media.

ENERGIZING LIFE TOGETHER

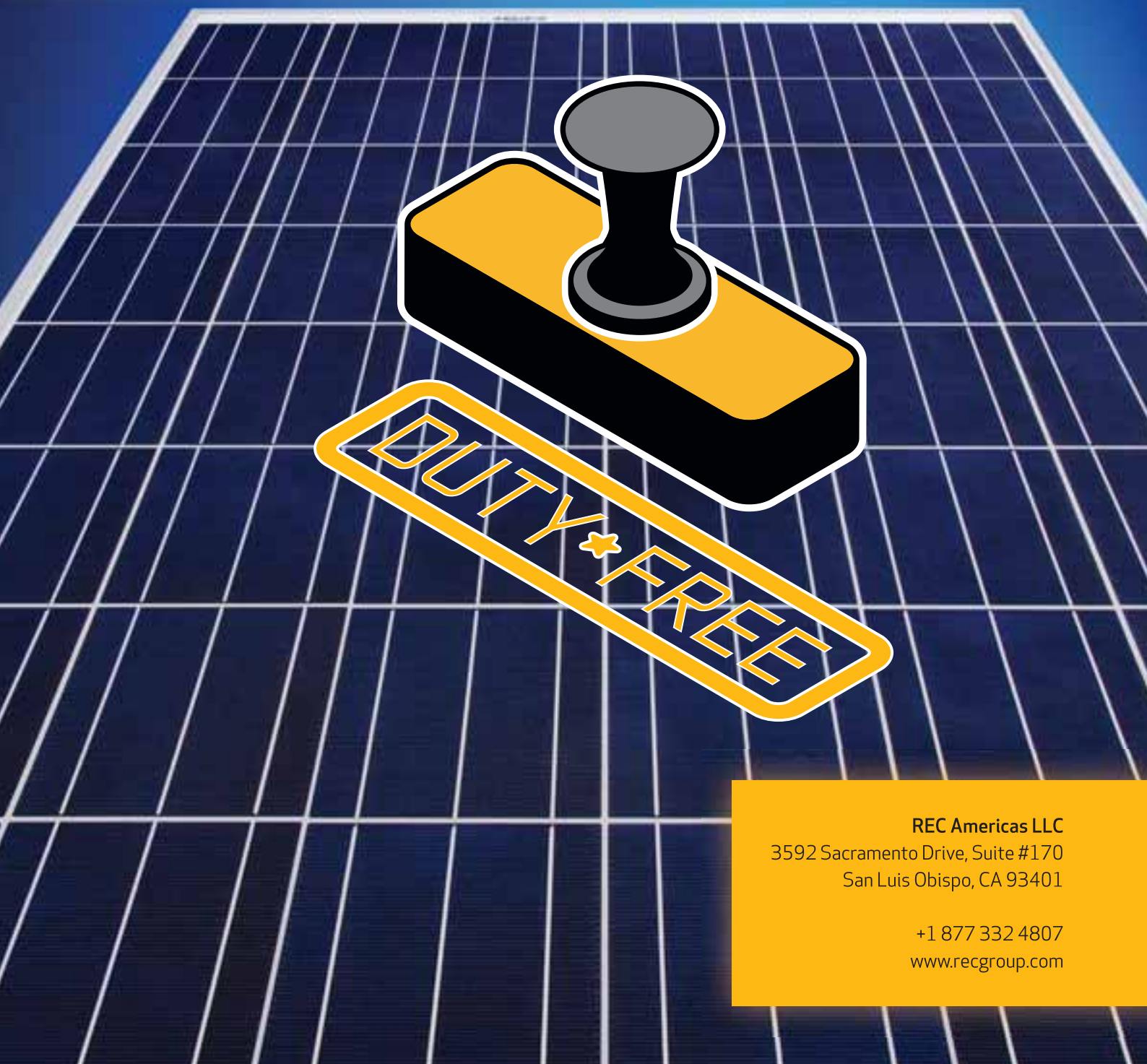
REC

DID YOU KNOW ...

... REC solar panels are US import duty free?

... US-produced silicon is used in REC panels?

... the high-quality REC Peak Energy Series is also available as 72-cell panels?



REC Americas LLC
3592 Sacramento Drive, Suite #170
San Luis Obispo, CA 93401

+1 877 332 4807
www.recgroup.com

Solar Power International 2014 preview

October 20-23, 2014 • Las Vegas, Nevada • USA

Two worlds collide at solar hits entertainment capital of the world

This year Solar Power International rolls into that haven for hedonism, Las Vegas. But as the chief executives of the two bodies behind the event tell Lucy Woods, behind the pazazz, some serious issues will be under the spotlight

An entertainment beacon in the middle of the desert, illuminated at all times with blazing bars and flashing casino lights, known as the Entertainment Capital of the World and home to an iconic solar-powered sign: Las Vegas is to host this year's Solar Power International.

From Nerf games and solar trivia to a poolside party at the Las Vegas Eiffel Tower, "it will not be like anything you can imagine; it is going to be really phenomenal", says Julia Hamm, president and CEO of Solar Electric Power Association (SEPA).

Further laying the foundations for an exciting conference atmosphere, the US solar industry is forecast to grow by 60%, with a further 7.4GW to be installed throughout the rest of 2014 alone, says Rhone Resch, president and CEO of the Solar Energy Industries Association (SEIA), co-organiser with SEPA.

"The message that people will hear most consistently at SPI is that the US is one of the most exciting markets for solar energy in the world, and that is going to continue to be the case for a while," says Resch.

The US industry is currently "constantly evolving with everything from kids coming out of business school with new ideas on how to advance solar, to well-established companies taking it to the next level", continues Resch.

Education, education, education

Both Hamm and Resch highlight SPI's standout attraction as the education on offer. "From a conference standpoint we have the strongest education out there just because SEPA and SEIA are the two organisations that produce SPI, so we have real insight in terms of the key issues of the industry at any given moment in time," says Hamm. SPI understands that the maturing solar industry needs "a variety of different education forums and formats", she says.

Rhone Resch, top, and Julia Hamm, predict big things for SPI 2014, left.

From 'QuickTalks', a solar industry version of TedTalks, to interactive sessions and technical workshops, SPI allows people to "get some education without having to step off the show floor", says Hamm.

"There will be over 100 different concurrent sessions in which participants have a chance to exchange ideas and learn from peers," says Resch. "We try to emphasise this is not a chance for a consultant to come in and pitch an idea or services; this is for companies learning from other companies."

Since SunEdison wrote the first solar power purchase agreement (PPA) in 2004 and shared its model with the industry, Resch says SPI has sought to build on that sharing mentality. "You have to think of the solar industry as an open source industry where the companies are willing to share what they are doing and how they are doing it," says Resch.

SPI has also caught the ears of decision makers – SPI is set to be politically charged

with a "record number" of politicians in attendance, providing industry with "quality face to face time with some of the most powerful elected officials in the US", says Resch.

Resch also reveals that on the attendee list is none other than senate majority leader and senator for Nevada, Harry Reid. "Having Reid there, experiencing one of the fastest growing industries in the US, does a lot to solidify political support," says Resch.

The US solar industry is currently embroiled in political drama, notably its ongoing trade dispute with China, which is still under negotiation. SPI promises to give real-time information from the heart of the US-China solar trade dispute, says Resch. Heading the conference's line up of critical speakers, the SEIA's vice president of trade, John Smirnow, is to give details on what Resch hopes will be an industry-backed settlement to the China trade dispute. Insiders from the Chinese and US governments, and SolarWorld will be "actively engaged" in "frank discussion on what is happening", says Resch.

Smirnow "is one of the nation's leading experts on that topic and will make sure everyone really understands the current status", agrees Hamm.

Also top of the political agenda and expected to be tackled head on at SPI is the demise of the income tax credit (ITC). scheduled to go down from 30% to 10% at the end of 2016. The SEIA is to roll out its solar support campaign at SPI 2014. Resch describes the ITC as "the backbone for the solar industry across every state". The SEIA aims to include all solar professionals attending SPI in its multi-year plan for solar in the run-up to the 2016 presidential election. Resch says SPI is a forum where Republicans and Democrats can come together to develop a shared plan for getting the credit reinstated "at a time when Congress has been highly dysfunctional".

Always a big topic at SPI, "the real meat of the conversation here in the US", says Hamm, with "a lot of discussion and debate back and forth", adds Resch - net metering will also be high on the SPI agenda.

SPI aims to create opportunities for utilities and solar companies from across the states to engage in debates on the benefit and value of solar. SPI will wade headlong into the heated debate over determining "what is the number that distributed solar is actually worth", explains Hamm. SPI's sessions and facilities will bring both sides together to move the discussion forward, with appropriate rates for solar and new incentive mechanisms proposed, says Hamm, as SPI caters for "the market and customers getting more sophisticated".

Meanwhile the SEIA is "certainly going to push back on any penalty" applied to solar adopters, says Resch, with SPI dialogue to focus on a 'minimum charge' for all grid users.

Storage, soft costs and finance

Another big issue for SPI will of course be storage. With Tesla announcing a 1GW battery factory in Nevada and storage hitting the mainstream with Nevada's neighbour California's 1.3GW of storage by 2020 mandate, SPI has, for the first time ever, dedicated a pavilion and lounge to addressing the industry's thirst for storage technology. Hamm reveals there will be information on how the Californian mandate is progressing, while storage and technology companies will showcase the latest battery gadgets. "We want to bring all the energy storage technologies together so it is a one-stop shop for businesses to look at the latest technology," says Resch.

Resch adds that closely related to storage, SPI will be discussing the logistics of putting together micro-grid deals. "We are increasingly seeing the partnership of storage with utility and small grid integration issues," he says. SPI offers a chance to "come together and answer some of the questions from developers trying to put together micro-grids".

Source: SEPA.

Extensive networking opportunities always form a core part of SPI.

Hamm also says to watch out for racking and smart converters on the trade floor, as higher concentrations of solar have been added to the grid.

One of the "biggest focus areas for the industry in the US today" to look out for at SPI, says Resch, is the US Department of Energy's SunShot Initiative to lower soft costs. With a myriad of costs arising from customers and contracts, SPI will focus on how the US market can continue to streamline. "Especially compared to Germany: Germany has a very streamlined process," says Resch – hinting at the prominent absence of SPI experts just before the show. To really stretch the education opportunity, SPI sent a team of researchers to Germany to bring back knowledge to be shared at SPI.

Also high on the SPI agenda is access to financing, hand in hand with the growing interest in community solar. Community solar is "one of the hottest trends right now", says Hamm. Potential solar customers for the rooftop industry face many access barriers to solar electricity, making community solar "quite a large theme throughout much of the education content [at SPI]. It is really about making solar accessible to everyone", says Hamm.

With that in mind, financing community solar will be a hot topic. "The equity issue is an important one that is coming up more and more in policy settings," explains Hamm; SPI sessions will address ways "everyone can have access to solar regardless of income levels".

Although the US industry has plenty to be excited about, it is cluttered with big obstacles and difficult questions, and SPI is just the place to tackle them – even when surrounded by the world's best entertainment, says Resch: "Las Vegas is a lot of fun but SPI doesn't shy away from the tough challenges and tough issues that the industry faces." ▶

Source: SEPA.

SPI 2014 top picks

From 20-23 October, busloads of solar professionals will roll into the Las Vegas Convention Centre for the 2014 Solar Power International, the annual industry jamboree led by the Solar Electric Power Association (SEPA) and the Solar Energy Industries Association (SEIA).

This year's SPI promises to dig deep into the most daunting to the most optimistic issues challenging solar professionals across the states and beyond, from the predicted collapse of utility-scale solar post-investment tax credit, to energy-saving grid storage, state-by-state net metering overhauls and the take-off of community solar.

With the US solar market is closing in on 16GW total solar deployment, while the US Department of Trade and the Chinese government negotiate, SPI promises real-time coverage of the headline grabbing global trade disputes and controversial anti dumping duties and trade levies.

The event stage will be set to hear from the negotiations expert, SEIA's vice president of trade and competitiveness, John Smirnow, and US and Chinese government representatives.

The must-attend solar event will showcase trends, speakers, experts, professionals, exhibitions, entertainment and essential networking. Starting with a gathering at the bar and some games, the SPI event is forecast to be a memorable one.

In terms of solar industry progression and education, hopefully this will be the one time that the "what happens in Vegas, stays in Vegas" adage doesn't apply.

Conference highlights

SOLAR CENTRAL

Booth 4920 (Upper Level Exhibit Hall)

A useful starting point for the huge range of events taking place is Solar Central, SPI's broadcasting and sales booth, an information hub for interviews, discussion, debates, expert panels and presentations. Attendees can browse more than 100 educational posters at SPI's Poster Reception, being held on Wednesday 22, with networking and drinks with poster authors all included.

QUICKTALKS

Wednesday 22 October, 3-5pm; Thursday 23 October, 1030am-noon

SPI is looking to maintain its reputation as the undisputed fount of solar industry knowledge through the premiering of 'QuickTalks'. Modelled on the popular Youtube phenomenon, TEDtalks, SPI will host short and simple 25-minute idea presentations from industry experts on critical topics, with an assembly of 'Master Speakers' – government officials and industry experts – taking the floor to discuss what challenges and opportunities the US solar industry faces over the next year.

INDUSTRY TRENDS

Tuesday 21 October, Wednesday 22 October, 1030am-5pm, Booth 3909

After its success last year, GTM Research and the Interstate Renewable Energy Council will join SEIA and SEPA to lead the educational sessions, featuring interactive information and leading market research and key industry data analysis on key trends.

ENERGY STORAGE

South Hall 3, Upper Level

To showcase the array of new PV storage technology, SPI will provide an Energy Storage Pavilion and lounge to host all the latest technology, products and trends in the storage market. SPI will also host numerous educational sessions on energy storage.

EXPLORING THE ENERGY TRANSITION

Tuesday 21 October, 9-10am. Room 229

US energy officials and executives recently jetted off to Europe on a SEPA-led trip to gather and research information from Germany, Europe's leading solar nation. Insights and lessons from the trip will be shared at this session, which is particularly aimed at attendees from a commercial and utility-scale PV background.

MEET THE SOLAR TWEEPS AT THE ANNUAL SPI SOLAR TWEETUP

Wednesday 22 October, 12-2pm, South Hall 3 Networking Area

The Solar Tweeps event allows attendees to meet prolific solar industry tweeters and master social media users, from Facebook to LinkedIn. Based on past SPIs the annual Tweetup is expected be well attended with RSVPs-only.

PV TECHNICAL TRAINING

21-23 October, various times. Booth 1933 (Main Level Exhibit Hall)

The lightning pace of the industry makes updating skills and improving on training imperative. For attendees looking to brush up or learn new skills, the PV Technical Training booth will offer beginner to advanced training for various solar professionals, from sales to installers with the help of the North American Board of Certified Energy Practitioners (NABCEP) and Solar Energy International (SEI).

Start-up Alley is one of SPI's highlights.

START-UP ALLEY

Wednesday 22 October, 10:30am-12:30pm. Pavilion in South Hall 1

After a great first year appearance for SPI 2013, the SPI 'Start-Up Alley' returns, providing a chance to witness a group of finalist companies pitch and showcase their business ideas to the SPI panel of judges, competing for the winning title of 2014's Start-Up Alley challenge.

PROFESSIONAL WOMEN IN SOLAR NETWORKING

Tuesday 21 October, 3-4pm. Room 222

To find out how all members of the solar industry can team together to attract the very best talent to the dynamic world of solar, SPI is hosting this networking and discussion event to explore how leadership, human resources, companies and individuals can work to help attract the best candidates and promote women in working in the industry.

BLOCK PARTY

Tuesday 21 October, 7-10pm. Paris Hotel Pool Deck & Chateau Nightclub

Keeping up with the captivating surroundings, Las Vegas' mini Paris promises gymnastics to live music, to the theme of Fire and Ice.

Tracking the PVEP business model in the US

PV energy business | A number of the US' leading solar firms have been pioneers of the integrated PV energy provider model. Mark Osborne charts the evolution of the model and explains how it could be emulated as other firms look to capitalise on burgeoning end-market demand

Source: SunPower

The 'photovoltaic energy provider' (PVEP) business model was first developed a few years ago in the US, led by its two largest integrated PV manufacturers, First Solar and SunPower. The success of the model, initially devised to ring-fence module manufacturing operations from competition from China-based producers, has led to more US-based companies following suit. This article provides an update on recent US-centric PVEP developments and strategies including new entrants.

In simple terms, becoming a PVEP enables a module manufacturer to match production to internal end-market demand as a major proportion of demand is driven by the development of internal PV power plant projects. These can be solely utility-scale, or a combination that could include utility-scale and commercial rooftop, or also include residential and off-grid markets.

The three major US-based PVEPs, First Solar, SunEdison and SunPower, all had relatively different preferences as to the end markets they would serve. However, that is starting to change and all three are beginning to converge and address all major markets under the PVEP business model.

In geographic terms, what has been common amongst all the US PVEPs has been the clear focus on US projects and business opportunities, predominantly within North America. However, that has been changing, with growth and project pipelines increasingly becoming diversified and an increased emphasis on emerging markets in Latin America, Europe (UK in particular), Japan, MENA and Africa.

Merging of PVEP business models

First Solar

Being the largest thin-film producer, First Solar's major market has always been the utility-scale and commercial rooftop segments. Having initially supplied project developers in Europe and then the US with modules before becoming a major project developer and EPC, First Solar has been highly dependent on those markets under its PVEP model.

However, First Solar acquired TetraSun, a very small early-stage c-Si cell developer in 2013, announcing a few months later that it would start a 100MW manufacturing line for monocrystalline silicon cells in 2014, with production scaling from 2015 onwards.

The company made it very clear that the decision was to address the residential and small commercial-scale markets globally, an area it was not able to participate in with CdTe thin-film modules. The PVEP has already signed a distribution agreement through April 2015 to sell the TetraSun developed cells/modules in Japan to the residential market through JX Nippon Oil & Energy Corporation.

Utility-scale projects have provided a steady supply of business for the US' integrated PV providers.

SunPower

In recent years, SunPower has boasted the most powerful c-Si cells and modules with cell efficiencies well over 20%. This has enabled the company to focus primarily on the residential and commercial rooftop sector, via a vast network of distributors and installers. Emphasis shifted to utility-scale markets under its PVEP model, benefiting from levelised cost of energy attributes offered by high-performance modules in high-irradiance areas where the majority of its projects have so far been built.

The company is also tapping third-party finance for residential and commercial rooftop markets as it competes directly with SolarCity, the largest PV installer in the US in key markets such as California.

SunEdison

The biggest business model change from the leading US PVEPs is that of SunEdison,

formerly dedicated polysilicon producer, MEMC. Having acquired PV project developer SunEdison the company has evolved rapidly into a major PVEP, tapping EMS subcontractor, Flextronics, and the entire supply chain to provide its own specified 'Silvantis' series modules for its utility and commercial rooftop projects.

Further changes to its business model are expected, with the company announcing feasibility studies earlier in 2014 on establishing a fully integrated PV manufacturing complex, including FBR polysilicon production through to module production, in partnership with the Saudi Arabian government. The plans called for an investment of US$6.4 billion in a major complex that could potentially be started later in 2014.

Although the EMS route would be continued as it gives SunEdison manufacturing and CapEx flexibility, actual in-house manufacturing would seem to have strategic advantages that the company wants to embrace sometime in the future.

This would seem to fit with its aggressive PV pipeline expansion plans over the next five years as well as having recently started supporting smaller installers in the residential and commercial markets with its Silvantis series modules.

manufacturing plant based on the technology it acquired with the purchase of small US-based module manufacturer, Silevo, means the US-centric installer has big plans ahead to expand its business and change its business model.

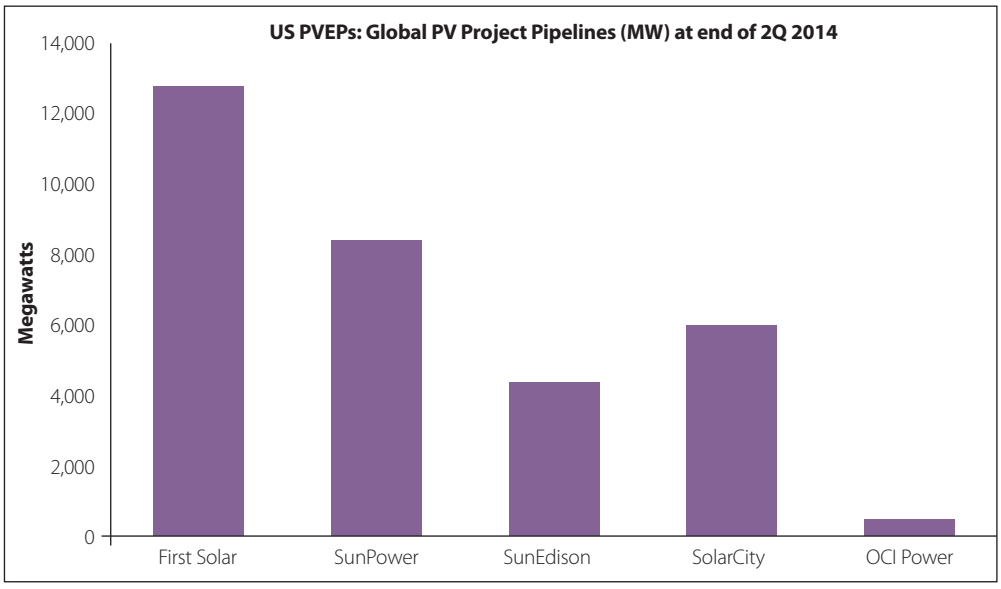
The company is well known as the largest US residential installer and pioneer of the third-party leasing model. SolarCity is also engaged in public/commercial rooftop projects. Though unclear at the moment, tapping in-house module production to build utility-scale projects in the future should not be ruled-out.

Mission Solar Energy/OCI Solar

Another new US-based PVEP is Mission Solar Energy, formerly known as Nexolon America, a joint venture with Korean-owned OCI Solar Power and partner of Texas-based CPS Energy. OCI Solar is a subsidiary of Korean polysilicon producer OCI.

The company started PV module production in June and expects N-type monocrystalline solar cell production to start in the early part of the third quarter of 2014. The San Antonio-based start-up is planning an initial 100MW ramp in support of OCI's PV power plant project plans, of which the bulk, 400MW, will be in Texas.

US PVEPs' global PV project pipelines (MW) at end of 2Q 2014. SolarCity pipeline is 1 million customers in 2018, equal to 6GW installed.



New PVEP entrants

SolarCity

The PVEP model in the US may be dominated by First Solar, SunPower and SunEdison but that is not stopping new entrants embracing the business model.

Following a recent significant move, SolarCity is fully embracing the in-house production model. Technically not yet a PVEP, recent plans to build a 1GW integrated PV

Expectations are that OCI Solar and Mission Solar will expand projects and production to grow their project pipeline in other regions of the US.

Yield co model gaining momentum

Further to the development of the PVEP business model is the trend towards building and owning PV power plants under a separate publicly listed company. The yield co financial structure enables PVEPs to extract greater overall earnings from PV power plants, compared to building and then selling them on completion.

The yield co financing model also enables investors to share in attractive annual income, while the PVEP gains access to low cost finance to further support the build-out of pipelines.

SunEdison has been the pioneer of this segment of the PVEP business model, recently undertaking a very successful IPO of its yield co under the name of TerraForm. SunEdison's TerraForm received initial net proceeds of over US$500 million from the IPO, which was quickly followed by Internet giant Google providing US$145 million equity finance to TerraForm.

And it looks as though the yield co financial structures look set to become a key low cost vehicle for PVEPs.

Although First Solar initially downplayed the benefits of the yield co model, more than likely due to its previous focus on US utility companies for business, the company is expected to announce future plans to adopt a version of the yield co model as soon as late September or sometime in October 2014.

It has also been rumoured that SunPower could announce a yield co strategy at its planned annual investment analyst event in November 2014.

In the middle of this year, Deutsche Bank Securities guided that as many as six yield cos could be publicly traded in the next 12-18 months, describing PV-based yield cos as "the most significant positive catalyst for the solar sector".

Future developments

Considering the different routes companies have taken to become PVEPs in the US, it stands to reason that more companies may be attracted to the business model, perhaps even more so now that a new way to access low-cost finance has been made available through the yield co model.

Whether this includes existing small-scale US-based manufacturers or others from the downstream sector like SolarCity, or a combination of both, has yet to unfold. However, there is no reason not to expect businesses from outside the sector to see the PVEP model as a route to access the market and potentially benefit from others' success. ■

Author

Mark Osborne is senior news editor at Solar Media.

Independent, Accredited Third Party Power Plant
ASSESSMENT SERVICES

As a recognized NRTL, TÜV Rheinland provides a trusted assessment of safety and performance of PV power plants. We offer global accreditations for market access worldwide and have an extensive global network of laboratories in North America, Europe, and Asia.

Excellent Advice – Safe Investment

The solar assessment center in Tempe Arizona, has a unique origin as a partnership between Arizona State University, an institution with more than 50 years of research on solar energy systems and devices, and TÜV Rheinland, a global provider of independent testing, assessment, and certification services. With its comprehensive line of services, TUV Rheinland is a competent partner for all solar energy manufacturers, operators, owners and investors.

TÜVRheinland®
Precisely Right.

Call 888-743-4652
www.tuv.com/us/solar

See us at Solar Power International
Booth 2224

Power Plant Services include:

- Site commissioning validation
- Solar resource assessment
- Climate-specific product procurement testing
- IR Thermography
- Site Inspection and measurement to validate field safety and performance
- Data acquisition system performance verification
- Weather station cross-check/calibration
- System capacity testing
- Short-term and long-term energy testing
- General support for AHJ approvals
- Warranty claims service
- Performance Class A – Power Plant Certification
- Module testing & certification
- Trackers and mounting systems testing and certification
- Power electronics testing and certification
- System voltage upgrade – gap assessment and compliance testing
- Lab support services

A RET old mess

Australia | The Australian parliament is undertaking final deliberations on the fate of the renewable energy target, a key enabler in the country's recent solar boom. Colin Marrs assesses where the country's PV industry would be left by the watering down or scrapping of the RET

Not long ago, the future seemed bright for solar energy investment in Australia. In March last year, Greg Combet, Australia's former minister for climate change, confirmed that the country's 2020 renewable energy target (RET) would remain unchanged at 45TWh of output by 2020. Two months later, an analysis by global consultancy Ernst & Young purred: "With stable policy measures currently at the top of the wish list for every investor and developer trying to make long-term project decisions, it seems at least one policy-maker is intent on making dreams come true."

Less than 18 months on, Australia has slipped from fourth to 10th position in E&Y's monthly Renewable Energy Country Attractiveness Index. A surprise fall in overall demand for energy has left the sector oversupplied. But last year's election victory by the National-Liberal coalition led by Tony Abbott – hostile to government intervention in the energy market – has added rocket fuel to the market uncertainty.

On coming to power, Abbott's government immediately repealed the carbon tax, a levy on polluters passed by the Labor government and seen as totemic in the party's desire to rip up environmental regulations it said were holding back business. In May this year, the government announced its intention to abolish the Australian Renewable Energy Agency. Michael Barker, senior analyst at solar market research firm Solarbuzz, says: "The overall policy environment has been declining in terms of positivity towards solar."

Andrew Stock, councillor for Australia's Climate Council, says that attempts to undermine the previously bi-partisan political approach to renewables began well before the election. He says: "The three large integrated generator-retailers – Origin Energy, AGL and Energy Australia – led this push, lobbying through the media, industry bodies like the Business Council of Australia, and with the then opposition in the halls of parliament."

The Australian government first expanded the RET to the current 45TWh target in 2010. The scheme was split into two categories defined by the amount of power produced.

Source: Greenough River Solar Farm.

The Large-Scale Renewable Energy Target (LRET) was required to deliver 41TWh of the target, while the Small-Scale Renewable Energy Scheme (SRES) would make up the remaining 4TWh. The overall aim is 20% renewables by 2020.

Aided by a generous feed-in tariff regime, a boom in small-scale renewable energy systems ensued. Demand for renewable energy certificates mushroomed, causing the big suppliers a problem – a surplus of REC certificates to meet their renewables obligations. Stock says this has led to their "refusing to sign new off-take contracts with renewable generation project developers for well over a year now".

Simultaneously, the large players have spent hundreds of millions of dollars buying large existing coal-fired generators at a time when such sources were facing much greater competition from renewables. Because solar plants can pump large amounts of electricity on sunny days, when air conditioning units are most in demand, the traditional providers are no longer able to push up their prices during peak periods. Stock says: "Solar PV output on previous high-demand summer days has reduced fossil-fuelled peak plant pricing power."

However, while this competition has driven wholesale prices down, the retail cost to consumers has remained stubbornly high. And in February, retail costs were cited as a major factor in the government's decision to announce a root and branch review of the RET regime. Environment minister Greg Hunt said: "We are a government that is unashamedly doing our best to take pressure off manufacturing and households through anything that can lower electricity prices."

Changes to the RET would mean further large-scale PV power projects such as the Greenough River Solar Farm would be unlikely for many years.

Investor woes

Many in the renewables industry raised an eyebrow at this justification. In 2012, a senate committee had blamed the regulatory framework for perversely encouraging over-investment in the network infrastructure. Jack Curtis, vice president, APAC region, at PV thin-film giant, First Solar, is clear: "It is network charges, not renewable energy, that are driving up household electricity bills."

The announcement of the review, with the accompanying prospect of the RET being abolished, threw the large-scale solar investment market into turmoil. Figures released by Bloomberg New Energy Finance show that in the first six months of 2014, just US$40 million was invested in large-scale renewable energy, compared to US$2.691 billion during the whole of 2013.

In August, solar developer Silex Systems announced that it was suspending plans for a 100MW CSP station near Mildura in Victoria, citing "low wholesale electricity prices and the uncertainty surrounding the Renewable Energy Target". Developer EnviroMission said it was holding back on developing its new solar tower technology in the country until "certainty is restored" to the RET. Stock says: "There are three projects ranging from 20MW to 60MW or so still under construction under previous contracts, but once these are completed, it is unlikely future large-scale solar projects will be advanced for many years."

Share prices also plummeted. In June, solar and wind developer Infigen's managing director Miles George said of his firm's stocks: "Over the last 18 months or so the price was pretty steady around 27¢ to 30¢ and when the review was announced with possible outcomes the share price fell quite dramatically to about 20¢. This is because of concerns about whether the regulations would remain in place."

In its submission to the RET review panel, the Investor Group on Climate Change, a joint Australian-New Zealand body, warned: "While some of our energy investments have

inter solar
connecting solar business

DISCOVER THE WORLD OF INTERSOLAR

Intersolar Europe | Munich
Intersolar North America | San Francisco
Intersolar South America | São Paulo
Intersolar India | Mumbai
Intersolar China | Beijing
Intersolar Summits | Worldwide

Discover the
world of Intersolar
www.intersolarglobal.com

A Clean Energy Council campaign leaflet highlighting the impact of changing the RET.

already been weakened by deteriorating market confidence on the future of the RET, we expect that reducing the LRET would change market conditions in ways that were not foreseen when the expanded RET was introduced, with bi-partisan political support, and would further undermine our investment activities."

In August, US solar plant developer Recurrent Energy was reported as having shut its Australian office because of the uncertainty over the renewable energy target. However, in a statement it told *PV Tech Power* that it continues its "work on a range of potential project sites around the country" and has "simply reassessed our approach to staffing". Barker says a full-scale retreat has yet to materialise: "I think primarily firms are taking a wait-and-see approach at the moment."

Curtis says the worst dangers are faced by the domestic supply chain. "While international companies will come and go, what we find disappointing is that many of our local suppliers such as IXL Solar have invested a lot of time and money building a capability in this area and now seeing their business models under threat," he says. IXL Solar has a contract to manufacturer mounting structures for First Solar's Australian projects.

Small-scale impact

In the small-scale sector, the effect has so far been more limited. John Grimes, chief executive of the Australian Solar Council says "the impact on small scale has been a pick-up in inquiries". He explains: "People are keen to get in before any changes are made. These seem to be people who received quotes in the past but did not proceed."

Which is not to say that small-scale suppliers are relaxed about the RET review. A report produced by the REC Agents Association, which represents bodies trading in renewable energy certificates, found that 96% of the 3,800 solar businesses in Australia are small and medium sized businesses, and that uncertainty hangs over the livelihoods of the 21,000 Australians they employ. The report said: "If the RET is axed, demand for solar will fall by 40-50%, with a similar decline in the number of jobs in the solar industry. The axing of the RET could result in the closure of thousands of small and micro businesses."

In late August, the expert panel convened to conduct the RET review delivered its conclusions. It said that the RET was indeed exerting downward pressure on wholesale electricity prices. This might sound like an argument in favour of the scheme's retention, but the panel was not convinced that this was necessarily a positive development. It said: "Artificially low wholesale electricity prices can distort investment decisions in the electricity market and are unlikely to be sustained in the long term."

It also concluded that the costs of the RET made up 4% of electricity bill prices during 2012-13, but added that the effect on bills was likely to be neutral overall by 2030. It said that incumbent generators, electricity retailers and consumers would end up subsidising the renewables industry to the tune of A$22 billion if the RET continues unaltered. "The RET does not generate an increase in wealth in the economy, but leads to a transfer of wealth among participants in the electricity market," it said.

The panel narrowed its recommendations down to two options for the LRET. The first – a "grandfathering" option – would close the scheme to new entrants. This approach "avoids the costs to the community associated with subsidising additional generation capacity that is not required to meet electricity demand", it said. The second option would be to modify the LRET to introduce yearly targets corresponding to 50% of new growth. "Importantly, this approach would protect the broader community from the cost of subsidising unnecessary additional generation capacity if electricity demand continues to fall," it said.

On SRES, it said there was a case for closing the scheme immediately. This would reduce install rates of rooftop PV by at least 30%, according to the panel's modelling, but the market would recover to normal levels by the 2020s, it claimed. Alternatively, the government could end cross-subsidy while avoiding market damage by closing the scheme ten years early in 2020.

Although the report leaves the government with the clear option of completely abandoning the RET, unexpectedly it hasn't armed it with enough weaponry to make the job easy, according to Darren Gladman, policy manager at the Clean Energy Council. He says: "All the review essentially does is argue that the RET is a transfer of market share of fossil fuels to the renewable energy sector – which was actually the argument for introducing the RET in the first place. The government is left in a bit of a difficult position."

After this article went to press, ministers were expected to seek negotiations with other parties to secure the senate numbers needed to pass reforms to the renewables regulatory regime. It will have its work cut out. Labor has said it will not negotiate on the issue without the government rejecting the report's recommendations, while the Palmer United Party has vowed to support the existing arrangements.

Opposition politicians are under no pressure from the electorate to accommodate the government. In fact, a survey by the Climate Institute in June actually showed that 60% of the population believes the RET should be increased. Grimes says: "The government's plans to scale back the RET are dumb policy and dumb politics. We are the sunburnt country, with global leaders in solar research and development. Carving out solar makes no sense at all."

But even if the recommendations are not watered down and the RET is completely axed, there could be a glimmer of hope. Stock says rising energy bills could make the economics of domestic solar installation increasingly attractive, even without support from the RET. And as battery storage becomes cheaper, more households could disconnect from the grid altogether, he says: "This could well create new industry growth options, and will be even more difficult for the incumbent network and integrated fossil fuel generator-retailer companies to attack." ■

Author

Colin Marrs is a freelance journalist.

India's solar stagnation waiting for some Modi magic

India | Policy uncertainty and a damaging trade dispute have undermined India's ability to realize its vast solar potential. But with a new prime minister now settling in, the worm could be about to turn for the country's beleaguered solar industry, writes Raj Prabhu

India needs power. The World Bank has estimated that 300 million people in India – more than a quarter of the country – live without access to power, and those who do have power face acute power shortages. In July 2012, more than 600 million people were affected by one of the largest blackouts in the country's history due to insufficient power generation.

India has long struggled to meet its power generation needs through conventional means, and solar energy shows tremendous promise as one of the most attainable sources of power in India. Solar energy's flexibility and increasing affordability make it a unique solution to India's growing appetite for power and the sector itself represents a great future for economy, industry, jobs and environment.

The solar sector in India was almost non-existent before 2010, and in spite of encouraging growth levels by 2012 the market has stagnated at around 1GW in annual installations since that time. Uncertainty surrounding the potential imposition of an anti-dumping duty froze project development activity earlier this year – just 500MW has been installed to date in 2014 – with many developers and manufacturers concerned about unworkable project economics. Along with choking project development, the proposed anti-dumping duties threatened to increase solar power prices, making the resulting product – clean, renewable energy – unaffordable for most consumers.

Although solar development in India has stalled, fresh policy momentum is expected from the new Modi government. Source: Tata Power Solar.

India's former United Progressive Alliance government committed to, but was unable to meet, its 'power for all' target, which aimed to provide electricity to all Indian households by 2012, due to an industry riddled with fragmentation and underinvestment. Positive change has arrived in the form of the new National Democratic Alliance administration, which recently announced ambitious plans to use solar power to bring 'round the clock' electricity to every home in the country by 2022. The new government has shown its support for existing initiatives that will reduce the country's dependence on fossil fuels, including the Jawaharlal Nehru National Solar Mission (JNNSM) policy, and its goal to install 20GW by 2022.

The new prime minister, Narendra Modi, has a strong track record as chief minister of Gujurat, where he spent 13 years working to modernise energy infrastructure and introduced India's first incentives for large-scale solar power, leaving the state with a 17% renewables share.

Following the election of Modi, the response from the solar industry has been positive. Many anticipate decisive action from the new administration that will bring about an end to the unpredictability that has dogged the industry and restore order to the energy sector.

Disaster averted

The Indian government let the 22 August deadline lapse on the proposed imposition of anti-dumping duties on cells and modules manufactured in China, Taiwan, Malaysia and the United States, indicating that there will be no anti-dumping tariffs placed on components imported from these nations. India's solar industry is collectively breathing a sigh of relief that a poten-

tial disaster has been averted and projects that were stalled can now re-start. However, the drama surrounding the anti-dumping case, which was entirely avoidable, brought project development in the country to a standstill with developers essentially stopping the procurement process due to uncertainty surrounding the case.

The optics were less than ideal – the industry and commerce ministry, lobbied by manufacturers, pushed for duties, while the renewable energy ministry opposed them, giving the perception that the government and solar industry are out of touch with the daily suffering of the citizens and businesses dealing with regular power shortages. Although this affected the short-term outlook on installation growth, the end result was good and the new NDA administration was able to take decisive action, making a pragmatic, 'big picture' decision that will remove uncertainty and help put the solar industry back on track for sustainable, long-term growth.

According to Mercom sources, to make up for anti-dumping case, the government has assured domestic manufacturers a guaranteed market by providing 'adequate offtake' through government programmes, which will employ domestic content requirements.

A draft policy guideline for JNNSM Phase II, Batch 2 projects was recently announced, which continues the status quo with policies developed under the former government. However, the new administration has assured us there will be a revised draft in the coming months, which will have the stamp of approval of the solar-friendly NDA administration.

If the upcoming policy is laid out with long-term visibility and a focus on healthy yearly installation growth, which appears to be the direction it will take, it could effectively shift the Indian solar market into the next gear. Most of our sources have indicated that the new power minister is extremely engaged and wants to 'go big' on solar. Some important changes the upcoming revised policy may include are outlined in the box, below.

What stakeholders are saying

We regularly speak with key industry stakeholders – developers, manufacturers and investors – and in our discussions this quarter we heard divergent views on the current state of the market. Developers are optimistic at the prospect of a new policy that is more robust in terms of installation targets, and provides a more sustainable tariff structure. They are relieved by the anti-dumping decision and welcome a new level of certainty in the market.

A number of the manufacturers we spoke to were positive about the increase in exports. Module manufacturers indicated that cell availability is low, with high prices and onerous payment terms, and lamented that profits are elusive if they buy cells domestically. Instead of protectionist measures, some manufacturers indicated that removal of duties on imports of raw materials like glass, copper interconnect, encapsulant film and backsheet, along with a 5.5% value added tax in Karnataka state and 5% central sales tax in other states, can cut their overall cost of production by about 8.1% and compete with imported modules. Manufacturers were optimistic that the new administration will bring about much-needed change as they see government officers working with a renewed sense of responsibility indicative of the new administration's priorities.

Investors were also more positive, with many confirming that they are increasingly comfortable investing in India's solar market. Banks, on the other hand, continue to express concerns about state policies due to both low tariffs and the more important concern of off-taker risk. Several states are behind in payments and continue to maintain poor credit ratings. Some investors mentioned that they are lending to projects with tariffs above INR6 (~US$0.1) as long as developers are experienced and off-takers are credible, without evacuation issues.

Investors spoke about risks they were encountering, including land acquisition issues, aggressive bidding, developers bidding for state projects and then dropping them for higher tariff projects (such as the JNNSM projects), and lack of RPO enforcement. All investors we spoke with viewed anti-dumping and domestic content requirement unfavourably, as they will significantly affect project IRRs, making most projects unviable. They had a positive view of the new energy minister whom they see as knowledgeable and hands-on. When asked about financing commercial rooftop projects, investors indicated they would look to provide financing on these projects as long as they were bundled into portfolios of 8MW and larger.

India solar policy wishlist

- An overhaul of the pricing mechanism, away from CERC tariff base, to a more market-based tariff mechanism
- An increase in the size of the batches from a current 1,500MW
- State-specific auctions where NTPC Vidyut Vyapar Nigam (NVVN) will handle the bidding process for states, while states with an NVVN payment guarantee will purchase power, provide land and infrastructure. Through our discussions we learned that Andhra Pradesh may be the first state to take on this programme with 1,000MW, while other states are showing interest
- The Ministry of New and Renewable Energy (MNRE) also just released a draft policy document which targets 20 solar parks of 500MW or more by providing support of INR2,000,000/MW (~US$33,333/MW) and an NVVN payment guarantee for states that provide land and infrastructure. Andhra Pradesh, Telangana, Madhya Pradesh, Gujarat and Karnataka could be first in line as it is believed they have already identified land for solar parks

'India's solar industry is collectively breathing a sigh of relief that a potential disaster has been averted and projects that were stalled can now re-start. The drama was entirely avoidable'

Good prospects for progress

Election year, along with the uncertainty surrounding the anti-dumping case, slowed installations this year, and as a result, 2014 was another missed opportunity for growth in the industry. We recently lowered our installations forecast from 1GW to approximately 900MW, citing these factors.

Following the significant developments in India's political sphere, decision-making and policy development now looks to be moving in a solar-friendly direction. The challenge for Prime Minister Modi will be to implement his vision while conveying the gravity of his administration's intentions and holding individual states accountable for their commitments to renewable energy targets. Strong leadership and careful collaboration between central and state governments and solar industry leaders will be key to circumventing political sensitivities and stimulating true, sustainable, long-term growth in solar power in India. ▶

Author

Raj Prabhu is CEO and co-founder of Mercom Capital Group, a clean energy communications and research firm with offices in the United States and India.

Renesola, ensuring you the fastest possible return on investment

We believe sound investment resonates in solar energy. Through our latest innovations our products are more efficient and effective than ever. Solid R&D on product optimization with high performance and guaranteed quality help you achieve the fastest and safest possible return on investment. Contact us today.

china@renesola.com or 0086.21.62809180

GREEN HOME
www.renesola.com

ReneSola

Reinsured by PowerGuard

India post anti-dumping: the industry's view

Back in May, when India proposed anti-dumping duties (ADD) on US, Chinese and Malaysian solar imports, solar project developers, including Welspun Energy, raised red flags, warning that ADD posed a serious threat to India's solar-powered future. On the other side of the divide, manufacturer Tata Power Solar, subsidiary of Indian conglomerate Tata Power, said the domestic manufacturing industry would be "dead in six months" without ADD. The final decision was expected to go all the way to Modi for approval, and in the end decided against ADD. But in the process the matter divided India's PV industry. PV Tech Power spoke to vice chairman for Welspun Renewables Energy, Vineet Mittal, and Tata Power Solar's CEO, Ajay Goel, for two perspectives on where PV is now headed.

Manufacturers

It's no secret India's domestic PV manufacturers have been "struggling", facing losses "due to subsidised imports", says Tata's CEO, Ajay Goel. Unless the government comes up with "a really robust policy" to support manufacturers, Goel stands by a prior statement: that the industry "will be dead in six months".

Goel says for Tata, ADD would have "increased demand significantly", and now, waiting for different policy announcements, "there is a little bit of a gap".

Tata has only supplied modules to meet the demand for the JNNSM national solar mission's domestic content requirement (DCR) element, of 250MW annually, but is now crossing its fingers for a DCR increase.

NSM "will eventually be scrapped and replaced with a larger more ambitious programme", believes Goel. He is also believes the government is genuine in the support it showed for domestic manufacturers after they abandoned ADD.

If policies change, or the DCR is raised, Tata will be working at full steam. "It is a good problem to have right?" Goel laughs.

Until anything is concrete however, Tata and other domestic manufacturers remain in a limbo of anticipation. Tata is poised to make new investments and expansions, explains Goel, but is just waiting for government to fire the starter pistol and define how much.

One hurdle surmounted post ADD however, is the reunion of the Indian industry. It was split down the middle; developers wanting cheap modules, and manufactures wanting fair pricing.

The government has "done a good job of walking this fine line of keeping both sides of the table happy, and in that process has made a significant commitment," explains Goel. "The amount of trust for this government is very high".

However, there is "no question that there is uncertainty in the market", adds Goel.

Support for domestic manufacturing "has been vaguely announced, and we have to wallow in that vagueness for a few more months to see what they come up with."

The major difference, from before ADD to post ADD, Goel says, "is the sentiment".

"When I talk to colleagues in other companies, be they developers, EPCs, or manufacturers, everyone is optimistic and willing," says Goel.

To banish the uncertainty, Goel reckons NSM should move from "phases and batches" to put a long-term policy, such as a feed-in tariff in place. "A stable policy environment is the biggest need of the hour of the industry," he says.

Developers

On the purely developer side, it's a different story. Mittal says the ADD lapse hasn't "had an effect" on Welspun, but India's solar industry can now "follow its natural growth progression".

The abandonment of duties means developers will continue using foreign imports; Mittal says developers "will be looking at high-performance, cost-effective solar modules" from markets like Japan, USA and China.

Mittal puts this down to challenges from inadequate manufacturing capacity at home, which "still remain". India's domestic manufacturing production scale is "inadequate and the offerings have not been judged against accepted industry performance standards", Mittal adds.

Welspun believes if ADD had been implemented projects would have been delayed and jobs lost.

The decision not to impose duties means a "significant barrier" to growth no longer exists and job creation will increase. It also shows the government's commitment to the sector, Mittal adds.

Mittal reckons "radical steps are needed" for the manufacturing industry to equip itself to meet the DCR as well as general market demands. For Mittal, if India's domestic manufacturing industry is to grow, an "entire supply chain has to be created" to boost capacity and deliver on cost.

Welspun has even been exploring partnership opportunities with domestic manufacturers; however, Mittal adds, currently "the quantum of this partnership is fairly negligible".

Nevertheless Mittal is in agreement with Goel that the "only way forward" is for the government "to intervene with necessary policy measures".

Mittal is optimistic government will "holistically" support renewables development, repeating India's minister for power, coal and new and renewable energy, Piyush Goyal's plans to create a solar industry "ecosystem".

Mittal also recommends the government encourages research and development growth, and for companies exporting to India to invest in the country's infrastructure development too, "to establish India as an export hub".

Mittal also backs stable policies to help investors "to plan better", and agrees overall there is "a positive surge to the industry". ■

Author Lucy Woods, Solar Media.

Japan seeks to regain footing after solar stumble

Japan | Japan's reputation as the PV star performer of the past two years has suffered a knock with the cancellation of 1.8GW of projects. With the country's nuclear debate threatening to reopen and rumours of a solar backlash, Andy Colthorpe assesses the future for one of the world's top PV markets

Japan is still projected to be the world's second biggest PV market this year. According to NPD Solarbuzz, it is one of five countries to make up 95% of global PV module demand. In all, Japan installed over 7GW across all segments during the country's 2013 financial year.

Yet the past year has seen some developments that could point at rocky times ahead. Due to the lack of available grid connection and a variety of other reasons, a bottleneck of un-built large-scale projects has developed. Meanwhile rising electricity prices led one analyst recently to talk of a possible looming public backlash against solar in a country where support has previously been nothing but forthcoming.

Image: Solar Frontier.

Kunitomi Megasolar, built by Solar Frontier's EPC partnership with Belectric.

Project cancellations, grid pressures

In the short term, Japan will continue to see plenty of activity in large-scale solar, while the residential and commercial markets also have manufacturers racing to meet demand. But further ahead the picture looks more complicated. The FiT will end in 2020 and preparing for that era is the most pressing concern for many. The road to getting to that point smoothly, as the tariff rate falls by around 10% each year from the original ¥40 (US$0.38) per kWh set in 2012, could also be a little bumpy.

Meanwhile, reports emerged in October last year that the government had decided to act on the fact that a large number of projects approved for the 2012 and 2013 tariff rates had yet to be built. There were concerns that some of Japan's huge pipeline of FiT-approved projects were less than serious and that some developers were even waiting for equipment costs to fall a significant amount before building the plant to receive a 2012 FiT and thereby maximising profit. In response, the Ministry of Economics, Trade and Industry (METI) imposed deadlines for developers to submit documentation relating to the equipment and land rights. At the first announcement of statistics made following the final August deadline, METI said that it had been forced to cancel 1.82GW of projects, almost 10% of the total approved in Japanese financial year (JFY) 2012. Hearings are also taking place for a further 2.7GW of projects. The grid connection problems are of equal, if not even greater concern, as shortage of available land. In a nutshell, 10 different companies are responsible for each of Japan's regional grids, with little interconnection if any between each of them. This is an ongoing problem in a country made up of a number of islands. A shortage of available land in many regions continues to put pressure on grids. Furthermore, consumer electricity prices have risen in Japan by between 10% and 20% since the inception of the FiT programme in 2012. According to Dr Hiroshi Matsukawa of Tokyo-based analysis firm RTS PV, the price rises, caused in part by the backlog of projects now coming online at the higher 2012 and 2013 FiT prices under which they were accredited, could have a "rebound effect" on public opinion of solar. Matsukawa said the situation could potentially become "extremely dangerous". Matsukawa said that in terms of threat to the industry, this could be worse in the short term than the current government's refusal to commit to a national target for renewable energy or to rule out entirely the chance of a return to nuclear power.

> 'Japan is a notoriously difficult country for foreign entrants to break, and this does not look like changing anytime soon'

However, advocacy groups including the Japan Renewable Energy Foundation argue that broad public sentiment against nuclear is very much alive and Japan's energy resilience in the time since the nuclear switch-off is proof the country can survive without it. Also, the 2012 and 2013-approved projects that are still expected to be installed will perhaps ironically give solar a healthy construction boost in the short term.

Buoyant projects

In addition to these latecomers, a regular flow of projects will continue to provide the industy's backbone, often built by the

Image credit: SS Nagoya Inc.

biggest Japanese firms and likely representing a strong showing in gigawatt term. Hitachi Hi Tech, for example, is targeting 300MW of Japan projects by 2017, in partnership with Swiss independent power producer Etrion. In a country synonymous with innovation and technology, some new steps are being taken to see what can be done to ease bottlenecks in PV pipelines and keep Japan's solar revolution on track. A joint venture company involving Kyocera is targeting 60MW of PV projects to be built on water by the end of the current Japanese financial year, for example. The first of the floating PV plants, a 2.9MW project across two arrays, will be built in Hyogo Prefecture, western Japan, using a mounting system produced by French company Ciel et Terre. According to Ciel et Terre, the cooling effect of the water will also contribute to increasing the floating power plant's efficiency. Somewhat less glamorous, but no less pragmatic, was an announcement in August that Japan's environment ministry will offer extra support to solar farm projects that are proposed for landfill sites that have reached their capacity for garbage. A study conducted by the ministry found that landfill sites could have the room to host up to 7.4GW of extra PV generation capacity.

There have also been some efforts made to accommodate the demand for solar from the finance sector. Between them, Japan's three biggest banks arranged loans for solar worth around ¥390 billion (US$3.8 billion) in JFY2013, according to one Japanese newspaper. One of those, Sumitomo Mitsui Banking Corp, has launched a 'solar loan' product aimed squarely at speeding up the process of financing a project up to 2MW in capacity down to one month from an average of two to three. Under a corporate financing structure it will lend up to ¥500 million (US$4.5 million) over a period of up to 16 years.

Tough nut to crack

Japan is still a notoriously difficult country for foreign entrants to break, and this does not look like changing anytime soon. Tier-one Chinese manufacturers are the obvious exception, but nonetheless according to the Japan Photovoltaic Energy Association, of just over 2GW total PV module shipments in the first quarter of JFY2014, the vast majority, 1.39GW, came from Japanese companies.

Nevertheless, the country's big names are experiencing mixed fortunes, according to recent news and financial results. Solar Frontier reported a year-on-year improvement in ordinary profit and reduction in production costs in its most recent financial results at the end of July and parent company Showa Shell approved a plan to separate the two entities. The company also continues to build a 150MW manufacturing plant in Japan at which it will trial methods of producing cells close to end markets.

Ise Futami Megasolar, a 5.2MW plant built by developer Chiyoda, with Solar Frontier thin-film modules.

On the other hand, while Sharp Corporation shipped the highest volume of modules in the world in the first quarter of 2014, the company also took a US$141 million hit on exiting 3Sun, its European thin-film JV with Enel. Sharp also warned earlier in the year that it is expecting a decline in sales and profitability in cell sales in 2014, due in part to a reduction in its overseas project development business, as well as a fall in Japanese residential installations. So Japan will continue to see a thriving PV industry, at least in the near future, in common with markets like the UK, where stimulus has come from external policy factors. Efforts including those to free up land and experiments with large-scale batteries and lithium-ion battery subsidies for residential customers (see storage overview article p.71) are being made to allow for capacity increases.

The current government's seemingly indecisive stance on the renewables versus nuclear debate notwithstanding, and following a METI denial of a rumour that drastic FiT cuts are imminent next year, we can almost certainly expect to see a healthy number of gigawatts installed in the coming few years that will keep Japan at or near the global top table. ■

Author

Andy Colthorpe is a reporter for Solar Media.

Quality control

Source: Suntech.

Module quality | According to some industry observers, rapid growth and cost cutting in the solar industry have created the conditions for a module quality headache. Ben Willis investigates how the industry is responding to the challenge

In February 2013, the Dutch Food and Goods Authority issued a public notice declaring hundreds of thousands of PV modules made by Scheuten Solar Holding to be a fire hazard. The authority alleged that up to 650,000 of the company's Multisol modules had been made with a design flaw that could lead to the melting of the junction box, system failure and, ultimately, fire.

Indeed, the authority gave details of 15 fires in Europe it claimed had started as a direct result of faulty Multisol modules. Its warning prompted an extensive in-field repair programme and, later that year, Scheuten's second filing for bankruptcy following an earlier bailout the previous year.

In an industry so conscious of the consequences of any flaws associated with PV modules, instances of widespread failure such as this are extremely rare. Yet with global PV demand having exploded in the past few years at the same time as PV manufacturers having undergone a period of brutal cost cutting, observers believe that module quality is emerging as an area on which the industry needs to keep a watchful eye to avoid repeats of last year's misfortunes but on an altogether bigger scale.

"There's definitely a concern there," says MJ Shiao, director of solar research at GTM Research in the US. "The biggest issue with the industry is you just don't really know. We have all this historical data produced 20, 25, sometimes 30 years ago, but those modules are completely different to those being installed today; around two-thirds of modules in the field today were installed in the past three to four years.

"The PV market has also seen record declines in costs, the result of Chinese manufacturers squeezing out costs. So there really is a hazard there in the mismatch between how much the industry has grown and how much knowledge there is about long-term reliability. There should be a lot more concern than there is."

The rarity of massive module failures on the scale of the Scheuten Solar example last year is underlined by available data. According to a paper presented at September's EU PVSEC event in Amsterdam by researchers from the National Renewable Energy Laboratory, assessments of 50,000 PV systems totalling 1.7GW between 2009 and 2012 showed that only 0.1% of the systems were affected by underperforming or defective modules.

SolarBuyer's Gregory says large cases of field failures are routinely concealed.

Nevertheless, behind the scenes, cases of failure certainly are going on, generally not making headlines because they get hushed up in non-disclosure agreements between manufacturers and owners, says Ian Gregory, co-founder of Boston-based SolarBuyer.

"There are a good number of large cases of field failures that get wrapped up very quickly in non-disclosure agreements," Gregory claims. "There's no public reporting obligation in the industry. In the EU or US where there are failures, there's no requirement to report them. Nobody's sure what the full extent of these issues is, but we know they're out there because we're involved in real cases."

SolarBuyer is a third-party due diligence organisation that operates as a bridge between the investors in and makers of PV modules. The company carries out independent testing of modules as well as extensive auditing of manufacturers' factories and processes to assess consistency of product. So far it has carried out 140 audits of 60 manufacturers, in the process compiling a database of module performance that it uses to help investors make better-informed decisions over which modules to purchase.

Source: Suntech.

Gregory says the insights he has gained from these processes suggest to him that the "conditions are there" for an industry-wide quality problem to emerge. "We see it when we audit factories, when we look at materials, when we look at extended lab testing results," Gregory says. "How much of that is going to present itself in the market as failed systems or underperforming systems, we don't know. What we know is the risk is there."

Gregory points to a number of factors that are of particular concern. Like Shiao, he identifies as a big issue the recent cost-cutting drive across the industry: "It was a matter of survival, but of course the question then becomes: what price did the product pay?"

Another has been what he describes as an "awful lot of material proliferation". Whereas there used to be only a few suppliers of key module materials, Gregory says the building out of supply chains by companies as they aggressively globalised changed that.

"Now you come across many, many different suppliers of materials that don't have a long track record, so no one really knows how good those materials are," he explains. "And many manufacturers will use multiple vendors of a particular material – so when you buy a module from one manufacturer, if you buy multiple megawatts, it will be made of different materials. That proliferation of material is a risk in itself and isn't well understood. If you find you've got uncertified material you're just not sure it's going to last."

Testing, testing

Exacerbating these underlying dynamics in the industry is the fact that, as Gregory and many others assert, the current testing regimes to which modules are subjected in order to gain certification are currently not designed to ascertain a module's durability over time. The main certification standards for modules are enshrined in the IEC 61215 and 61646, which cover crystalline silicon and thin-film modules respectively and specify a range of qualification tests equipment must pass in order to be certified.

Cordula Schmid of Fraunhofer USA explains that this system is fine up to a point, particularly in detecting so-called "infant mortality" failures early in a module's life. "But they only give you pass or fail – and most modules pass those tests," Schmid adds. "They tell you nothing whatsoever about the long-term reliability or potential issues you will run into with those modules in the long run."

Another limitation of the IEC standards is that manufacturers can "cherry pick" a small number of modules to submit for certification testing. There is no process in place to verify that what has been submitted is representative of the module that will eventually be sold or, again, how long it will therefore last, Gregory says.

Together these two shortcomings mean there is no satisfactory safeguard enshrined in industry-accepted standards to give investors any assurance that the product they have bought for a system expected to generate a certain amount of power – and therefore money – over a certain period will do that.

Alongside that, there are concerns that current testing regimes simply do not subject modules to tests that would identify their propensity or otherwise to suffer what appear to be relatively common failures emerging in the field.

Earlier this year a report published as part of the International Energy Agency's PV Power Systems (PVPS) programme looked at the common types of failure modules are displaying in the field. After cross-referencing against the current test requirements for IEC certification, the report highlighted a number of areas where modules appear to be failing in the field but which don't feature in standard tests.

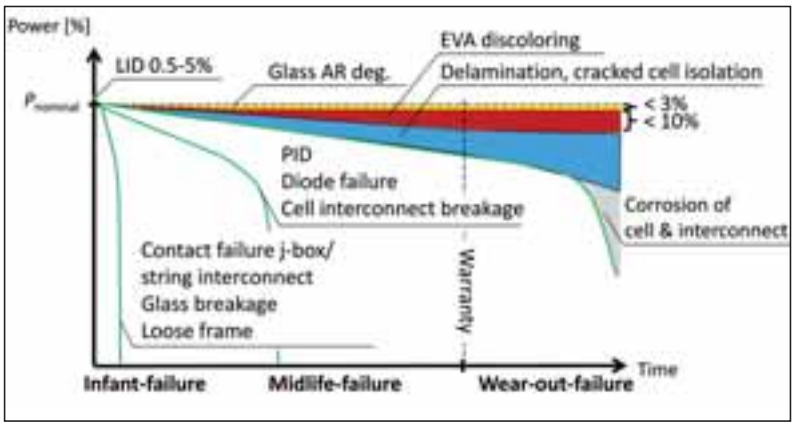
Among these the report picked out mechanical loads caused by transportation or snow loads on modules mounted on an incline, UV degradation, ammonia corrosion and potential induced degradation. Although testing is carried out on this latter, high-profile failing in modern modules, the PVPS report included it as it points out that a recognised standard for the determination of PID does not yet exist.

"These four things are very important because they're likely to affect modules but aren't covered by the current standards," says Mark Köntges of the Institute for Solar Energy Research in Hamlin, and lead author of the report. "They're the most important missing things."

New standards

Of course, the industry is well aware of the limitations of current standards. Since 2011

The IEA found a number of frequent causes of failure that were not part of IEC certification.



Source: 'Review of Failures of Photovoltaic Modules,' IEA PVPS.

Three typical failure scenarios for wafer-based crystalline PV modules. Definition of the abbreviations: LID – light-induced degradation; PID – potential induced degradation; EVA – ethylene vinyl acetate; j-box – junction box.

WOULD YOU PURCHASE A PHOTOVOLTAIC MODULE THAT LOOKS LIKE THIS AFTER TWO YEARS IN FLORIDA?

Other Backsheet Type 1

Severe cracking, flaking after just two years in Florida weathering

Time Zero *2 Years in South Florida*

DON'T SETTLE FOR POOR PERFORMANCE WHEN YOU CAN INSIST ON HIGH PERFORMING YET LOW COST KYNAR® PHOTOVOLTAIC BACKSHEETS.

Kynar® PVDF Backsheet

No chalking, no pitting, no erosion, no cracking, no changes after two years in Florida weathering

Time Zero *2 Years in South Florida*

Kynar® PVDF based backsheets have exceptional durability and value. Protect your Investment™, specify Kynar® PVDF in the construction of your photovoltaic backsheets!

- Exceptional UV protection
- Excellent weathering resistance
- Exceptional thermal stability
- 150°C UL RTI Rating
- Resistant to fire, UL VTM-0 rated
- Excellent moisture and chemical resistance
- High total solar reflectance
- Good electrical insulation

For more information contact:
Ron Partridge, Kynar Business Development Photovoltaics and Foam
610-205-7874 • ron.partridge@arkema.com
www.kynar.com

KYNAR® BY ARKEMA

the NREL has been spearheading efforts through the industry-wide Quality Assurance Task Force to devise new standards that reflect some of the current deficiencies in testing regimes.

The NREL's John Wohlgemuth, one of the task force's main convenors, tells *PV Tech Power* that the group's aim is to come up with a single PV module rating system that enables a rapid assessment of a module's likely durability in any region of the world.

The draft standard, which is currently out for consultation and should be approved by next year, contains a variety of new or enhanced tests, including some of those identified by the PVPS, in areas such as thermal and mechanical fatigue, delamination, diode failures and PID. It will also set out guidelines for how manufacturers should ensure consistency of product through quality management procedures.

"It's got a lot more detail about things that module manufacturers should be doing," says Wohlgemuth. "For example, it says you have to have a system for ensuring that the suppliers continue to deliver the product they say they're delivering. It also says if you get warranty returns you have to understand why a failure occurred and put that information back into your manufacturing system."

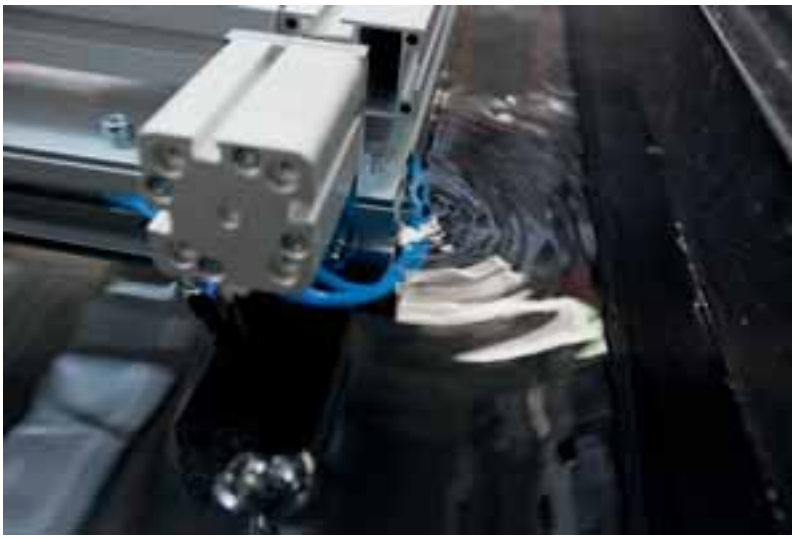
Key questions about the new standard are how quickly and widely it will be adopted, and who will enforce it. On the second question Wohlgemuth is hopeful that an entirely new IEC regime – IEC RE ('renewable energy') – due to come into force next year to regulate renewable energy systems will settle the enforcement question.

"The idea is that there be will a system in place by the end of next year [through the IEC RE] that will audit PV systems for design, installation and the components in it," Wohlgemuth says. He hopes the new system will work its way down to a module level, requiring manufacturers to follow IEC guidelines and have their factories audited to ensure consistency.

On the adoption question, Wohlgemuth believes two main factors will be the main drivers for the new standard: customers asking for it but also larger manufacturers taking an early lead and getting qualified for it.

"We've had four or five manufacturers on the group, including SunPower, Solarworld and First Solar, who are interested, as soon as this becomes standard, in getting qualified for it," he says. "When 1215 came out, in the beginning some people ignored it, others jumped right in, but it wasn't very long before if you didn't have 1215 you didn't sell into a lot of markets. And the new system is going to be the same way."

NREL's Wohlgemuth says the new IEC regime will become a must for firms looking to sell into multiple markets.



Source: Hanwha Q CELLS.

Source: Suntech.

Third-party testing

Opinion on how effective the new standards will be varies greatly, but the biggest concern is what happens until the new system is launched and beds in. Quality is an issue that requires attention now, but two years would seem to be about the earliest the industry could realistically expect any significant impact from the new regime.

To fill the space, a number of third-party quality assurance programmes are popping up that aim to offer investors the sort of hard information they need about module performance.

One example of this is the PV reliability scorecard published by GTM Research in conjunction with module testing company PV Evolution Labs in California. Shiao, one of the authors of the scorecard, explains that although not exhaustive, it begins to offer some comparative information on module performance in different circumstances.

"It compares different module manufacturers on an apples-to-apples basis through the same test regimes, which is something you don't necessarily get in the market today," Shiao says. "For testing like UL and IEC, they're really just pass-fail safety tests. What we're trying to do is to dig deeper and say it's also about how you perform and what sort of degradation you have – did you pass with flying colours or did you just barely make the cut.

Third-party quality assurance programmes are increasingly popular in the absence of new international rules.

"That makes the conversation around reliability more complex. But as we grow as an industry, we need to be a bit more mature in understanding what modules are going to look like in 25 years' time."

Another third-party assurance initiative is the PV Module Durability Initiative offered by Fraunhofer USA. This subjects modules to tests that aim to build up a picture of likely durability by simulating real-world conditions – for example carrying out snow-load tests at -40 degrees Celsius, rather than at

Sikasil®

SYSTEM OPTIMISATION BY ADHESIVE TECHNOLOGY

BONDING TO MOUNTING SYSTEMS
- Reduced material consumption and handling
- Reduction of installation time by up to 40 %
- Minimised loads on glass and cells
- Higher yield through self cleaning thanks to frame elimination
- Reduced system cost of up to 15%
- Eliminates the need for electrical grounding

BONDING ON ROOFS (BAPV)
- Reduces system costs thanks to material and time savings
- Eliminates heavy mounting constructions on roofs
- Shortens installation times on existing roofs
- Allows installations on light weight roofs
- Facilitates self cleaning of modules thanks to frameless system

BUILDING INTEGRATED PHOTOVOLTAIC (BIPV)
- Right balance between demands and functionality
- BIPV improves building energy consumption
- Support in planning, design and implementation of BIPV
- Many years of experience in facade, insulating glass and building construction

TRUSTED FROM PLANNING TO IMPLEMENTATION

Sika's global team of solar experts supports solar system providers from planning to implementation and onwards. Our solar engineers assist you with the development of the most appropriate solutions. Sika's application engineers achieve a smooth integration of the bonding technology into your fabrication or installation process.

Call us to find out more. Sika – Locally, Globally.
www.sika.com/solar · Phone: +41 58 436 52 87

www.sika.com/photovoltaic

BUILDING TRUST

Source: Hanwha Q CELLS.

Von Zitzewitz says Hanwha Q CELLS won't do extra audits just to prove it is one of the "good guys".

room temperature as is the industry standard, to create stress conditions in module encapsulants.

Fraunhofer's Schmid says the PVDI does not just test modules harder, but also seeks to correlate failures from accelerated stress testing with results from the field. "You can always test something to death in accelerated testing; but you want to develop tests that really simulate the failures you would see in the real world," Schmid says.

Ian Gregory, whose SolarBuyer is one of the pioneers of the third-party quality assurance model, believes that in lieu of more rigorous industry standards, such programmes are greatly needed to enable investors to start cranking up the pressure on the module manufacturers. "Buyers and investors need to be better educated and be proactive about it once they understand. That will drive manufacturers and standards," he says.

This would certainly seem to be the view among some of the larger players on the demand side of the solar business. Dirk Morbitzer is supply chain manager at US solar leasing company Sunrun. Sunrun recently announced it had enlisted SolarBuyer to provide independent quality assurance services on all the equipment it procures for its systems.

Morbitzer says of the tie-up with SolarBuyer that it is borne of a need to have greater certainty about a module's performance rather than any sense that it will prove defective. "The solar as a service model that Sunrun and other companies are following depends on the materials working for an extended period of time. So it's not driven by defects, but by a wish to know what the situation is," Morbitzer says. "It's not because of failure rates. It's based on: are we really sure? No we're not, so let's be sure."

For example, Sunrun puts modules through 3,000 hours of damp heat instead of the IEC's 1,000, through 800 thermal cycles instead of the IEC's 200 and subjects them to dynamic load tests where the IEC only requires static testing. "That's much harder on the materials than the standard programme," Morbitzer says.

Morbitzer echoes Gregory's point that third-party testing is needed in the absence of stronger standards within the industry, suggesting that even the new ones may not be enough.

"I do hope that the standards will be stringent enough; on the other side I'm aware that as a company we have enough influence on manufacturers to require tests however stringent we want them to be," he says. "So even if the task force's new standards would not meet our requirements, we would still be able to go back to the manufacturers and say if you want to supply to us, these are the tests you have to go through."

Among manufacturers themselves, certainly those who pride themselves on the quality of their products, the view is that additional testing, for example through a third-party body, is not needed. According to Hanwha Q CELLS' chief operating officer, Andreas von Zitzewitz, the motivation for manufacturers to strive to produce the highest quality product is simply one of "survival" (see box).

"Quality is the core pillar of our presentation into the market. And therefore we're certainly looking at what others are inventing, or whether there is an additional process which it makes sense for us to incorporate, but we're certainly not in the business of adding additional audits just to demonstrate that we are good guys," von Zitzewitz says.

But for now its looks as though the third-party quality assurance model is here to stay. A combination of the solar industry's growth trajectory, the concerns many are expressing over potential module reliability issues emerging and the apparent shortcomings in basic quality standards may mean that a manufacturer's word, however solid its pedigree, is no longer enough. Too much is potentially at stake.

"It's not like a 'playing with fire' analogy but we are coming to a point where even if you're talking about tiny percentages of failure that's pretty bad at the scale we're now at," says GTM's Shiao. "But I worry more about characterising long-term performance and understanding what that means, because as the industry gets more complicated and we're exploring new regions, little fluctuations can have a massive effect on the industry when we're at this scale." ■

Author

Ben Willis is the head of content at Solar Media.

Source: Suntech.

CASE STUDIES

Hanwha Q CELLS

In the labs and fabs of Germany's Korean-owned module manufacturer, Hanwha Q CELLS, there is a slogan that underpins everything the company does: "Quality without compromise."

According to the company's chief operating officer, Andreas von Zitzewitz, those few words are at the core of Hanwha Q CELLS' philosophy, pervading all facets of the company's operation.

"The motivation for Hanwha Q CELLS not to compromise on quality is twofold: to safeguard our company, but also the balance sheet of our customers – the investor," von Zitzewitz says.

"You have to start with the right culture," he says. "And it has to be demonstrated by senior management. For instance, I'm looking at every claim made about our products worldwide, including by our suppliers, once a week."

On a practical level, von Zitzewitz says Hanwha Q CELLS takes the standard testing to which products must be subjected to a level far beyond what it is required for certification.

What is even more important is that we monitor our production. So we're not just doing this test once; we're doing it constantly with all our products and all our production sites. That is not established as a standard across our industry because the pressure on cost reduction is so tremendous."

Von Zitzewitz says Hanwha Q CELLS has taken its observation of quality to a level where it is now a key plank in the company's differentiation.

"Although every company in principle wants to survive, the question is whether everyone understands this is a core subject you should never forget," he says. "If you compromise on quality that can ruin the existence of your business."

Suntech

Since its acquisition earlier this year by Shunfeng, module manufacturer Suntech has introduced a number of changes to its quality assurance procedures.

"We have introduced automatic production lines and have replaced manual solar panel production," the company's director of quality Weihong Huang explains.

"We've also integrated our technical team into the design, manufacturing and quality assurance process, to ensure that our panels are fully functioning and meet above industry standards. Lastly, we've introduced a quality guide, which our Quality Assurance team can follow in order to ensure reliability and stability of our solar products."

Weihong Huang says all Suntech's modules have received the VDE Quality Tested certification, which exceed industry standards. For example, compared to the various IEC standards, she says the VDE seal requires double the number of samples to be tested, over an increased period of time, and allows only a 5% loss of power over the test period compared to the standard 8%.

"These changes dramatically increase the confidence that a module will fulfil its performance requirements throughout its warranty period," she says.

Another important element in Suntech's processes is how it ensures quality in all its factories.

Each factory has in place a quality control team to monitor production line quality on a daily basis, Huang says. "We also employ a special technical team for each of our manufacturing hubs, who can research the materials used and survey our optics and mechanics, guaranteeing that we are adhering to our own set of quality standards which are above PV industry standards," she adds.

ReneSola

Since 2011 China's ReneSola has handled its overseas module production through a global network of 11 original equipment manufacturer (OEM) suppliers. The dispersed nature of these factories, spanning seven countries from Japan to Turkey, presents the company with a unique challenge in managing quality control.

According to Aaron Pu, the company's OEM director, shortly after the move to the OEM model, ReneSola assembled a central team at its Jiangsu headquarters to manage the network. These were drawn from senior management and combined various language and technical skills.

Pu says the selection of an OEM partner begins with an extensive audit of the company's production and testing equipment. "This audit is focused on each process, reviewing the different points or gaps in the facility or in their products' quality," he says. "This audit also examines the expertise and skills of the operators and the quality-consciousness of the management of the OEM partner. This is followed with discussions on their investment in technology, ameliorations in quality, and management."

To manage the issue of material variability, ReneSola handles the procurement of all raw materials centrally. Any new material selected by Jiangsu will initially be put into mass production at the main factory before being used by OEMs.

TUV undertakes all module certification for ReneSola, with tests once a year "at a minimum", says PU. "Besides all of the functional tests of IEC in TUV Nord, we regularly carry out relative tests in TUV Rheinland and UL," he says. "Also, our own lab in Jiangsu, which is validated as a 'satellite lab' by CSA, UL, and Intertek, will do routine follow-up on some key indicators such as Gel-content tests and PID free tests."

Large-area solar irradiance mapping

Irradiance mapping | As PV systems proliferate, it is increasingly important to forecast their energy output in order to ensure a safe and reliable integration of their variable output into electric power grids. Dazhi Yang, André Nobre, Rupesh Baker and Thomas Reindl of SERIS outline a technique for generating large-scale 2D irradiance using data from pyranometers and plane of array reference cells

There are two main reasons for the development of accurate solar irradiance mapping, namely to calculate the so-called 'performance ratio' (PR, in %), and to use it as a critical input to perform solar irradiance forecasting. Many owners of PV systems do not know how well their installations perform because they have no on-site readings from an irradiance measurement device. They would only be able to gauge the quality of the systems if they had at least a close estimation of the irradiance values at their respective locations, which would then enable them to calculate PRs. The sheer solar energy generated over time, even if it is related to the installed capacity (so-called 'specific yield' in kilowatt hour per kilowatt peak – kWh/kWp), is not sufficient for judging the performance, since the baseline reference is missing and the output also fluctuates because of the year-on-year variability of the irradiance (there are 'good' and 'bad' solar years). So without the on-site irradiance, the PV system owner would not know whether the system 'could do better' or if the PV modules were possibly degrading faster than what had been guaranteed by the PV module manufacturer, for example.

Power system operators are often worried about the possible impact of the variability of energy generated from the increasing share of solar PV systems on the stability and resilience of the electric power grid. The solar power generation from PV modules naturally fluctuates with the available irradiance at the site, which is influenced by clouds and the absorbing or scattering constituents of the atmosphere. In order to support the power system operations, the ability to forecast the output of the PV systems would be helpful, probably not to the extent of advanced bidding as required from conventional power generators, but at least in terms of having a reasonable estimation of the solar power output over the next 15–30 minutes (typical dispatch cycles), intra-day (for ramping up or down of conventional capacities) or day-ahead (for futures trading). 'Reasonable' in that sense strongly depends on the climatic conditions and the forecasting horizon, but could go as low as less than 10% uncertainty. Forecasts (even long term) with greater than 50% accuracy are most probably not meaningful anymore.

Both the above-mentioned challenges could be addressed if (together with other techniques) there were a constantly updated, area-wide mapping of the solar resource available. Ideally, such a map is based on a dense network of irradiance sensors, but is restricted in many cases by the cost of high-precision pyranometers, real-time monitoring and frequent maintenance. However, many PV systems are in fact equipped with reference cells which are typically installed in the plane of array (POA) of the PV modules for evaluating and monitoring the performance of the PV system. Adding this network of reference cells to existing pyranometer networks (from meteorological services or research institutes) would allow the generation of large-area irradiance maps with improved resolution, which could then be used either to evaluate the performance of PV systems without an on-site irradiance reading capability, or to have a base for irradiance and solar power output forecasting for the grid operator. Since POA readings cannot be added to horizontal irradiance sensor data, this paper describes an irradiance conversion technique which allows POA irradiance measurements from an on-site reference cell to be converted to global horizontal irradiance (GHI). The converted GHI from each location can then be used for maps through spatial interpolation techniques, such as kriging – an interpolation technique which uses the spatial covariance to generate weightings.

Why and how to assess the performance of solar PV systems?

The performance of a PV system is usually assessed via two metrics: 1) the specific yield in kWh/kWp over a certain period of time (typically one year); and 2) the PR in %, which is a measure of how well a PV system converts the incoming solar flux into electricity, based on a) the amount of the solar resource reaching the POA of the PV installation, and b) the nominal system capacity at standard test conditions (STC). The latter measure gives the ratio of the actual AC energy yield to the 'theoretical' maximum DC yield, based on in-plane irradiance measurements and on the assumption of full DC-to-AC conversion.

Relatively independent of the irradiance on site, the PR is an internationally recognised metric for PV system performance assessment and is used for system evaluation all around the world. It has been adopted by the International Energy Agency (IEA) Photovoltaic Power Systems (PVPS) programme and is described in the IEC standard 61724 (1998).

'The performance ratio is an internationally recognised metric for PV system performance assessment and is used for system evaluation all around the world'

In order to measure the irradiance, silicon-wafer-based reference cells ('silicon sensors') are normally used in PV system installations, while pyranometers or calibrated silicon sensors are commonly used for research-grade investigations (see Fig. 1). It should be pointed out that the irradiance readings from a calibrated pyranometer (used for solar radiometric measurement, see below) are ~3–4% higher than those obtained using reference cells (due to the fact that pyranometers absorb a larger fraction of the solar spectrum), which in consequence results in a lower PR. In a later section, some of the loss mechanisms (the deviations of the reference cell measurements from the pyranometer measurements) will be discussed in detail. These deviations, however, are well known and can be accounted for in the conversion of POA readings to GHI to enable the generation of large-area irradiance maps from a network of multiple measurements devices.

Fig. 2 shows the performance ratio of 11

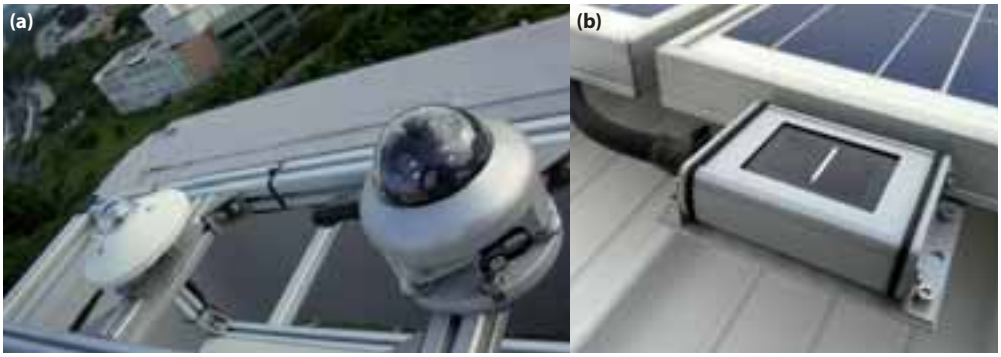


Figure 1. (a) Two pyranometers: a CMP11 from Kipp & Zonen (left), and an SPN1 from Delta-T (right); (b) a silicon sensor installed in the plane of array of a PV system.

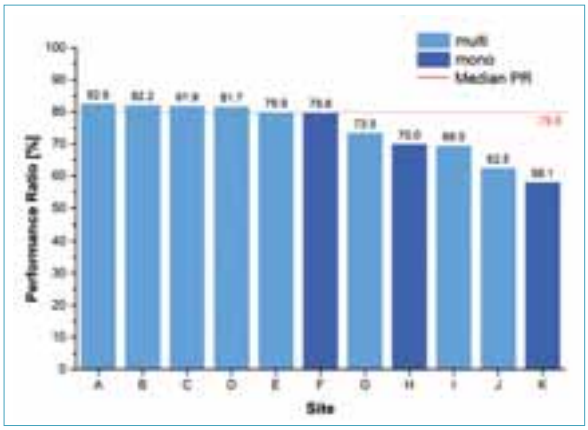


Figure 2. Measured PR of 11 silicon-wafer-based PV systems in tropical Singapore. The median performance value for the year 2011 was ~80%. (See Nobre et al. [1].)

silicon wafer-based PV systems in Singapore, assessed during 2011. PV systems in hotter climates will generally display a lower performance than in temperate climates.

Why and how to forecast solar irradiance?

Power system operation centres need to concurrently manage grid parameters (voltage, frequency, etc.), load flow, unit commitment, transient stability and transmission. A common goal of these operations is to meet the changing electricity demand and to minimise outages. Although highly complex, power system operation is well developed for conventional power generation, transmission and distribution. With the increasing penetration of distributed solar power into the electricity grids, the inherently introduced variability (i.e. from different irradiance levels because of cloud movements) potentially poses challenges for the power system operations. Despite there also being positive impacts on the power grid – such as the reduction of peak demand (especially in countries where the air conditioning load pattern matches the irradiance curve of the day) or reduced voltage drops in the distribution grid – the high ramp rates and sudden drops when clouds move over a PV installation are still seen as a threat by many grid operators. Apart from the more conventional approach of increasing the spinning reserves in the power system (which is a rather costly option), there are various other ways of managing this variability, some of which are:

- Suitable regulations for active and passive inverter reaction.
- Demand-side management (DSM) – advance notice in the range of hours.
- Direct load control – an extreme form of DSM for short notice periods (minutes).
- Energy storage – e.g. battery based, with instant reaction.

Complementary to the above-mentioned options, the forecasting of the solar power output on different timescales for a certain area is a very powerful tool, which brings solar PV one step closer to being 'dispatchable', and thereby making it more compatible with the current power grid operation. Solar energy forecasting is also compliant with future smart grids, where various devices and communication gateways can make automated decisions with respect to energy flows (e.g. self-consumption) and economic considerations (e.g. selling to the grid at peak demand).

Among various timescales of solar energy forecasting, medium-term forecasting (15 minutes to one hour, depending on the local dispatch cycle) is particularly important, especially with regard to the operations of peaking and load-following power plants. However, these forecast models are less developed than long-term and very short-term forecasts.

For long-term (several hours to a few days) solar irradiance forecasts, satellite-based techniques are commonly adopted [2]. The forecasts are usually derived from the output of so-called 'numerical weather prediction' (NWP) models; model output statistics are then used to post-process the forecasts. Depending on the location on the Earth, cloud motion analyses can be added in order to capture and project the dynamics of the clouds, from which the irradiance maps are then derived through a projection of the sky conditions. These prediction model methods can be traced back to the 1920s (when NWP was first proposed).

Very short-term (a few seconds to five minutes) irradiance forecasts can be separated into two classes of methods – one based on sky cameras and the other using high-spatial-resolution (a few metres apart) irradiance sensor networks. Both methods aim to provide a better understanding of cloud movements. Unlike NWP, these methods analyse cloud motion under local sky conditions. As the cloud motion is considered to be persistent within a small time window, these forecasts can accurately account for the up-and-down ramps in PV output [3].

Medium-term forecasting is a much more challenging problem, with no dominant strategies being available at the moment. Currently, spatio-temporal statistical models (such as time-forward kriging [4]), which use multiple irradiance sensors, or purely temporal statistical models [5], which use only one sensor, are usually adopted. In view of the effects of cloud propagation [6], spatio-temporal models are preferred over purely temporal models, which seek to identify the relationship between the points of forecast and past observations. In other words, past values are combined, either linearly or non-linearly, to form the forecasts through a regressive framework. In a spatio-temporal model, the past values from a particular station and from its neighbouring stations are used [7]. Space–time kriging and vector autoregressive models are examples of such spatio-temporal statistical models [8]. A common pre-requisite for applying these statistical models is a network of horizontally installed irradiance sensors, which measure the spatio-temporal irradiance distribution. Using the satellite-derived irradiance data for these statistical models may also be considered; however, satellite-derived irradiance usually has a higher uncertainty of ~8–25%. Moreover, it has low temporal resolution (typically 30 minutes to one hour) and low spatial resolution (1km to 10km), which may not capture the fast-changing irradiance random field. From a sampling point of view, a high spatial resolution of irradiance sensors is always desirable.

Irradiance measuring instruments

There are several accepted terms describing irradiance components (measured in W/m^2) used in modelling. Global horizontal

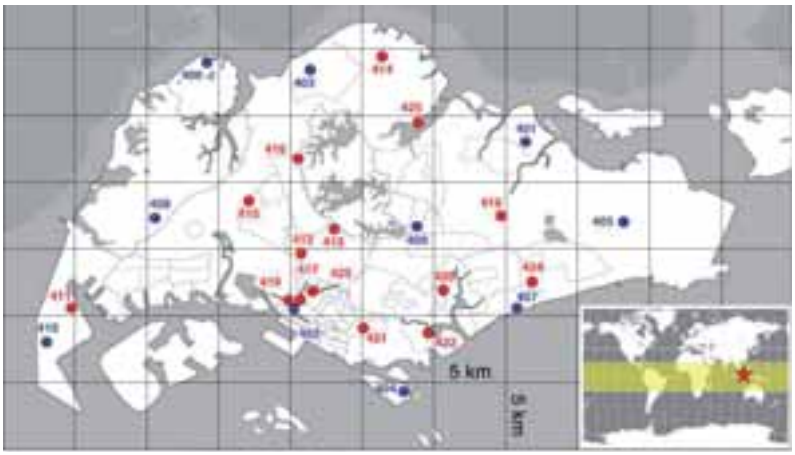


Figure 3. A network of 25 ground-based irradiance measurement stations in Singapore. The blue dots represent stations where both silicon reference cells and pyranometers are deployed. The red dots are stations where only reference cells are installed. The bottom right corner shows Singapore's position (red star) on the world map, as well as the 'sunbelt' region (yellow band) between the tropics of Cancer and Capricorn.

irradiance (GHI) refers to irradiance measured on a horizontal surface. It can be decomposed additively into two components: the horizontal beam irradiance (HBI), i.e. the beam irradiance on a horizontal plane; and the diffuse horizontal irradiance (DHI). On a tilted surface, tilted global irradiance (TGI) can be decomposed additively into the tilted beam irradiance (TBI), the tilted diffuse irradiance (TDI) and the reflected irradiance (RI). Theoretically, if any two (out of seven) types of irradiance listed above are known, the others can be 'deterministically' calculated through transposition models (see details below).

To measure the above-mentioned irradiance, two types of device – namely thermopile-based instruments and PV reference cells – are used. Pyranometers and pyrheliometers are thermopile-based instruments that convert heat to an electrical signal which can then be recorded. A pyranometer is typically used to measure GHI; if equipped with an additional shadow band to block the direct irradiance, it can also record DHI. Pyranometers are often installed in larger PV systems to also measure TGI (and possibly TDI), but in this case need to be installed in the tilted module plane. However, each pyranometer only records one of the irradiance components mentioned above.

A pyrheliometer measures the beam irradiance with a solar tracking system that aims the instrument at the sun. HBI and TBI can then be calculated using the zenith angle and the incidence angle respectively. Pyranometers and pyrheliometers are often used for solar radiometric measurements [9]. The price range of industrial-grade pyranometers can reach a few thousand US dollars.

The alternative reference cell is a PV device, which converts a flux of photons directly into an electric current using an external circuit, working similarly to a PV system. Most reference cells are silicon wafer based; they are less accurate than thermopile-based devices (the major loss mechanisms are discussed below). Hundreds of reference cell types are available on the market and are cheaper than pyranometers (a few hundred US dollars). This type of sensor is therefore often used to measure the POA irradiance at a PV site in order to assess the system performance [9]. A more detailed comparison of these instruments can be found in Meydbray, Emery & Kurtz [9].

In solar irradiance forecasting, solar radiometric measurements are preferred: hence high-precision pyranometers are typically used for this application [5]. Many research institutes – such as the Solar Energy Research Institute of Singapore (SERIS) – have taken the initiative to build irradiance measurement networks using pyranometers and/or reference cell devices [7,8]. Such an example is given in Fig. 3, which shows an irradiance network deployed in Singapore by SERIS.

'Once the loss mechanism issues are addressed, the reference cell can be used to approximate a solar radiometric measurement device'

In comparison to most networks currently available in the world, the network shown in Fig. 3 is rich in both temporal and spatial resolution for metropolitan-scale applications. Research has shown that the irradiance random process is extremely volatile [8]; a typical de-correlation distance of 1–10km is observed in many places of the world (a de-correlation distance is defined as the geographical distance over which cross-correlation between two irradiance time series is not observed anymore or is statistically insignificant). It should be noted that the de-correlation distance is a function of sampling frequency: a higher frequency corresponds to a smaller distance. With such considerations, an even denser network of irradiance sensors than the existing one described above would be desirable when the medium-term forecasts are performed at, for example, 15-minute intervals for grid utility management.

Should reference cells be used for radiometric measurements?

As mentioned earlier, reference cells are typically used for PV efficiency and performance measurements. When they are used in solar radiometric measurements, three issues need to be addressed.

The temperature response of the silicon reference cells is similar to that of a PV system, but needs to be adjusted in order to obtain accurate solar radiometric measurements. Although the temperature coefficient is a function of irradiance and temperature, it is typically assumed to be linear with respect to temperature [10]. Some of these reference cells possess an on-board temperature sensor that provides real-time temperature measurements, enabling irradiance readings to be corrected (either at the sensor output level, or via post-processing in the data acquisition system). To optimise their performance, such reference cells need to be calibrated. The Fraunhofer Institute for Solar Energy Systems (Fraunhofer ISE), along with other leading solar research institutes, provides such calibration services, thereby reducing the uncertainty of reference cells to as low as 2% under indoor testing conditions.

Furthermore, reference cells have a narrower wavelength response than pyranometers. This is straightforward to deal with, as the spectral loss is considered to be linear with irradiance. The spectral loss is compensated during post-processing after the measurements are obtained.

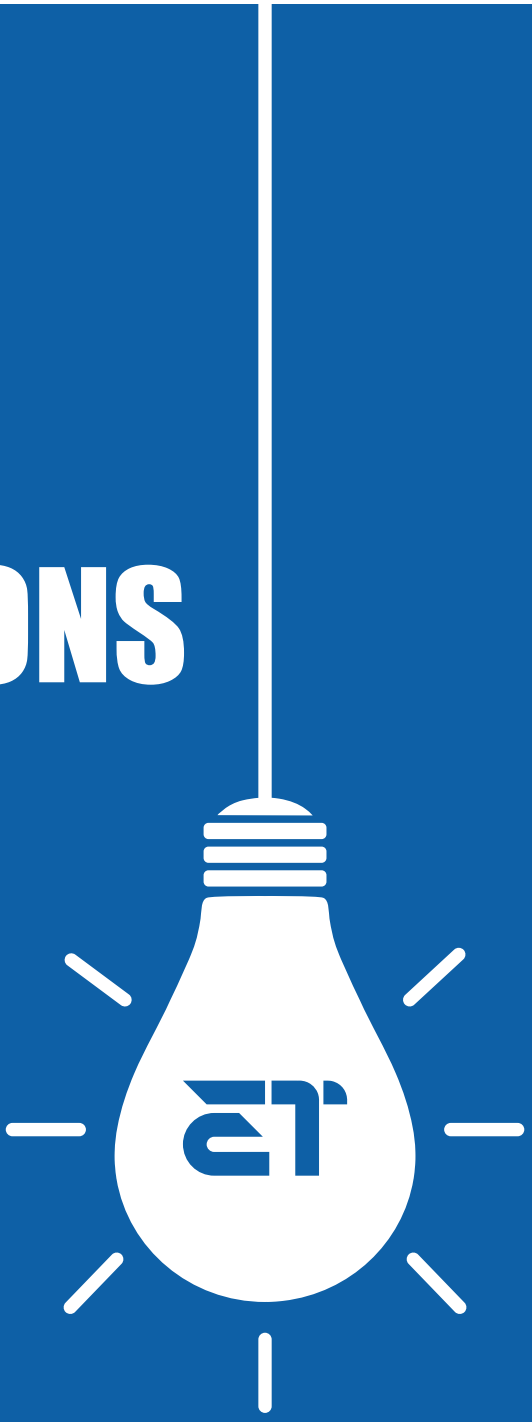
The third loss mechanism is the reflectance loss. As the response to the angle of incidence falls off at angles greater than 80°, this loss can be regarded as a function

Tilt	MBE [W/m²]	RMSE [%]	U95 [%]
10°	2.09	2.63	5.07
20°	–5.12	3.00	6.47
30°	–1.70	4.10	8.17
40°	–6.40	4.86	9.90

Table 1. Horizontal-to-tilt irradiance conversion errors using the Perez transposition model. The calculated TGI is compared with the actual TGI measured by reference cells tilted at four different angles. Mean bias error (MBE), root mean square error (RMSE) and the 95% expanded uncertainty (U95) are used as error metrics. All error terms include temperature, spectral loss and reflectance loss corrections.

www.etsolar.com

SMART ENERGY SOLUTIONS PROVIDER



Project Development

Project Finance & Investment

Project Design & Engineering

Project Procurement

Construction Management

Operations & Maintenance

We are devoted to providing optimized solar energy solutions to meet the needs of worldwide industrial, commercial and utility customers. By constantly developing innovative solar technologies and tailored finance solutions, ET Solar is creating smart energy solutions that maximize value, mitigate risk, and optimize the Levelized Cost of Electricity (LCOE).

SOLAR POWER INTERNATIONAL 14 Booth:518 | SOLAR ENERGY UK Booth:C15

Tel: +86 25 86898096 Fax: +86 25 86898097 Email: info@etsolar.com

Towards Excellence

of incidence angle. The compensation for the reflectance loss is performed at various bands of incidence angle using linear regression, i.e. for each band:

$$\textit{Reflectance loss} = a + b \times \textit{angle of incidence} \quad (1)$$

where a and b can be determined empirically.

Once the loss mechanism issues are addressed, the reference cell can be used to approximate a solar radiometric measurement device. The remaining challenge is to convert the tilted reference cell measurements to horizontal so that they can be integrated in spatio-temporal irradiance maps.

Conversion from tilt to horizontal using two reference cells

Transposition is used to calculate TGI based on actual GHI and DHI measurements. There are two types of transposition models: isotropic and anisotropic. The isotropic transposition model does not include the azimuthal dependency of the DHI; in other words, the diffuse component is assumed to be homogeneous in all directions. However, in reality, the diffuse component is affected by two main anisotropic mechanisms – the circumsolar and horizon brightening effects. Both mechanisms are due to the scattering of solar radiation by aerosols in the atmosphere. For these reasons, anisotropic transposition models are proposed in order to account for such characteristics.

Among various scientific models, the Perez transposition model [11,12] is considered to be a very reliable and universal model. It separates the sky hemisphere into three parts: an isotropic background, the circumsolar disk and a band near the horizon. The circumsolar disk and the horizon band contributions can be expressed as fractions of the diffuse background radiation. These coefficients are determined empirically using irradiance measurements from a selection of geographical locations, mostly in the USA. The performance of the Perez model has been validated numerous times in the literature and can be considered to be robust, even for regions outside of the original training pool.

▼Figure 4. The irradiance measurement station located on the roof at the Solar Energy Research Institute of Singapore (SERIS).

►Figure 5. Scatter plots of the 'inverse Perez model' using various combinations of reference cells. A hexagon binning algorithm is used for visualisation. The black solid lines are the identity lines, while the red dashed lines are the linear regression lines on the scatters.

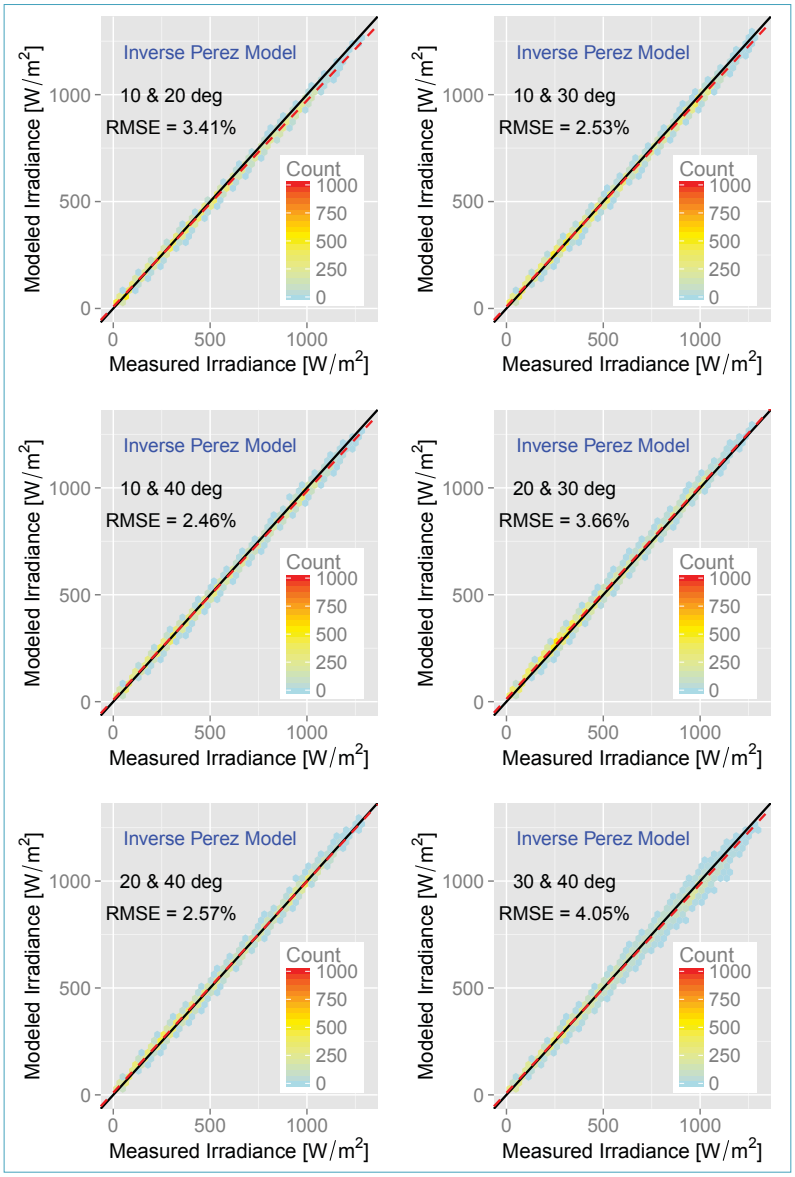


Table 1 shows the Perez model errors for various test cases that have been conducted for Singapore. In this experiment, four tilted silicon reference cells from Mencke & Tegtmeyer (±5% uncertainty) were installed at 10°, 20°, 30° and 40° respectively, with a common azimuth angle of 64° NE (see Fig. 4). A Kipp & Zonen CMP11 pyranometer (±3% uncertainty) was installed horizontally. In addition, a SPN1 sunshine pyranometer (±5% uncertainty) from Delta-T Devices measured the diffuse horizontal irradiance. The horizontal irradiance measurements were used to calculate the tilted irradiance at four different tilts; the results were then benchmarked with the reference cell measurements. During the conversion, all three loss mechanisms (temperature, spectral loss and reflectance loss) of a reference cell were accounted for.

From Table 1 it can be seen that the Perez model errors are well within the measurement uncertainties, which indicates a good performance of the model in a tropical environment (in this case Singapore).

The horizontal-to-tilt irradiance conversion uses two horizontal irradiance components to construct the tilted measurements following the Perez model. What is not shown above is that the diffuse components on the tilt can also be readily calculated. This leads to the following conversion method: two tilted reference cells are used to 'back calculate' the GHI; the modelled irradiance is then benchmarked using the GHI measurements obtained from the horizontally installed CMP11. This conversion is called the 'inverse Perez model'. Fig. 5 and Table 2 show the performance of the inverse Perez model, demonstrating that the modelling errors are smaller than the measurement uncertainty, and that the model can therefore be considered to be robust.

KIPP & ZONEN
SINCE 1830

Solutions for the Precise Measurement of Solar Radiation

Accurately measuring solar radiation is the key to finding optimal locations, helping investment decisions, maximising operating efficiency, scheduling maintenance, monitoring performance and improving technology in solar energy, both PV and CSP.

As the experts, we develop high quality instruments for solar radiation measurements such as the well-known CMP series pyranometers, the CHP 1 pyrheliometer and the SOLYS 2 sun tracker.

Our latest innovation is the CMP10 Secondary Standard pyranometer. A new design that does not require inspection or change of desiccant for at least 10 years! The CMP10 is the first pyranometer in the world supplied with a full manufacturer warranty of 5 years.

Combining CMP10 with the new CVF4 ventilation unit provides a low maintenance and high accuracy measurement solution. CVF4 greatly reduces soiling of the dome of pyranometers, extends the cleaning interval, and improves the data quality of your solar monitoring system.

www.kippzonen.com

The Netherlands • France • United States of America • Singapore

Conversion from tilt to horizontal using one reference cell

One question that might arise is why is it necessary to use measurements from two different tilts to reconstruct the GHI values? The answer is because the global-to-diffuse mapping is non-injective, i.e. it is a one-to-many mapping. In other words, for a particular GHI value, for example 800W/m^2, the corresponding DHI can have a varying range because of different meteorological conditions. Therefore, the use of one reference cell to reconstruct GHI and DHI simultaneously equates to solving for two unknowns using one equation [13]. Including another set of tilt measurements, however, provides an additional equation, which is then sufficient for solving for the two horizontal irradiance components.

Despite the mapping from GHI to DHI being non-injective, the irradiance conversion from tilt to horizontal is still possible by means of a decomposition model. A decomposition model separates DHI and HBI from GHI in situations when the DHI or HBI measurements are not available. Fig. 6 shows the first zero-energy house in Singapore: it has an 18.3°-tilted east-facing roof and a 6.1°-tilted west-facing roof, and reference cells are installed in each of the two corresponding POAs. An SPN1 sunshine pyranometer is installed horizontally at the ridge of the roof (sensors are not visible in the photograph). The application of the decomposition model is demonstrated using this set-up.

As the aim of this section is to reconstruct GHI using only one reference cell, the two reference cells (at different tilts) are used to separately reconstruct GHI. In the following experiment, the diffuse irradiance component obtained by SPN1 was assumed to be an unknown. The TGI measurements from the east-facing roof reference cell were decomposed into TBI and TDI by applying decomposition models (see Erbs, Klein, & Duffie [14], for example). The decomposed tilted irradiance components were then used to reconstruct GHI. A similar experiment was conducted using the west-facing reference cell alone. Table 3 shows the error terms in these two experiments.

It is concluded from Table 3 that the reference cell with smaller tilt produces better GHI estimates. It is also observed that the RMSE varies with the months owing to the fact that the decomposition model is very sensitive to sky conditions. Lastly, the errors of the tilt-to-horizontal conversion using only one reference cell are larger than those using two reference cells.

To analyse the results further, the converted GHI values are compared. In principle, if the conversion is accurate within an acceptable range, the GHI values obtained using the east-facing reference cell should be similar to those obtained using the west-facing reference cell. Fig. 7 shows a visual comparison of the converted GHI. In Fig. 7(a), GTI measurements on 2011 July 5 are plotted: it is clear that in the morning, the east-facing reference cell received more irradiance than the west-facing reference cell, whereas in the afternoon, the west-facing reference cell received more. In Fig. 7(b), it can be seen that the converted GHI values using the east-facing reference cell agree with the conversion results using the west-facing reference cell. Although the tilt-to-horizontal conversion errors when using a single reference cell are larger than those when using two reference cells, the conversion accuracies are still in the range of ~10% RMSE, which is acceptable for both PR calculations of PV systems without on-site readings and irradiance forecasting for power systems operation.

Tilted reference cells used	MBE [W/m^2]	RMSE [%]	U95 [%]
10° and 20°	–9.08	3.41	5.60
10° and 30°	–4.22	2.53	4.71
10° and 40°	–3.82	2.46	4.61
20° and 30°	10.59	3.66	5.66
20° and 40°	4.23	2.57	4.79
30° and 40°	–3.71	4.05	7.82

Table 2. Tilt-to-horizontal irradiance conversion errors using the 'inverse Perez model'. The calculated GHI values are compared with the pyranometer measurements. Mean bias error (MBE), root mean square error (RMSE) and the 95% expanded uncertainty (U95) are used as error metrics. All error terms include temperature, spectral loss and reflectance loss corrections.

Generating area-wide irradiance maps

Using the conversion technique described above it is now possible to combine readings from both horizontal pyranometers and reference cells in the POA, which helps in the creation of a denser network of sensors. To generate a fully spatially-resolved 2D irradiance map, a suitable interpolation algorithm needs to be developed. Conventional interpolation techniques – such as inverse distance-weighted interpolation, various types of kriging and optimal interpolation – have strengths and weaknesses in different circumstances.

Application of the spatio-temporal interpolation model developed by SERIS for the case of Singapore, using the readings from 25 stations for an area of ~700km^2, resulted in a fully interactive irradiance map for the country, shown in Fig. 8. The map displays the irradiance at any point within this area, either via cursor movements or by entering zip codes. When the 2D irradiance maps are referenced with actual measure-

Credit: Photo courtesy of Phoenix Solar Pte. Ltd.

Figure 6. The first zero-energy house in Singapore: the east-facing roof is tilted at 18.3° (right side of the roof), while the west-facing roof is tilted at 6.1° (left side of the roof).

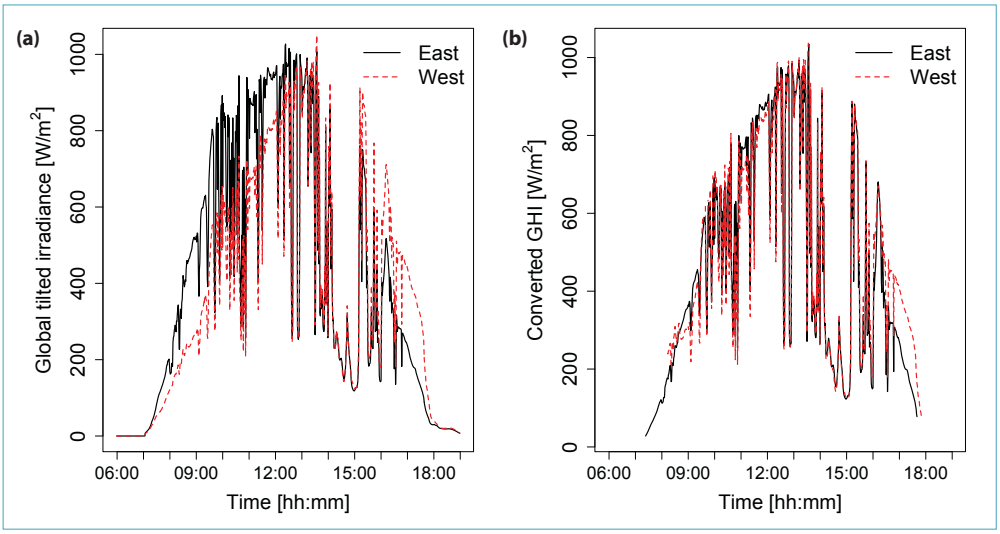


Figure 7. (a) Global tilted irradiance measurements on 5 July, 2011; (b) irradiance conversion from tilt to horizontal using only one reference cell. The converted GHI values using the east-facing and west-facing reference cells are in agreement.

Data	East MBE [W/m²]	East RMSE [%]	East U95 [%]	West MBE [W/m²]	West RMSE [%]	West U95 [%]
2011 Jan	–6.35	15.21	30.07	–1.87	9.65	18.96
2011 Feb	–15.66	12.00	24.40	–11.47	6.28	13.33
2011 Mar	–4.30	13.56	26.67	–4.78	9.29	28.39
2011 Apr	–9.14	12.80	25.44	–13.78	8.29	17.54
2011 May	–5.52	12.14	23.93	–12.90	8.10	17.16
2011 Jun	–5.18	13.45	26.51	–6.99	9.55	19.10

Table 3. Performance of the decomposition model of irradiance conversion from tilt to horizontal over a period of six months. TGI measurements from the individual reference cells are used as inputs; the outputs are benchmarked against the respective SPN1 GHI measurements. Mean bias error (MBE), root mean square error (RMSE) and the 95% expanded uncertainty (U95) are used as error metrics. All error terms include temperature, spectral loss and reflectance loss corrections. (Adapted from Yang et al. [13].)

ments from the 11 PV systems that were shown in Fig. 2, the uncertainties range from 6 to 31% for fine-time-resolution (<1 minute) irradiance interpolation, depending on the location and the spatial resolution. The higher values are naturally found in the outer areas of the island, where there are only one or two stations available for interpolation. This is less critical in larger countries, where the perimeter effect is less pronounced. The average uncertainty in the area with more sensors is 14%. This value can be significantly reduced through extending the sensor network, which would be possible by adding reference cell readings from existing – and future – PV installations and leveraging the conversion technique as described above.

Conclusion

Generating large-area irradiance maps would solve two challenges in today's PV industry: how to assess the performance of PV systems that do not have on-site irradiance measurement equipment installed, and creating a critical input for forecasting irradiance (and eventually the energy output of PV systems) in a spatially-resolved way for the grid operator to schedule the conventional power plants accordingly. Such irradiance maps require a dense network of irradiance sensors, which either is costly or does not necessarily provide the time or spatial resolution required (e.g. when using satellite data). Leveraging on the increasing number of PV systems that have irradiance measurement devices installed, typically in the plane of array, is therefore a cost-effective method for improving the accuracy of such forecasts. The technique described in this paper allows POA readings to be converted into GHI data, since the latter are required for a homogeneous, interpolated irradiance map. This has been successfully demonstrated in the case of Singapore. ■

Figure 8. An interactive tool developed by SERIS, showing a live irradiance map taken at 12:00 noon on 1 February, 2014. Locations of the 25 irradiance measuring stations (numbered 401–425) in Singapore are shown. (Map: Google Maps, retrieved 1 February, 2014.)

Authors

Dazhi Yang received his B.Eng. and M.Sc. from the National University of Singapore, where he is currently working towards a Ph.D. His research interests include statistical modelling for solar irradiance, forecasting methodologies and environmental data mining.

André Nobre received his M.Eng. in technology management from the University of South Australia. He is currently working towards a Dr.Eng. at the Universidade Federal de Santa Catarina in Brazil on short-term irradiance forecasting in tropical regions.

Rupesh Baker graduated with B.Eng. (mechanical engineering) from the National University of Singapore and has been involved in renewable energy consulting over the last three years. He is currently a PV systems engineer at SERIS.

Thomas Reindl received his Ph.D. from the University of Regensburg, Germany, and an MBA from INSEAD. He is currently the deputy CEO and cluster director of solar energy systems at SERIS. His research interests include high-efficiency PV systems and irradiance forecasting.

References

[1] Nobre, A. et al. 2012, "High performing PV systems for tropical regions – optimisation of systems performance", *Proc. 27th EU PVSEC*, Frankfurt, Germany.

[2] Dong, Z. et al. 2014, "Satellite image analysis and a hybrid ESSS/ANN model to forecast solar irradiance in the tropics", *Energy Conv. Man.*, Vol. 79, pp. 66–73.

[3] Yang, D. et al. 2013, "Block matching algorithms: Their applications and limitations in solar irradiance forecasting", *Energy Procedia*, Vol. 33, pp. 335–342.

[4] Gu, C. et al., "Spatial load forecasting with communication failure using time-forward kriging", *IEEE Trans. Power Syst.* [in press].

[5] Dong, Z. et al. 2013, "Short-term solar irradiance forecasting using exponential smoothing state space model", *Energy*, Vol. 55, pp. 1104–1113.

[6] Yang, D., Jirutitijaroen, P. & Walsh, W.M. 2012, "Hourly solar irradiance time series forecasting using cloud cover index", *Solar Energy*, Vol. 86, pp. 3531–3543.

[7] Yang, D. et al. 2013, "Solar irradiance forecasting using spatial-temporal covariance structures and time-forward kriging", *Renewable Energy*, Vol. 60, pp. 235–245.

[8] Yang, D. et al., "Solar irradiance forecasting using spatio-temporal empirical kriging and vector autoregressive models with parameter shrinkage", *Solar Energy* [in press].

[9] Meydbray, J., Emery, K. & Kurtz, S. 2012, "Pyranometers, reference cells: the difference", *pv magazine* (April).

[10] Ye, J. et al., "Determination of the PV module temperature coefficient from outdoor testing data" [submitted to Solar Energy].

[11] Perez, R. et al. 1987, "A new simplified version of the Perez diffuse irradiance model for tilted surfaces", *Solar Energy*, Vol. 39, pp. 221–231.

[12] Perez, R. et al. 1990, "Modeling daylight availability and irradiance components from direct and global irradiance", *Solar Energy*, Vol. 44, pp. 271–289.

[13] Yang, D. et al. 2013, "Evaluation of transposition and decomposition models for converting global solar irradiance from tilted surface to horizontal in tropical regions", *Solar Energy*, Vol. 97, pp. 369–387.

[14] Erbs, D.G., Klein, S.A. & Duffie, J.A. "Estimation of the diffuse radiation fraction for hourly, daily and monthly-average global radiation", *Solar Energy*, Vol. 28, pp. 293–302.

Fundamentals of the commissioning tests of large-scale PV power plants

Utility solar | Large-scale PV contractors must perform tests to verify the correct operation of a new installation. Jorge Coelle and Leonardo Perez outline the minimum aspects to consider for the commissioning of large-scale PV plants using a methodology that has been successfully implemented in the commissioning of more than 40 PV facilities worldwide

In order to guarantee their investment, developers of PV facilities require the contractor to perform a series of tests that determine the correct operation of an installation prior to its commissioning. These tests are referred to as the commissioning tests of a PV project and are essential in both technical and economical terms.

The purpose of the main tests involved in the commissioning of PV plants is to reduce the uncertainty of the final performance of the PV plant under construction. Dealing with this uncertainty is essential for the three main parties involved in the construction of a PV plant: the owner, the contractor and the bank which finances the construction. For the owner, this methodology assures the quality of the components and installation while providing accurate information for the energy production estimation. For the contractor, it is useful to guarantee that total installed peak power and PV plant performance agree with the purchase contract. For the bank, it is clearly useful to reduce an important parameter – the risk – and to offer better credit conditions.

Methodology

Enertis Solar specialises in the provision of integral services within the solar PV market. Its approach focuses on the implementation of quality-control processes in each phase of the project, from PV module manufacturing to the design, installation and operation of a large PV plant. The company is a pioneer in the implementation of quality-assurance programmes: in the past it has proposed the carrying out of extensive quality control for PV modules [1], the monitoring of power degradation in PV modules [2], the introduction of electroluminescence (EL) imaging in the quality control of large PV plants [3], a methodology for estimating the actual installed peak power from the measurement of a sample of PV modules in the lab, the implementation of additional field tests to estimate peak power [4], and so on.

The methodology proposed in this paper for the commissioning has a wider scope and includes certain procedures that aim to verify not only the PV modules, but also the whole construction, components and performance.

It is important to note that these procedures should be included in advance in construction contracts in order to facilitate aspects such as fixing the price to the actual installed peak power or the acceptance and rejection of components, among others.

The proposed methodology can be divided into four main groups:

1. Mechanical completion
2. Electrical completion
3. Monitoring system
4. Availability and performance ratio.

The aim of this paper is to describe some of the tests included in the above-mentioned groups; these tests should be regarded as the minimum requirement for a good commissioning.

Mechanical completion

The mechanical completion includes all inspections related to the support structure (or trackers). The inspections should be performed from the very beginning of the construction in order to avoid recurrent errors and thus minimise the cost of solving any potential issue regarding the structures or their installation. For instance, if a batch of structures is not accepted because of galvanising defects, and a new consignment is therefore necessary, the installer will then have to discontinue work until the new material arrives, resulting in delays and extra costs. This kind of situation can be avoided if the mechanical completion verification is carried out during the construction and not just before the commissioning. Table 1 presents crucial aspects that need to be included within the mechanical completion review.

Electrical completion

The electrical completion includes many inspections that can be done during the construction stage (peak power, insulation resistance, visual inspections, etc.). There are many others, however, that can be performed only when the facility is in operation (voltage drops, efficiency of inverter, infrared (IR) thermography, etc.). For this reason it is very important to dedicate considerable effort to seamlessly accommodating the inspections in the construction and testing schedules. The electrical comple-

Mechanical completion
• Inspection to ensure structure built in accordance with plant layout designs (spacing, tilt, orientation, etc.)
• Visual inspection of support structures, including galvanising defects, rust, cracks, torque, etc.
• Foundations inspection

Table 1. Main aspects of the mechanical completion.

Electrical completion
PV modules and strings
• Verification of peak power
• Verification of I_{sc} and V_{oc}
• Polarity
• IR thermography
AC/DC boxes and system
• Visual inspection (fuses, control terminals, fuse holders, cable entry, cable glands and seals, etc.)
• Test of breakers and protections
• Electrical continuity and insulation resistance of cables
• Electrical grounding
• Voltage drops
Inverters
• Visual inspection
• Efficiency of the inverter
• Maximum power point tracking
• Verification of voltage and current
Transformers
• Visual inspection
• Torque of connections

Table 2. Main aspects of the electrical completion.

Figure 1. Oxide on a structure as a result of insufficient galvanising.

tion is divided into the four main subgroups shown in Table 2.

Monitoring system

The monitoring system is a very important tool for the correct operation and maintenance of the PV plant; the installed solution should be flexible, precise and adaptable. It is the authors' recommendation that the system offer two operation possibilities: a basic level and an analysis level.

Traditionally, the commissioning of the monitoring system has been based on checking the installation and verifying that the SCADA (supervisory control and data acquisition) provides reasonable values. In the authors' experience, this methodology is not effective, and ultimately the owner does not really know how the facility works. For this reason, the commissioning of the monitoring system should consist of two main procedures:

1. *Hardware and installation:* all sensors should be checked and the traceability of their calibration certificates verified. It is important that sensors be calibrated in a laboratory that complies with IEC 17025 [5] and be included in an annual calibration plan. Moreover, the correct installation of all components should be checked: many irradiance sensors, for instance, have been found with important tilt differences with respect to the modules.

2. *Data acquisition and communication:* the test should be performed to verify that the monitoring system operates in accordance with IEC 61724 [6]. The minimum scope of this procedure should consist of the verification of irradiance, temperature, voltage, current, power, etc., including the verification of:

- linearity of response
- stability
- integration
- zero integral value

Availability and performance ratio

Unavailability is defined as the period of time during which the PV facility is not producing energy at full capacity. It should be noted that losses of availability may occur within the PV plant premises, for which the operation and maintenance contractor is liable, or outside the PV plant facilities, i.e. in the transmission infrastructures. In the authors' experience, an availability of 98% is adequate and likely to be achievable by most of the large PV facilities.

The performance of a PV plant is expressed by the performance ratio (PR) factor, which is defined as a percentage representing the ratio between the expected energy output in real conditions (taking into account all of the losses that occur in the energy generation) and the theoretical energy output in ideal conditions.

The PR measurement should be carried out during a period of 240 hours of continuous operation. The protocol establishes that the availability of the plant must be 100% and the availability of the recorded data should be at least 99.9%.

The availability of the plant is analysed through the study of the low-voltage meter records, the alarm records of the inverters, and the trackers' position when applicable. In this test period, the protocol establishes that the real production (the energy produced by the plant during the test period) has to be greater than or equal to the theoretical production (the energy that the plant would produce in the guaranteed performance conditions).

Methodology application

A third party involved in the supervision of commissioning tests must be totally independent and possess extensive technical know-how. An accredited laboratory seems to be the best option for carrying out these services, since its staff includes experienced engineers and scientists with Ph.D. degrees who specialise in photovoltaic energy. Moreover, the IEC 17025 accreditation guarantees complete independence. Three different possibilities of collaboration exist and can be classified according to their confidence levels:

1. *Tests totally performed by an accredited laboratory* (high confidence level). This is the option preferred by the bank; however, in the case of large PV facilities, the cost can be high if the procedures and the selection of samples are not well designed.

2. *Tests partially performed by the contractor under supervision of an accredited laboratory* (medium–high confidence level). This option is a combination of critical tests performed by an accredited laboratory (peak-power measurement, inverter efficiency test, etc.) and simple tests performed by the contractor and supervised by the laboratory (IR thermography, polarity, etc.).

3. *Tests totally performed by the contractor under supervision of an accredited laboratory* (medium confidence level). This kind of

Figure 2. An incorrectly installed omega junction.

	Facility A
Total capacity	20MWp
Module technology	Crystalline
Total modules	100800
Structure type	10º fixed-tilt 0º azimuth
Total inverters	40 (500kWp)

Table 3. Main characteristics of the tested PV plant.

collaboration is usually the most affordable and most attractive option for the contractor, because the externalisation of tests is minimised.

In collaboration types 2 and 3, the laboratory should at least perform all tests on a randomly selected sample and compare the results with those obtained by the contractor. If these are in agreement, the results of the contractor can be validated.

Examples of application

The commissioning testing proposed in this paper has been successfully implemented in more than 40 PV plants worldwide, in Spain, Italy, the USA, Puerto Rico, India, etc. Some of the results obtained in the commissioning of different PV facilities will be presented in this section.

Mechanical completion: visual inspection of support structures

Figs. 1 and 2 show an example of typical defects detected during the mechanical completion of a large PV plant. Fig. 1 shows that oxide is present on the structure two weeks after its installation. It is very important to perform an adequate galvanising of the profiles, since the high humidity in tropical locations can be critical for the failure of the project. Fig. 2 shows an incorrectly installed omega junction typically used to fix the modules to the structure.

String	V_M [A]	I_M [V]	P_M [W]	Power deviation
1	617.81	7.87	4864	–1.43
2	622.80	7.85	4892	–0.87
3	625.63	7.65	4784	–3.06
4	626.45	7.73	4842	–1.88
5	635.90	7.70	4899	–0.74
6	634.08	7.73	4901	–0.69
7	624.41	7.78	4855	–1.62
8	629.88	7.63	4803	–2.68
9	626.82	7.55	4731	–4.13
10	627.94	7.69	4832	–2.09
11	619.30	7.59	4703	–4.69
12	631.50	7.77	4908	–0.54
13	634.38	7.83	4969	0.69
14	630.73	7.77	4901	–0.69
15	634.43	7.65	4856	–1.60
16	635.81	7.76	4937	0.03
17	628.40	7.80	4902	–0.67
18	635.54	7.70	4896	–0.79
19	627.41	7.76	4866	–1.40
20	635.21	7.74	4918	–0.35
21	627.06	7.81	4898	–0.74
22	622.44	7.68	4778	–3.19
23	629.54	7.82	4925	–0.20
24	635.69	7.72	4905	–0.60

Table 4. Peak-power measurement results (array field 1, combiner box 1).

Electrical completion: peak-power measurement of strings

This test is performed to measure the maximum power of the strings in standard test conditions. It is important to point out that the main purpose of the test is to measure the maximum power in order to detect any defects in the installation and connection of the modules, and not to establish an accurate characterisation. The reason for this is that the on-site measurement of maximum power depends on the soiling, electrical interconnection and existing solar spectrum conditions during the test period. Nonetheless, all precautions for minimising measurement uncertainty should be taken during the tests, which should therefore be carried out by experienced technicians.

The following equipment was used for the maximum-power measurement procedure:

- A reference cell in accordance with IEC 60904-2 [7].
- A temperature sensor to measure cell temperature.
- An electronic load equipped with a data logger to obtain *I-V* curves.

The *I-V* curve was obtained in accordance with IEC 60904-1 [8], while temperature and irradiance corrections were performed in accordance with IEC 60891 [9]. The test was conducted on a sunny day; to minimise spectral errors, the measurements were taken during the period two hours before and after solar noon, when the irradiance in the plane of the modules was above 700W/m^2.

The facility was a 20MW PV plant: the main characteristics are presented in Table 3.

Table 4 shows the test results of 24 strings measured directly in a combiner box and their power deviation values with respect to the nominal value. The power losses due to mismatch and cabling are not considered in the calculation of the nominal power. Fig. 3 shows the peak power of each string within the tolerance range of the modules. The error bars correspond to an uncertainty of ±5% (K = 2). According to the results shown in Table 4, the deviation with respect to the nominal power is lower than the uncertainty of the measurement: all strings can therefore be considered to conform.

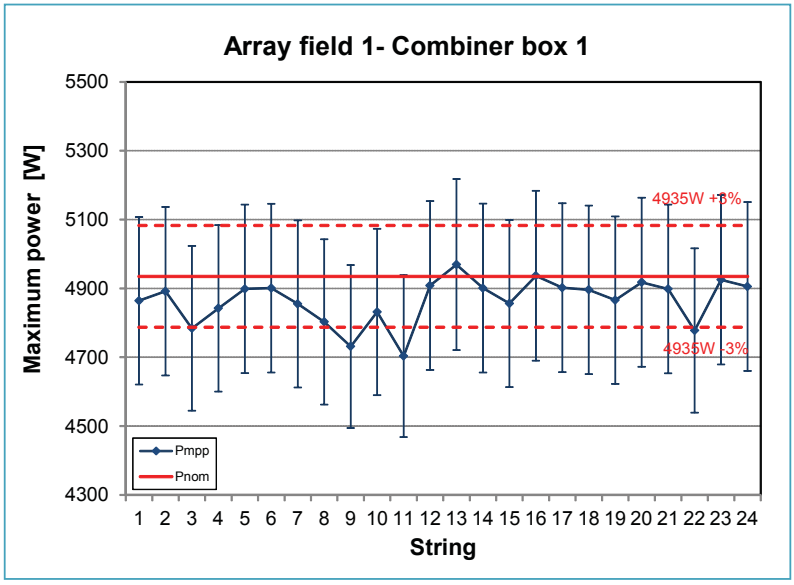


Figure 3. Peak-power position of each string in the tolerance range of the modules (±3%).

Monitoring system: DC voltage verification

The verification of the DC voltage presented in this section was carried out at two large PV plants located in India: Table 5 shows the main characteristics of the plants.

This test aims to verify data provided by the SCADA system for the measurement of the DC voltage in the inverter. The equipment used was a high-precision wattmeter that had been accurately calibrated. The DC

	Facility A	Facility B
Total measurements	361	361
Accepted	346	351
Rejected	15	10
Gaps	0	0
% rejected	4.15	2.77

Table 6. Results of the DC voltage verification in the monitoring system.

	Facility A	Facility B
Total capacity	5.5MWp	16.7MWp
Module technology	CdS/CdTe (First Solar FS 382)	CdS/CdTe (First Solar FS 382)
Total modules	67200	203100
Structure type	20° fixed-tilt, 0° azimuth	20° fixed-tilt, 0° azimuth
Total inverters	7 (680kWp)	22 (680kWp)

Table 5. Main characteristics of the tested PV plants in India.

voltage values were measured and recorded by the wattmeter; these measurements were then compared with the values displayed by the SCADA system, taking into consideration the uncertainty of measurement.

Data acquisition was performed during sunny days without clouds. To minimise spectral errors, measurements were taken during the period three hours before and after solar noon, when the incident irradiance was greater than 500W/m^2. The measurements were collected in one of the lines of the DC input of the inverter.

In accordance with the acceptance and rejection criterion of IEC 61724, the measurement is accepted when the SCADA measurement does not differ from the wattmeter value (reference value) by more than ±1%. Table 6 shows the accepted and rejected measurements.

Results of the DC voltage verification at facility A indicate that out of 361 measurements during the test, 15 samples exceeded the 1% limit: these samples represented 4.15% of the total number. However, better results were obtained at facility B, with the percentage of rejected measurements being 2.77%.

Facility A			
Date	***E* [kWh]**	**I_{gen} [Wh/m^2]**	***PR* [%]**
27 Feb	33,891	7,384	82.79
28 Feb	33,622	7,448	81.42
01 Mar	31,183	6,556	85.80
02 Mar	34,859	7,701	81.66
03 Mar	34,571	7,774	80.21
04 Mar	34,659	7,733	80.85
05 Mar	34,029	7,548	81.32
06 Mar	33,713	7,367	82.54
Total	270,526	59,509	82.0

Table 7. Performance ratio calculations for facility A.

Facility B			
Date	***E* [kWh]**	**I_{gen} [Wh/m^2]**	***PR* [%]**
11 Mar	89,972	6,444	83.33
12 Mar	89,963	6,412	83.74
13 Mar	54,851	3,693	88.65
14 Mar	100,720	7,009	85.77
15 Mar	105,255	7,293	86.13
16 Mar	84,606	6,251	80.80
17 Mar	104,679	7,458	83.77
18 Mar	101,908	7,402	82.17
Total	731,955	51,962	84.07

Table 8. Performance ratio calculations for facility B.

Availability and performance ratio

The performance of a PV plant is commonly specified in terms of its PR, which is represented by a percentage given by the ratio between the expected and theoretical energy outputs. On the basis of the data provided by the energy meters and the irradiance measured in the PV facilities during an eight-day period, the PR was calculated for both of the facilities detailed in Table 5: the results are given in Tables 7 and 8.

It should be noted that the PR includes the following losses: spectral, angular, shading, soiling, temperature, irradiance level, mismatch, low-voltage wiring, inverter, MPP tracking, availability, degradation, transformation (at plant transformer) and medium-voltage wiring (from plant transformer to plant energy meter).

However, neither the medium-voltage wiring losses from the plant's energy meter to the network operator's high-voltage transformer, nor the high-voltage transformer losses, where the recording energy meter is located, are included in the calculation.

"The results of the implementation of the proposed methodology demonstrated a reduced uncertainty in the final performance of the plants in all cases."

Conclusions

It is worth noting the importance of assuring quality-control aspects throughout the entire implementation process, beginning at the PV module manufacturing stage and continuing beyond the commissioning, to the operation and management of PV plants that are up and running.

This paper has described some key aspects of one specific step of the quality-control process: the commissioning tests. This was considered to be the most critical stage for the future performance and reliability of a PV installation. The proper commissioning of a new PV installation allows the accurate determination of essential aspects: the detection of early failures and the assurance of availability once the plant is in operation.

The results of the implementation of the proposed methodology for the commissioning tests of large PV plants demonstrated a reduced uncertainty in the final performance of the plants in all cases. The consequence of this is an increase in investor confidence in the PV market. ■

Authors

Jorge Coello has14 years' experience in the solar energy sector and currently manages the R&D department at Enteris Solar.

Leonardo Perez is currently a Ph.D. candidate in photovoltaic solar energy at the Solar Energy Institute of the Polytechnic University of Madrid.

References

[1] Coello, J. et al. 2008, "Quality control during the supply of PV modules: Fundamental key to guarantee the profitability of PV installations", Proc. 23rd EU PVSEC, Valencia, Spain, pp. 3784–3787.

[2] Coello, J. 2011, "Degradation of crystalline silicon modules: A case study on 785 samples after two years under operation", *Proc. 26th EU PVSEC*, Hamburg, Germany, pp. 3500–3503.

[3] Coello, J. 2011, "Introducing electroluminescence technique in the quality control of large PV plants", *Proc. 26th EU PVSEC*, Hamburg, Germany, pp. 3469–3472.

[4] Coello, J. et al. 2012, "Verification of the installed peak power in the commissioning tests of large PV plants", *Proc. 27th EU PVSEC*, Frankfurt, Germany, pp. 3983–3985.

[5] ISO/IEC 17025:2005, "General requirements for the competence of testing and calibration laboratories".

[6] IEC 61724:1998, "Photovoltaic system performance monitoring – Guidelines for measurement, data exchange and analysis".

[7] IEC 60904-2:2007, "Photovoltaic devices – Part 2: Requirements for reference solar devices".

[8] IEC 60904-1:2006, "Photovoltaic devices – Part 1: Measurement of photovoltaic current-voltage characteristics".

[9] IEC 60891:2009, "Procedures for temperature and irradiance corrections to measured I–V characteristics".

POWER ELECTRONICS®

Power Electronics launches new head quarters in Phoenix, Arizona

Power Electronics has enjoyed fantastic success in the USA; since its beginning in 2010, the company has spread itself across the country to areas such as Boston, San Francisco and Austin, allowing the business to remain close to clients to provide assistance and support. Thanks to the rapid growth in such a large market a new HQ was necessary to provide a base of operations in the country.

The company is proud to announce their new HQ in Phoenix, Arizona. This location will be the central hub for the ongoing expansion into the North American market thanks to its ideal central placement and excellent distribution networks. The facility has ample office space for the sales and rojects departments, who ensure that every client gets technical support and assistance throughout the completion of their project. The large Phoenix facility allows for the storage and distribution of the entire product range while allowing dedicated engineers to perform quality control measures and ensure the product is ready to be received by the customer. This location is perfect for showcasing the products and growing the business further by hosting customers, prospects and partners in a first-class setting. The new HQ will ensure the delivery and commissioning of over 1GW of UL certified and compliant inverters across North America.

Power Electronics believes in providing exceptional customer service and a world-class product. The Freesun HEC-UL central inverter boasts a 2mm thick stainless steel enclosure which gives it NEMA 3R protection and enables it to last for 25 years in some of the world's harshest and most extreme climates. The Automatic Redundant Modular Master Slave System allows for the competiveness of central inverters and the availability of string inverters. The exclusive iCOOL system allows the inverters to work at 50ºC with no power de-rating by completely enclosing the electronics. Freesun HEC-UL inverters are equipped with the latest industrial developments which offer the maximum yield and proven reliability for any utility-scale projects. The HEK Skid Solution is a turnkey solution, complete

with factory integrated AC & DC disconnects and protection, two HEC-UL inverters, a step up pad-mount transformer and auxiliary equipment, powering up to 3MW per skid.

Power Electronics strongly believes in a customer-orientated strategy; since the beginning, customer service has always been a cornerstone of the business and the company is proud to say that even after expanding into more than 30 countries we still maintain this value. After analysing the North American solar market, it was clear there was a need for a company who could provide not only a world-leading product;, but also an equally impressive service to go alongside it.

Our family business values on an international scale have enabled us to get closer to the customer and ensure every client gets a fully customised product for their project. Power Electronics does not have customer categories or preferred areas; we offer an onsite service 24h/365 given by Power Electronics trained personnel. With over 1,000MW of projects set to be completed in the coming months and over 300MW scheduled before the end of 2014, Power Electronics' North American venture is proving to be a major success story.

Power Electronics

Power Electronics is a multinational company who began manufacturing industrial electronic devices in 1987, with our subsidiaries in over 30 countries and more than 700 employees – allowing us to see our products all over the world. Our expertise is divided into two main fields: the industrial division, where we manufacture Variable Speed Drives and Soft Starters, both in low and medium voltage, and the solar division, where we manufacture solar inverters; our product range covers any possible requirement for your solar installation. Power Electronics has used the same philosophy worldwide and in the USA, based on service and customer support, with free 24-hour dedication to our clients and locally stocked parts to guarantee that you get the best product and the best service.

Power Electronics New North American Headquarters:
4777
N 44th Avenue
Phoenix, Arizona
85031

Contact:
Javier Pérez – Marketing Director
jperez@power-electronics.com
T: (+34) 961 366 557
F: (+34) 961 318 201

Anthony Carroll, CEO
Ronald Puryear VP & GM

POWER ELECTRONICS®

SAVING ENERGY FOR THINGS THAT MATTER

UK MOST POPULAR CHOICE #1

Truly Modular & Redundant outdoor inverter
Extreme durability IP54/NEMA 3R stainless steel enclosure
Fully mineral isolation
Extended MPPt range
Extended power factor control
Reactive power at night
Active turn-on voltage
External or built-in DC protection
Up to 24 Strings monitoring

Outdoor Solar Inverter

FREESUN HEC 600kVA - 1700kVA
FREESUN HEC-UL 160kVA - 1500kVA

WARRANTY 5 YEARS FOR RENEWABLE DIVISION
IMMEDIATE DELIVERY EXPRESS
24HRS. SERVICE POWER ON SUPPORT 24h
CUSTOMER SUPPORT
ENGINEERING AND CONSULTING

Visit us at
Solar Energy UK
Booth H46
14-16 OCT 2014

Visit us at
SPI Las Vegas
Booth 312
20-23 OCT 2014

www.power-electronics.com

The next-generation utility-scale PV plant

Utility solar | A next-generation PV plant architecture based on increasing direct current system voltage from 1,000VDC to 1,500VDC holds the promise of a more cost-effective and productive utility-scale plant due to lower installation and maintenance costs. Mahesh Morjaria, Kevin Collins, Michael Stavish of First Solar and Greg Ball of DNV-KEMA Renewables explore some of the challenges associated with the development of the technology and the efforts to address some of those challenges

Over the past several years, the rapid drop in PV module price has made a significant dent in reducing the cost of utility-scale PV plants and in making solar energy affordable. However, further cost reductions are necessary to reach the goal of making solar-generated power fully cost-competitive with traditional power sources. For example, the US DOE's SunShot programme has set a goal to reduce the installed cost of a utility-scale PV system to less than US$1/W, resulting in less than US$0.06 per kilowatt hour (kWh) solar energy production costs by the end of the decade.

Since the SunShot programme's inception in 2010, the average cost per kWh of a utility-scale PV project in US has dropped from about US$0.21/kWh to $0.11/kWh. For a typical utility-scale PV system that feeds power directly to the grid, the balance of system (BOS) cost now represents between 60-70% of the total cost of the system from a previous value of less than 50%. Therefore, a significant opportunity for further cost reductions lies in improvement in the BOS.

Major cost and efficiency improvements have been gained in the past decade as utility-scale PV plants in the US have moved from $600V_{DC}$ to $1,000V_{DC}$ architecture. Similarly, the transition to $1,500V_{DC}$ provides still greater efficiencies and cost reductions. The higher voltage operation translates to greater power throughput for the same ampacity (current carrying capacity) of DC components such as cables, combiner boxes and inverters. It enables greater consolidation of low voltage to medium voltage transformers and related switchgear. It further enables greater flexibility in general to design systems optimally for efficiency and/or cost.

Table 1. Engineering assessment results

System Aspect	$1,500V_{DC}$ relative to $1,000V_{DC}$ system implementation
Electrical design: DC wiring, grounding, and protection	Meaningful differences are limited to the voltage rating of overcurrent protection and switching components. The vast majority of design fundamentals match those of the $1,000V_{DC}$ systems.
Electrical design: AC	No fundamental difference in the design of medium voltage AC collection systems or interconnection
PV module	FS Series 4 modules certified to IEC standards to $1,500V_{DC}$.
Inverter	Overall cost-efficiency improvements can be demonstrated using larger $1,500V_{DC}$ inverter due to higher power density. Certifications to IEC 62109 and ultimately UL 62109.
Other DC BOS equipment	No issues with majority of components. Some parts such as string and module connectors, and harnesses cannot be officially listed to UL standards due to $1,000V_{DC}$ scope limitation, but are equivalently tested based on the higher voltages for UL 'recognised' status.
Safety in the DC system design	No salient differences. First Solar incorporates a high level of safety-driven design aspects.
Regulatory risk	Some regulatory risk inherent for early adaptors of $1,500V_{DC}$ platform. Risk in the US in general higher than in select international markets evaluated because of NEC preference for US-based product standards.
Cost performance	Design takes advantage of opportunities for cost-performance optimisation with electrical losses and greater array scale, enabling fewer inverter-MV transformer pads. No inherent reduction in performance from increase voltage.
Module PID	Third-party tests certify PID within limits similar to $1,000V_{DC}$-rated modules
Installation/qualified personnel	Little difference in electrician training and qualification for $1000/1500V_{DC}$ systems. May be some jurisdictional dependency.
Arc-flash protection requirements	For some equipment, higher-rated arc-flash PPE required for maintenance personnel compared to $1,000V_{DC}$ systems.
O&M procedures and cost	Reduced O&M costs due to reduced number of components per megawatt of installation. Similarly reduced number of repetitive O&M tasks
Pilot site installation	Significant installation efficiencies demonstrated despite little apparent difference in $1,000V_{DC}$ and $1,500V_{DC}$ array segments. No design element changes required as result of AHJ review.

1,500V_{DC} products and standards

The adoption of 1,000V_{DC} utility-scale systems in the US was enabled by the availability of international products and the precedence of installations, mostly in Europe, during the early to mid-2000s. These products were initially only available with international certifications but over time, more and more have been certified to US standards to meet demand. Recently the 2014 edition of the US National Electrical Code has bumped its low voltage threshold from 600V DC to 1,000V_{DC}, eliminating unnecessary distinctions in the installation requirements of 600V_{DC} and 1,000V_{DC} projects. As in the past, the current move to 1,500V_{DC} is again partially enabled by International Electrotechnical Commission (IEC) standards that classify 1,500V_{DC} in the low voltage range, making components and products readily available.

As a vertically integrated company with PV module manufacturing among as its core competencies, First Solar has the unique ability to 'tune' the output characteristics of its modules to support this new 1,500V_{DC} standard. An unintended benefit was derived during the development of these next generation thin-film CdTe modules (Series 4) in that additional conversion efficiencies were realised. Effectively, modules optimised for 1,500V_{DC} offer better performance with respect to efficiency and maximum output power compared to the 1,000V_{DC} predecessor.

Additionally, First Solar and its BOS component suppliers are collaborating to develop the next-generation 1,500V_{DC}-based plant capability. These technologies, which have been used widely in the wind power industry, have been adapted to suit the characteristics of PV DC systems. For example, GE has developed a new 4MVA ProSolar inverter/transformer system based on the previous 1MVA ProSolar platform that was introduced in Europe in 2009 as a derivative of its wind converter products. Compared with 1,000V_{DC} plants, these products enable a power plant design platform with significant flexibility to increase the size of the solar array served by each inverter or maintain the solar array size while reducing wire and cable sizes. The 1,500V_{DC} plant design platform maintains high power delivery while lowering installation and maintenance costs.

Technical and regulatory challenges

There are several technical and regulatory challenges associated with approvals and adoption of the proposed next-generation plant into the North American as well as other international target markets. Some of the challenges are inherent with early adoption of any new technology.

In this case, both the modules and the inverters have limited field history. The regulatory challenges in many places, particularly outside of North America are lower due to existing International Electrotechnical Commission (IEC) standards, which address 1,500V_{DC} design and safety. Greater challenges are faced in the US, where the lack of established standards that address 1,500V_{DC} applications often make it challenging to obtain plant construction permits from local authorities having jurisdictions.

However, much like the earlier transition from 1,000V_{DC} architecture, these issues are addressable and no long-term barriers to adopting this architecture are expected. Active steps are underway in the standards and codes community to address the needs of the growing large-scale PV plant market. The recent announcement by UL

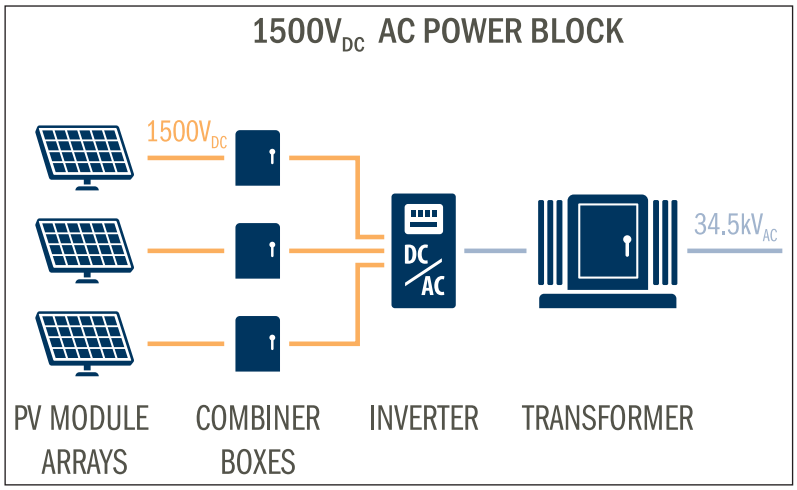


Figure 1. Illustration of 1,500V$_{DC}$ AC Power Block.

to adopt ANSI/UL 62109-1 as the American National Standard for Safety of Power Converters for Use in Photovoltaic Power Systems enables US-based certification of 1,500V$_{DC}$ inverters, and is a step in the right direction. UL is working towards the adoption of similar standards for modules and other DC BOS equipment, and in parallel, changes to the National Electrical Code (NEC) are anticipated that will better accommodate the unique aspects of design platforms utilised in large, utility-scale PV plants.

Independent engineering assessment

An independent engineering study was conducted by DNV GL to review the design and 1,500V$_{DC}$ systems. The assessment of various relevant aspects, with emphasis on salient distinctions from 1,000V$_{DC}$ systems, is summarised in Table 1. In general, the 1,500V$_{DC}$ system architecture was found to be very promising with respect to performance, value and overall technical merit. Some risks and uncertainties are identified that are inherent with early adoption of any advanced architecture, but no issues have been identified that are a long-term concern.

PV plant system design

A typical 1,500V$_{DC}$ PV plant designed around an 'AC Power Block' of either fixed-tilt or tracking arrays ranging in size from 1 MW DC up to 5MW DC is described next (see Figure 1). The key plant components are similar to what have been deployed previously on the 1,000V$_{DC}$ utility-scale PV plants – modules, DC wiring, combiner boxes, inverters and pad-mount transformers to step up the AC voltage. However, in this case the components are specifically designed to meet 1,500V$_{DC}$ requirements.

The modules are connected in series strings of 15, up from the 10 per string used in the 1,000V$_{DC}$ systems. The strings are connected to harness cables with in-line fuses, which are in turn combined in harness combiner boxes. A typical harness combiner box delivers the power of 96 strings (133kW) to the inverter via underground feeder cable pair. The 1,500V$_{DC}$ inverter is equipped with dedicated fused inputs for each of the harness combiner boxes and can be configured for grounded or ungrounded arrays.

The increase in DC voltage and use of large-scale 4MVA inverters leads to a significant increase in the DC array size. The typical 1,500V$_{DC}$ system design will incorporate between 5 and 5.3 MWp DC of PV capacity, corresponding to a DC/AC ratio between 1.25 to 1.33. The inverter converts the input DC power to 60Hz AC at 550V$_{AC}$, which is stepped up via a close-coupled transformer to 34.5kV for aggregation with other inverters throughout the plant. The aggregated inverter outputs are ultimately stepped up again to a selected transmission voltage for interconnection to the utility power grid.

The impact of array size increase and reduction in the number of inverters is very apparent when two plant layouts are compared side by side as illustrated in Figure 2. The figure on the left consists of typical 2.0MW$_{DC}$ arrays of modules while the figure on the right consists of typical 5MW$_{DC}$ arrays of modules. In this illustration the number of power conversion stations is reduced from 10 to 4 (60% reduction). There is also improvement in land utilisation with fewer access roads and less area occupied by the power conversion stations.

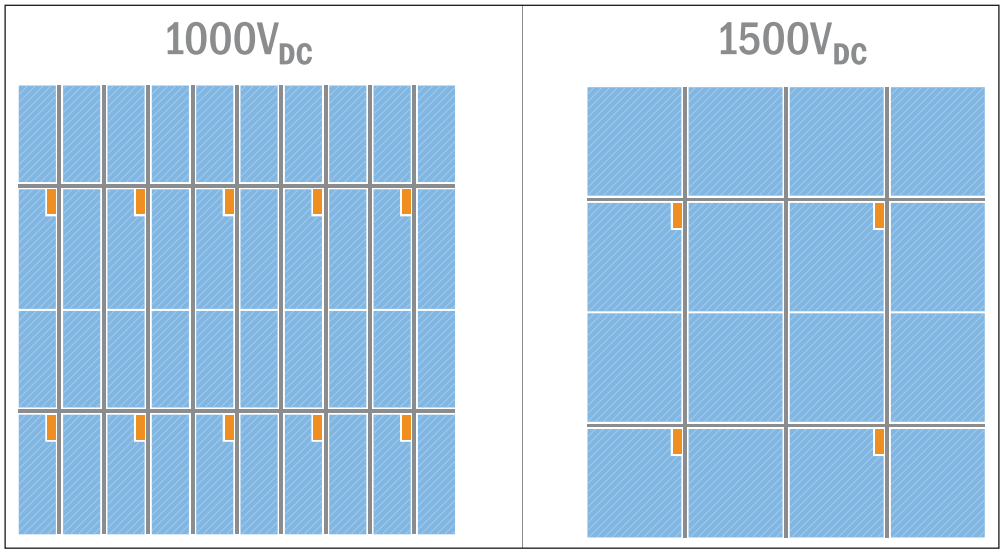


Figure 2. Sample 1,000V$_{DC}$ and 1,500V$_{DC}$ plant layouts.

1,500V$_{DC}$ inverter

Inverters for 1,500V$_{DC}$ plants currently range in capacity from <1MVA to 4MVA in modular rating increments. This facilitates the flexibility of ensuring plant cost optimisation, depending on plant size, while closely matching plant capacity and availability requirements. 1,500V$_{DC}$ inverters deliver almost 50% more power for each ampere of current from the array, meaning higher power density that reduces the overall installed cost compared with same 1,000V$_{DC}$ inverter capacity.

By and large, 1,500V$_{DC}$ inverters have the same fundamental converter topology as 1,000V$_{DC}$ inverters – with power semi-conductors and DC power circuit components appropriately rated for the higher DC voltage. These components are covered by the existing IEC standards and readily available as they are similar to those components used in wind converters and industrial drives. 1,500V$_{DC}$ inverters have the same AC grid interface circuits, controls, protection, and grid management features as 1,000V$_{DC}$ inverters.

An example of 1,500V$_{DC}$ inverters is the

Figure 3. GE Prosolar 4MVA inverter with close-coupled transformer at a field site.

GE 4MW ProSolar unit shown in Figure 3, which is installed at a field site. The unit includes a transformer that is specifically designed to couple with the inverter and provide medium voltage output. The inverter has been developed as a derivative of GE's 1MVA ProSolar product introduced to the European market in 2009, leveraging the field experience and relative maturity of the technology platform.

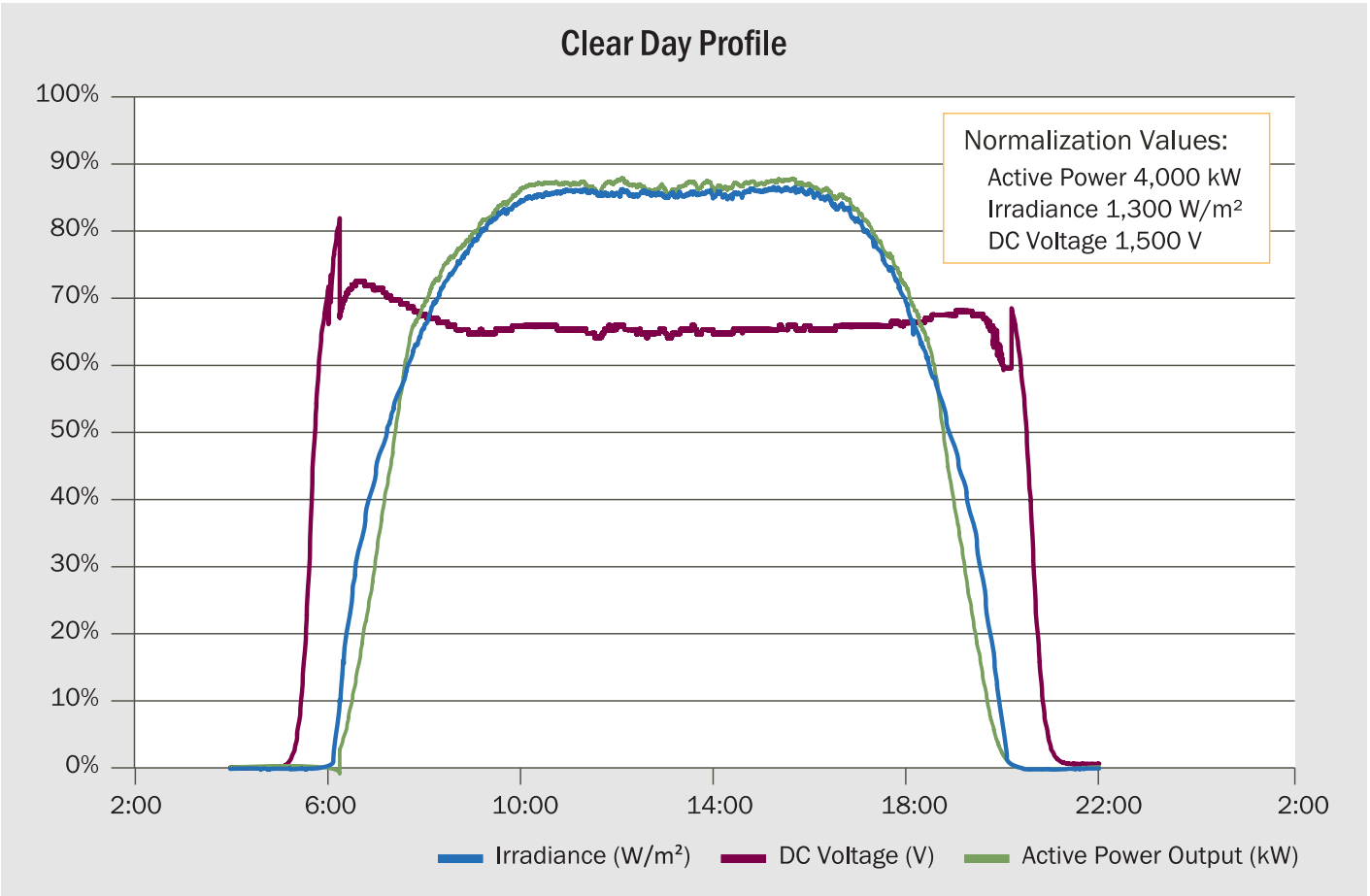
Figure 4. Inverter performance on a clear day.

1,500V_{DC} modules

There are many module suppliers that are developing products to support 1,500V_{DC} applications. First Solar has developed the next-generation thin-film CdTe modules called Series 4, which is specifically optimised for such applications. The modules are IEC certified. They have gone through rigorous testing including TUV LST (Long Term Sequential Sandstorm and PID test) to ensure high reliability and performance.

Field experience

In the spring of 2014, First Solar commissioned its first 1,500V_{DC} AC Power Block at the Macho Springs Solar Plant in Deming, New Mexico, M, operated by First Solar and owned by Southern Company. The PV plant, with an overall capacity of 52MW, has 34 arrays that utilised 1,000V_{DC} architecture. An additional array using 1,500V_{DC} architecture was added to the plant to demonstrate the viability, commercial readiness, and accept-



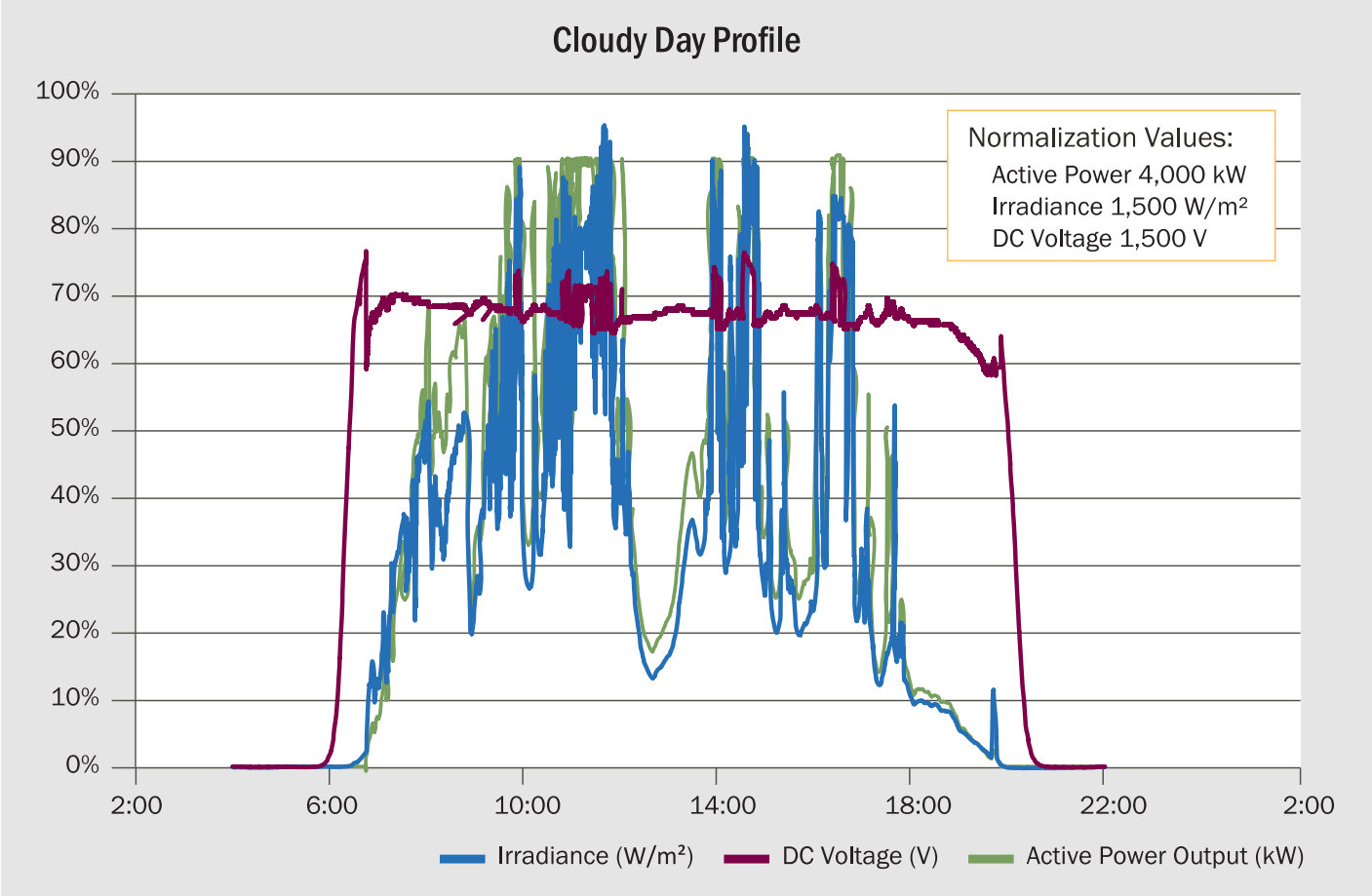


Figure 5. Inverter performance on a cloudy day.

ability of this new industry standard.

It consists of a 3.6MW_{DC} array using First Solar 1,500V_{DC} CdTe modules and a GE ProSolar inverter and transformer. Due to the specific project (land) constraints, the array size was designed smaller than an optimal design. Enhanced commissioning procedures and field tests were performed to verify performance and operational characteristics. The field tests included PQ curve validation, harmonic compliance verification, check of audible sound limits, DC ripple current check and high irradiance start up.

Data collected by the plant SCADA is being analysed by First Solar on an ongoing basis to validate performance and reliability. In particular, ground leakage testing was performed on the array and base-lined against 1,000V_{DC} arrays within the Macho Springs plant with comparable results. Plant operations and maintenance procedures are largely unchanged from that of the 1,000V_{DC} platform, and there are fewer components per megawatt to service.

A typical performance of the inverter on a clear day is shown in Figure 4. As expected the inverter output closely follows the irradiance measurement taken at the plant. The DC voltage is consistent with the module IV characteristic when the inverter is producing power.

A typical performance of the inverter on a cloudy day is shown in Figure 5. Again as expected the inverter output closely follows the irradiance measurement taken at the plant and the DC voltage is consistent with module IV characteristic.

First Solar plans to build two more 1,500V_{DC} AC Power Blocks at the Barilla Solar plant in Texas, owned and operated by First Solar. Each of these arrays will be 5MW_{DC}/4MW_{AC} and will utilise GE inverters that are further refined, offering improved efficiency and "overdrive" operation at temperatures below 50C. These arrays are planned to be installed and operational by the end of 2014 to gain further operational experience on a small scale prior to a large-scale commercial deployment in 2015.

Summary

The next-generation utility-scale PV plant based on 1,500V_{DC} architecture has a significant impact on the plant costs and its efficiency. This is illustrated through a number of utility-scale PV plants that First Solar has developed or is in the process of deploying over the next several years. Some of the key elements that contributed to this accomplishment include First Solar's development of high voltage-capable thin-film modules and GE's development of the world's largest PV inverter (4MVA). The ability to install significantly larger solar arrays served by each inverter reduces the installation and maintenance costs of the plant. This BOS cost reduction in turn contributes to the primary goal of making solar energy affordable. As in the case of the previous transition of 1,000V_{DC} architecture, the industry is poised to take this next step as some of the technical and regulatory barriers are overcome. ■

Authors

Mahesh Morjaria is vice president, systems development, at First Solar, overseeing new products and grid integration capability for utility-scale PV plants.

Kevin Collins is director of power systems development at First Solar, responsible for the development of strategy and road-maps relative to power conversion, and energy collection and delivery systems.

Michael Stavish is senior programme manager at First Solar, overseeing PV plant products.

Greg Ball is principal engineer with DNV-KEMA Renewables, based in California.

A lasting bond

Module bonding | PV modules are commonly installed with mechanical fixings. But as installers look to drive down system costs, structural bonding is emerging as a reliable and cost-effective alternative, writes Michael Niederfuehr

Source: Sika Services.

A 3.1MW on-site bonded project in Bari, one of Italy's largest PV installations.

For approximately half a decade, cost pressure on photovoltaic power generation has remained at an exceptionally high level. This fact forces the PV industry to find innovative and cost-effective solutions across the value chain – from wafer production to module installation.

The sub-construction and installation of PV modules represent a major share in the cost structure of PV power plants, both small scale and also utility scale.

Commonly, PV modules are installed using mechanical fixing devices, which clamp the modules' edges or frames usually to metal sub-constructions on a roof or on a greenfield installation.

As an alternative to mechanical fixation, structural bonding offers very attractive features which can help to gain notable cost savings regarding installation effort and sub-construction.

The cost savings either come from the very fast installation or moreover from a significantly optimised sub-construction, provided that the PV modules are, by design, considered as an integral part of the whole assembly.

A perfect example for gaining maximum benefit of bonding technology for PV module installation is the direct bonding of PV modules to corrugated steel roof claddings without any sub-construction involved. In this case, the backside of the PV module is directly bonded on to the corrugations of the sheet metal roof claddings using suitable adhesives.

Such suitable adhesives offer both structural properties – to assure long-term mechanical integrity – and also flexible properties – to assure stress-free compensation of relative dilatation of the bonded elements due to different thermal expansion rates. Due to the perfect electrical insulation properties of the adhesives, grounding can be prevented. In addition, the lean as well as fast installation, and the maximum area utilisation of the roof, allow further cost savings and maximum energy harvest.

The low static weight and the perfect watertight roof due to eliminated penetration of the sheet-metal roof claddings, which is necessarily required for mechanical fixation, bring additional value. Besides these cost savings the equal load distribution of bonded joints reduces stress concentration in the PV module's superstrate (mostly glass) and hence helps to reduce local cell breakage or even breakage of the glass layer and further helps to extend the lifetime of PV modules.

The nonexistence of frames and clamps and thus stepped edges makes it more difficult for efficiency-reducing dirt, soiling, snow or debris to attach to the glass or the clamps as there is no risk of retention at those stepped edges or clamps respectively. Also the O&M costs are positively affected by directly bonded PV modules: the 'improved flatness' without protruding parts makes the PV modules easier to clean without getting stuck with the cleaning device.

The favourable adhesive technology for such on-site bonding applications is silicone – usually one-component, moisture-curing silicone adhesive. This is because it requires less sophisticated application equipment without need for a mixing device.

Generally, silicone adhesive technology is preferred mainly for the following reasons: easy handling and outstanding longevity due to chemical inertia with regard to UV-radiation and outdoor conditions. The chemical inertia is the root cause for the insignificant degradation of the adhesive's mechanical, physical and chemical performance even under harsh ambient conditions such as high relative humidity and heat, or an acidic atmosphere which can occur at coastal areas or at installation sites adjacent to heavy-industrial areas.

Structural silicone adhesives with excellent weather resistance have been successfully and site-independently proven for decades, for example in structural glazing applications for high-rise buildings.

Provided that the project was executed according to state-of-the-art procedures, a load-bearing function of the adhesive joints can be considered over the PV module's intended lifetime of approximately 25 years.

Bonding procedures

As already mentioned, silicone adhesives often demand a clean surface only, whereas

Source: Sika Services.

Detail of a structurally bonded backrail.

Source: Sika Services.

Backside of on-site-bonded PV modules as part of a greenfield PV installation.

other adhesive technologies require not only cleaning but also priming of the bonding area. Of course, the fundamental suitability of the substrates with regard to adhesion build up and longevity needs to be proven for the actual substrates. The main criterion for the approval is the doubtless proof of adhesion before and after application-relevant ageing conditions according to construction and PV standards, e.g. EOTA ETAG 002 or IEC 61215/61646 respectively.

After successful testing and substrate approval, one of the most crucial parameters required to be controlled is the substrates' quality. For a reliable and long-lasting bond, a consistent surface quality is absolutely mandatory. Dependent on project size and in case of a system approval, the elaboration of a specification, i.e. defining the surface quality of the elements to bond, is advisable in order to minimise the risks of varying substrate quality and of varying adhesion performance. In case of bonding directly on corrugated sheet metal roof claddings, also the approval of the roof cladding supplier regarding additional load is advisable. In any case, local regulations and standards have to be exactly followed.

Older substrates, which have been exposed to random ambient conditions, are generally out of scope for being bonded on, as in this case, the substrates cannot be considered as consistent and defined. As an example, just imagine an industrial building, erected several years ago: areas next to chimneys are affected by the fallout of exhaust products, areas under or next to trees can be affected by contamination with tree resin or residues from fallen leafs, unshaded areas are mainly affected by influence of solar irradiation – all these conditions can occur, even within on continuous roof area.

As a result, PV modules always need to be bonded straight after erection of the roof or of the sub-construction respectively. Of course, this is not viable for every project and for such cases there is only one option: a defined interface for bonding has to be created, for example by riveting aluminium rails to the corrugated roof, that must be instantly bonded on

The cleanliness of the surface also plays an important role in overall consistency and must be assured by cleaning the bonding areas prior to applying the adhesive, as per the definition based on the adhesion testing.

Bonding challenges

To be fair, structural bonding of PV modules on-site does present some challenges and limitations. The major limitation is the dependency on ambient conditions during installation. Like other construction works where chemical products are involved, on-site bonding is somewhat dependent on weather conditions: installation during rain or snowfall, freezing temperatures or in the case of extreme hot ambient and surface temperatures – depending on the preferred adhesive system – is absolutely not advisable. The actual temperature limits may vary slightly with the actual adhesive system used, however these values can be considered as a rule of thumb for commonly used, neutral curing silicone adhesives.

Especially if temperatures are hardly above 5 degrees Celsius and/or the relative humidity level is very high, also the dew point has to be respected as there is a risk of water condensation on the substrates which could hinder the wetting of the substrates with adhesive. Temperatures below 5 degrees Celsius greatly delay flash-off of the cleaning agents and further delay the curing of the adhesive since mostly moisture curing silicone adhesives are used for on-site bonding applications. In case of high temperatures, especially during high solar irradiation on the usually dark coloured PV modules, there is a potential risk of exceeding the maximum allowed curing temperature, which may lead to bubble formation of the uncured adhesive inside the joint. This could finally weaken the cross-section of the adhesive joint after full cure.

All of this underlines the fact that the whole bonding process needs to be planned properly and adapted to actual site conditions, including clear definitions of all the points mentioned above and beyond. Furthermore, everything needs to be documented in working instructions which define all relevant steps to be followed and their actual limitations. As part of the working instruction, in addition a suitable quality control procedure needs to be put in place to assure a smooth and faultless installation process and thus reliable structural bonded joints. Such QC procedure is based on established procedures borne from structural glazing applications with similar requirements and demands with regard to application, lifetime and safety.

Of course, as with the installation of mechanically fixed PV modules or any other professional work, the installation should be executed by well-trained professional staff only, to assure correct execution of the bonding application.

Last but not least, and as valid as for any other technical device, there is a definite need for a specific maintenance programme for bonded PV modules, reflecting the special needs of bonded elements. Depending on specific environmental factors, such as the presence of leafs, frequency of rainfall, moss growth etc, cleaning on a regular basis is mandatory to enjoy the utmost lifetime of the PV power plant. In particular, excessive dirt accumulation underneath the PV modules, in combination with humidity or even standing water, may harm the polymeric components of the bond and above all pose a potential electrical shock hazard if the moisture finds an access point to a live part.

Summing up the above, structural on-site bonding of PV modules is a cost-competitive, technically advantageous and reliable alternative for PV module installation compared to mechanical fixation, provided that the bonding technology has been fully understood, the project is properly planned and simple basic rules have been respected. ■

Author

Michael Niederfuehr is a market field engineer for Sika Services, with responsibily for bonding technology in international solar projects.

Tackling solar's dust problem

Soiling | The build-up of dust and other particles on PV modules can impact on the efficiency of a power plant. Understanding how soiling can vary in different regions of the world is crucial in maximising plant performance, writes Dmytro Podolskyy

Due to the increasing interest in renewable energy around the world, solar plants are more frequently being installed in challenging conditions. Many of the locations are arid or desert-like areas, as they provide very high solar irradiance and the land is rarely used for other purposes. Examples of such sites are in the USA, North Africa, the UAE, Saudi Arabia, the Atacama Desert in Chile, Australia and India.

In such areas soiling by dust and sand is a serious issue that affects the efficiency of the plant and understanding it is crucial for the whole process of calculating the viability of a project. Soiling-related issues need to be studied to understand output losses, schedule maintenance, calculate life-cycles of components and evaluate bankability.

Soiling is a complex process that strongly depends on the local environment. Surface conditions, wind patterns, humidity and the temperature of the air are the main natural parameters that affect soiling. Anthropogenic factors also play important roles; agricultural activities, traffic and air pollution contribute to deposition of dust and pollutants on PV panels and CSP plant mirrors.

The causes of soiling

In solar energy projects the main contributors to soiling are the following:

- Dust, pollen, sand and other airborne particles naturally accumulate on the surfaces of PV modules, concentrating mirrors and lenses. This reduces the energy output of solar plants and household installations. This effect is stronger when the solar plant is located in an arid area with agricultural activities and loose soil.
- Airborne pollutants such as vapours, smog and soot can form a layer on PV modules that is harder to clean than dust or sand. This is especially relevant in urban and industrial areas.
- Deposition of sand and dust in arid areas can be increased by night dew as the dust and sand sticks to wet surfaces. During the day the dust dries out and is baked by the sun and the next night more accumulates on the dew-damp surface.

Particle build-up on PV modules can undermine system performance.

Source: Hassan Qasem

The process repeats, forming a thick layer of dust that can completely block the light.

- Dirt often accumulates on the lower part of PV panels that have a raised mounting frame, providing partial shading and reducing the efficient area of the PV module. This is especially relevant in areas close to the equator as the panels are usually installed with low tilt angles to receive the maximum amount of solar radiation during the day.
- Mould can grow on the surface of PV panels in warm and wet areas. The heat accumulated during the day and the humidity during night-time provide the conditions for micro-organisms to proliferate and form an opaque layer on the surface of PV modules.
- Bird droppings in some locations can be sufficient to provide partial blocking of cells in modules. This affects the current flow in the modules and usually causes a drop of efficiency of the module or of a complete string.

The relative significance of the various contributors to soiling at any given location will vary throughout the year due to the local climate and weather processes.

How soiling is measured

Soiling can be estimated in a number of ways, depending on the required precision and the practical application. As it is hard to estimate soiling theoretically, due to its local and variable nature, a number of empirical methods are used by researchers and solar plant operators.

In smaller projects the effect of soiling is often estimated by using a reference PV cell or module that is subject to the same environment as the rest of the installation. The output of the module is compared to the expected theoretical reference output and the soiling rate is calculated. This method separates the measurements of the efficiency of the plant from the soiling measurements to provide independent data for analysis. However, it can miss the influence of several variable parameters such as the available irradiance, degradation of the modules and the effects of temperature and wind.

Another practical method is to use two reference PV modules installed at the same site and at the same angle as the working modules. One module is used as a reference and cleaned regularly (manually or automatically), the other is left un-cleaned. Comparing the energy output from the two modules gives a good estimate of the total energy loss of the plant. When the difference in outputs of the modules reaches a certain value the cleaning of the entire plant can be scheduled.

The optimal soiling level threshold to trigger cleaning the modules is calculated from the loss of output compared to the cost of the cleaning procedure. This method provides a simple method to optimise returns by reducing the loss of energy in a PV plant.

PV panel soiling tests at KISR in Kuwait.

Prospecting of new sites before deciding to embark upon a large-scale commercial solar park requires a more comprehensive study of potential soiling issues. Such a study needs to take into account several factors: differences between soiling rates on PV modules with different tilt angles, varying PV technology characteristics, effectiveness of

Weather station and solar irradiance measurement

Source: Hassan Qasem

anti-soiling coatings, efficiency of cleaning methods, soiling of concentrating mirrors for CSP plants, etc.

The variation in effects at different times of the year are very important for calculating the return on investment of future projects and need to be monitored. For such studies researchers use specially designed scientific stations that monitor soiling, solar radiation and meteorological parameters.

Scientific soiling monitoring stations

Kuwait Institute for Scientific Research (KISR)

Kuwait has very high levels of irradiance and many ambitious solar projects are being developed in the country, and in the whole Middle East North Africa (MENA) region. Understanding soiling-associated issues in solar energy projects is an important research topic. Dr. Hassan Qasem, a research scientist at the Energy and Building Technologies Department of the Kuwait Institute for Scientific Research (KISR) studies the accumulation of dust and sand on PV modules and its effects on the efficiency of a solar plant, depending on the PV technology used, installation tilt angle, dust particle size and other parameters.

Dr. Qasem's research is based on laboratory testing of dust samples' physical and optical properties as well as on outdoor testing. His set up consists of multiple PV modules and glass samples installed at a range of tilt angles outdoors. To monitor irradiance and weather conditions a meteorological station is installed on site. The station includes two pyranometers (to measure horizontal and tilted global irradiance), wind speed and direction, ambient temperature, relative humidity, precipitation and a data logger [1].

The results of the research enable a better understanding of the spectral effects of dust on PV modules and how the methodology may be applied to other sites. This knowledge can provide important information for selecting and developing the most appropriate PV technology for projects in Kuwait and the MENA region.

First Solar

First Solar of the USA installs solar energy projects based on its frameless thin-film PV module technology all around the world, more than 8GW to date. A good understanding of soiling is crucial for the success of such projects. The researchers at First Solar study soiling at various sites using a wide geographical network of stations covering the USA, India, Australia and the Middle East. The research has been conducted on both fixed panels and on tracking systems and these stations provide insights into the local differences in soiling patterns.

Source: First Solar

First Solar extensively tests soiling effects across a broad geographical area.

The research methodology includes the correlation of energy output with rain events and cleaning processes in order to develop an optimal strategy for operations and maintenance practices tailored to a specific site, to reduce the costs associated with soiling losses and cleaning. Such practices also give a confident basis for the prediction of energy output for the future.

'The variation in effects of soiling at different times of the year are very important for calculating the return on investment of projects'

It has been demonstrated that, apart from optimisation of cleaning schedules, smarter installation design can considerably reduce the losses from soiling. The stowage position for tracking panels at night can be optimised to reduce soiling losses considerably. The reduction of soiling on fixed panels by using a steeper tilt angle can more than offset a slight loss in the theoretical maximum output.

First Solar's soiling stations include several reference modules with different cleaning patterns as well as weather stations with pyranometers and meteorological sensors to monitor local irradiance and climate conditions. The most advanced stations have a precision automatic sun tracker to measure accurately all the components of solar irradiance; DNI, GHI and DHI [2,3].

Mainstream Renewable Power, Chile

The Atacama Desert in Chile is considered to be the place with the highest solar irradiation on Earth and many solar projects are being developed in the area. But the soiling conditions are quite different from those in the USA or Middle East and it is necessary to study them with accuracy in order to predict the profitability of future projects.

Soiling in this region is not only determined by different dust and sand types, there are also very unusual climatic phenomena characteristic of this region which can affect soiling rates, for example the Camanchaca. This is a fog which forms in the early hours of the morning along the coast of the Pacific Ocean and moves inland covering the desert area, but without precipitating as rain. In some regions it has been shown that the water can condense on PV panels, forming a very sticky crust on the panel surface. In other regions, this same phenomenon can result in the panels self-cleaning and very

much reduced soiling.

Patricia Darez, the energy analysis group manager of Mainstream Renewable Power, conducted the pioneering research in the Atacama Desert that demonstrated this effect. The researchers at Mainstream Renewable Power use an experimental soiling monitoring station which includes measurement of the electrical output of four panels with different cleaning patterns, as well as using an anti-soiling coating to study its efficiency. The station features solar irradiance and weather monitoring equipment [4].

This pioneering research provides an understanding of the conditions in this remote region, which is not yet well modelled but has very high potential for solar development. Such research is important to reduce the uncertainties and increase the financial value of future projects in the area.

Source: Adio Stefoni (MRP)

Mainstream Renewable Power soiling research station in the Atacama Desert.

Accurate monitoring

Soiling is one of the main factors that reduce energy generation in PV projects and needs to be accurately monitored and analysed to develop efficient practices to mitigate the losses and efficiently predict energy generation. It is important to develop the routines and methodologies to study and understand all the effects of soiling on PV and CSP systems.

Instruments of high quality and performance are required for reliable soiling studies. Monitoring of parameters such as irradiance, ambient temperature, humidity, wind and precipitation with the lowest uncertainties are important for obtaining reliable data. To optimise the value of local data high-quality soiling research stations need to be integrated with the radiation and weather stations used for prospecting and the monitoring of solar energy plants.

A good monitoring system that is properly maintained will enable the determination of changes in efficiency resulting from soiling and other environmental parameters that will lead to reducing the associated losses and make solar energy projects more profitable. ■

Tilted and horizontal solar irradiance pyranometers with ventilation units.

Source: Adio Stefoni (MRP)

Author

Dmytro Podolskyy is business manager at Kipp & Zonen, working with markets in Latin America, India and Middle East. He has an MSc in applied physics and nanotechnology from Technical University of Delft, the Netherlands, and is specialised in optical properties of materials and optoelectronic devices.

References

[1] Hassan Qasem, Thomas R. Betts, Harald Müllejans, Hassan AlBusairi and Ralph Gottschalg. "Dust-induced shading on photovoltaic modules." Prog. Photovolt: Res. Appl. 2014; 22:218-226, June 2012

[2] Raed Bkayrat. "Lessons learnt with PV power plants in the US desert. November 2013." http://saudi-sia.com/wp-content/uploads/2013/05/9-Lessons-learnt-from-PV-power-plants-in-the-US-desert-v5.pdf

[3] Frank Teofilo. Phase I, Mohammaed bin Rashid Al Maktoum Solar Park, Operators & Maintenance Best Practice. March 2014 http://www.pv-insider.com/menasol/pdf/PV-Tech-O&M-webinar.pdf

[4] Patricia Darez. "Soiling Losses in the Atacama." Proceedings of Intersolar Europe 2014 Conference, June 2014.

Performance and reliability of tracker and fixed-tilt mounting systems

Mounting | Fixed and tracker solar mounting systems offer various relative cost and performance benefits. But as JA Solar's Zhang Lan Jun and Gong Tie Yu describe, surprising results from field analysis of different systems used in China hold important lessons for developers wondering which one to choose

Generally JA Solar uses three types of solar mounting structure in ground projects: fixed-tilt, single-axis tracker and dual-axis tracker.

The fixed-tilt structure is a widely used solution for most scenarios, offering simple installation and the lowest cost whilst being well designed for high wind speed and earthquake situations. There is almost no maintenance requirement during the system life, the only disadvantage being the relatively lower power output in high latitude areas.

Single-axis structures have the benefit of better production performance. Horizontal tracking is commonly used for single-axis solutions, the axis of rotation being parallel to the ground. Multiple posts of the axis of rotation of a tracker unit can be shared between trackers to lower the installation cost [1]. One motor can control multiple arrays. Regular maintenance is required for bearings and gears.

Dual-axis structures can produce the highest unit yield [2]. There are two small servo motors to adjust the tilt angle and azimuth. With complex tracking controls and servo mechanisms, dual-axis structures usually combine historical data with light sensors to catch the sun direction precisely. But the complex controls and infrastructure may cause additional material cost, more regular maintenance work and higher failure rates.

▼ Fixed-tilt racking system parameter:
Tilt angle: 35º
Installation tolerance: ±1º
Racking unit quantity: 109
Solar module quantity per each unit: 40pcs
Total installation capacity: 1.024MW
Average Failure Rate per Year: ≤0.1%
Inverter: 2x 500kW transformerless inverter

Sample project information

Interesting insights into how the different systems operate cane b gained through comparison between tracker system and fixed-tilt system. The analysis is based on a typical project located in Qinghai Province, China, latitude 36.3. Total installation capacity is 5MW: a 2MW dual-axis system, a 2MW horizontal single-axis system and a 1MW fixed-tilt system (pictured). All solar modules are JA SOLAR JAP60 series 235Wp polycrystalline. There is abundant solar resource, according to climate data: annual irradiation on 35º optimal plane is about 1800kWh/m2/year, and over 60% of which is direct irradiation. The average temperature ranges from -8.9˚C to 16.6˚C and wind speeds from 6m/s to 23m/s. The altitude of the sample project is 2,990m above sea level. The landscape type is yellow earth with dust and sand.

▲ Single-axis tracking system parameter:
Tilt range: ±80º
Tracking tolerance: 0.3º
Tracking method: light sensor with historical data
Racking unit quantity: 438
Solar module quantity per each unit: 20pcs
Total installation capacity: 2.058MW
Nominal average failure rate per year: ≤5%
Inverter: 4x 500kW transformerless inverter

The results

Typical conditions in Qinghai in June are high irradiation and variable weather. This will put controller and driving mechanisms, tracking sensor and tracking algorithms under windy, sandy, rainy, cloudy situation over more than 10 hours of daytime operation. All arrays use the same 500kW transformerless inverter and the same JA SOLAR 235Wp polycrystalline high quality solar modules; 0.2S class power meters are installed on the AC output side of the

inverters. Production data exported from the monitoring system over the challenge month shows some interesting results.

Everybody was very surprised that the most productive system was the single-axis tracking system instead of the dual-axis system. The single-axis system gains an additional 46.9% power than the fixed-tilt system. The dual-axis system had 43.9% more production than the fixed-tilt array. We all know that the dual-axis tracking array should have the best productivity system in theory. Previous research shows single-axis tracker systems may have more than 25% greater output than fixed-tilt [3], while dual tracker systems can produce 41% more power than a fixed-tilt system at peak generation [4]. Why was it that in this case a single-axis was able to achieve such outstanding performance and what was it that caused the dual axis does not to perform as well as expected?

Analysis of varying results

On-site maintenance crews have confirmed all the modules run very well by testing each string. Neither the DC source circuit nor output circuit has any insulation problems or short circuit fault record. No fuse in the combiner boxes has melted. All surge arresters still remain in 'green' state. None of the 10 500kW inverters has ceased operating in any day. The power meter is designed not to allow metering tolerances to exceed ±0.2% in any circumstances. On-duty staff also confirmed with the national grid that there was no energy injection limit order over the whole month. After getting detailed production data, people began to shift the focus of the investigation into the solar tracking systems.

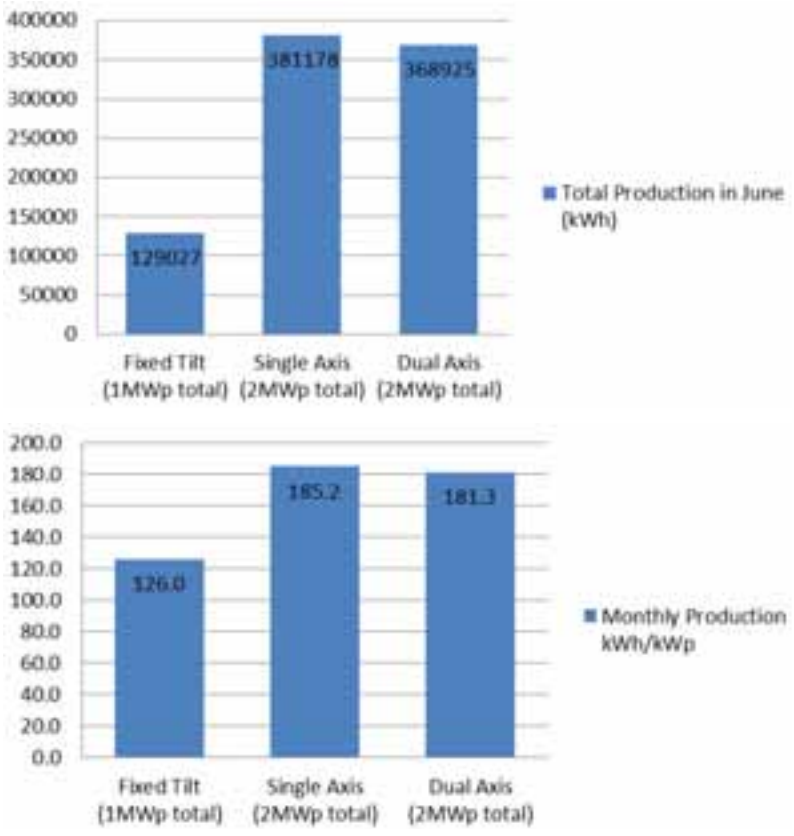


Figure 1: Total and unit production from the three systems over the month of June.
Source: QHBX

◄Dual-axis tracking system parameter:
Tilt range: -10º-70º
Azimuth range: 0º-320º(180º for south)
Tracking tolerance: 0.2º
Tracking method: light sensor with historical data
Total racking unit quantity: 433
Solar module quantity per each unit: 20pcs
Total installation capacity: 2.035MW
Nominal average failure rate per year: ≤5%
Inverter: 4x 500kW transformerless inverter

The 1MW fixed-tilt system has two arrays, each with a capacity of 500kW. Production results are almost the same, as expected, but some differences emerged. The performance of Array 1 is a little lower than Array 2 on day 22. The primary reason was found to be that a new temporary lighting tower had been constructed next to the solar project site. After the light pole was removed, power from the two arrays returned to the same levels.

The single-axis tracking system has four sub arrays. Each 500kW array generated almost the same power on most days. Small differences between the arrays was due to random clouds across the large project area. The only failure situation is in Array 4, which ceases operating for several hours in a day due to the failure of a bearing. Array total availability is still not less than 95%; the data is consistent with the nominal value. The tracking system has a production advantage over the fixed-tilt system over 10 hours of daytime in a high latitude area.

The dual-axis tracking system also has four 500kW arrays. But none of the arrays gave satisfactory results. Actually the tracking system began to have some problems after 6 June. The failure was not limited to a small range of units. The on-site maintenance team was very busy fixing problems for two weeks and got it back in operation by 19 June. According to data from day 19 to day 29, although the dual-axis system operated well, there was no significant improvement in production compared to the single-axis system. Which factor leads to this poor score?

Weak points of a complex system

Initial inspections performed by the O&M crew showed that the primary mechanism looked good, but found the servo motor had

www.cipvexpo.cn/www.intersolarchina.com

China's most international influential
And end consumer oriented solar business platform

CIPV EXPO

Intersolar China

1-3 April 2015
China International Exhibition Center，Beijing

Organizers

Contact

Beijng Tiger Exhibition Co., Ltd.
Ms. Lingling Zhang
Tel:+86 10 8460 0657/58
Email: info@tigerzl.com

Koelnmesse
Mr. Jean Ning
Tel: +86 10 6590 7766 ext 760
Email: j.ning@koelnmesse.cn

China Electricity Council (CEC)
Mr. Wu Wei
Tel: +86 10 6341 5262
Email: weiwu@cec.org.cn

Jing Mu International Exhibition Co.,Ltd
Mr.Yuliang
Tel: +86 10 8460 0392
Email: yuliang@ciec.com.cn

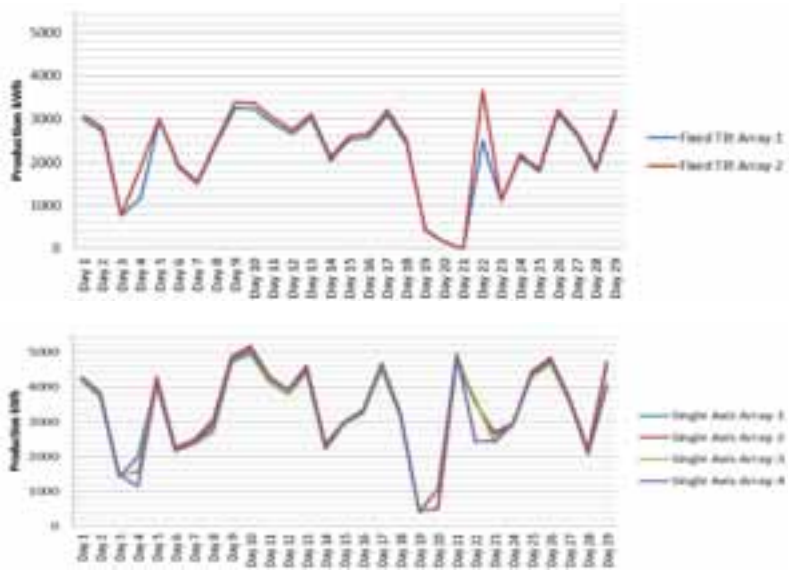


Figure 2 (top): Fixed-tilt array production. *Source: QHBX.*

Figure 3 (bottom): Single-axis array production. *Source: QHBX*

burned out abnormally in some dual-axis tracker units. After detailed investigation, they found the reducer gear protection cover was not fully airtight, so sand could run into the gear bearing in windy weather. The motor got stuck and temperature rose quickly after the bearing failed. The controlling system lacked the necessary failure protection so did not cut off motor power supply until the tracker structure arrived at a given position. This would damage the servo motor, explaining why so many units failed after one week of operation.

The technical team also checked the dual-axis controller and its tracking program. The controller used a well-known international brand, but the developer chose open-loop control infrastructure instead of a closed-loop control method. No linear position feedback sensor was installed, so the controller did not know the exact azimuth and tilt parameter in real-time. Only two zero-point sensors were installed to provide initial position references for the flat state. Meanwhile, the technical team found that the tracking controller did not use a 'pulse width modulation' (PWM) motor control; it simply used a contactor switch, which can lead to tracking position mismatch.

PWM controlling can be applied to control the amount of power delivered to a motor with a continuously changing value, so tracking control systems can reduce motor output power before reaching at target point, and thus minimise any mismatch [5]. In this project, the dual-axis tracker system used only the contactor controlling method, meaning any tracking mismatch would accumulate over time unless the user resets the whole system. These facts explain why we cannot see any benefit from dual-axis tracking compared to single-axis tracking systems.

The more complex a system, the lower its MTBF – or 'mean time between failures'. This is one of the key indicators to measure the reliability of a system. Lower MTBF systems need more maintenance work and labour time to fix. The more downtime, the less energy is produced and the longer it takes to achieve payback and profit. Dual-axis tracking systems have double the number of components than single-axis systems, which means the quantity of possible failures modes also doubles [3].

Lessons from the field

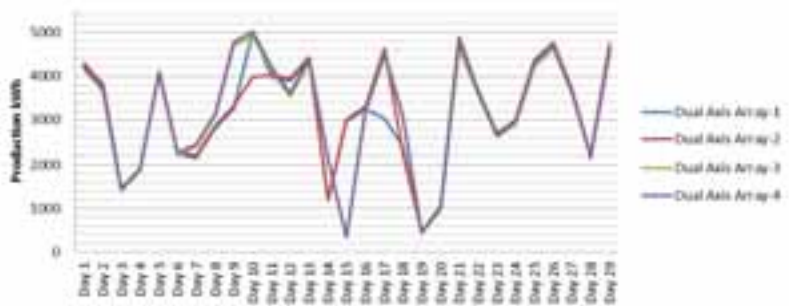
Although this analysis is limited to one month of operation, all three types of solar structures were tested under high irradiation sun, cloud, heavy rain, wind and sandy conditions. The dual-axis tracking system may produce more power than single-axis tracking systems in theory. But complex components and tracking controllers lower the reliability performance of the dual-axis system in variable environments. The stability of the single-axis system is satisfactory for the client; its tracking accuracy was sufficient to keep at a nominal level with proper control all the time so power production increased significantly. Fixed-tilt systems usually require little additional maintenance other than cleaning and regular checking; the only disadvantage is a lower power output in high latitude areas.

The O&M team needs to take extra effort with regular maintenance to keep fault risks down whenever the dual-axis tracking system is deployed. In addition to checking the tightness of screws and mechanical drive parts, maintenance engineers should check all protection covers and motors carefully as well. Control systems including sensors are another key point in maintenance work. O&M teams should pay attention to the power output curve falling continuously in sunny weather as this may be the evidence of tracking system failure.

This case also can teach a lesson to future solar power plant owners. It is very important to choose a high-quality tracking system supplier. The decision maker should consider not only the hardware parameters and price of tracking systems, but also software infrastructure and reliability. Although dual-axis systems offer performance advantages over single-axis systems, the higher failure risk can negate all extra income. The simpler system one could be a better choice to consider in the long term.

A tracking solar system will have an advantage over the fixed-tilt system in high irradiation and latitude areas. If someone is looking for a reliable, lower maintenance solar tracker solution in a high-irradiation area, a single-axis tracker is the better choice. ■

Figure 4: Dual-axis array production. *Source: QHBX.*



Author

Gong Tie Yu is an engineering professor and Zhang Lan Jun a senior system engineer at JA Solar PV Engineering.

References

[1] Yu Hai, 2004, "The application of solar tracking systems".

[2] Salam Abdallah, Salem Nijmeh, 2004, "Two Axes Sun Tracking System with PLC control".

[3] David Cooke, 2011, "Single vs. Dual Axis Solar Tracking".

[4] Dan Chiras, Robert Aram, Kurt Nelson, 2011, "Power from the Sun".

[5] Barr Michael, 2001, "Pulse Width Modulation".

Source: First Solar

Monitor this

Monitoring | Investors are looking for steady and predictable returns from their PV plant assets. Ben Willis charts the rise of monitoring technology and how it is becoming an increasingly indispensable part of the PV equation

A non-spinning wind turbine does not necessarily mean it isn't working, but it's a pretty useful indicator that something may be amiss. A malfunctioning PV module on the other hand is altogether harder to spot. Whether they're doing their job or not, PV panels just sit there. Some degrading panels will display symptoms that are visible to the naked eye, but without these visual clues the poor performance of a PV panel or whole system is not immediately obvious.

That's why monitoring is becoming such a critical part of the PV power generation equation. The need to know how a system is performing, whether it's falling short of its projected output, or has broken down altogether, is a key capability for its operator or investor.

"PV plants are going to be out in the field exposed to the elements for 20 years – so you do need to have some idea of how that asset is performing if you want to see the return on investment," says Adrian De Luca, vice president of marketing at sales at Locus Energy, a US-based monitoring system developer. "Usually for the first three years of a system's lifetime, it performs with no problems. Once you get past year three, there are whole load of issues that can come up."

These broadly fall into the "catastrophic" and "non-catastrophic" camps, De Luca says. Catastrophic would be an event such as an inverter blowing up, but De Luca says it's the non-catastrophic events for which monitoring is most needed.

"Non-catastrophic events are ones such as when you're starting to develop degradation in the panels that's faster than it should be as per the warranty, or the inverter becomes less efficient," he explains. "And if you're losing only 7% to one of those loss factors, that does add up to quite a lot over the life of the asset."

A burgeoning market

The need for monitoring becomes even more pertinent when you consider the trends now shaping the market. One of these is that subsidies such as feed-in tariffs, which guaranteed steady returns to investors, are losing ground to self-consumption models, where every kilowatt of hour of power counts. Monitoring therefore has a crucial role to play in ensuring PV systems are being used optimally and giving the owners maximum bang for their buck.

First Solar's operations room. The US thin-film giant's recent foray into the European monitoring market is part of a growing trend.

According to Cedric Brehaut, author of a recent report for GTM Research on PV monitoring, the attachment of monitoring systems to PV plants at the larger end of the spectrum is now near enough universal, but falls to about 25% in smaller systems. This gives plenty of scope for the retrofitting of monitoring systems to smaller plants to ensure they're delivering projected outputs.

Indeed Brehaut's May report for GTM revealed retrofitting to be one of the fastest growing segments of the monitoring market, accounting for 6.3GW – or 15% – in 2013.

Part of this trend stems from the retrospective attachment of monitoring units to PV systems that were originally built without them, something happening particularly in the pioneer European markets such as Germany and Italy.

Another factor in the retrofitting trend, though, is the fact that investors are amassing larger fleets. The individual projects within an investor's fleet will more than likely have been built by a multitude of different contractors, meaning a very fragmented patchwork of different systems operating within a single portfolio. Investors are therefore looking to standardise the technology through which they keep tabs on their fleet.

"When plants get sold on the secondary market, it's common for the investor to say, 'I bought these new assets and my standard solution for monitoring is x, consequently I'm going to upgrade everything to x'. That's one of the big factors driving retrofits," Brehaut says.

Growing fleets

The growing size of investors' PV fleets is also behind some of the big technological developments currently taking place in the monitoring space.

As Brehaut explains, with investors' portfolios now numbering the hundreds or thousands of plants, it is becoming impossible for operators to monitor all of them. "You don't want to see a status for all of them. You just want to know which ones have a problem and what you need to do about it," he says.

Monitoring for large fleets is about "less data, and more information", De Luca adds: "If you have 35,000 PV systems, each sending data every five minutes, that's a lot of data. But what you can do with big data techniques to draw insights from that big batch of data? By making the management of that system cheaper over time, can we extract insight from that data and help operators drive costs down?"

O&M

Such capabilities clearly make monitoring invaluable from an operations and maintenance point of view, where the chief objective is to run a plant or portfolio smoothly and profitably for as little expense as possible. With this in mind there was little surprise when, in early June, the US thin-film and project development giant First Solar announced its acquisition of Germany monitoring firm, Skytron.

With a background in very large utility-scale PV power plants, for which it has developed its own bespoke monitoring system, First Solar's self-professed aim with this deal was on one level to gain access to Skytron's knowhow and technological solutions for smaller projects. But beyond that, the deal also gives First Solar a solid basis for expanding its O&M business in Europe.

"We see there's a big opportunity in Germany to begin with and throughout Europe for more traditional O&M services that First Solar provides globally," Bob Callery, First Solar's vice president of O&M says.

"There are a number of O&M providers who are the old EPC companies that actually built these plants – those guys, many of them are going out of business, and we see an opportunity to do what we do really well in the US, which is full O&M services, and use Skytron to bolster our capabilities and go after that market."

Brehaut and De Luca both believe that deals such as the Skytron buyout by First Solar will become more common in the near future. One driver for this will be the same motivation stated by First Solar – of acquiring data and expertise to be able to offer value-added services such as an O&M in a new geographic area and market segment.

> 'We can build these PV plants, but they do have failure, and really the interface is your monitoring system'

According to De Luca another will be a consequence of decisions taken by large downstream companies such as First Solar or, say, Sunpower, or even inverter manufacturers that make their own monitoring systems, to turn to an independent monitoring provider when their own bespoke systems become outmoded. This is a prospect over which Locus and other independent monitoring are licking their lips.

"One of the dirty secrets of monitoring software is that the initial development is only a fraction of what it takes to maintain that software over its lifetime," De Luca says. "So when you get a big company like First Solar or SunPower developing their own solution, we always ask at what point do they re-evaluate and start to [turn to] independent providers.

"So the First Solar deal is very interesting, because it starts to make other companies start to ask that same question – do we want to continue to do this or do we want to buy or partner with another company? For that [section] of the market serviced by the downstream players, if we can open that up, that's huge for us."

Grid control

The final big piece in the evolving monitoring jigsaw is the extent to which monitoring can help support grid operation. This will become more of priority as the penetration of PV increases and measures to ensure grid stability are needed.

De Luca says the amount of data being collected by monitoring companies and the analytics capabilities now available offer utilities a potentially valuable insight into the functioning of the grid and how intermittent renewables can be balanced with other generation capacity. Monitoring and control systems will therefore play a vital role in the widespread adoption of PV.

"Solar is now getting large enough where companies like Locus have quite a bit of intelligence about the edges of the grid, and utility companies are starting to understand that," he says. "Things like voltage levels, power factor and frequency are being tracked by devices attached to our network; understanding what is happening here is important. But then once you understand that, you could adjust, say, the ratio of active to reactive power and potentially see massive impacts on the grid and lower costs overall."

Callery agrees such capabilities will be increasingly important as the industry matures by allowing solar operators to interact with the grid like any other generator and prevent utilities from regarding PV operators as "those solar guys". He says that one of the reasons for First Solar's acquisition of Skytron was because of the grid control functions it offered.

Long term, Callery adds, monitoring is going to be "huge" because of its status as the crucial link between PV equipment and people that allows a solar system to function.

"These plants have failure; they don't just run by themselves," he says. "So you need to determine soiling, when is it cost efficient to wash the panels, how do you manage outages, how do you find outages, how do you reporting, how do you report to banks, owners, how do you analyse failures or you can be proactive in fixing persistent problems. We can build these PV plants, but really the human interface is your monitoring system." ■

Author

Ben Willis is head of content at Solar Media.

skytron®
pioneers of energy

5 GWp
worldwide relies
on skytron®

YOUR NO. 1* PARTNER FOR UTILITY-SCALE SOLAR PLANTS

System Engineering for Monitoring, Control and Supervision

Photo acknowledgement: Solarpark Neuhardenberg / Credit: SommerReich

PLANT CONDITION MONITORING
for real-time data acquisition and fault diagnostics

LIFE-CYCLE DATA HOSTING
for performance analysis and sound due diligence

MULTI-SITE CONTROL ROOM SCADA
for remote supervision of complete plant portfolios

DYNAMIC POWER PLANT CONTROL
for stable and secure grid integration

OPTIMIZED O & M SOLUTION
to reduce operating cost of PV plants

SYSTEM MIGRATION & RETROFIT
for an efficient upgrade of existing PV plant

www.skytron-energy.com

*World's Largest Utility-Scale Monitoring Vendor in 2013 (GTM Research / June 2014)

MEET US: SPI 2014 | 21 – 23 OCTOBER 2014 | LAS VEGAS, USA | BOOTH 4706

The solar leaders getting ahead in the storage game

Solar-plus-storage | Leading US firms SolarCity and SunPower have taken an early position in the fledgling residential energy storage market. Andy Colthorpe investigates how their involvement could shape their own fortunes and that of storage itself

Source: SolarCity.

For some time now, solar installers have been offering storage with PV mainly for what SolarCity's head of grid integration Eric Carlson calls "off-grid, cabin-in-the-woods type battery backup" focused on lead acid battery chemistries. But recently launched products offered by SolarCity and fellow US industry heavyweight, SunPower, offer the promise of a lithium-ion based, grid-interactive future for residential storage on an altogether bigger scale.

Both companies have taken an early lead in initiating residential storage pilot programmes in California (SolarCity has also already rolled out some commercial systems), as well as in a handful of other carefully selected markets, where policy, regulatory and economic conditions have combined to provide them with the opportunity to test out what SolarCity says represents a "new paradigm" for the generation, transmission and distribution of electricity.

"We're very excited about how these battery systems can both enhance the value of the PV system by offering firmer energy, but also, these battery systems can provide value to the grid operators, both to the distribution and transmission utilities but also to the wholesale market," says Carlson. "There's a whole list of services that can be provided."

Meanwhile, SunPower's chief executive, Tom Werner, tells *PV Tech Power* that not only does he see storage as a natural fit with solar, strong comparisons can also be drawn with solar's early developmental stages.

"If you look back 10 years ago at the size of the market in solar and how fast it grew, we think that storage could have a similar trajectory," Werner says. "Storage and solar go hand in hand because you can overproduce [solar energy] during the sunny part of the day and then store it and use it during the other parts of the day. And as the cost of solar comes down it makes more and more sense to do that, and when the cost of storage comes down, then it really makes sense to do that."

SolarCity has taken an early lead among big-name solar companies in looking for ways to incorporate storage into its PV systems.

The waiting game

The pilots launched by the two companies may be relatively small, in the hundreds rather than thousands of homes, and only limited in scope, but the significance of these two leading players taking an early lead in residential storage can be explained by taking a longer-term view.

Chris Edgette of the California Energy Storage Alliance (CESA), a trade body with around 80 member companies, works closely with the California Public Utilities' Commission (CPUC), the regulator for Califor-

nia's utilities. He explains that there are three distinctly different scenarios for the use of residential storage going forward.

In the short term, there is the basic advantage of offering battery backup to customers, while in some parts of the world including California, there are also time-of-use charges for electricity, which storage can hedge against. In the medium term, changes in regulation and technology could allow for the aggregation of electricity from combining the storage capabilities of many systems, while a much longer-term outlook offers the possibility of storage units being used for self-consumption of PV-generated electricity onsite.

So far SolarCity's residential storage systems offer backup and load shifting for avoiding peak use charges, while SunPower's storage systems are set up to provide backup only. However it is the medium-term possibilities that really appeal to companies like SolarCity and SunPower, according to Edgette. He says both companies have launched products with future-proofing in mind, preparing for a day when technology and regulation align to allow storage to do more than just backup and a limited amount of load shifting.

"A lot of the systems are being put in to allow emergency backup capabilities for the customer but they're being set up so that when the rules allow them to do distributed aggregation, where they can basically take many storage units on a thousand customers' homes and then sell the capabilities of all those systems together into the market, they'll be able to do that. So basically they're developing and rolling out the systems now for policies that are coming."

Werner agrees that from his company's point of view, aggregation is the most overtly attractive future business opportunity that could be offered by solar-plus-storage. He says companies could sell the aggregated energy into the demand response market, or alternatively "you could just sell it to your neighbour". "Of course that's policy driven, but SunPower is absolutely working toward those different revenue streams including demand response," Werner explains.

Eric Carlson of SolarCity also cites the future possibility of aggregating systems as the "primary reason" for SolarCity's early investment in storage.

The challenges of scaling up

But running a couple of pilots is one thing. Scaling up is something altogether different and brings a whole host of challenges with it. How ready are the two companies to scale up their activities in storage?

In SunPower's case, its pilot programme includes a deal with a production homebuilder, KB Homes, about which Werner says "expect more later". Werner quotes statistics that put KB Homes in the top 10 of production home building companies in the USA, which between them build 80% of new homes. For SolarCity, the company's links with Tesla will provide it with access to the output from the electric vehicle maker's forthcoming 'gigafactory', expected to open next year and aiming to produce 500,000 battery packs annually by 2020. In other words the two companies may well be ready to start looking at the medium-term scenario sooner rather than later.

But standing in the way of that are two major obstacles. The first is in the regulatory space – specifically the fact that customer-sited storage is so new a concept that it has barely been discussed by policymakers.

Edgette offers a succinct explanation for the complicated policy problem solar-plus-storage faces in the US, a problem likely to be faced in other developed regions where the electricity market revolves around the use of a grid for transmission and distribution: "Storage can be at various times generation, load and it can help transmission and distribution. And those areas of the grid are very siloed in the US system. In some cases there's a firm regulatory wall. So when you have a resource that can help with all four of those things, you end up with policy and regulatory challenges."

Werner says companies need to be active in the regulatory space to not only keep up to speed or ahead of developments, but also for the chance to have some input in the discussions themselves.

"As a company we believe in free markets, but on the other hand energy is a regulated industry so having the regulations that allow competition with solar and storage is really our goal. So yes, we are very active in policy."

To be sure, SunPower has employees in some key positions – its director for market development and policy, Oliver Schaeffer, is chairman of the European Photovoltaic Industry Association (EPIA), while the vice-chairman of the American Solar Electricity Industries' Association (SEIA) is Tom Starrs, SunPower's vice president of market strategy and policy. "In terms of future-looking policy, we want to be aware of things that are developing. The degree to which we influence things – I don't want to overstate that. Our goal is to educate the legislators, so they can make good decisions," Werner says.

Companies will continue to seek out the areas – like California – where this kind of discussion is already at a more advanced stage than others, Werner adds.

"We're doing pilots in Australia, California, and, in the first half of next year, Germany. And the reason why we're doing those is that the policy environment is favourable and of course the idea is to create scale, and with scale you can get costs down, and perfect your solution. Then as you perfect the solution you can take it forward into other markets, and that's exactly what we've done with photovoltaics," he says.

The big standardisation question

The second big challenge is the need for greater standardisation of the relatively new technology involved. Carlson says that a uniformity of understanding of technical

SunPower and SolarCity's storage pilots

SunPower launched its storage pilot earlier this year with KB Home in the Californian communities of Irvine, El Dorado Hills and San Diego. The company is also conducting a residential pilot in Australia, and a commercial equivalent could be launched as soon as 2015. SunPower is also preparing to launch a residential scheme in Germany, where subsidies already exist for residential lithium-ion based storage systems. According to Tom Werner, the pilot will happen in the first half of next year.

SolarCity has rolled out pilot storage programmes for residential customers in California, Massachusetts and Connecticut. The systems in California are subsidised by the state's Self Generation Incentive Programme, which pays for around one-third of the cost of the systems. These were joined in December 2013 by the rollout of DemandLogic, a storage product for businesses that can offset peak demand charges.

'If you look back 10 years ago at the size of the market in solar and how fast it grew, we think storage could have a similar trajectory'

SunPower CEO Tom Werner believes storage could follow the same rapid deployment trajectory as solar.

SunPower is eyeing the long-term possibilities offered by storage of aggregation.

Source: SunPower

standards is lacking at present, making it harder for the industry to cut costs and perhaps even to attract funding. Yet he thinks lessons can be learned from solar.

"The energy storage industry is in many ways where the PV industry was 10 years ago in terms of power electronics and warranties and standardisation of product specification. The good thing is that I think the energy storage industry is going to learn very fast from the example of the PV industry. Those lessons are going to be learned much more quickly in partnership with the upstream equipment suppliers and so it's not going to take us a decade to get to the same place, but right now there's a whole lot to learn," Carlson says.

Another standardisation challenge that needs to be overcome is in the battery itself. "From the perspective of a system integrator, another challenge is that there's limited standardisation in how the products are categorised and specified," says Carlson. "Really basic things, like the energy that's stored in a battery – is that a DC value or an AC value?

"I can buy a crystalline-silicon solar panel rated for 250W and I have a pretty good idea without running any testing what conditions the product will operate in. With batteries if a device is rated at 20kWh it takes some time in the lab to understand exactly what that means in terms of operation in the field."

Carlson thinks California's history as a pioneering solar state could stand it in good stead for trialling some of these technical aspects of storage and finding agreement across different stakeholders.

"The California market really led the standardisation of some of the ratings of solar panels and inverters, and so through the incentive programmes that are operating in California for storage, there's an opportunity to drive that early stage of the industry. Through those incentive programmes that standardisation is naturally happening, through the fact that the products are being sold between vendors and project developers, so that's encouraging and very important."

PV energy providers

Both SunPower and more recently SolarCity, with its acquisition of Silevo, have both been pursuing integrated business models in which they operate as manufacturer and installer – so-called PV energy providers. Through storage and its furthest imagined step, aggregation, both companies would be taking integration to another level. Werner says that the recognition of the value of storage could have a dramatic effect on the company's overall competitiveness.

"I've been CEO of SunPower for 11 years. We've gone from being a solar cell producer to a module producer to a system company. Over the last few years we've introduced PPAs and leases so that we sell energy, and essentially the relative economic metric is levelised cost of energy (LCOE). As you add storage, then you can do things that will look at the total economic equation, not just the cost of generation."

Edgette explains that although ultimately the successful companies in storage could come from a variety of backgrounds as long as the execution is right, as experienced residential installers and leasing companies, SolarCity and SunPower are in an opportune position to step into this new arena.

"A lot of the costs of doing solar [in the US] aren't even in the installation; they're in the permitting, the sales, the customer acquisition. So if you can share those costs with a solar and storage system and then potentially share the same equipment – so that the same inverter's dealing with storage as dealing with the solar – there's kind of a natural fit to doing those two things together. They're already financing a system. So they can roll it into their existing financing package, they can roll it into seamless leasing arrangements, so the customer just sees one value proposition." ■

Author

Andy Colthorpe is a reporter for Solar Media.

To boldly go

Storage policy | Parallels are frequently drawn between the nascent energy storage business and PV 10 years ago – that it needs strong policy direction to take off. Andy Colthorpe profiles some of the areas that emerging as the world pioneers in supporting the deployment of storage

Storage now is in roughly the same position solar was in a decade ago: almost everyone can see its potential, the technology is pretty much there, but the costs are still too high to allow the mass penetration that PV is now starting to see. What is needed is a push from a group of bold policy makers to prove the concept and then let the market do what it does in driving out cost.

Well, some parts of the world are beginning to take the initiative. It's happening at different scales, led by both national and local authorities, but the first generation of storage leaders is beginning to emerge. We look at some of the areas embracing storage.

California: Progressive beacon?

Almost all the talk when it comes to solar-rich California has been centred around Assembly Bill 2514, the mandate that orders the state's investor-owned utilities to put 1.3GW of energy storage to the grid by 2020. This includes behind the meter storage. So in addition to a growing commercial market for demand charge reduction, the state seems well motivated to keep installing batteries. Along with pilot schemes in residential launched by some of the solar industry's big-hitters (see p.68), the state is likely to see continued activity across several segments including the scaling up of those pilots.

Yet the USA is a deeply market-oriented culture and regulators and utilities alike are still only just getting to grips with how to look at storage. Many of the problems stem from how to compensate storage when it can perform so many tasks across the electricity network and some of these questions are being tackled first in California. Chris Edgette of the California Energy Storage Alliance (CESA) tells *PV Tech Power* that to some extent the state's industry is lucky to have progressive legislators and a progressive regulator, the California Public Utilities' Commission (CPUC), which issued AB 2514 in the middle of last year. According to Edgette, his organisation was among those which worked with CPUC to launch AB 2514.

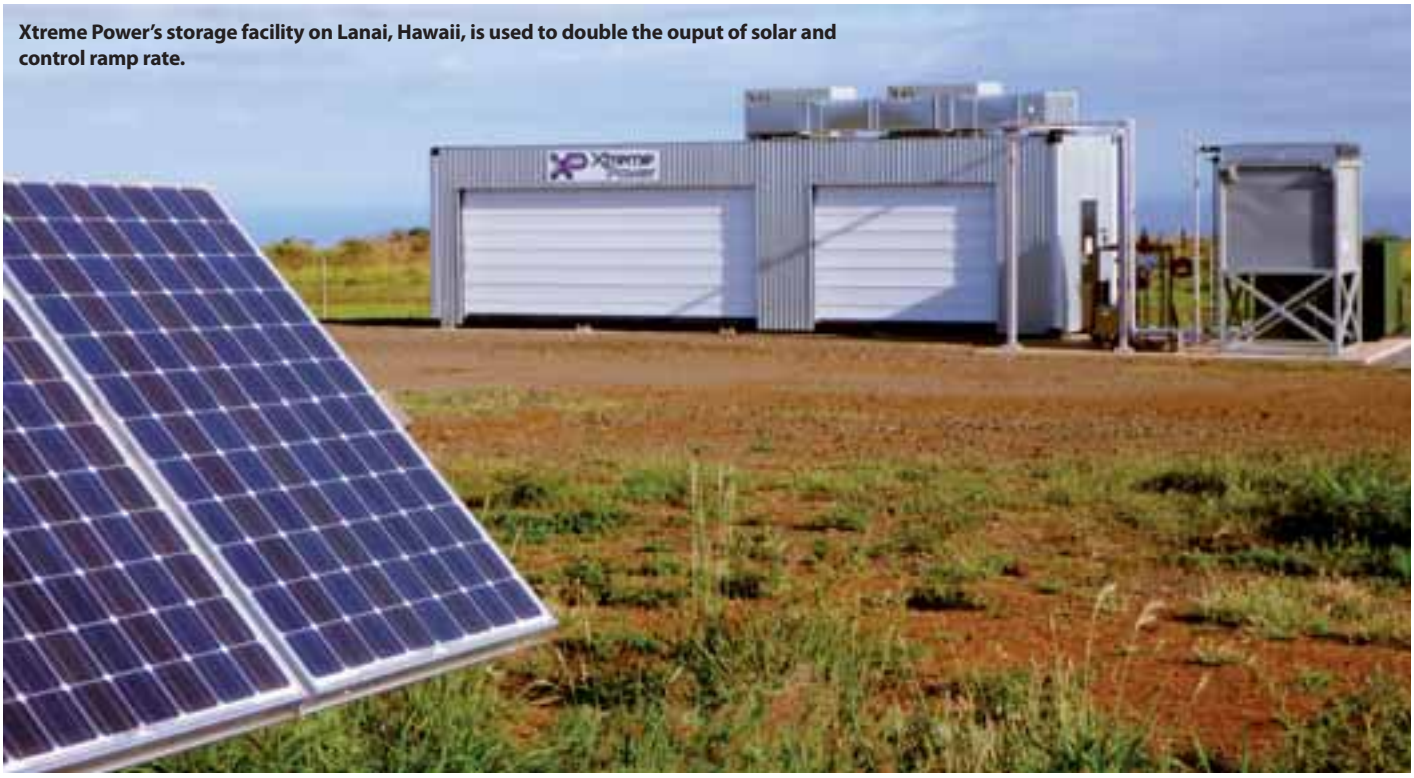
Storage requires a policy push at both national and regional levels to gain momentum.

Source: Portland General Electric.

CESA is currently also looking at the potential for storage to supply demand-side response, perhaps aggregated from a number of behind-the-meter systems capable of responding to requests from the grid to ramp up or absorb demand. As one of the trendy electric vehicle (EV) capitals of the world, California is home to Tesla, which supplies SolarCity with its battery packs. It will be interesting to see what impact an upturn in EV sales of the kind Tesla is hoping for could have on the wider battery market in California and beyond, although Tesla's battery production itself will take place at the forthcoming Gigafactory in Nevada.

New York: Anything you can do I can do bigger

New York is also developing as one of the USA's storage-hungriest states and like California has some forward-thinking policies and people in high places that are helping move the sector along. Audrey Zibelman, the chair of the New York Public Service Commission, the state's equivalent to CPUC, was one of the founders of Viridity Energy, one of the first companies in the US to execute aggregated demand response. As a densely packed urban hub on the Atlantic coast rather than a mixture of cities, towns and desert, New York sees wildly contrasting drivers for storage deployment to California. John Cerveny, vice president of NY-BEST, which he describes as part technical trade association, part economic development agency, says that New York is more concerned with easing the burden on its ageing and complex infrastructure than the need to "keep the lights on". Programmes like the NY SUN Initiative for large-scale solar may change that in future, Cerveny says, but this is still some way off. While investor-owned utilities in the USA are often seen as resistant to change, one is taking the lead in New York on storage. Seeking to offset the forthcoming loss of a 2,000MW nuclear plant 100 miles up the Hudson River from New York City, ConEdison, which serves most of New York City, has put out a request for 125MW of storage – 25MW of combined heat and



Xtreme Power's storage facility on Lanai, Hawaii, is used to double the ouput of solar and control ramp rate.

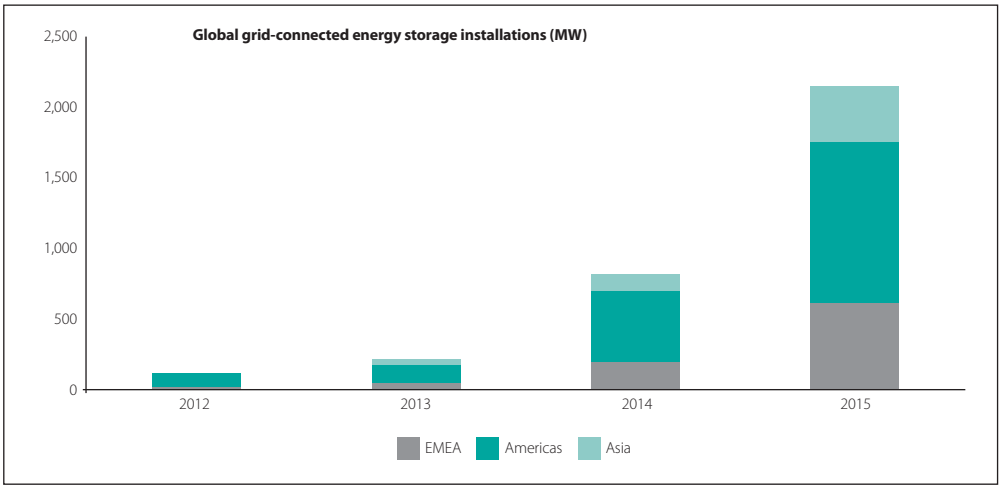
Source: DOE/Sandia National Laboratories.

power and demand reduction in the order of 100MW. Put out in conjunction with New York State Energy Research Development Authority (NYSERDA) in February this year, the requirement could and probably will be met to some extent with large-scale storage. ConEdison is also looking to defer costly investment in grid infrastructure using storage and cited that it is seeking to stave off the need to upgrade a substation which could cost around US$1 billion. "When they have 60 [substations] in their territory, the costs are daunting," says John Cerveny. "In New York as soon as you open up the street, you don't know what you have. So if you can leave the existing infrastructure in place but use it more efficiently, it's a much better use of dollars than accidentally opening up a gas line no one knew about." NY BEST was itself started up through policy support, with US$25 million of investment, most of which came through NYSERDA. Meanwhile, residential storage for self-consumption is not yet on the agenda in the Big Apple, nor in California. For the most part, net metering, which is in place in 43 US states, is considered a fair enough compensation mechanism, for the time being. Meanwhile power outages are less of a concern in New York than California, so backup power is also less of a market driver there.

Hawaii: Island power

While California and New York get many of the headlines, Hawaii's storage is notable, particularly to the solar community, as one of the first tests of the limits of renewables integration. With their geographical isolation and tropical climate the islands have a high penetration of solar. More than one in ten customers of one utility, Maui Electric, are estimated to have rooftop solar.

In May Maui Electric's parent company Hawaiian Electric Company (HECO) issued a request for proposal for 60MW to 200MW of energy storage across one or more systems with 30 minutes of storage capacity. This was followed in late August by HECO's proposal to meet 65% of the island's energy needs with renewables by 2030, an ambitious plan that the utility says will require energy storage, along with a tripling of the state's distributed solar resources. In the state that burns more oil than any other in the USA, this makes solar-plus-storage an attractive enough proposition that HECO has pledged its grid upgrades, distributed solar and energy storage will cut customers' energy bills by around 20%.



Source: IHS Research

Germany: House proud

Germany is at present sporting a solar-plus-storage market driven almost entirely to serve the residential sector. One of the earliest countries to recognise the importance of kick-starting a solar industry is also trying to live the dream of using your own electricity onsite, albeit to a limited extent.

Policy is moving to enable that, but domestic manufacturers including Sonnenbatterie and ASD Sonnenspeicher claim that uptake directly driven by subsidies introduced by the government in 2013 remains limited. A Sonnenbatterie spokesman said that while the subsidies had led to greater standardisation and raised awareness, it had

often slowed down the process of getting a system into a customer's house who would have bought a system anyway, rather than enticing new market entrants.

Indeed, the market even for residential systems remains fairly modest for now, with only around 4,000 sold in the first year of subsidies, according to federal industry association BSW Solar. When you consider the average system is probably around 5kW, that doesn't add up to a lot of megawatts, but analysts EU PD Research predicts total sales to double this year, rise to just over 12,000 in 2015 and keep going.

At much larger scales, activity has been limited to a handful of pilots, with one notable exception being a 5MW/5MWh 'battery park' for grid stabilisation, installed in an area of northern Germany with a high penetration of renewables. Battery specialist younicos, which constructed the facility, claims it is capable of competing with a 50MW gas turbine in frequency regulation markets. Despite this, German think tank Agora Energiewende argued in a recent report that in the next 10 to 20 years, the use of energy storage is not likely to be a more effective integrator of renewable energy technology in Germany than a mixture of other options aimed at giving energy systems more added flexibility, such as energy trading with close neighbours.

Germany's first commercial battery park, which recently opened, aims to compete with gas in frequency markets.

Source: Younicos.

Japan: 1.4GW by 2017?

The explosive growth in PV capacity in Japan in the past two and a half years has among its unwanted consequences spawned problems with adequate grid connection and a rise in consumer electricity bills. Measures taken to solve these problems are expected to be contributing factors toward 100MW of storage installations this year. Peak shaving is also a driver at commercial level, in a market largely created this year and the last by lithium-ion subsidies that also compensate up to one third of the cost of residential battery systems. Earlier this year, Sam Wilkinson, research manager at IHS, predicted that, also driven by subsidies, 100MW of storage will be installed in 2014, contributing to a total 1.4GW of totalled installed storage capacity in Japan by 2017.

Faced with a high number of utility-scale projects unable to get connection, Japan is also trialling the world's largest battery to date, a 60MWh vanadium redox flow system built by Sumitomo Industries on the northern island of Hokkaido. The country's approach at grid scale has been mostly to put money into a handful of one-off pilots, mainly through the Ministry of Energy. The project has been commissioned by the Ministry of Economy, Trade and Industry (METI), which has also expressed an interest in commercialising the technology if successful. The pilot will be joined by a 20MWh lithium-ion system in Sendai to the north of the mainland, and two similar projects on islands in the south.

Yet most of the energy storage activity this year will be in the residential space, according to Yoshiyuki Ohhashi of Tokyo-based solar industry analysis firm RTS PV. In Japan, where people buy land and build new houses if possible, one homebuilding firm, Sekisui Heim, claims to have installed 10,000 units so far, Ohhashi says.

Government budget has gone into research into smart communities too. Backup power in the event of earthquakes and other emergencies is also a serious concern in Japan, driving demand for storage at public facilities like schools and shelters. Next year, Ohhashi says, the requested budget for the lithium-ion subsidy, to be approved, will be around ¥7 billion (US$64.4 million).

Puerto Rico: Paradise renewed

Faced with similar creaking grid problems to Hawaii, and fluctuating power, Puerto Rico, has put a mandate in place that almost sounds like the whole thing could have been invented as a technical study in renewable integration. Puerto Rico's only utility, transmission, distribution, generation and regulation authority, Autoridad de Energia Electria (AEE), ruled that every new renewable energy projects must provide the equivalent to 30% of its nameplate capacity in storage for frequency regulation over a 10-minute duration. They must also provide 45% of the equivalent to the system's nameplate, for one-minute ramping. The high power nature of the MTR means there may be space for supercapacitors and flywheels as well as batteries, according to Dean Frankel of Lux Research. AEE plans to sign PPAs with developers of 600MW of renewable energy projects, boosting the islands' share from renewables by 5%. ■

Noteworthy others

Ontario Aided by a decent amount of hydroelectric, Ontario has given itself ambitious renewable energy targets and to match that has kicked off a long-term energy plan this year by seeking to add 50MW of energy storage. Five projects were selected in July totalling 33.5MW, including a flow battery for solar.

India India has a long history of coupling solar with batteries, albeit of the lead acid kind. Now that the recently incoming government of Narendra Modi has promised measures to bring electricity to the 300 million Indian citizens that do not have access within three to five years that will include the building of over 1,000 micro-grids, of which storage and solar will be a key part.

Rest of the USA At a national level, the IRS has recognised the value of energy storage and provides a modest tax break for storage in combination with solar, while commercial storage is sold for peak shaving across the States.

Rest of the world The UK and Italy are trialling large scale systems and cautiously spending here and there on pilot projects and smart energy management. Meanwhile, in rural and remote areas, there will always be a compelling argument for energy storage, for economic as well as development reasons. From using storage to refrigerate food to sell, to micro grids for rural electrification and saving money by replacing diesel at Australian mining operations, the use cases for storage look very different in remote environments than they do in built-up areas. Then again, as we've seen, from the many examples, almost every region of the world has its different possible and actual uses, values and understanding of storage.

Author

Andy Colthorpe is a reporter for Solar Media.

Reliable models for PV power plant performance testing

TESTING | PV power plants require proportionally more up-front capital investment to develop and build than their fossil fuel counterparts. Modelling the lifetime performance of a PV power plant is therefore a critical exercise in proving a project's bankability and securing finance to cover that cost. However, inaccuracies and uncertainties in modelling techniques create risk in the structuring of project finance. Evan Riley of Black & Veatch explores methods for improving the reliability of performance models and how they can be used to demonstrate that a PV facility will meet expectations

In the past five years, the renewable power generation market in much of the USA and Europe has undergone a fundamental shift. Driven by rapid declines in equipment prices and installation costs, improved performance and strong policy support, market participants have deployed an unprecedented amount of renewable wind and solar generating capacity. Once viewed as niche resources, renewable generating facilities are now changing the electric power industry and expanding participation in the electricity supply market.

One of the most striking differences between fossil fuel-based and renewable power generating facilities is the way in which the construction of these projects is financed. Both require a significant amount of up-front capital to develop and construct. However, unlike fossil fuel power plants, renewable energy power plants typically have minimal operating costs. As a result, the up-front cost of a renewable energy facility is a significantly greater fraction of its overall lifetime cost than that of a fossil fuel facility.

The cost of capital for long-term project financing is directly related to project risk. For fossil fuel power plants, which have well-understood performance characteristics and operating costs, the primary risk is the uncertainty in the future price of fuel. In contrast, because renewable generation does not operate in a fuel price risk environment, the primary financial risk is the accuracy and uncertainty of the performance model used to estimate the expected production from the facility. It is therefore critical to have reliable performance models and accurate performance-testing protocols for renewable generating facilities. Reliable models reduce expectation uncertainty risk, and accurate testing provides a means of demonstrating that a constructed facility will meet the expectations upon which the financial model of the project is based.

Performance modelling and testing of solar PV generating facilities

To determine the pro forma bankability of a potential future solar PV generating asset, a project developer typically begins by forecasting the expected energy production from the proposed facility by inputting historically typical solar resource and weather data (i.e. metrology or 'met' data) into a performance model that simulates the facility's efficiency in converting sunlight into electricity. For solar PV projects, a bankable performance model may include upwards of 50 parameters which specify a wide variety of important factors, including the characteristics of the solar resource, the PV module performance, the inverter performance, the DC and AC electrical losses, and other performance factors.

The combination of the large number of performance modelling parameters and the uncertainty in each produces an aggregate modelling uncertainty in an energy production estimate for a facility that can range from 1 to 10% based on the skill of the modeller, the capabilities of the performance modelling software used, and the quality of information provided to the modeller. This in turn directly determines the uncertainty in the expected revenue for the solar PV project from the sale of electricity it produces.

In addition to performance modelling uncertainty risk, project developers and financiers must also have a means of addressing construction quality risk. The construction quality of a solar PV facility can directly impact its performance and the revenue it will produce. Construction quality factors that can impact performance include:

- The types of PV modules, inverters and electrical cables and components used.
- The installation accuracy of the PV modules.
- The correctness, quality and completeness of electrical connections.
- The correct programming of inverters and other equipment.

In order to mitigate the risk that a solar PV project will not perform as expected because of modelling and/or construction errors, the industry has begun to utilise comprehensive system-level performance testing in order to evaluate how completed projects perform, on a resource-adjusted basis, to the expectations established by their production estimate. Consequently, to reduce project financing risk and the associated cost of capital, both the modelled production estimates and the results of performance testing need to be valid. A valid performance test satisfies the following criteria:

- It is well defined, unambiguous and reproducible, such that two independent analysts will always arrive at the same result when analysing the same test data.
- It is effective at testing the ability of the project to convert the available solar resource into electricity, as modelled.

'It is critical to have reliable performance models and accurate performance-testing protocols for renewable generating facilities'

www.multi-contact.com

Solar*line*

Connectors for Renewable Energy

The Evolution of the MC4 Connector Portfolio

The **MC4-EVO 2** is the latest addition to the MC4 PV connector range. The connector MC4-EVO2 is the first connector worldwide to have been entered into the JET component database.

- MC4-EVO2 is certified internationally with IEC, UL, JET, cTÜVus, CAS
- Approved for 1500 V DC (IEC), 1000 V DC (UL)
- MULTILAM Technology, has proven the quality and durability several 100 million times since 2004
- Suited for all climatic environments thanks to resistance to UV, ammonia-, salt mist and spray water
- The MC4-EVO2 is available as a field and preassembled connector, MC4 tools can be used

Visit us:
www.multi-contact.com > News > Exhibitions

Multi-Contact

MC

STÄUBLI GROUP

- It specifies a performance target in a manner that is consistent with how measured performance is determined.
- It specifies reference operating conditions, under which measured performance is compared with expected performance, that are within the operating conditions of the project.
- It produces a result that is not influenced (biased) by factors outside the control of the project, including variations in the solar resource, ambient temperature, wind speed and soiling of the PV modules by dust and dirt.

To achieve these goals, performance tests commonly used in the industry are being improved and evolving into trusted standards through the efforts of a wide range of industry participants who are working together to create more-comprehensive testing methodologies.

The PVUSA performance test specification

The first well-documented performance test specification for a solar PV power plant was developed by the Bechtel Corporation in 1995 and published by the United States Department of Energy in the "PVUSA model technical specification for a turnkey photovoltaic power system" [1]. This specification included a performance test which was intended to help ensure that the completed facility met the requirements set forth in the project specification, but did not necessarily reach a specific energy production target.

The PVUSA test specification defines the test target for a facility by applying a series of derating factors to its DC capacity (kWp), which is defined as the sum of module nameplate ratings (Wp) specified at PVUSA test conditions (PTC), i.e. 1000W/m^2 irradiance, 20°C ambient temperature and 1m/s wind speed. The idea is that each derate can be contractually stipulated in the technical specification of a construction contract, and that the expected energy production of the facility can be forecast using those contractual derates. In this *indirect* way, the test could be used to demonstrate to a potential project owner that the project was built as specified and is capable of performing as expected. The diagram shown in Fig. 1 illustrates the process flow of the PVUSA performance test method.

Shortcomings of the PVUSA test method

As discussed above, the most important element of modelling the performance of a solar PV facility from a project financing perspective is the *expected energy production*, which determines expected future revenue flows as a pro forma baseline. An assessment of the actual performance of a facility once it has been constructed is then performed by comparing its *measured energy production*, in a consistent way, with the baseline expectation. The goal is to provide a reliable basis for confidence that the project will perform as expected over its useful operating life.

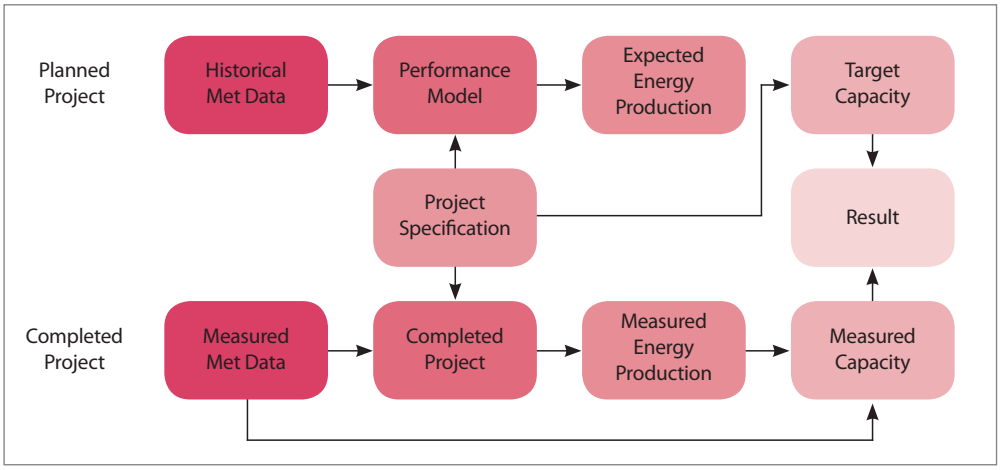


Figure 1. PVUSA performance test process flow.

As shown in Fig. 1, the primary deficiency in the PVUSA test method is that the *target capacity* of the facility is determined solely by the project specification without referencing the expected energy production. This can, and often does, create inconsistencies which bias the test results.

Overall, there are five critical shortcomings of the PVUSA test method:

1. It does not specify what test equipment should be used to take the measurements, or how the instruments should be calibrated.
2. It does not specify how to filter the measured data, nor does it specify important data requirements, such as the minimum number of data points to be analysed and the time interval between them (over which measured data within each interval are averaged).
3. It requires a detailed and comprehensive project specification that is consistently applied in building the project and modelling its energy production; a weak or incomplete project specification may give a project constructor an opportunity to knowingly or unknowingly create a mismatch between the target capacity specified and what has actually been built.
4. It does not address the fact that the measured capacity of a PV power plant varies seasonally, often testing low in the summer and high in the winter.
5. It suggests, but does not mandate, how best to determine the test reporting conditions; this is problematic when a plant is operating far from the reporting conditions, because the test results would then need to be extrapolated far outside the measured performance dataset.

ASTM standards that address the shortcomings of the PVUSA test method

ASTM International, formerly known as the American Society for Testing and Materials, is a globally recognised leader in the development of international voluntary standards [2]. From 2009 to 2013, teams throughout the solar PV performance community worked with ASTM to develop two new standards:

- ASTM E2848 – Standard test method for reporting photovoltaic non-concentrator system performance [3].
- ASTM E2939 – Standard practice for determining reporting conditions and expected capacity for photovoltaic non-concentrator systems [4].

ASTM E2848 and ASTM E2939 address the shortcomings of the PVUSA test method: the E2848 standard addresses the first and second, and E2939 addresses the third, fourth and fifth.

ASTM E2848

ASTM E2848 was developed as a first step in advancing the testing of solar PV facility performance from a rough guideline published in the PVUSA technical specification to a comprehensive suite of industry standards [3]. This ASTM standard does many things, including specifically:

- defining the scope of the test;
- defining terminology;
- defining measurement equipment and

calibration;
- providing criteria for filtering data;
- specifying minimum data requirements.

One of the most important improvements provided by ASTM E2848 is to define the scope of the test as "useful for acceptance testing and performance monitoring of a solar PV power plant, but not for testing single modules or comparing different projects in different locations or of different technologies". For example, because of the complex nature of solar PV performance, two co-located solar PV facilities with identical DC capacities but using different technologies, and/or with differences in row spacing or module tilt, can have significantly different capacity factors, generation profiles and measured capacity values under ASTM E2848.

To reduce measurement uncertainty, ASTM E2848 also specifies measurement instrumentation and minimum calibration requirements. It further specifies minimum data requirements and establishes data filtering criteria to remove ambiguities about how data should be aggregated, parsed and filtered. This reduces analysis uncertainty and allows test results to be repeatable. This is an essential feature of the specification because it enables different project stakeholders to independently calculate the test results in a consistent manner and arrive at the same result, which helps ensure the test's validity.

While ASTM E2848 sets the foundation for a comprehensive capacity test protocol, by itself it does not address all the shortcomings of the PVUSA test method.

ASTM E2939

ASTM E2939 was specifically developed to create consistency in determining the *expected capacity* and *measured capacity* of a solar PV facility by recognising seasonal variability and by specifying a better method for determining reporting conditions [4]. However, to do this required a restructuring of the process by which the test was carried out. The goal of this restructuring was to ensure consistency by directly tying the expected capacity to the performance model used in financing the project. This was done by applying the same regression curve to both the performance model used to determine the expected capacity, and the measured data used to determine the measured capacity. This was something that was not feasible when the PVUSA technical specification was issued, because sufficiently accurate solar PV performance modelling software did not exist at that time. The diagram shown in Fig. 2 illustrates the restructured process flow specified in the ASTM performance test standard.

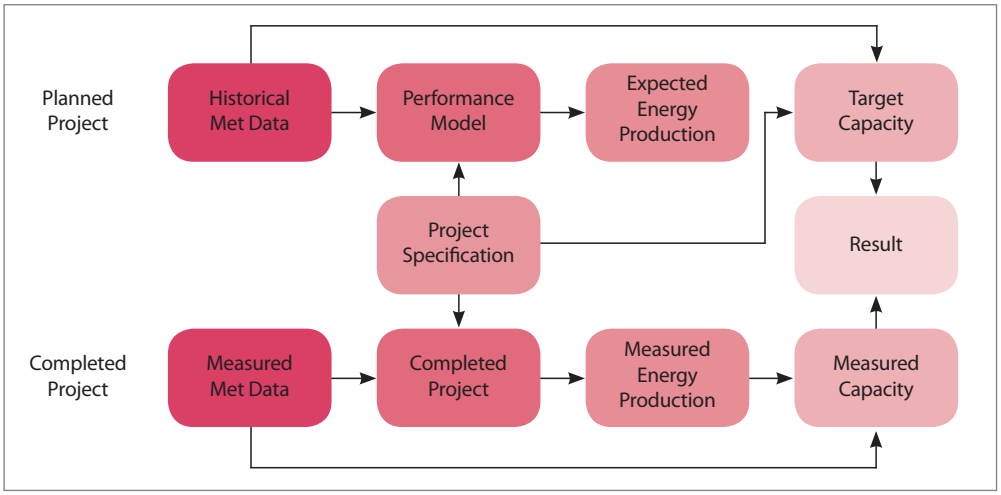


Figure 2. ASTM E2848–E2939 performance test process flow.

'The legacy PVUSA test method has been transformed into a comprehensive, bankable and trusted standard that can be used consistently by technical and financial practitioners across the industry'

Calculating the expected capacity according to the ASTM standards has three advantages over using the PVUSA test method:

1. The expected capacity of a facility is directly tied to its performance model.
2. Seasonal biases are minimised, because the performance targets display the same seasonality as the measured performance.
3. How performance targets and measured values are determined is specified in a consistent way.

The logic of the ASTM performance test protocol is based on ensuring symmetry, and therefore consistency, in the methods used to determine the expected capacity and the measured capacity. Another important advantage of this protocol is that the process of making consistent financial decisions based on a test result becomes straightforward for individuals who are not necessarily technically versed in photovoltaic performance.

Conclusions and the future of performance testing for PV power plants

ASTM E2848 and E2939 constitute the first published suite of comprehensive standards for testing the performance of flat plate (non-concentrator) solar PV facilities. Through the work of the ASTM committee, the legacy PVUSA test method has been transformed into a comprehensive, bankable and trusted standard that can be used consistently by technical and financial practitioners across the industry. Black & Veatch has extensive experience with applying these protocols for acceptance testing on projects ranging from 2 to 50MW.

Although performance testing for PV power plants has improved significantly since the days of the PVUSA model technical specification, there is still more work to be done. Black & Veatch champions the idea of collaborative innovation and improvement, and actively contributes to these efforts by participating in industry working groups and publishing technical papers in the field of PV performance testing. ■

Authors

Evan Riley, PV specialist, Black & Veatch

References

[1] Dows, R.N. & Gough, E.J. 1995, "PVUSA model technical specification for a turnkey photovoltaic power system", Report No. DOE/AL/82993-27, Pacific Gas and Electric Co., R&D Dept., San Ramon, California, USA.
[2] ASTM International [details online at http://www.astm.org].
[3] ASTM E2848:2011, "Standard test method for reporting photovoltaic non-concentrator system performance", DOI: 10.1520/E2848-11.
[4] ASTM E2939:2013, "Standard practice for determining reporting conditions and expected capacity for photovoltaic non-concentrator systems", DOI: 10.1520/E2939. <AQ2>
[5] Dierauf, T. et al. 2013, "Weather-corrected performance ratio", DOI:10.2172/1078057 [http://www.osti.gov/scitech/servlets/purl/1078057].
[6] Kurtz, S. et al. 2013, "Analysis of photovoltaic system energy performance evaluation method", DOI:10.2172/1111193 [http://www.osti.gov/scitech/servlets/purl/1111193].

Solar's coming of age

Investors are popularly characterised as risk averse and fickle when it comes to new technologies. David Giordano, of the world's largest asset management firm, BlackRock, tells John Parnell what has persuaded the investment community that solar is a safe bet

The solar industry can at times talk about the investment world as some kind of ephemeral being. We hear about the "investors" but all many of us know about these unseen creatures is that they crave stability and hate uncertainty and if you displease them, they will move on elsewhere.

The investment view of the solar industry can offer some extremely helpful, impartial and clear-headed insights that may not be possible from within.

So where are the opportunities in the solar industry, how can impending policy challenges be mitigated and what exactly does the impact of dreaded "uncertainty" do to investment decisions?

David Giordano, managing director at BlackRock Alternative Investments, tells PV Tech power what some of the current trends on the north American market mean to their decision making process as merchant projects and developer-led funding through yield cos become more prevalent.

With vast experience in the more mature wind sector, (Giordano closed US$4 billion of wind transactions for one of his prior employers) he has had a glimpse of what financing looks like when the technology approaches the end of a cost reduction curve and underlying policies start to take on a look of something approaching stability.

"Solar is following a consistent trajectory to the one we saw in the early days with wind, a combination of policies that have related incentives, the maturation of the technology and with that a growing sophistication around the financing options," he says.

"The equipment providers and the contractors become more financeable and more mature developers move in to the space, and that brings more capital. The cost of that comes down and you end up with a positive spiral that makes things more competitive, more accepted."

Falling costs, of finance and of technology, have helped to put utility-scale solar in competition with traditional fuels. In the US this means competition without the aid of a lucrative feed-in tariff or clean generation certificates of one description or another.

Giordano downplays the impact of so-called merchant-based solar projects on BlackRock's focus.

"Solar has a particular advantage because it offsets peak power in most situations, the most expensive wholesale part of the 24 hour curve. For us, as you approach grid parity, as you look at markets where there is more of an accurate representation of time of day pricing, it opens up the opportunities," he explains.

Competition has in some cases forced utilities in the US to push back. This is another metric for BlackRock and co to monitor, but ultimately cooperation will be needed between the industry and the incumbent power firms.

ITC cliff

Despite progress towards standing on its own two feet, the economics of projects in the US face the hurdle of the cut in the Investment Tax Credit (ITC) from 30% to 10%.

Giordano acknowledges that the route the market takes tends to be set by the developers with the finance following on afterwards. This means they need to be ready to react, and for many developers the ITC means changing the geographic focus of their efforts.

"We're a bit of a market follower on that," he says explaining that a broad geographic focus is key. "If things shift in one particular jurisdiction, it gives us the flexibility to refocus and deploy capital in other markets, be that Canada or in European markets," he says.

Despite solar power being part of BlackRock's Alternative Investments arm, the company is not looking to assume high risk. Alternative does not mean fringe, or perilous or unproven. They aren't interested in development risk and they only look at markets with "stable jurisdictions".

'If things shift in one particular jurisdiction, it gives us the flexibility to refocus and deploy capital in other markets, be that Canada or in European markets'

So where does PV's most mature utility-scale market rank?

"I think we'd count portions of Europe as stable at the moment. We've invested in portfolios of projects in France, in the UK, on the wind side, and in Ireland. It boils down to the market structure and the way the policy has been enacted."

For Giordano there is a huge difference between policy changes affecting future projects and those applied retroactively.

"If you look at the places where there have been retroactive changes, their policies have put direct pressure on annualised budgets. Where you have seen consistency of policy, which is the situation in the UK, there have been changes but there has been nothing that has gone back and retroactively hurt the capital that has been deployed in existing assets."

The industry's lawyers, solar advocates and trade groups will invariably respond to such changes with warning of the consequences on investor confidence. So how would BlackRock assess a project in a market such as Greece or Spain where retroactive changes have been implemented in the past?

"Certainly with an awful lot of caution," Giordano says. "You'll be able to see from the investments we have made to date that we have

not participated in the Spanish market. That's not to say we wouldn't. Going forward changes are one thing, they are manageable and it's our responsibility to pay attention to those factors as we develop our strategies."

Retroactive changes are a different beast.

"In those markets we will look for an awful lot of premium associated with that risk of future retroactive changes or we will be very cautious about investing at all until we get some clarity on going forward policy and stability," he says.

While the disruptive nature of solar is throwing down new challenges for policymakers and utilities, it is also generating a new challenge for traditional finance sources.

The rise in the number of yield cos, public companies created to own and take revenue from completed solar projects usually on behalf of a developer parent company, means there is competition for finance.

Giordano is unperturbed by the "trend" for yield cos and accepts that if that offers someone a more efficient route, so be it.

"The attractiveness of the yield co is in creating your own source of capital, your own take out for the term equity and the assets. With that comes the additional expense of handling the admin of that public company and tying yourself to the projections and the growth targets. Doing it on a project basis with us, we have ready capital available to invest in assets, it's our core mandate to invest in those types of projects so we can be a good partner for a single project or for a portfolio of assets and without the same scrutiny of a public vehicle," he says.

The CFOs of major PV developers spent chunks of their second quarter analyst calls fielding questions on the prospects of them starting a yield co. Given the burdens described by Giordano, will this option only ever be open to the largest players?

"I think it's a story that is playing out in real-time right now. There will be opportunities for some of the smaller players to partner with the larger developers that do put yield cos in place. I think we'll see the full spectrum of outcomes but it will be difficult for the smaller players," he says.

"The ones we have seen be successful out there have this growth story. In most cases, possibly all cases, it's a built-in growth story that already exists within their development pipeline."

The growth story means showing that you have the pedigree and track record to add a decent chunk of capacity and continue improving the prospects for the yield co's shareholders. "That's where developers with either a targeted geographic region or a more modest development pipeline will find it a harder hurdle to overcome," says Giordano.

Investment in clean energy

2009	US$196bn
2010	US$262bn
2011	US$318bn
2012	US$286bn
2013	US$254bn

Source: BNEF

Growth in the solar industry looks like a near certainty right now but whether you're an established developer in the US or Europe, extending that geographic spread is important. Whether it's outmanoeuvring the ITC cut in the States, looking beyond Germany's annual 2.5GW cap or for more capacity than the UK's new auction scheme will offer, developers have good reason to look to the new markets that are on the cusp of growth.

BlackRock, of course, doesn't want to give too much detail away about where it is preparing for business but Giordano acknowledges that the potential among the usual suspects of Chile, Brazil, Turkey, Mexico and the Middle East.

"We look at each market individually and focus on the ones where we think we are strategically advantaged. The currency plays a big role too. If you're using a foreign currency to invest in an overseas market, your returns can sometimes be disproportionately affected by currency moves that have nothing to do with the underlying risk-return characteristics of the assets themselves."

With the addition of currency, Giordano says assessing any new market comes back to one thing: policy stability.

Warnings against uncertainty are too often lost during campaigns against regressive policy shift. Investor certainty in isolation sounds rather nebulous. Giordano has explained that it is far from that. Put simply, retroactive changes deflect money out of your economy.

Governments that use energy bills as an excuse for solar cuts are being short-sighted. Investor uncertainty means that people like Giordano and his peers will bench mind-popping volumes of investment and sideline your economy as a risky gamble.

The technology is mature, the supply chain is stable, the financing is economically sound. The final part of solar energy's progress needs policymakers to assume these three attributes.

Author John Parnell, deputy head of content, Solar Media.

Credit: SunEdison.

SunEdison is enjoying success with its TerraForm Power yield co and plans another for emerging market projects only. Giordano says that while yield cos work for some, they are not a catch all solution for the industry as a whole.

The legal maze of solar globalisation

New market regulation | Solar companies are always looking for new markets in an effort to remain competitive. Monica Wilson offers some advice on how developers and contractors should navigate the legal labyrinth that will face them as they go global

As the utility-scale solar market continues to expand and globalise, project developers and engineering, procurement and construction (EPC) contractors increasingly find themselves considering unfamiliar jurisdictions. A new project or new business opportunity is exciting – but successful entrepreneurs will measure this excitement with thorough analysis of all aspects of the opportunity, including accounting for the diverse and unknown risks of operating in foreign markets.

First and foremost, a company considering this type of expansion must build a foundation for operation in the new jurisdiction. The underlying principle for achieving success in new markets is to develop an understanding for and respect of local culture and customs. Understanding and accommodation of a new culture communicates a company's good faith and motivation to partner with that culture in mutually beneficial, long-term business relationships within that jurisdiction. Conversely, lack of understanding of cultural norms in foreign markets may lead to significant friction, loss of productivity and, ultimately, hostility that could prevent continuing successful business relationships in foreign markets.

Developing familiarity with and respect of local culture requires time and investment in the new jurisdiction. For many companies, hiring a local representative will serve both to educate the company internally but also to project an image locally of the company's commitment and investment in the new market. A well-respected local representative may have knowledge of key business methods in his local market and variable permitting and licensing regulations. Certain markets even require resident local representatives to certify the business' compliance with these regulations before issuing a permit.

The letter of the law

Corresponding with the solar industry's rapid expansion, developers and contractors' operating across jurisdictions has become common. New offices and

additional personnel are key to a company's growth, but they bring new risks that must be purposefully controlled. To maintain uniformity across offices and personnel, companies should implement strict internal compliance and corporate training programmes for new hires and inform local representatives of company policies and expectations.

The more geographically diverse a company and its employees become, the larger the risk of a miscommunication that could subject the company to legal liability. As one example, an increasing number of countries have passed anti-corruption legislation that regulates companies based in that country or operating within that country. In the United States, companies must comply with the US Foreign Corrupt Practices Act in every jurisdiction within which they operate. The same applies to companies in the United Kingdom through the UK Anti-Bribery Act of 2010, which establishes strict standards against offering or accepting bribes. Many anti-corruption laws require more than mere compliance but instead require companies to implement adequate procedures in an effort to prevent bribery. Violation of these laws will result in significant harm to the company, including both civil and criminal penalties.

A successful multi-jurisdictional company will combine training of its employees in company culture and policies with strategic use of the employees' local knowledge and business contacts. This integration is key to projecting the company's image in new jurisdictions, and also to

'In the long term a company who demonstrates high level commitment to a new market will become a market leader'

maximising its competitiveness and profitability in these jurisdictions. Third parties seeking to engage the company in business who perceive the company as sophisticated and knowledgeable about the local jurisdiction are more likely to offer fair terms of business (and are less likely to attempt to negotiate pricing and conditions out of line with the local market).

To ensure the company projects a sophisticated image, the company may engage local counsel in that market to ensure the company's documents comply with local laws and account for cultural standards. From the legal perspective, when a foreign company presents a proposed form of agreement to a local third party that contains provisions void and unenforceable under local law, the foreign company has communicated to the third party that it has not performed sufficient due diligence in that jurisdiction to account for its laws. This oversight may be a result of schedule pressures from the new opportunity, or apathy to local culture – but it will inform the third party that the foreign company is also ignorant of pricing and terms in that market, and will increase the chances of less competitive pricing while reducing the company's negotiating leverage.

In addition, failure to conform company policies and

Utility-scale PV development in new markets presents a range of challenges.

documents to local laws poses further risk to the company that its agreements may not be enforced. Some jurisdictions, for example, will void venue selection provisions or will dishonour alternative dispute resolution provisions in favour of local courts or processes. (Even within one jurisdiction, if the proposed project is located on regulated or protected land, additional or alternative laws may apply.)

Consistent with the company's goal to project sophistication in a new market, a local representative and local counsel should be able to assist the company in its efforts to understand and comply with various business regulations, including licensing laws. Most jurisdictions require trade licensing prior to a company's submission of a proposal for a project, and certainly prior to filing for permits. Labour laws and requirements also vary widely by jurisdiction, with some jurisdictions requiring use of local labour. Certain jurisdictions may require the company to contract with labour unions according to the type of work to be performed.

Operating on the ground

Once a company establishes a foundation in the new market by hiring a local representative, obtaining regulatory approvals and offering documents appropriately representing the company, the company is ready to engage in business. The company will need to adapt to the dynamic opportunities of a new market as they unfold. For utility-scale solar plants, this involves review and analysis of each potential project site and purpose, as well as an understanding of geographically specific risk.

Risk in new markets may be legal or regulatory, as detailed above, but it may also involve the challenges of altered terrain. Desert terrain will pose very different construction challenges than tropical terrain - from engineering of posts and tracker systems, if required, to construction scheduling around typical weather patterns (a dust storm requires different construction accommodations than a flood event). Partnership with local subcontractors or suppliers may assist in planning for projects in new jurisdictions. Many local companies may be willing to assume more risk specific to known territory, helping the foreign company better manage its project.

Developers who finance utility-scale solar projects may find separate financial risks of operating in new jurisdictions. Lenders wary of political instability or of the developer's inexperience in the foreign market may be more reluctant to provide competitive financing models. Many lenders (such as the World Bank, for example) require companies to demonstrate compliance with their regulations and publish debarment lists as a way to better control their investment. These may require a developer or contractor to commit to investigate its business partners, subcontractors, and suppliers in order to avoid entering into agreements with anyone found deficient in business practices by the lenders' standards. Common standards include human rights commitments, anti-corruption policies, diversity commitment programmes and environmental policies.

Although most lender requirements are indicative of strong internal business practices, companies who commit to meeting these requirements for utility-scale solar plants in new jurisdictions should ensure robust internal documentation and compliance policies in order to protect the company in the event of a problem or investigation during the course of the project. In addition, companies must ensure daily monitoring of project construction, and must act immediately to investigate complaints or evidence of failure to follow these policies. To uphold these high standards of business practices, the company must foster an open internal environment that allows for the discussion and resolution of issues that arise during the course of a project.

For example, should a company representative on-site suspect a subcontractor has failed to comply with its contractual obligations regarding hazardous materials, that representative must be aware of his internal reporting requirements (and must be comfortable that doing so is an act to protect the company and his career). The company should investigate and resolve the issue according not only to legal requirements but also with lender regulations and the company's policy promoting social responsibility.

With risk comes opportunity

In the short term, a company may see such compliance as a significant risk to project profitability (albeit a risk that may be priced and controlled), but in the long term (and especially in a jurisdiction without significant investment in utility-scale solar), the company who demonstrates this type of high-level commitment will become a market leader. Likewise the contractor who develops this reputation in the community will be the contractor with whom lenders and developers desire to establish a partnership. Especially as the utility-scale solar market continues to expand, the reputation of projects as producing clean energy but also contributing to a socially responsible world is important for long-term commercial success in the industry.

New challenges and opportunities across jurisdictions bring excitement to the expanding utility-scale solar business model. A company committed to multi-jurisdictional operations must first, however, release any expectation that its domestic business model can be exactly translated and created in a foreign jurisdiction.

When a company enters a new jurisdiction, the investment to become knowledgeable and skilled in the local culture and laws within that jurisdiction may be significant – but correspondingly significant is the potential for continued ongoing success and partnerships in the new region when the company demonstrates its respect and compliance with the region's unique culture. ■

Author

Monica L. Wilson is an attorney with Bradley Arant Boult Cummings LLP who advises utility-scale energy developers and contractors on EPC projects throughout the United States and internationally, focusing on risk management and claim avoidance.

Product reviews

Racking — Sollega's 'FastRack510' cuts commercial PV project installation time

Product Outline: Sollega has developed a new lightweight ballasted hybrid roof-mount solution in partnership with plastics producer BASF. The new 'FastRack510' (FR510) is manufactured with the advanced plastic 'Ultramid', engineered to weather extreme rooftop conditions, and weighs only 4.5lb. The FR510's lightweight material and streamlined design reduces overall project costs while maintaining system reliability, according to the company.

Problem: As equipment costs for solar projects fall, soft costs play a more prominent role in determining solar system prices. According to a recent National Renewable Energy Laboratory study, soft costs are now the largest component of commercial solar project pricing, primarily driven by labour and supply chain costs.

Solution: The FR510 is claimed to significantly reduce installation costs and time with its universal one-piece, stackable design. It arrives at the project site fully assembled and accommodates any type of module at 5 and 10 degree tilt angles. The glass-reinforced nylon with built-in UV inhibitor allows for each mount to hold over 200 times its own weight and retain its strength over the lifetime of the product, even in the face of intense weathering .

Applications: Commercial rooftops.

Platform: The lightweight, one-piece, stackable design simplifies project logistics by keeping part counts low and enabling half a megawatt of racking materials to fit in a standard 40-foot-long shipping container. The new FR510 is an improvement over the proven FastRack5 by reducing weight and increasing fire resistance while maintaining the simple design.

Availability: June 2014 onwards.

Piling — Trimble's 'DPS900 Piling System' reduces planning and installation costs for PV power plants

Product Outline: Trimble has developed and introduced a dedicated, land-based 3D machine control system for a variety of piling machine makes and models. The 'DPS900 Piling System' provides increased accuracy for operational efficiency and a reduction in costs for building structural foundations for ground-mounted PV power plants.

Problem: Reducing balance of system (BOS) cost in building large-scale PV power plants remains the key driver in lowering the levelised cost of electricity (LCOE). The ability to reduce piling planning and installation times with fewer errors and corrections is required.

Solution: The DPS900 Piling System reduces surveying costs associated with staking and as-built checks. In addition, the system can increase on-site safety by reducing the number of people around machines, pilings and foundations. Accurate positioning in DPS900 can ensure navigation time between piles is reduced, resulting in increased piling time to maximise production and revenue per day. Built-in, automated quality assurance and quality control reporting includes capture of start and end positions, time and elevation as well as actual embedment depth, blow count reporting and inclination and orientation control. In addition, unique system logins allow managers to filter reports by operator for better accountability, production optimisation and forecasting.

Applications: Piling construction for ground-mounted PV power plants.

Platform: HCE office software by Trimble is used to create pile plans in the office, and allows for integration with data prep, estimating and reporting functions. Piling machines can be connected to the office using 'Trimble Connected Site' solutions for wireless data transfer and GNSS corrections. In addition, machines can be tracked and monitored using 'VisionLink' for location, hours and utilisation information.

Availability: Currently available in Australia, Europe, North America, Chile and South Africa through Trimble's SITECH Technology Dealer Channel.

Products in Brief

REC Solar adds Peak Energy 72 Series panels to portfolio

REC Solar has launched its first 72-cell, 1000V DC solar panels into the US market, targeting large commercial/industrial and utility-scale PV power plant projects. Modules with 72 cells have claimed benefits that include lower installation costs, the use of fewer balance of systems components and less overall cost per installed watt.

Saft's containerised EES provides reliable compact capabilities

High-tech industrial battery manufacturer, Saft, has developed the 'Intensium' Max+ Energy Storage System (ESS), a containerised system that provides energy storage capacity of up to 1MWh or power of up to 1.8MW in a standard 20-foot container. The Ni-Cd, Ni-MH and Li-ion technologies are claimed to deliver high performance, long service life and low/zero maintenance requirements even in extreme conditions.

Schneider Electric's XW hybrid inverter designed for grid-tied solar with backup

Schneider Electric Solar Business has introduced the next generation of the 'Conext XW Hybrid' inverter, specifically designed for backup power for homes and businesses, residential retrofit of grid-tie solar with backup, residential self-consumption, off-grid homes and businesses, community electrification and micro-grids. It comes with scalable modular architecture in single-phase or three-phase system sizes from 5.5 kW to 102 kW, supporting DC coupled and AC coupled PV systems.

Combiners — Skytron energy's new 'ArrayGuard' CP combiner box designed for utility-scale PV

Product Outline: Skytron energy's new 'ArrayGuard' CP combiner boxes have been designed to meet the demand for highly power-efficient BOS components in utility-scale PV installations.

Problem: There is a need for the highest reliability combiner boxes without significantly impacting the LCOE. Reduced BOS costs are integral to lower LCOE metrics. Systems also need to provide long life in tough-temperature and high-altitude zones, while combiner boxes need to facilitate high-resolution analysis of string and plant performance and thorough plant diagnostics, which is vital for efficient O&M work, maximum plant uptime and optimum yield.

Solution: Skytron's 1000V DC component family has been expanded to include a redesigned smart combiner box that features a neatly arranged interior layout and compact, lightweight design, which makes the new ArrayGuard CP model particularly efficient with respect to power dissipation. This in turn ensures reliable operation even at outdoor operation temperatures from -40 to +50 degrees Celsius and altitudes of up to 4000m above mean sea level. The models are claimed to offer an outstanding price/performance ratio whilst preserving the reliability that this product's reputation has been built upon.

Applications: Combiner boxes for utility-scale PV installations.

Platform: The ArrayGuard CP model comes with the measurement, switching and protection functions fully integrated. Other key features include efficient DC connection

of up to 24 strings and integrated DC load disconnector and real-time string current monitoring at 100ms scan intervals. Reliable string protection is provided by gPV plug-in fuses for both PV+ and PV-.

Availability: June 2014 onwards.

Mounting — SolarCity's ZS Peak mounting system provides higher panel density on commercial rooftops

Product Outline: SolarCity has launched a flat-roof solar mounting solution that is claimed to be twice as fast to install and can generate significantly more solar electricity from each rooftop than alternatives for the commercial market. The ZS Peak mounting system provides an innovative snap-together system to simplify and accelerate installation.

Problem: Maximising commercial flat rooftop space for PV panels often has to take into consideration loading, shading hazards and maintenance access, limiting the overall size of the PV system. The increase in panels per roof is particularly valuable in the commercial market, as conventional flat-roof solar systems typically power less than half of a commercial building's load.

Solution: Following on from the highly respected residential rooftop mounting systems from Zep, SolarCity estimates that ZS Peak can increase generation capacity on flat-roof buildings by 20-50%, without requiring any penetrations. SolarCity said the system's dense, east-west layout structure would allow to fit up to 20% more solar panels on standard roofs and up to 50% more panels on lightweight roofs, such as those commonly found on warehouses.

Applications: Commercial flat roofs.

Platform: ZS Peak's east-west orientation allows installers to fit more solar panels on each roof than standard south-facing systems. The system allows the capture of peak power production throughout a longer period of the day. By lengthening power production time and eliminating the typical midday spike of standard solar systems it can also make more efficient use of solar inverters to further reduce costs for customers. ZS Peak has also improved on the aerodynamics of conventional systems so that it can be installed on many roofs that would otherwise require the solar panels to be bolted down.

Availability: SolarCity is currently installing its first project with ZS Peak and expects to begin installing the product in volume in January 2015. Currently aimed at US markets only.

Bonfiglioli provides containerised inverter station

Bonfiglioli has introduced a new containerised inverter station, the RPS Station ICON-LV. These ISO-container stations are specifically designed for the Chinese PV market and are available in a 20ft version up to 1000kW AC and in a 40 ft version up to 2000kW AC, making the ICON-LV stations the largest available turnkey solutions in China.

Delta's transformerless PV inverters feature asymmetrical loading for higher yields

Delta has introduced three new transformerless models known as the RPI M6A, M8A and M10A featuring 6, 8 and 10kW power outputs respectively. The new three-phase solar inverters are designed for residential or small commercial applications and feature a high maximum efficiency up to 98.5%. The new units are compatible with major types of PV modules and the IP65-rated enclosure allows outdoor installation.

Parker Hannifin's '890GT-S' central inverter uses two-phase refrigerant cooling technology

Parker Hannifin's Global Energy Grid Tie Division has launched a new utility-scale PV solar inverter with grid-friendly features for applications up to 2MW. The 890GT-S features a 1000V design that integrates IGBT power conversion with Parker's new two-phase refrigerant cooling technology. Fault ride-through logic for low voltage and grid frequency excursions ensures maximum uptime. Slew rate control for both real and reactive power make the 890GT-S grid friendly, and MPPT control ensures the maximum energy harvest, even during non-optimum days. The modular design enables modules to be replaced in under 15 minutes, according to the company.

Inverter — Advanced Energy's AE 3TL string inverters benefit from space-saving mounting orientation

Product Outline: Advanced Energy Industries (AE) has developed a new accessory for its AE 3TL PV inverter designed to conserve space and increase project yield on commercial rooftop systems. Advanced Energy will showcase its AE3TL string inverter technology and horizontal mount accessory at the Solar Power International conference and exhibition in Las Vegas.

Problem: With large-scale commercial rooftop designs increasingly using three-phase string inverters, Advanced Energy has developed an innovative mounting solution to tackle one of the challenges of roof-mounted inverters – the shade cast by the inverters on the PV array. In the US, commercial rooftop inverters also need to meet NEC 2014 code compliance with inverters being close to a PV array.

Solution: The low-profile accessory that is used to install AE 3TL string inverters at the edge of a rooftop solar array is claimed to increase site design flexibility and improve overall system performance, while enabling compliance with new NEC 2014 rapid shutdown requirements. The system is said to have already been field proven at sites across North America. The mounting system design is claimed to provide balance-of-system cost savings and reduces shading setbacks for additional surface space for up to two additional 300W PV modules per inverter when compared with competing angled mounting systems. The solution is said to be particularly ideal for projects that require NEC 2014 code compliance, which specifies string inverters in roof-mounted installations must be installed within 10 feet of the array.

Applications: The solution is commercially available for AE 3TL 12 kW, 16 kW, 20 kW and 23 kW models used in commercial rooftop installations.

Platform: Engineered specifically for AE 3TL inverters, the mounting kit accessory allows the string inverters to be quickly and easily installed at a range of angles from 0° up to a 30° tilt.

Availability: Currently available in the US.

Monitoring — Valentin Software's 'PV*SOL premium' calculates own consumption precisely

Product Outline: Valentin Software's new planning software, 'PV*SOL premium', succeeds the company's simulation program PV*SOL Expert, calculating own consumption more precisely and providing display of the electricity stored in the battery systems, in contrast to its predecessor.

Problem: Greater accuracy in PV plant yield planning analysis is required to provide better matching and lower system costs, especially in respect to self-consumption and the use of energy storage systems.

Solution: PV*SOL premium analyses the shading for rooftop and free-standing plants in 3D mode: it calculates how often the modules are under shade on average and how that affects the plant yield, then presents these results graphically. Among its new features, PV*SOL premium takes own consumption into account precisely, since it can also display the electricity stored in the battery systems, in contrast to its predecessor. The program imports current load profiles on the basis of hourly, quarter-hourly or minute values. PV*SOL premium represents the energy balance of the total plant in an extensive table. Detailed project reports for grid operators and customers, as well as the circuit diagram it creates automatically for the grid connection, ensure additional transparency and safety.

Applications: Residential and commercial rooftop system design and planning.

Platform: PV*SOL premium enables users to select as many possible arrays per PV plant as desired, which increases flexibility and maximum plant size. They can select different inverters and combine them with each other in any way needed. The new software is available in German, English, French, Italian, Polish and Spanish. Valentin also offers training seminars and beginner webinars free-of-charge for PV*SOL premium.

Availability: June 2014 onwards.

SunLink's 'Precision RMS' avoids rooftop mounting obstruction issues

SunLink has developed the Precision-Modular RMS (roof mounting system) that tackles issues surrounding installations caused by rooftop obstructions. The system is assembled, laid out and installed module-by-module to maximise layout flexibility and facilitate last- minute on-roof changes. The modular approach also significantly shortens design/engineering, shipping and installation timelines. The system offers full connectivity north/south and east/west to better distribute loads and is available for 60 and 72-cell modules, and 10 degree tilt.

AEG Power Solutions offering short-term energy storage battery

AEG Power Solutions (AEG PS) has developed a megwatt-scale battery energy storage system (BESS) for short-term energy storage, designed to facilitate the transition to new ways of generating and distributing electricity. BESS offers grid stabilisation and increased power quality, namely four-quadrant operation, peak shaving and load balancing, day to night shifting of renewable PV energy, and reliable PV power supply.

Anchor Products' U-Anchor 2600 tackles racking duties on asphalt roofs

Anchor Products' U-Anchor 2600 rooftop solar racking system is specifically designed for flat rooftops protected by asphalt. The attachments can be installed on a variety of asphalt roofs, providing solar project teams a means to attach in virtually every commercial rooftop condition. The U-Anchor 2600 is a lightweight rooftop attachment system that can be quickly installed at a rate of 12 per man hour.

Inverter — AET's flexible PV inverter mounting system tackles space constraint issues

Product Outline: AET (Applied Energy Technologies) has launched the Rayport-I, a solar inverter mounting kit for string inverters, giving installers a simple and cost-effective mounting solution for both rooftop and ground-mounted solar arrays.

Problem: Typically, solar rooftop system designers have been hampered by space constraints and would have to develop their own ad-hoc custom solution for the inverter placement. It is often time-consuming and challenging to find a suitable and easy place to put the inverter in roof-mount systems.

Solution: The Rayport-I is ideal for solar systems in a variety of sizes and configurations. For rooftop installations, the Rayport-I can be installed without penetrating the roof, saving time and helping minimise installation-related maintenance issues.

The Rayport-I is said to withstand the most challenging environmental conditions. It fits most string inverters on the market, can mount at a 15 or 30 degree tilt and can be used in both rooftop and ground-mount systems.

Applications: PV inverter mounting kit for string inverters on rooftop locations.

Platform: Made of stainless steel, Rayport-I is corrosion resistant and offers superior durability. At only 13lbs, it is lightweight and compact, reducing shipping costs and enabling easier handling on the job site.

Availability: Currently available in US.

System reliability — Eaton's Circuit Protection division offering higher direct current protection solutions

Product Outline: Power management company Eaton's Circuit Protection division is helping original equipment manufacturers (OEMs), contractors and system owners safeguard PV power systems by offering a complete range of solar circuit protection solutions. Eaton's portfolio includes fuses and circuit breakers to power distribution blocks and surge protective devices (SPDs).

Problem: PV systems require equipment manufacturers to develop solutions that are increasingly efficient at higher direct current (DC) voltages in harsh environments. As the solar market evolves, system owners are demanding lower cost of ownership solutions and faster return on their investment. Therefore there is a need to develop innovative and energ-efficient over-current and over-voltage solutions to ensure system reliability.

Solution: Eaton's Circuit Protection division offers a range of solutions to protect PV panels, conductors and equipment. Eaton helps ensure that wire harnesses, combiner boxes, recombiner boxes and inverters are operating with maximum reliability, while adhering to the applicable solar-specific code requirements. This includes PV fuses that offer global acceptance with ratings up to 1,500 volts DC, as well as high-speed and alternating current fuses. It also offers SPDs for PV overvoltage and lightning current protection in systems up to 1,200V DC. Utilising patented, fast-acting 'short-circuit interrupting' technology, these solutions isolate systems to help prevent direct current arch damage. SPD solutions are available for Underwriters Laboratories (UL) and International Electrotechnical Commission (IEC) applications.

Applications: Solar PV circuit protection solutions for higher direct current voltage in commercial and utility-scale PV systems

Platform: Additional solar solutions available for residential, commercial and utility-scale systems include in-line PV string protectors, modular fuse holders, AC/DC safety switches and power distribution blocks.

Availability: Currently available.

Inverter — KACO's blueplanet 1000 TL3 outdoor central inverter is IP54 enclosure protected

Product Outline: KACO new energy will launch its next-generation high-power blueplanet 1000 TL3 outdoor central inverter, in the first quarter of 2015. Its IP54 protection class does not need to be housed in a separate enclosed room.

Problem: Outdoor central inverters using ingress protection such as IP54 enclosure protection not need to be housed in a separate enclosed room. This can save of PV power plant enclosure costs and minimize construction requirements and installation.

Solution: The blueplanet 1000 TL3 is a transformerless solar PV inverter with an AC power of 1,000kVA. It is designed to be a cost-effective, dependable solution for the centralised design of open-field commercial and utility-scale solar power plants, using the latest signal-processing technology. The fully digital controller makes operation and maintenance user friendly and offers a multitude of options for monitoring and communications.

Applications: PV power plants, all regional locations.

Platform: The blueplanet 1000 TL3 comes with internal power supply , while a powerful cooling system protects all of the sensitive components. As such, the cooling fans can be controlled independent of the load and the ambient temperature. Maximum efficiency is 98.7 %, while European efficiency is 98.3 %.

Availability: First quarter 2015 onwards.

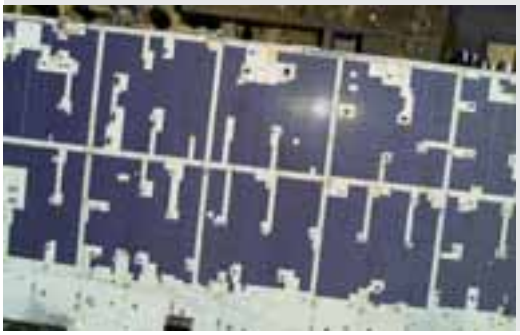
Projects | news

Project 1: Indianapolis, US

Project capacity: 3.18MW | **Completion date:** September 2014

- Largest commercial rooftop installation in Midwestern US
- Receives Feed-in-tariff from utility, Indianapolis Power & Light

The 3.18MW Rockville Solar II is located in Indianapolis, and was developed designed and constructed by Melink Corporation. The project uses more than 12,000 of REC's 260W Peak Energy series PV panels, installed across a 600,000 square foot warehouse roof owned by Equity Industrial Partners. The rooftop array is expected to generate more than 4 million kW hours a year, enough to power 400 US homes. The array is grid connected, benefitting from local utility, Indianapolis Power & Light's feed-in-tariff. Finance was provided by tax equity investment, sponsor equity and debt.



Source: REC.

Project 2: Quezon City, Philippines

Project capacity: 1.5MW | **Completion date:** October 2014

- Largest commercial rooftop solar installation in the Philippines
- Part of a natural disaster resiliency programme

Philippines mall and real estate developer, SM Prime Holdings, is building a 1.5MW rooftop solar array at the SM City North Edsa mall, Quezon City. The array will be used to provide most of the mall's energy requirements. The rooftop is being built by installers, Solar Philippines, and will be complete October 2014. The installation is part of continued efforts to increase sustainability and disaster resiliency, due to repeated disasters hitting over the last decade. SM Prime already has a 1.1MW rooftop project at its Xiamen mall in China, built last year.

Source: Ramon FVelasquez, Wikimedia Commons.

Project 3: Pembrokeshire, UK

Project capacity: 28MW | **Completion date:** September 2014

- Utilises a newly constructed substation, belonging to the plant itself
- Employed 200 local people

Renewable energy company, Bester Generación's third photovoltaic plant has been connected to the UK grid, in Tiers Cross, a community located in the county of Pembrokeshire, south-west Wales. The 28MW plant is expected to generate 31.65GWh a year of clean electricity a year. The plant utilises a newly constructed substation, belonging to the plant itself, connecting the plant to the 132kV Western Power Distribution line. The plant site covers an area of 60 acres, with 113,800 panels installed on fixed structures. Bester Generación is already operating two other photovoltaic plants in the UK.

Source: Bester Generación.

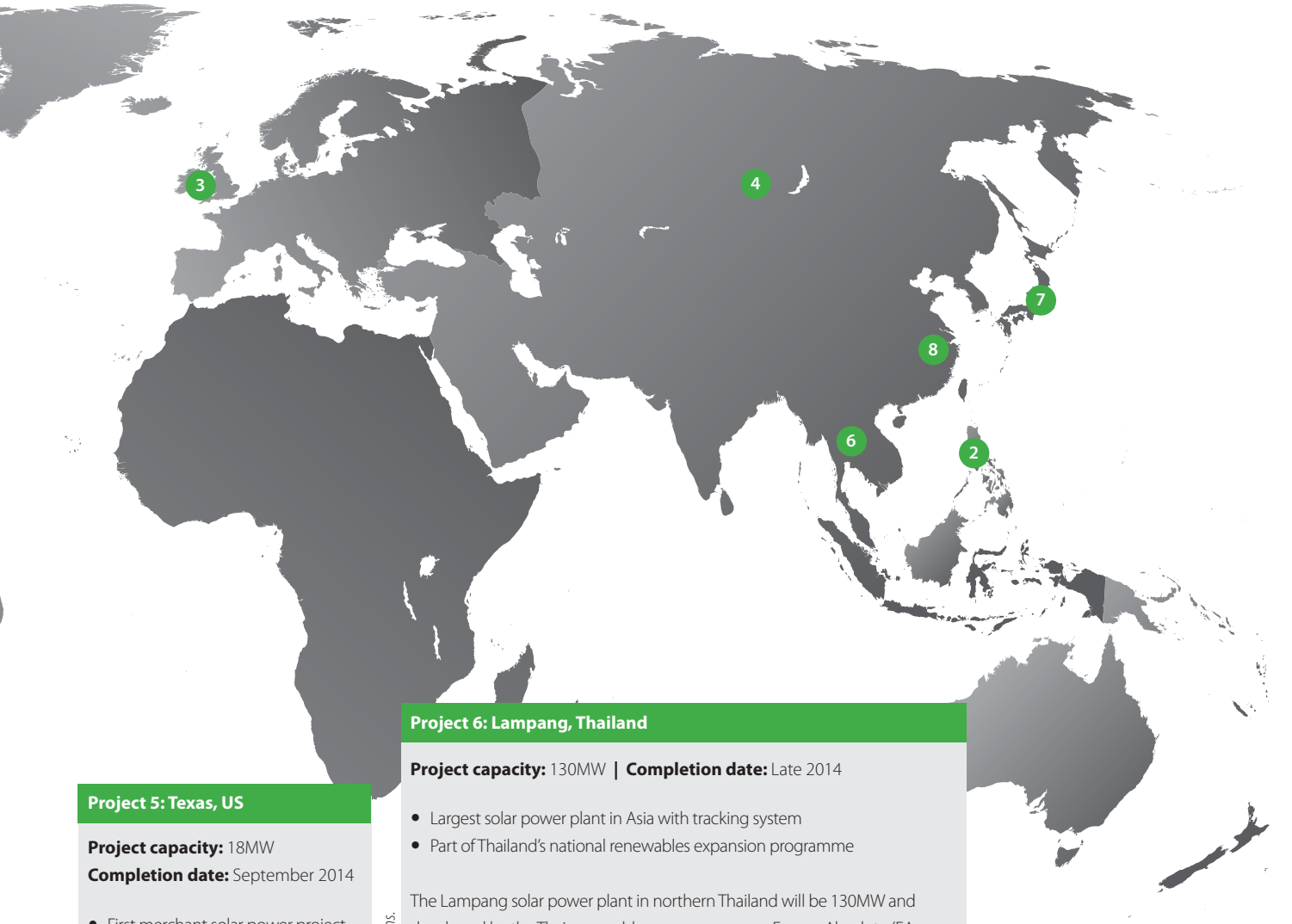
Project 4: Altai, Russia

Project capacity: 5MW | **Completion date:** September 2014

- Largest solar installation in Russia to date
- Praised at launch by president Putin

Russian president, Vladimir Putin opened the Kosh-Agach solar power station this September. During a trip to the Republic of Altai, Putin spoke after a videoconference of the launch of operations at the The Kosh-Agach solar power station. According to the president's office, Russia's solar generation was at 2MW, making Kosh-Agach the largest solar plant in Russia and the first dedicated generating unit in the region, helping the Republic of Altai to reduce its power deficit and produce clean energy. Kosh-Agach will also be the first of five solar projects expected to total 45MW planned in the Republic of Altai and costing an anticipated RUB5 billion (US$129 million). Putin said the project was an example of how solar energy can be applied to powering remote areas.

Source: Ondřej Žváček, Wikimedia Commons.



Project 5: Texas, US

Project capacity: 18MW
Completion date: September 2014

- First merchant solar power project in Texas
- To sell electricity on Texas' ERCOT grid spot market

The initial 18MW phase of the Barilla PV plant in Texas is now complete, becoming the first plant in the state to operate without a power purchase agreement. First Solar completed the 'merchant' PV power plant in Pecos Country, west Texas, in September. Projects without subsidies or PPAs are emerging in regions such as South America, but have not been widely tested yet in the US. Although solar has been slower to take off in Texas than other parts of the US, the National Renewable Energy Laboratory says it has the highest potential for solar development in the US, and recent completions including the first phases of the 400MW Alamo project have put the state firmly on the solar map.

Source: First Solar.

Project 6: Lampang, Thailand

Project capacity: 130MW | **Completion date:** Late 2014

- Largest solar power plant in Asia with tracking system
- Part of Thailand's national renewables expansion programme

The Lampang solar power plant in northern Thailand will be 130MW and developed by the Thai renewable energy company, Energy Absolute (EA Solar). International consulting and engineering company, Pöyry, is to carry out engineering work. The solar power plant will have 424,800 solar modules installed on a single-axis tracking system with annual generation from the plant expected to be 207GWh. Pöyry will also provide technical assistance, until the plant is operational, scheduled for later in 2014, and operations and maintenance services for the system until 2025.

Source: Hdamm, Wikimedia Commons.

Project 7: Chiba, Japan

Project capacity: 40.4MW
Completion date: July 2014

- Former gravel quarry
- Observation deck and visitor centre

Source: Mitsuuroku Green Energy.

A 40.4MW solar power plant fitted with an observatory deck and visitor centre has been completed by Mitsuuroku Green Energy and its partners in Chiba, near Tokyo, Japan. It is hoped that the installation could serve an educational purpose, featuring an observation deck and display readout which shows energy generation statistics and other information. The plant also features an educational exhibition on solar panels. The project was completed in early July, built by Mitsuuroku with Fuyo General Lease Co, and developer, Renova. According to Mitsuuroko Green Energy, the ground-mounted installation spans 44 hectares, with an annual output of 42,000,000kWh. Sited on a former gravel quarry in the city of Futtsu, Mitsuuroku claims the PV plant is the largest on the Kanto Plain, the region which encompasses Tokyo and four regional prefectures, including Chiba.

Project 8: Shanghai, China

Source: DuPont.

Project capacity: 210kW
Completion date: September 2014

- Powers DuPont's Research and Development centre
- Demonstration of using renewables to meet growing energy demand

PV materials provider DuPont Photovoltaic Solutions and PV module manufacturer Yingli Green Energy have completed a 210kW PV rooftop project for the DuPont China R&D Center in Shanghai. Yingli Solar was responsible for design, construction and connection of the plant, which is expected to generate 202,000kWh of electricity per year. The installation covers 0.21 hectares on top of the facility and is comprised of Yingli's PANDA monocrystalline panels.

Projects | briefing

STILLWATER HYBRID POWER PLANT, NEVADA, US

Project: Stillwater hybrid power plant
Location: Nevada, US
Project capacity: 26MW PV, 33MW geothermal, 2MW CSP

Nearing completion this quarter is the world's first integrated geothermal-solar hybrid power plant. The hybrid power station integrates solar photovoltaic, geothermal and concentrating solar power (CSP) across a 240-acre site in Nevada, USA.

Construction of the 2MW CSP part of the plant began April 2014, in Fallon, Nevada to join the 33MW Stillwater Geothermal Project built in 2009 and the 26MW of solar PV completed in 2012.

The hybrid power station has more than 89,000 polycrystalline silicon PV panels installed across 110 acres, generating 40 million kWh of clean energy per year, enough power for 15,000 American households. Last year the 26MW of PV and 33MW of geothermal together generated 200GWh of energy. With the completion of the CSP plant, 3,000MWh a year is to be added to the plant's total generation capacity.

Named the 'Stillwater Hybrid Project', the project was developed, financed and constructed by Italian renewable energy corporation Enel Green Power's North American subsidiary, EGP NA, which will now own and operate it.

Bill Price, the head of engineering and construction at Enel Green Power North America, explains that Stillwater is the world's first hybrid project that combines "the continuous generation capacity of binary-cycle, medium-enthalpy [heat content] geothermal power with solar photovoltaic and solar thermodynamic".

To achieve a level of integration never before attempted was no easy feat, says Price, as the main driving factor in determining the design of the new plant was to make sure the solar additions were "harmoniously integrated" with the already operating, commercial geothermal facility.

Price explains blending the energy sources means that "precisely when the thermal efficiency in the geothermal unit is lower – generally during the hottest and sunniest times of the day or year – the solar PV is at its most productive, contributing to stabilise production hence further improving plant performance".

While the average daily generation during peak hours is significantly enhanced by the PV system, the geothermal plant returns to its best generation levels later on, "when solar generation ramps down", says Price.

The integration of the solar CSP thermodynamic facility is expected to further enhance the plant's smooth production.

A mix of benefits

The benefits of this cocktail of various renewable generation sources has so far proved beneficial in the generation measurements to date, as well as saving on cost, and environmental impacts, Price claims.

Using multiple renewable technologies not only increases the generation of zero-emission energy, but also makes it possible to use the same infrastructure, such as, for instance, electrical interconnection lines, thereby saving costs and further reducing environmental impact, explains Price.

Also due to the hybridisation and stable load all year around, the plant does not need any battery storage technology, adds Price.

To keep track of the multiple forms of generation, Enel Green Power has an on-site control room, and is responsible for all operations and maintenance.

Price reveals an ambitious vision for future renewable energy generation and hybrid power plants should the project prove successful.

Source: EGP.

Source: EGP.

At the global level "we record a sizeable overlap in the resource areas of geothermal and solar, which suggests the possibility of a scaled application of solar and geothermal solutions", he explains.

In these cross-over areas, "hybrid projects that enable both base-load and peak power delivery will be more attractive to utilities serving load with similar consumption patterns", predicts Price.

In some cases, hybridisation may also allow renewable energy projects that were previously deemed unfeasible – stand-alone geothermal or solar projects – "to become more economically and technologically viable", adds Price.

Research and development

To explore the potential of hybrid renewable power plants better, EGP NA earlier this year embarked on a research project with the US National Renewable Energy Laboratory (NREL), and Idaho National Laboratory (INL).

Under the oversight of the US Department of Energy Geothermal Technologies Office (GTO), EGP NA will work with NREL and INL to model the combination of geothermal and solar systems, validating simulated results with real-world data from the Stillwater facility.

The study is ongoing this year. "We look forward to digging into what we believe will be a fruitful hybridisation and we will disclose results when they become available," says Price.

"The fruits of this work will be used to explore and quantify the potential benefits of different operating strategies and integration schemes, with the goal of opening doors for the development of future hybrid renewable energy facilities."

Hybrid future

EGP NA hopes to continue its research and development of hybrid renewable power, owning and operating over 90 plants across 21 US states, and two Canadian provinces, with a total installed capacity of around 2GW, working in solar, wind, geothermal and hydro.

EGP's subsidiary in Chile is also constructing a hybrid project which combines PV power, a mini-wind turbine generator and a co-generation system for electricity and hot water, coupled with a storage system. It is hoped this hybrid will be capable of meeting most of the annual energy needs of the village of Ollagüe, with an expected installed capacity of 232kW, as well as generating approximately 460MWh a year, equivalent to the electricity consumption of 150 households. ■

By Lucy Woods, Solar Media

Source: EGP.

advertisers & web index

Advertiser	Web address	PAGE No.
Arkema, Inc.	www.kynar.com	31
CIPV Expo / Intersolar China	www.cipvexpo.cn/www.intersolarchina.com	63
ET Solar	www.etsolar.com	39
Solar Power International	http://www.solarpowerinternational.com/	5
Intersolar	www.intersolarglobal.com	22
JA Solar Holdings Co., Ltd.	www.jasolar.com	Inside Front Cover
Kipp & Zonen	www.kippzonen.com	41
Mondragon Assembly	www.mondragon-assembly.com	81
MultiContact	www.multi-contact.com	75
Panoptes s.r.l	www.panoptes.it	63
PolyOne	www.polyone.com/whatif	51
Power Electronics	www.power-electronics.com	49
REC Americas LLC	www.recgroup.com	13
ReneSola	www.renesola.com	25
Sika	www.sika.com/photovoltaic	33
Skytron	www.skytron-energy.com	67
SNEC 2015	www.snec.org.cn	Inside Back Cover
Suntech	www.suntech-power.com	Outside Back Cover
Tata Power Solar Systems Limited	www.tatapowersolar.com	9
TÜV Rheinland	www.tuv.com/us/solar	19

next issue

Energy storage technology overview

Distributed versus central architecture in solar arrays

Utility-scale PV installations and their challenges to grid code compliance testing

Dim prospects for a lasting end to solar's trade wars

The trade wars that have convulsed solar in recent years ultimately help no one. Ben Willis assesses the prospects for a permanent solution to a problem that has become a thorn in the industry's side

Source: Flickr/Luke Price.

So, once again SolarWorld has landed its catch. It has cast its bait and for the second time hooked its prize fish, in the form of the US government, which announced its latest round of anti-dumping duties on Chinese solar products in late July.

The ruling was a response to a petition launched at the start of the year by SolarWorld Americas in which it claimed Chinese solar manufacturers have evaded earlier anti-subsidy and anti-dumping duties by using cells manufactured in Taiwan.

The big question the global PV industry must now address is where it goes from here.

Leaving aside SolarWorld's debatable claim that it is acting in the best interests of the solar industries in the US or Europe, where it was the chief agitator behind the EU's trade spat with China last year, the repeated pattern of petition followed by investigation and then either tariff (US) or fragile settlement (Europe) is unsustainable and ultimately does no one any good, probably not even SolarWorld.

Yet SolarWorld appears determined to pursue its anti-Chinese agenda as far as it must to achieve its aims.

This has become apparent in Europe, where, after making clear its dissatisfaction with last summer's price undertaking, it said in June this year it had submitted a dossier of "evidence" to the European Commission of Chinese firms allegedly flouting the deal.

In the US, meanwhile, *PV Tech* has reported Taiwanese firms already starting to look for new territories to open factories to beat the latest duties. What's to stop SolarWorld launching anti-dumping and anti-subsidy petitions against outsourced Chinese equipment made in Mexico or Malaysia or wherever Chinese and Taiwanese suppliers choose to relocate their operations? This is a scenario that could theoretically roll on, ad infinitum, to the benefit of nobody.

So what are the options? Rhone Resch, chief executive of the US Solar Energy Industries Association (SEIA) optimistically heralded a "silver lining" to last July's ruling, claiming that a "negotiated solution" to the dispute between the US and Chinese remained on the cards.

Since last year, the SEIA has been leading efforts to try to reach a settlement with all parties to the dispute that avoids tariffs, in the same way that the EU agreed a minimum price undertaking with China as an alternative to duty payments. It has until the US government finalises the duties in December in which to reach its agreement, but so far SolarWorld has not engaged with these talks. Any agreement without a SolarWorld signature is likely to be vulnerable to further challenges.

Beyond the slim possibility of a lasting settlement between the US and Chinese (and for the EU-China deal to hold), the only other real option currently on the table is a positive outcome to the multi-nation negotiations underway to reach an 'environmental goods agreement'. Led by the US, Chinese and EU, the discussions are aimed ultimately at ending trade tariffs between 14 regional and national governments on a range of products including solar cells and modules.

This level of international cooperation could be bolstered by the formation of a global solar trade association, currently being scoped out by the European Photovoltaic Industry Association.

As such, these two developments offer only glimmers of hope. The global environmental goods trade talks, for example, would not have any effect on the existing case in the US, and the global association would be toothless without buy-in from players in key markets such as the US and Japan. This has yet to be achieved.

But as things stand they look to be the only hopeful prospects for any kind of lasting solution to the trade war treadmill. Observers have suggested that early successes in the international trade discussions could eventually bring an end to the sort of punitive trade remedies demanded by the likes of SolarWorld and by complainants in other markets such as India where duties are being sought. Backed up by a global trade body, this could offer the industry a chance of escaping the damaging consequences of trade actions pursued by a few rogue players.

The alternative is a future dominated by an endless cycle of trade petitions and levies from which no one really wins. Protectionist policies will ultimately only stunt solar's growth. That's why a suspension of hostilities, negotiation and – hopefully – consensus remain the best hopes the global PV industry has of sustaining its momentum at a time when it is truly beginning to come into its own. ■

This article originally appeared on PV-Tech.org

SNEC 9th (2015) International Photovoltaic Power Generation Conference & Exhibition

SNEC 2015
PV POWER EXPO
Dialogue & Conference & Exhibition

www.snec.org.cn

180,000sqm	1,800+	5,000+	150,000
Exhibition Space	Exhibitors	Professionals	Visitor Attendances

May, 2015

Shanghai New International Expo Center

(2345 Longyang Road, Pudong District, Shanghai, China)

member of GLOBAL SOLAR ALLIANCE

Tel: +86-21-64276991 +86-21-33561099

Fax: +86-21-33561089 +86-21-64642653

For exhibition: info@snec.org.cn

For conference: office@snec.org.cn

The future of solar is us.

Suntech-Be Unlimited!

Learn more at: ***www.suntech-power.com***

Visit us at SPI 2014
21th-23th Oct 2014,Las Vegas

Booth No. **S1,1306**

SUNTECH
BE UNLIMITED