08 | 2016 | 78538


Photo: European Parliament/Flickr

Markets & Trends

UK: Already facing an uphill battle, can the U.K.'s solar sector find ways to thrive post-Brexit? *Page 22*


Photo: SolarWatt

Industry & Suppliers

Made in the EU: Module production in Europe explored through the lens of five manufacturers. *Page 50*

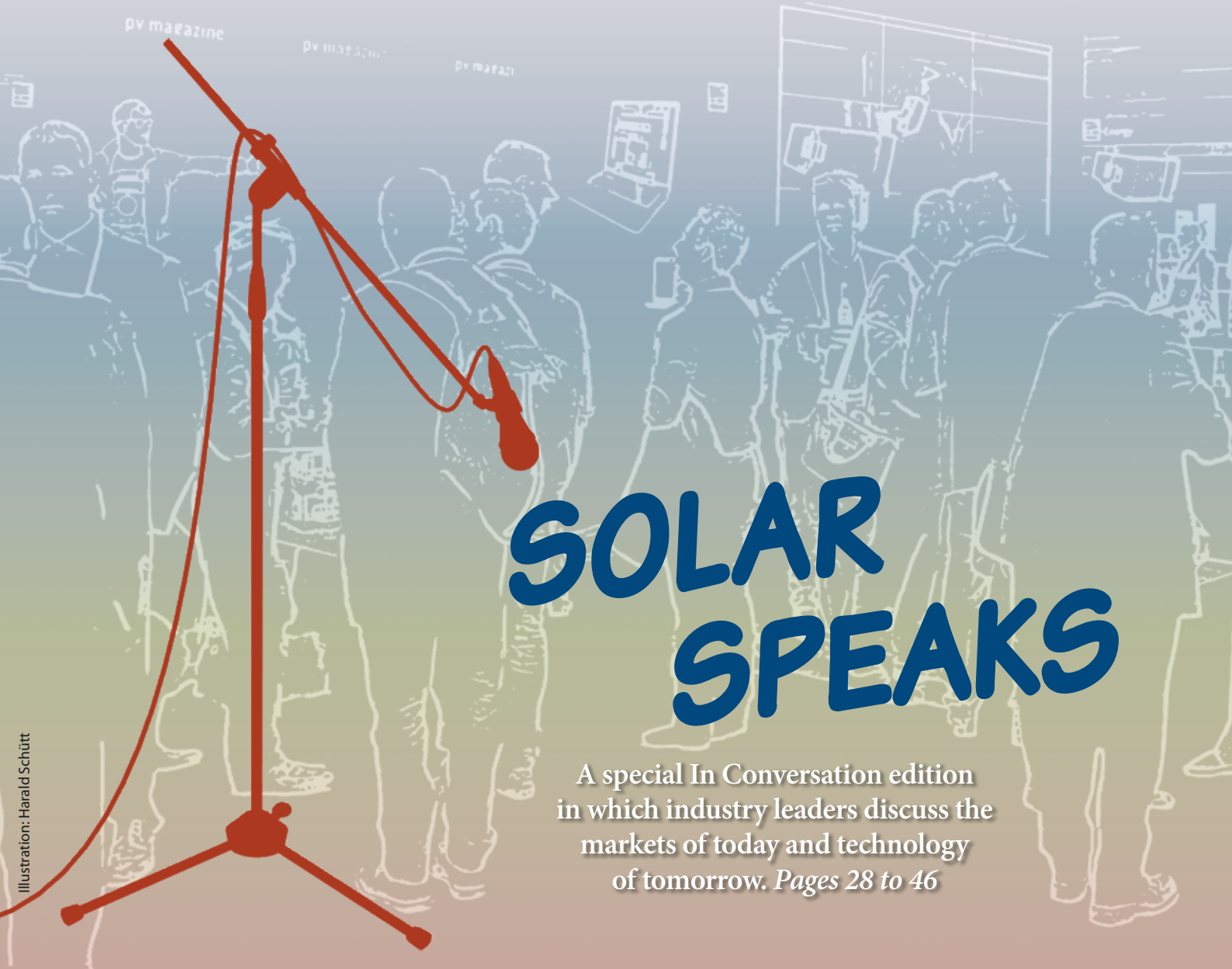

Photo: ARENA

Applications & Installations

Offgrid+storage: Solar, backed by storage, is proving its worth in the vast Australian outback. *Page 72*

pv magazine

PHOTOVOLTAIC MARKETS & TECHNOLOGY



SOLAR SPEAKS

A special In Conversation edition in which industry leaders discuss the markets of today and technology of tomorrow. *Pages 28 to 46*

Illustration: Harald Schütt

A second half to remember

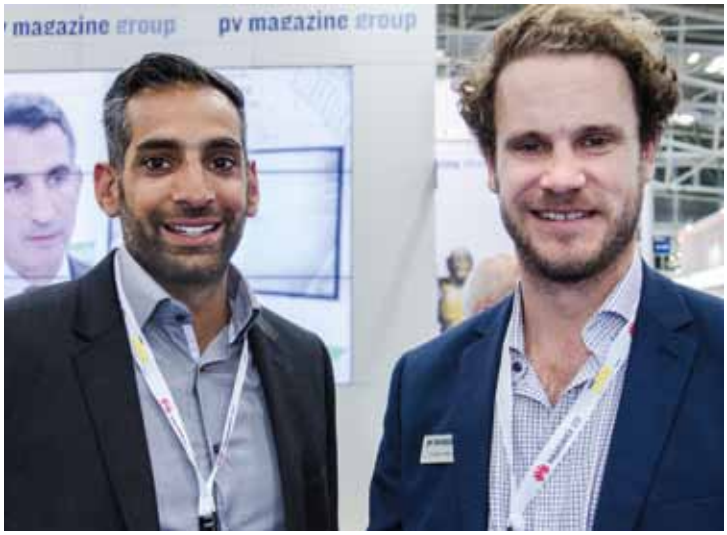


Photo: pv magazine/Maximilian Rügamer

Jonathan Gifford with IHS Technology's Ash Sharma at Intersolar Munich.

Cue: a collective sigh of relief. Solar's silly season has passed. The eight-week crunch of three major solar events in quick succession – the SNEC, Intersolar Europe and Intersolar North America – is now behind us. And it's summer, in the northern hemisphere at least, so time to take stock and get in some much-needed rest and relaxation. If only it were so simple.

The ever shifting solar landscape will unlikely let sleeping dogs lie this August as the second half of 2016 shapes up as being every bit as intriguing as the first. A rapidly cooling China market, looming module oversupply and the first determination in Hemlock's legal action against SolarWorld subsidiary SolarWorld Industries Sachsen (formerly Deutsche Solar), which was published at the time of writing, are likely to contribute to another intriguing six months.

In a ruling handed down in the dispute between Hemlock and SolarWorld over multi-year polysilicon contracts signed by the two companies, U.S. District Court Judge Thomas L. Ludington detailed the process through which Deutsche Solar and SolarWorld executives sought to renegotiate the multi-year poly supply agreements with Hemlock. The PV market was rapidly changing in 2012 and 2013, and poly prices undergoing steep declines.

Most interestingly, the ruling sets out the precise moment in which Dow Corning, Hemlock's parent company, stepped in to request that SolarWorld petition the U.S. Department of Commerce to seek a resolution to solar antidumping proceedings between the U.S. and China. The ruling indicates that SolarWorld did not follow through on this request in the manner requested of it by Hemlock, and the relationship between the two companies deteriorated to what it is today.

While there is no doubt that the major winners of the affair have been the respective companies' legal teams, there may be a silver lining for the global solar industry in this largely sorry story. In responding to the judgment, PV industry analysts were quick to observe that if a resolution to the matter were to be achieved, and SolarWorld would likely be seeking such given the $770 million at stake in the suit, a push towards the removal of duties on PV cells and modules bound for the U.S. from China, and solar-grade polysilicon headed precisely the other way, may be the end result.

With the U.S. market continuing to forge forwards with both the distributed and utility scale sector in robust health, a reduction of tariffs all round would likely lead to continuing expansion and market growth. Expectations are for some 10 GW of PV to be added to the country's grids in 2016. Solar's resultant increased competitiveness with traditional generation sources would also be enhanced, helping to pave the way for unsubsidized solar projects to become the rule rather than the exception. However, the case is at the very least expected to drag on for some time, so it's best not to get too far ahead. But it is promising nonetheless.

In the European markets, the minimum price undertaking (MIP) does not look set to budge any time soon, much to the chagrin of the downstream sector. European solar is not expected to grow in 2016, with up to 9 GW of installations forecast (pp. 30 – 31). While the MIP provides some support to manufacturers in Europe, they still face a host of challenges (pp: 44 – 53). Storage deployment is certainly presenting a most significant opportunity both for installers and suppliers, and it was the major talking point at the ees shows in both Munich and San Francisco, co-located with Intersolar (pp. 16 – 19). Another topic on the lips of those attending the European trade show was Brexit, which has posed more questions than answers (pp. 22 – 25) since news of the shock vote broke.

Multiple reports are coming out that storage cost reductions are exceeding expectations, which is pointing the way for some exciting applications both off (pp. 72 – 75) and on-grid. What better way to learn about the latest storage offerings than by taking a guided tour of some of the leading suppliers' trade show booths, which **pv magazine** – along with industry expert Götz Fischbeck – has duly produced. Our findings can be viewed on the **pv magazine** global YouTube page.

At Intersolar Europe this year, **pv magazine** ramped up its video coverage, producing more than 20 reports in German and English across the three days. So on the back of these and other discussions, our annual In Conversation special (pp. 28 – 43) touches base with some of the leading and most innovative suppliers and analysts in the solar industry. Hear from the industry in its own words, in print, online and in video format. Either with a magazine, laptop or smartphone in hand this summer, you can take solar's story with you!

Jonathan Gifford
Editor in Chief

Photo: pv magazine/Harald Schütt

Photo: London Public Library/Flickr

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Special: In Conversation

Markets & Trends

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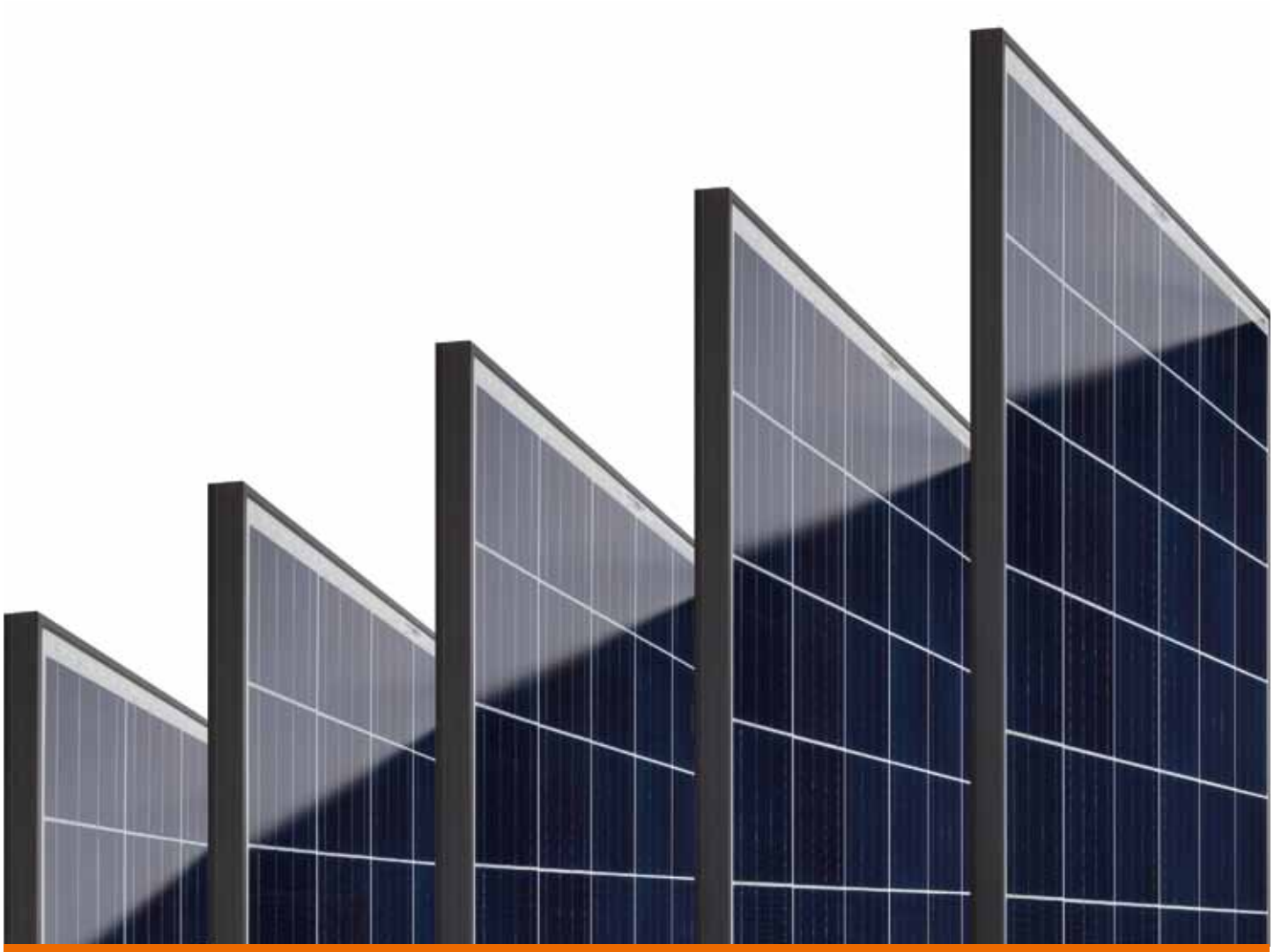

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Solar Impulse on course to make history

At the time of going to press, the penultimate flight of the historic Solar Impulse 2 (si2) aircraft had just been completed, with pilot Andre Borschberg touching down in Cairo, Egypt, amid a sunny desert backdrop that quickly came to epitomize this sky-breaking feat.

The actual journey began back in March 2015 in Abu Dhabi, UAE, but the entire project has been years in the making. The seed was first planted in 1999 when Swiss aviator and innovator Bertrand Piccard completed his global circumnavigation in a hot air balloon. Weighed down by the physical and psychological reliance on fossil fuel, Bertrand vowed to make it around the world again – only next time to do so without burning any fuel whatsoever.

Photo: Solar Impulse

Retreating to the alpine valleys of his native Switzerland, Bertrand created Solar Impulse with the help of Borschberg and a who's-who of high-tech companies, including D'assault Systems, ABB, Solvay and SunPower.

The creation of the Si2 aircraft was painstaking, involving the filing of thousands of new patents as molds were broken and boundaries pushed. The resulting craft was a revelation: with a wingspan wider than a Boeing 747 but weighing less than a standard family car, the Si2, if made out of standard paper, would be heavier than it is now.

SunPower provided the 17,000 thin-film solar cells that adorn the plane's wings, tail and fuselage, charging the four lithium-ion batteries that power the aircraft when the sun goes down. The batteries proved to be the 'weakest link' in the overall ecosystem of the plane, adding weight and expense in the first instance, and suffering "irreversible" damage after the Japan-Hawaii leg last summer, causing a nine-month delay.

But such challenges are there to be overcome, and when **pv magazine** caught up with pilot Borschberg in Paris last December at the COP21 conference, he was bullish about the prospect of completing the journey and tearing down mental and physical barriers that he believes continue to hold clean energy back.

"The aircraft behaved extremely well and worked extremely well throughout the journey," Borschberg said. "We had two issues. One, with what I call the virtual co-pilot. This software supervises what the airplane is doing when I am resting. This did not work properly. It is a question of the software not being tested enough, but we are working on that. This created some difficulties when I left Japan.

"Secondly, when I landed in Japan from China, it was unplanned. And because it was unplanned we didn't have all of our infrastructure on the ground so, after landing, we damaged the airplane. It wasn't serious damage and it was repaired easily, but because there had been repairs we then needed to conduct what is called a maintenance flight, which is normal for any type of airplane.

"However, I was unable to do a separate maintenance flight because there is so much traffic in the region where we were, so I had to do it at the same time as I left for Hawaii. So a combination of the maintenance flight and the five days, five nights flight led to temperature increase in the batteries that was over the designed point that we had.

"We decided to change the batteries in Hawaii, and that's the reason why we had to stay there. The technology was no trouble at all. It is the matching of the mission profile with the design of the airplane that didn't work out."

The longest journey

The route taken by Si2 since launching in Abu Dhabi last March may seem arduous, even inefficient, but there is method to the apparent madness. Because the aircraft can only reach a top speed of 70 kmh, and the fact that – in order to reduce the weight of the plane – the cockpit has very little in the way of insulation, the team had to watch weather patterns and seasons very carefully, which is largely why the specific location and date of launch were chosen.

Heading east, the aircraft made stops in India and at various locations in China over the course of last summer before touching down in Japan. From there, Borschberg had to take the controls of the longest leg yet – the five-day flight from Japan, over the Pacific, to Hawaii.

The nine-month-long hiatus gave the team a chance to recharge their mental and physical batteries, with the record-breaking flight resuming in March this year. The Solar Impulse team then made its way eastwards across the U.S., touching down in New York in June. What followed then was more history in the making – the Si2 soaring over the Atlantic on its way to Seville, Spain.

Which brings us to the here and now. From Spain, on to Egypt, and shortly back into the skies for the triumphant final leg to Abu Dhabi, it's been an incredible journey for all involved. The question on everybody's lips now is: what's next?

"Technically we will begin work on an unmanned version of the aircraft, with the aim being to develop an aircraft that can fly into the stratosphere, using solar power of course," Borschberg said. "This will hopefully be capable of flying above bad weather, so higher than 20 km altitude. For one year we have to build up the experience to either replace or complement what satellites can do. There is huge potential in building solar-powered aircraft that can perhaps perform better than satellites, delivering better information and services, all while being completely sustainable and independent from energy you take from the ground."

REAL VALUE

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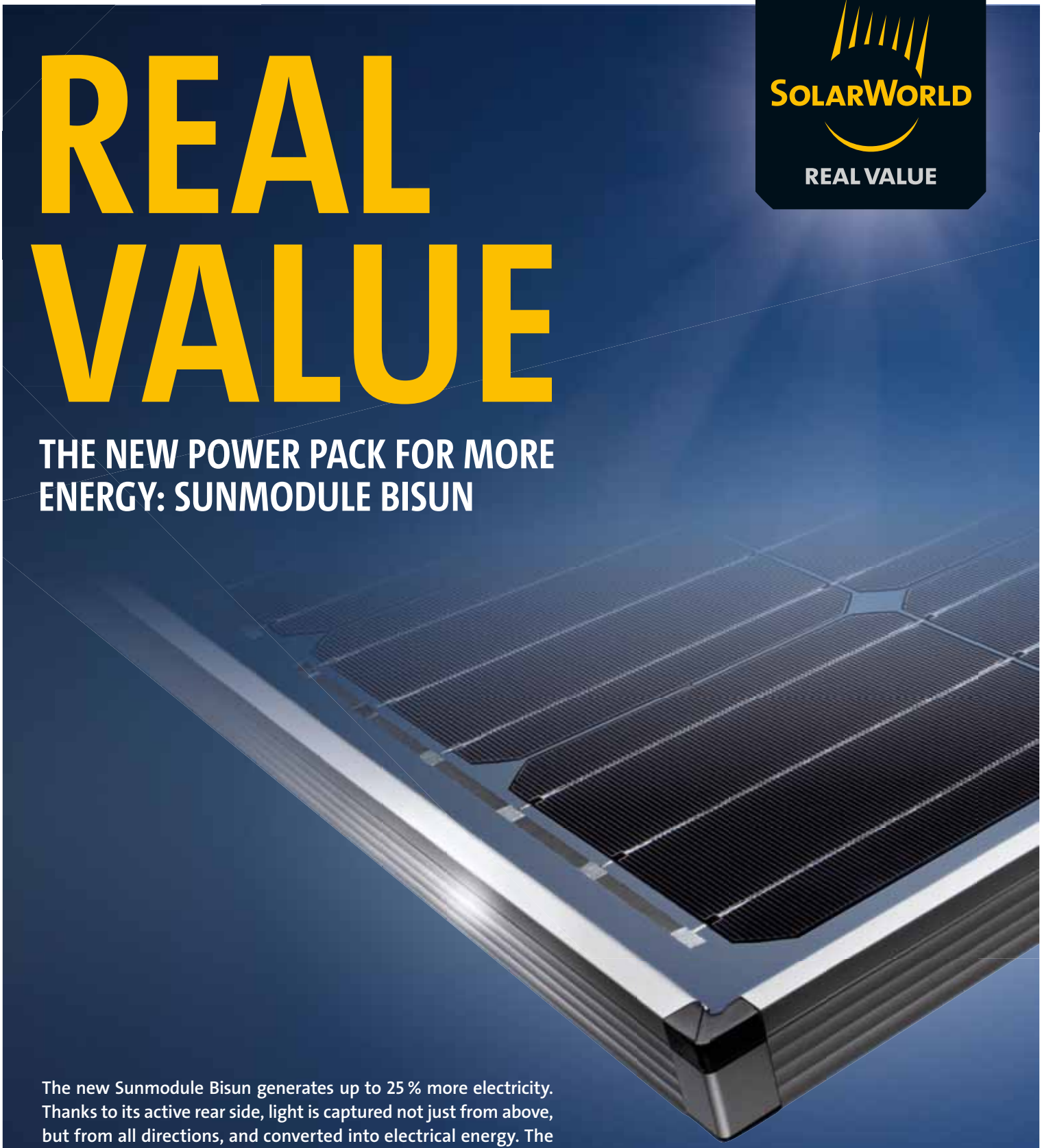
THE NEW POWER PACK FOR MORE ENERGY: SUNMODULE BISUN



The new Sunmodule Bisun generates up to 25 % more electricity. Thanks to its active rear side, light is captured not just from above, but from all directions, and converted into electrical energy. The Sunmodule Bisun is suitable for commercial roof and ground-mounted systems. And it is extremely durable thanks to its use of the latest glass technology.

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pv magazine news roundup

The most important solar stories and eye-catching headlines from the past four weeks

EU opens China MIP investigation

At a time when the EU's MIP and export measures for Chinese PV manufacturers are coming under close scrutiny, the European Commission has announced that it is investigating three Chinese companies for allegedly breaching the terms of the undertaking. The three accused companies are Ningbo Osda Solar, Ningbo Qixin Solar and Shandong Linuo Photovoltaic Hi-Tech, which will be removed from the MIP agreement should the EU's suspicions be substantiated.

The MIP and import volume restrictions were agreed upon by the EU and the Chinese Chamber of Commerce for Import and Export of Machinery and Electronic Products (CCCME) in December 2013 as an anti-dumping measure and were accepted by a large majority of Chinese PV manufacturers. Those who declined the agreement would have large duties placed upon their exports to the EU. The current MIP is set at €0.56 per watt for crystalline modules. In the document, Ningbo Osda Solar, Ningbo Qixin Solar and Shandong Linuo Photovoltaic Hi-Tech were accused of violating the terms of the MIP undertaking. The European Commission listed the suspicious sales and invoices, which all took place last year, in the document. The investigation is set to determine, based on the listed invoices, whether the three companies sold modules under the MIP, which would result in them being excluded from the MIP, as well as duties of around 50% being added to the listed transactions.

Photo: Stuart Chalmers/Flickr

Australia launches storage auction

The government of the Australian Capital Territory has received 17 proposals for its Next Generation energy storage auction, under which as much as AU$2 million ($1.5 million) will be allocated and shared between five companies to install PV solar storage solutions in the capital city of Canberra, New South Wales. A number of Australian companies — some backed by foreign partners — have applied to install more than 8 MW of storage capacity in the national capital. "This grant round is expected to support the roll-out of more than 2 MW of energy storage across more than 600 Canberra homes and businesses," said Environment and Climate Change Minister Simon Corbell in an online statement. "It was a requirement of this grant round that interested companies only use energy storage systems that are capable of responding to changes in energy markets in order to maximize the value for consumers and the electricity network."

The ACT government has positioned solar battery storage as a key element of its plans to slash emissions and develop renewable energy. All bids in the competitive round, which closed on July 6, include at least 10-year product warranties as a minimum requirement. Companies are also expected to open offices in Canberra to provide local support.

Steag connects 15 MW storage system

German energy provider Steag has finalized the installation of its inaugural large-scale battery system next to a power station in the town of Lünen.

Photo: US Dept of the Interior/Flickr

The 15 MW storage system uses LG Chem lithium-ion batteries and is the first of six test projects planned for across Germany over the next 12 months. The 90 MW, €100 million project is scheduled to begin commercial operation in early 2017, with the pilot test plant poised for commercial connection later this summer.

Construction of this storage project began at the end of March, and this testing stage marks a significant milestone for what will, once complete, become one of the world's largest storage projects. The 15 MW storage system is located across one hectare and comprises 11 containers and all associated transformers and auxiliary equipment.

Steag, which is based in Essen, will complete the remaining five storage systems over the coming months, locating each one

close to its own power plants as a means of providing primary control power – essentially stabilizing network frequency during moments of short-term fluctuations in the grid.

Solar corporate funding falls

Mercom Capital's latest report on solar funding and merger and acquisition (M&A) activity does not paint a pretty picture of the sector. The report finds that Q2 2016 venture capital funding fell by more than half while debt funding fell 43% from the previous quarter. Public market financing remained at only $179 million, more than double last quarter but less than 10% of the level achieved a year ago.

The result is a 41% collapse to only $1.7 billion in all sources of corporate funding during the quarter, the lowest level of financing in three years. Mercom CEO Raj Prabhu notes that Q2 was a continuation of the decline seen in Q1, and that the ill fortune of the solar industry coincides with a number of factors, citing SunEdison's bankruptcy and the collapse of yieldcos. However, the biggest factor cited by Prabhu is the ongoing decline in solar stocks, spurred not only by high-profile bankruptcies but also the ongoing collapse in oil prices and other factors.

Photo: Steag

"All of these things have made the public market valuations lower, and with lower valuations it becomes expensive to go out and raise money," Prabhu told **pv magazine**. "We're hoping that it bottoms out now, because it is as low as it can go."

South Korean plans $36bn RE investment

South Korea's Ministry of Trade, Industry and Energy recently announced that the government would be making a series of huge investments into the whole renewable energy industry within the country in an attempt to stimulate growth in South Korea's clean energy sector, with solar PV set to feature heavily. In total, the government plans to invest a meaty KRW42 trillion (US$36.6 billion) over the next four and a half years, which will go into renewable energy infrastructure, innovation and capacity expansions.

Within the announcement, the ministry stated that US$28.8 billion would be invested directly into the renewables sector, US$3.9 billion would be invested into energy storage, US$2.2 billion would be invested into smart metering and $1.7 billion would go to environmentally friendly power development. As part of the investment, the government plans to build renewable power plans with a combined capacity of 13 GW.

The move comes as the government aims to increase South Korea's clean energy economy as well as the renewable energy share in the country's energy mix. To keep up the drive for the planned investment, the government has also increased the target for renewables within the country's energy mix by 2020 from 6% to 7%.

France rolls out solar tender

French Environment and Energy Minister Segolene Royal announced last month the introduction of a number of new solar tenders in France for the development of various PV applications. Chiefly, France is aiming to triple its solar PV capacity to 20 GW by 2023, with the tenders expected to hit incremental goals of 10.2 GW by 2018, and between 18.2 to 20.2 GW by 2023.

Photo: Gary Craig/Flickr

Other tenders announced aim to support France's stuttering building integrated photovoltaics (BIPV) sector, with the French government earmarking 450 MW of BIPV tenders over the coming three years. Another tender will be aimed solely at the country's self-consumption sector, particularly in C&I and agriculture, while 1 GW of tenders for ground mounted PV will be issued annually for the next six years.

An additional 50 MW tender for solar+storage has also been introduced for France's overseas territories. This latest suite of support for solar development follows the previous round of tenders – first introduced in 2014 – that have collectively attracted more than US$1 billion in investment.

For the latest solar news head to www.pv-magazine.com

Brexit bounce-back

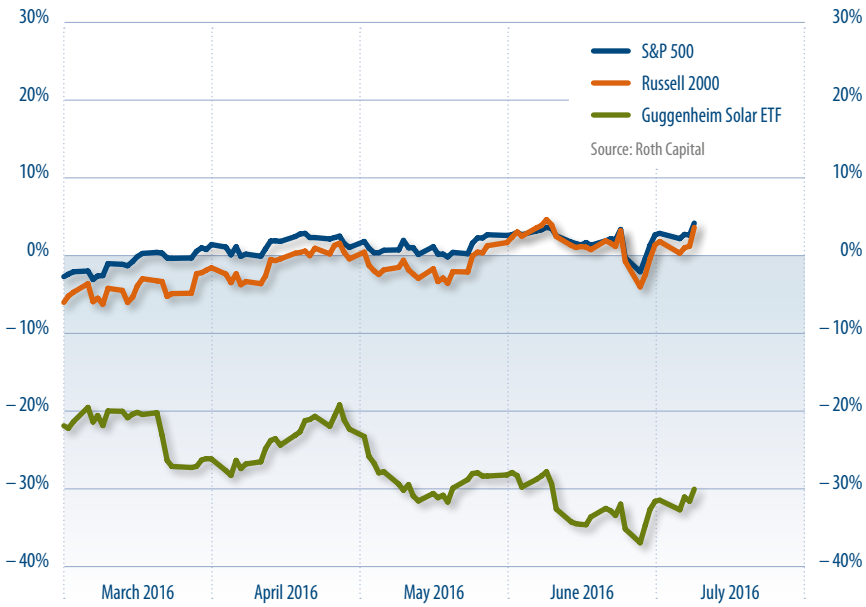
Guggenheim Solar Index: The broader stock market has been on the rise since mid-July despite the Brexit scare pushing market and solar stocks down. Recovery was swift, and for the U.K.'s energy sector in particular it is not all doom-and-gloom.

While the consensus is that Brexit is a negative for the U.K. renewable market in the near term, the longer term impact is more uncertain. It is unlikely Brexit will alter the U.S. and EU charge towards renewable energy. Near term, it will take two years for the Brexit process to run its course. In the meantime, the volatility and drop in the British pound makes overseas ownership of U.K.-based projects less attractive. PV panels, inverters and other infrastructure projects in the U.K. are purchased in Euros, and debt providers and project buyers (many from Germany) will take a pause given the currency drop and less attractive yields.

Longer term, EU 2020 targets for the U.K. are also called into question, and the country has consistently reversed from its support for solar with severe subsidy cuts. The U.K. remains a global leader in offshore wind, but it is reported that much of that is funded by EU nations such as Germany. Ironically, the largest threat to U.K.-based solar and wind may have been the planned EU intercontinental transmission lines to Scandinavia and Northern Europe, which would lower the high wholesale energy rates in the U.K. If a transmission network is stalled, wholesale electricity rates may remain high, but in turn would make U.K.-based solar more competitive since project PPA rates under the ROC revert to wholesale rates after 10 – 15 years. This reversion had been an ongoing negative for project buyers that anticipated a drop in rates. Also, EU duties on imported panels would be removed, thus making them less expensive. Additionally, it is reported that while removal of EU requirements/regulations may make it easier to develop renewable infrastructure in the U.K., there may be no strong incentive to make that happen, other than high fossil energy prices. And since the EU has no formal free trade agreement with the fast growing India market, it is thought that the U.K. may be in a better position to negotiate a free trade agreement with this market. ◆

Jesse Pichel, ROTH Capital Partners

Guggenheim Solar ETF (TAN) Holdings



Graphic: pv magazine/Harald Schütt

Company	Ticker	Month close price	% change June	% change year to date
TerraForm Power, Inc.	NasdaqGS:TERP	12.05 USD	– 10.0%	– 4.2%
TerraForm Global, Inc.	NasdaqGS:GLBL	3.37 USD	+ 0.6%	– 39.7%
Atlantica Yield plc	NasdaqGS:ABY	20.32 USD	+ 4.0%	+ 5.3%
Trina Solar Ltd.	NYSE:TSL	8.25 USD	– 9.3%	– 25.1%
AU Optronics Corp.	TSEC:2409	10.90 TWD	+ 8.5%	+ 12.0%
Hanwha Q CELLS Co., Ltd.	NasdaqGS:HQCL	14.42 USD	+ 15.7%	– 34.3%
SolarCity Corp.	NasdaqGS:SCTY	23.80 USD	+ 8.3%	– 53.4%
8point3 Energy Partners LP	NasdaqGS:CAFD	15.81 USD	+ 0.3%	– 2.0%
REC Silicon	ASA OB:REC	1.68 NOK	– 17.5%	– 6.6%
GCL-Poly Energy Holdings Ltd.	SEHK:3800	1.14 HKD	– 4.5%	– 1.7%
E-Ton Solar Tech. Co., Ltd.	GTSM:3452	11.80 TWD	+ 17.5%	– 4.8%
Meyer Burger Technology AG	SWX:MBTN	3.72 CHF	+ 0.8%	– 37.7%
Sino-American Silicon Products	GTSM:5483	36.90 TWD	+ 12.8%	– 21.1%
Hannon Armstrong, Inc.	NYSE:HASI	21.66 USD	+ 4.4%	+ 14.5%
Xinyi Solar Holdings Ltd.	SEHK:968	3.23 HKD	+ 0.0%	+ 1.9%
Motech Industries, Inc.	GTSM:6244	32.70 TWD	+ 4.1%	– 27.7%
Daqo New Energy Corp.	NYSE:DQ	23.33 USD	– 5.4%	+ 40.1%
China Singyes Solar Technologies Holdings Ltd.	SEHK:750	2.81 HKD	+ 5.1%	– 49.6%
Gintech Energy Corp.	TSEC:3514	24.55 TWD	+ 19.4%	– 23.4%
Danen Technology Corp.	TSEC:3686	8.38 TWD	+ 18.6%	– 23.8%
JA Solar Holdings Co., Ltd.	NasdaqGS:JASO	6.91 USD	– 10.3%	– 28.8%
Sunworks, Inc.	NasdaqCM:SUNW	2.36 USD	– 1.3%	– 36.2%
Solartech Energy Corp.	TSEC:3561	18.80 TWD	+ 13.7%	– 7.4%
Neo Solar Power Corp.	TSEC:3576	17.45 TWD	+ 10.9%	– 28.2%
JinkoSolar Holding Co., Ltd.	NYSE:JKS	19.48 USD	– 3.2%	– 29.6%

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Pimp my PV

Module prices: New installations not on the cards? Then at least tune up the existing systems! Retrofitting storage systems to arrays is a lucrative business.

Prices for modules from Germany, Europe, Japan and Korea, as well as those from Chinese factories, are slowly converging toward the level of Southeast Asian modules, whereas prices for the latter seem to be set in stone. It's tempting to think that we've hit bottom – a market price that cannot go any lower.

That is not the case, but understanding why requires knowledge of what goes into the price index figures. The average values for Southeast Asian modules contain not only prices for Taiwanese, Vietnamese and Chinese brands with local production facilities, but also increasingly prices for German brands produced in the region. Modules from German brands are usually offered at higher prices. These brands can also show up in several categories of the price index if the companies produce modules in both Europe and Asia. This can make market prices for Southeast Asian modules somewhat deceptive, whereas modules that are manufactured in Germany appear to get cheaper and cheaper.

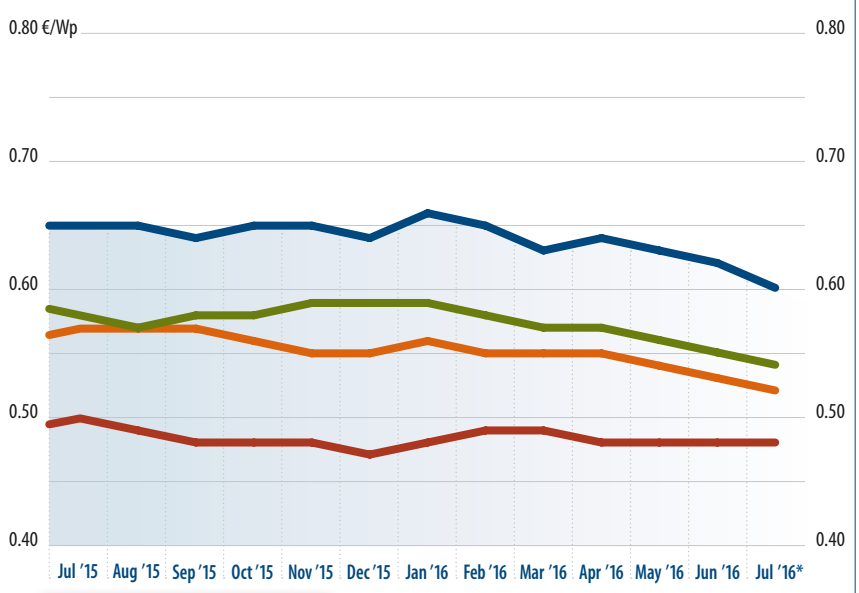
The desolate state of the PV market is not likely to change anytime soon. Its fate has been sealed by, among others, members of government in Berlin who waved through a half-hearted revision of Germany's Renewable Energy Act (EEG) without any major opposition.

Consequently, reactions to the revised EEG have been mixed. A change that met with broad approval was improved support of tenant-PV models through the reduction of the EEG surcharge, which will pave the way for new business models. As anticipated, cuts in PV and wind power through expansion of the tender and a concurrent reduction of volume have been rejected. What remains for PV professionals? If installed capacity cannot be increased significantly in the foreseeable future, they will have to resort to increasing the yield of existing systems. This goes well beyond simple service and maintenance tasks. Let's think about retrofitting storage systems, particularly for PV plants installed between 2010 and 2012 – a highly attractive business. In many cases, expanding systems is also worthy of consideration in areas where the grid connection capacity has not yet been reached. Perhaps most promising is seeking out so-called distressed systems, and then repairing and optimizing them.

A distinction should be made between repowering and refitting. The latter describes the restoration of the proper, expected functionality; for instance, by reworking the substructure or wiring concept without interfering with the actual array capacity. If, however, aging modules and inverters are replaced by the latest high-performance models, this is repowering, a term borrowed from the wind industry. In the latter case, it is advisable to follow the letter of the law to avoid a potentially nasty surprise in the form of lost feed-in payments or even the withdrawal of a feed-in permit. ◆

Martin Schachinger pvXchange.com

pvXchange: EU spot market module prices



Graphic: pv magazine/Harald Schütt

With more than 10,000 registered trade customers, pvXchange is one of the world's biggest brokerage platforms for solar modules and inverters. Ten years of experience in the market and the expertise of more than 20,000 successful business transactions are the basis for pvXchange's monthly analyses of the module price developments in the European PV market.
More information: www.pvXchange.com

Overview of the newly introduced price points in June 2016 including changes

Module class	Price (€/Wp)	Change over previous month	Description
High Efficiency	0.67	-1.5%	Crystalline modules, 275 Wp and above with PERC, HIT, N-Type, or back-contact cells or a combination thereof
All Black	0.55	-3.5%	Module types with black back sheets, black frames and a nominal capacity between 190 Wp and 270 Wp
Mainstream	0.51	0.0%	Modules with usually 60 cells, standard aluminum frames, white back sheets and 245 to 270 Wp; represents the majority of modules on the market
Low Cost	0.36	-5.3%	Low-performance modules, factory seconds, insolvency goods, used modules (crystalline), products with limited or no manufacturer guarantee

(The prices shown reflect average asking prices for duty-paid goods on the European spot market in the month June 2016.)

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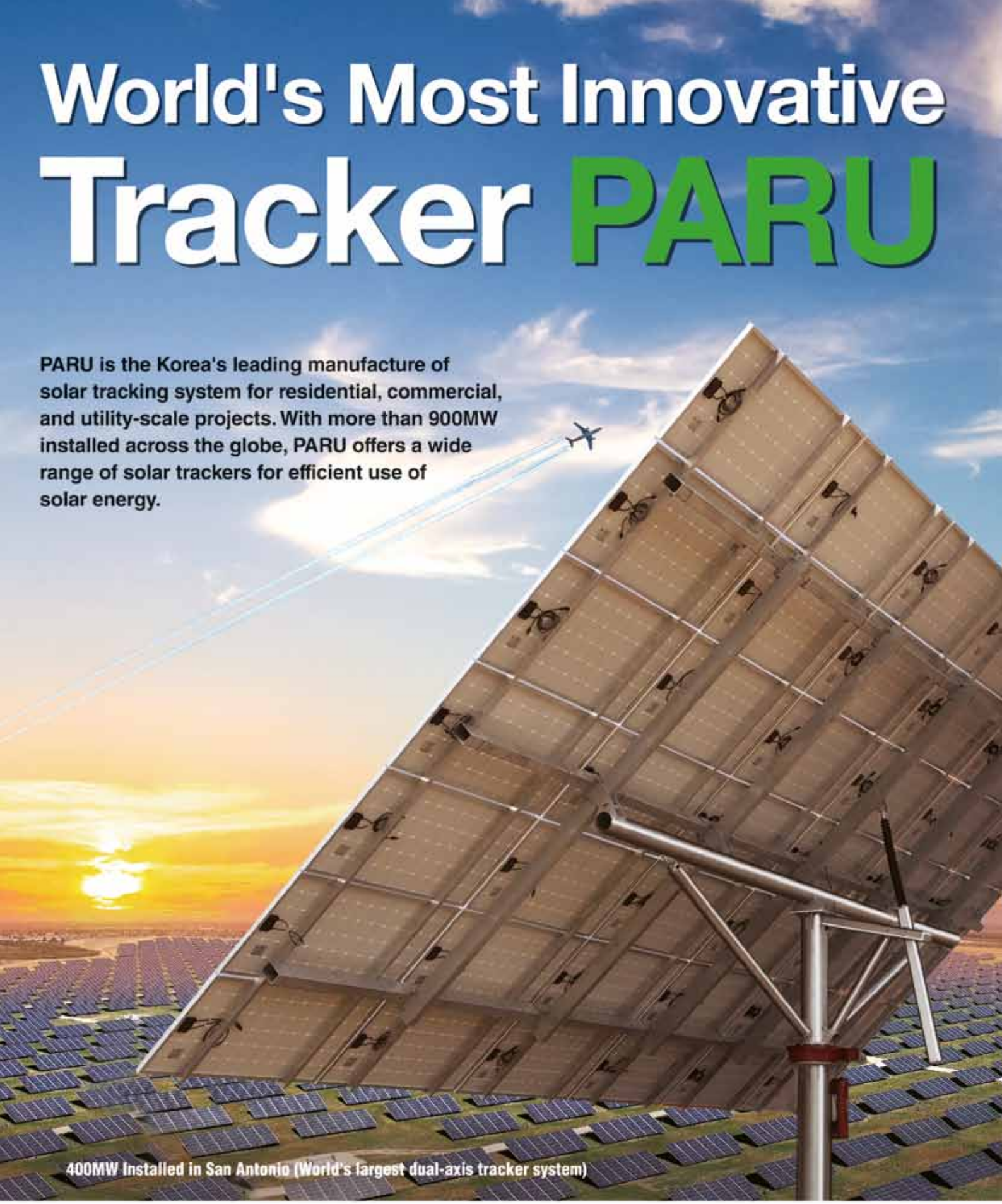
PARU is the Korea's leading manufacture of solar tracking system for residential, commercial, and utility-scale projects. With more than 900MW installed across the globe, PARU offers a wide range of solar trackers for efficient use of solar energy.



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Highlights

- Lowest & Optimized Production Cost
- Minimum Annual Power Consumption
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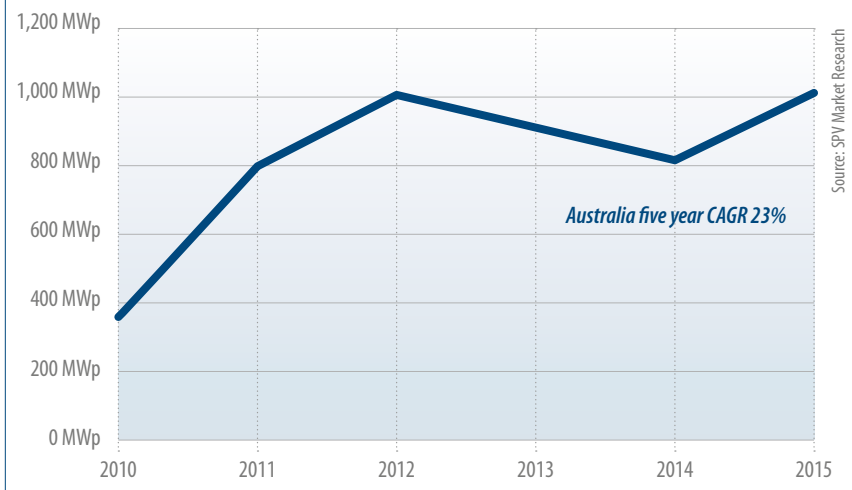
Australia – eventually the land of solar opportunity

Solar Down Under: The progress of Australia's solar PV industry is multifaceted, with residential and commercial strength boosting storage adoption in many regions, but large-scale arrays are still relatively few and far between. Clear and consistent government incentives to support solar would be a huge help, but like many other countries, such stability has been hard to come by.

Graphics: pv magazine/Harald Schütt

Australia solar PV growth 2010 through 2015



The sun resource in Australia is outstanding, its solar manufacturing industry is close to nonexistent and its market is about 1 GWp annually into all applications. In terms of solar PV, the country's most significant export is education. The University of New South Wales (UNSW), the Australian National University (ANU) and other Australian higher education establishments are educating the world's PV scientists. In fact, Australia could well be considered the parent of China's manufacturing industry.

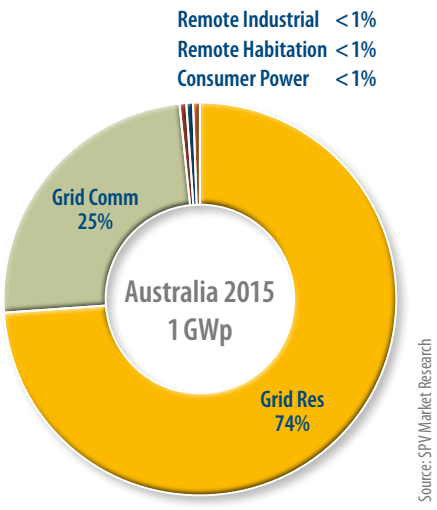
Australia is the world's sixth largest country in terms of land mass after Russia, Canada, China, the U.S. and Brazil. The majority of the country's 23.8 million people are concentrated on the two coasts east and south. Since deregulation, electricity prices have increased. At the present time more than 70% of the country's electricity is coal generated, and the use of natural gas is growing. The country exports more energy resources than it uses.

Australia's PV penetration is highest along its south coast, where electricity generation is sometimes 100% via solar and wind. The government has indicated a switch to renewables and more energy efficiency. It will take time and, most importantly, market incentives to encourage the strong adoption of solar.

As indicated in Figure 1 (left), from 2010 through 2015, solar PV deployment in Australia grew at a compound annual growth rate of 23%.

Australia continues to have a market for off-grid deployment, particularly in remote areas. Mining operations have indicated an interest in PV and CSP microgrids. The market for large scale solar has yet to emerge. In Australia solar PV deployment is primarily rooftop into commercial and the residential applications. Solar PV system buyers have an active interest in the use of batteries primarily to provide independence from the local utility. Concerning the latter, in this regard utility consumers in Australia are like rate payers everywhere – eager for

Australia's PV deployment mix 2015



SPV MARKET RESEARCH

Paula Mints is the founder and chief market research analyst of the global solar market research firm SPV Market Research. Paula began her solar market research career in 1997 with Strategies Unlimited. In 2005 she joined Navigant, where she continued her practice as a director in Navigant's Energy Practice until October 2012, when she founded SPV Market Research.

Mints' areas of expertise include global markets and applications for solar products; cell and module cost and price analysis; system and system components (including inverters, trackers and other BoS components) analysis; and trend analysis.

CHINESE WIND FIRM GOLDWIND TO BUILD 20 MW SOLAR PLANT IN AUSTRALIA

The White Rock PV array, which will be situated on the northern end of the Urumqi-based company's 175 MW White Rock wind farm, 18 km west of the town of Glen Innes, near the Queensland border, was approved for development in mid-June by the planning and environment department of the state of New South Wales.

It has not revealed the PV module supplier for the project. Goldwind began preliminary work on the site, roughly 500 km north of Sydney, in May. The solar array will likely generate about 46 GWh of electricity in its first year of operation, or roughly enough to cater to the needs of approximately 7,200 homes in New South Wales.

If the company manages to secure an undisclosed sum under the Australian Renewable Energy Agency's (ARENA) competitive grant scheme for large-scale PV projects, it expects to complete the solar portion of the White Rock site in late 2017.

The array will share the infrastructure of the wind farm, including TransGrid's 132 kV transmission line in the area, as well as access tracks and a portion of the internal electrical cabling.

The company claims the use of the wind farm's infrastructure could ultimately contribute to total savings of AU$5 million ($3.77 million). The adjacent White Rock wind farm will be the biggest wind farm in New South Wales when it is completed in late 2017. John Titchen, managing director of Goldwind Australia, said in an emailed statement that the group sees enormous potential to develop solar and wind projects in the Northern Tablelands region of New South Wales.

Goldwind - the world's leading wind turbine supplier in 2015, according to Navigant Research - has been gradually diversifying into solar project development in recent years.

In February of this year, it finished building a micro-grid project in northwestern China's Ningxia Hui region that pairs a 2 MW wind turbine with a 375 kW solar array with a vanadium flow storage system.

The pilot site includes PV modules mounted on a dual-axis tracking system, specifically designed by wholly owned group unit Etechwin for use in industrial parks and applications in isolated locations. And in June, Goldwind obtained local approval to start developing an 11 MW solar project in the New South Wales town of Crookwell, roughly 120 km north of Canberra. ◆

Brian Publicover

independence from the utility but needing an incentive of some sort to get them there.

It should be clear by now that all over the world increased deployment of solar (all technologies) requires government incentives or mandates of some sort. Coal, oil and natural gas enjoyed direct and indirect incentives for, well, thinking of diesel, coal and oil (not to mention natural gas), hundreds of years. Nuclear likewise requires incentives to build or it is simply too expensive. Renewable energy technologies need, and there is nothing wrong with this need, government-backed direct and indirect incentives. This brings to mind something else that Australia has in common with other countries in terms of incentives for solar: incentives are popular one year and unpopular the next depending on the makeup of the government.

Australia has high potential for increasing deployment of solar PV way above the 1 GWp market. Here's hoping it institutes the consistent, stable programs needed to do so. ◆

Paula Mints

Photos: Solar Promotion

While crowds diminished significantly by day three of Intersolar Europe 2016, the event grew visitor numbers back to 2014 levels.

Europe's leading show goes on

Intersolar Europe 2016: Battery storage was the main topic as Intersolar returned to its spiritual home of Munich again this year for the 25th iteration of the key solar event. Alongside the battery providers, key suppliers from across the PV supply chain were present and signs of opportunities on the horizon and beyond Europe's borders delivered an event more upbeat than the contracting European market could have offered.

25 years is no mean feat. And some of the other numbers behind in the 2016 Intersolar Europe, which saw organizers Solar Promotion hit the quarter century milestone, are equally impressive. 44,000 attendees from 160 countries made their way through the Intersolar turnstiles in Munich this year, a YoY increase of 18% and roughly on par with 2014.

Booths also appeared to have grown in size, with the exhibition covering 66,000 m^2 across six halls, up 8.4% on the previous year. Strikingly, storage companies at the co-located ees Europe exhibition truly arrived in 2016, with the storage hall bringing together established providers such as Sonnen, E3DC and Senec, alongside newer arrivals like Mercedes Benz Energy Storage and Solarwatt. The links between battery storage and e-mobility were clear with the latest e-cars, and even a Formula E race car, adding some glamor to the event.

The 2016 Intersolar Europe was held alongside the leading European PV academic conference, the EU PVEC for the first time. This brought the leading

EU PVSEC 2016: PERC AND HJT

Photo: EU PVSEC


Photo: EU PVSEC

From June 20 through 24 more than 1,700 PV experts gathered in Munich to attend the 32nd edition of the European Photovoltaic Solar Energy Conference and Exhibition (EU PVSEC). More than 1,000 oral and visual presentations were given on the latest developments, both at research institutes as well as at the industry R&D centers, making it the world's largest PV research and innovation event.

Photovoltaic industry contributions to the advances in PERC production technology as well as in heterojunction cell technology played a prominent role in the presentations.

Hanwha Q-Cells showed how over a period of eight years the company has been able to increase cell efficiencies by 0.4% absolute on average per year by continuously tweaking all the different levers from optimizing fine line printing to adopting novel metallization pastes and improving rear side passivation.

As cell technology advances the focus areas where losses can be minimized in the future also shifts. The rear contact contributes roughly a quarter of the overall recombination current. At efficiencies above 20.5% the front side passivation becomes an equally relevant contributor to recombination losses thus drawing more attention to optimizing this aspect in future developments.

Ultimately Hanwha Q Cells expects that advances of the assembly and interconnect technologies at the module level can yield similar efficiency improvements as the cell technology roadmap.

Meyer Burger, as one of the key equipment suppliers for HJT cell technologies, co-authored a number of presentations on this technology.

With pilot production runs of more than 1,200 cells per day the company achieved more than 22.5% cell efficiency on average.

Researchers at INES in France used equipment from Meyer Burger to produce cells with efficiencies above 22% on wafers as thin as 80 µm.

For breakage rates to remain within reasonable boundaries when using current production tools the researchers found it was advisable to use wafers 100 µm – 120 µm thick. Going to thinner wafers would require major adjustments to current handling and automation tools.

An interesting approach to manufacturing HJT solar cells was presented by the Chinese cell and module manufacturer ENN.

Back in 2009 the company had purchased a Sunfab from Applied Materials for thin film a-Si/µ-Si module production on large area glass substrates. As the limited module efficiency of 10% – 11% achieved in industrial production on these tools soon killed the business case for thin film a-Si/µ-Si modules, ENN decided to reconfigure the tools and use them with silicon wafer substrates instead. After many years of redesigning and improvements ENN reported average cell efficiencies of 21.6% for HJT solar cells manufactured on these retrofitted tools.

Given the fact that Applied Materials has shipped some 20 Sunfabs to customers around the globe in 2009 and 2010 one could envisage to upgrade these tools and establish more than 2 GW of HJT cell production capacity.

One stand-out presentation from research institute imec in Belgium was on a novel interconnection and assembly technology for modules based on a woven fabric into which conducting and insulating wires are interwoven.

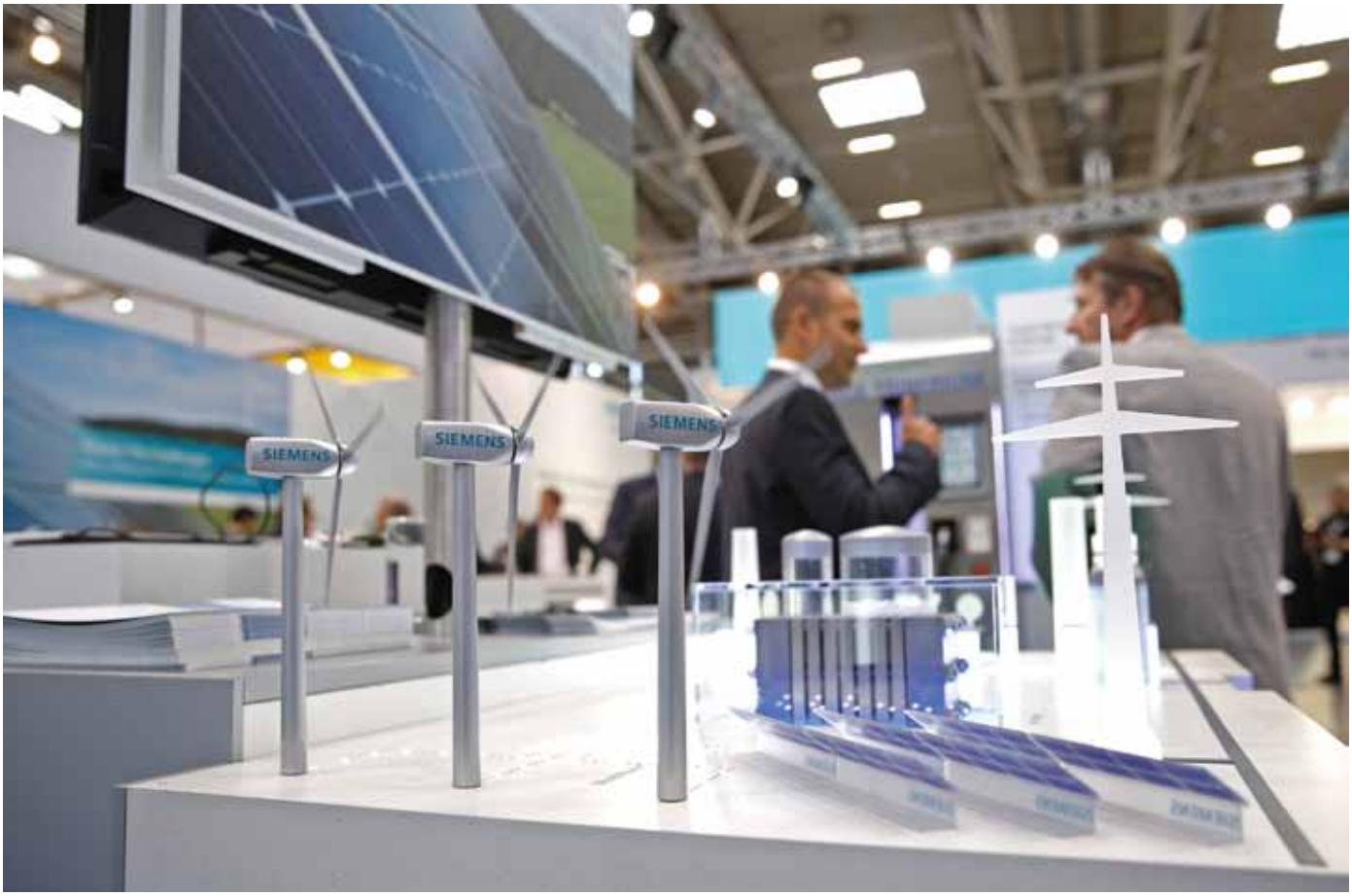
Such a technology is particularly interesting for back-contact cells where an interconnect design adapted to the cell design is required.

As of now this approach has only been tested at research lab level. Yet manufacturers of encapsulants have voiced their interest to participate in the effort to explore the chances of making this approach a viable production technology.

Maybe at EU PVSEC 2020 we might discover presentations of manufacturers that have adopted such a novel interconnection approach to their module production. ◆

Götz Fischbeck

"As cell technology advances, the focus areas where losses can be minimized shifts"



Siemens came onboard as the Gold Sponsor of the Smart Renewable exhibition, in which Intersolar organizers Solar Promotion showcased the technologies and companies enabling higher penetration rates of PV on the grid today.

minds from the research community to the exhibition floor, although reports as to the success of this coupling of events were mixed. One criticism was that by bringing the two events together, to create "the international solar energy sector's top event," in the words of Intersolar organizers Solar Promotion, was that there was insufficient time over the week to fully participate in either. **pv magazine** spoke to one CTO of a major Chinese manufacturer racing from one venue to the other who summed it up simply: "It's just too much!"

"The organizers are still evaluating the recent event, however, so far the cooperation was very successful and we assume that it will continue," said a Solar Promotion spokesperson in a statement. The Intersolar conference and side events, which admittedly had never been the center of attention in Munich, attracted 1,400 participants, but the logic of hosting both the EU PVSEC and Intersolar conferences concurrently may be questionable.

Alongside storage, Intersolar organizers Solar Promotion embraced the evolving renewable landscape this year, bringing together providers of renewable-enabling technology under the banner Smart Renewable Energy. This admittedly broad classification encompasses a range of technology and business models, including smart home, smart grid technology and the Internet of Things, platforms for the trading of electricity, virtual power plants, and the intersection of renewables and information technology. Siemens came onboard as the Gold Sponsor of the Smart Renewable exhibition space with inverter suppliers SMA and Fronius along with utility E.ON and Viessmann sponsoring the Smart Renewable Forum. More than 60 companies came together to form the Smart Renewable exhibitors.

EXPERIENCE INTERSOLAR EUROPE WITH PV MAGAZINE ON YOUTUBE

While the power of the written word is unquestionable, the **pv magazine** team embraced video like never before at this year's Intersolar Europe. Visit the **pv magazine** global YouTube page to watch coverage of the event, including interviews with Solar Power Europe, IHS, Jinko Solar, NEO Solar Power, ABB, flexible module producer Das Energy, Dow Elastomers and Coveme. The Solar Superheroes made their European debut in Munich, and that was captured in a stylish video, and Smart Solar Consulting CEO and **pv magazine** expert author Götz Fischbeck took the time to take viewers on a guided tour of the hall B1, in which the major storage suppliers were based, to provide a whirlwind overview of the offerings and strategies being deployed in the surging German storage market.

Europe remains cloudy

While the sun came to the party at Intersolar 2016, with glorious conditions outside giving rise to at times sweltering conditions within, the forecast for European markets in 2016 remain somewhat clouded. IHS tips 8.8 GW to 9 GW (see p. 30) for 2016, with France and the Netherlands performing strongly, while Germany limps along, Italy stumbles and Spain remains largely prostrate. Positively, IHS expects growth to return to the European markets "within the next years."

On the edge of Europe there are better stories to tell and Turkey continues to grow in its own unique fashion, and projects in some former Soviet markets, including Russia, are getting off the ground (see **pv magazine** 05/2015). In what has been a growing trend over the past few years, Intersolar Europe again drew visitors from far beyond the EU: Turkish developers were on site meeting with components suppliers, and there were reports of Russian developers in the market for production equipment, to be deployed to meet the opaque domestic content provisions within the country's project allocations.

Industry body Solar Power Europe had a strong presence at Intersolar Europe in 2016 and while its forecast for the continent's markets is for contraction to below the 8.2 GW achieved in 2015, CEO James Watson said that there "might be a [demand] spike in 2017" but that it remains dependent on how French and German tenders pan out.

"It is very hard for all of the manufacturers along the value chain and all along the supply chain, from polysilicon, to fabs and equipment all the way down to balance of systems," explained Watson. "When markets are relatively stagnant, it is difficult to make money." However, Watson pointed to opportunities "beyond these shores," such as in North Africa, sub-Saharan Africa, the Middle East and India where, "manufacturers can go, support these countries to develop solar systems and to take advantage of the opportunities there." Solar Power Europe hosted a conference, with sponsors RECP, about African PV markets on day two of the show. Watson's message was simple: "You've got to look a little bit overseas, as well as focusing on the European market. Diversification is key."

Europe today remains the base of many leading EPC companies operating globally, and component suppliers exhibiting at the show reported to **pv magazine** that while some of the deals done and contacts made during the event may not be for installations in Europe itself, European developers still play a key role in the global industry. ◆

Jonathan Gifford

Storage providers attracted big crowds to even bigger booths this year.

Photo: Government of Pernambuco

The largest PV plant to date in Brazil is a 11 MW complex of Enel Green Power, located in the state of Pernambuco.

Sufficient market to create an industry?

Brazil: Brazil's current energy glut and political and economic difficulties have forced it to cancel one of its 2016 solar power auctions. Nevertheless, the industry hopes that in the October tender up to 2 GW of solar will be awarded. Meanwhile, of the 3 GW awarded previously, and which ought to go into operation between 2017 and 2018, only 700 MW are currently under construction.

Developers of more than 9 GW of solar power projects have recently been forced to reconsider their strategies. They were getting ready for the tender scheduled for the end of July when, out of the blue and just a month before the publication date, the Brazilian government decided to postpone it. In fact, it may even be cancelled, which is one of the sector's fears following Minister for Mines and Energy Fernando Coelho's statements at the Brazil Solar Power show.

Dangling a metaphorical carrot in front of the sector after applying the stick, the minister told the solar industry at the recent event in Río de Janeiro that the tender scheduled for October 28 would go ahead. The ambiguous statements that there will be at least one solar power tender this year and that the Brazilian government "will continue to buy energy" led more optimistic industry insiders to believe there may yet even be a second auction in 2016. They also settled the nerves of more pessimistic stakeholders who feared for all the solar power tenders scheduled for 2016. "Before buying new energy, the ministry needs to address several issues, diagnosis of which is almost complete," the minister said. "Several steps are already being taken, above all regarding overbuying." In the three rounds involving solar power since the country held its first annual renewable energy auction in 2014, the government has awarded almost 3 GW of 20-year PV PPAs. However, electricity consumption doesn't appear to have risen at the same rate: according to the bulletin published by the EPE, Brazil's national energy planning body, in the 12 months up to May electricity consumption fell 2.5% year-on-year.

The drop in demand is closely tied to Brazil's ongoing recession. GDP slumped by 5.4% in the first quarter and was accompanied by a political scenario that in May led to President Dilma Rousseff's temporary dismissal, a situation that could be made permanent in August. According to the head of Brazil's Absolar solar power association, Rodrigo Lopes Sauaia, acting President Michel Temer intends to continue the transition to solar power begun by the Rousseff administration.

"Continuity is vital if the sector is to keep developing," stated Sauaia. "This year, Brazil needs to put those 2 GW out to tender. What's more, to meet energy demand they'll need to be up and running by the end of 2019," he explained. According to Absolar's calculations, that's the solar capacity that would need to be auctioned every year to meet Brazil's energy targets.

Uncertain October auction

In 2017, 2 GW awarded in previous rounds are due to come online, with the remaining 1 GW set to become available in 2018. That's the same date by which the power quota awarded in the canceled tender would also have had to be operational. "And power still hasn't been contracted for 2019," Sauaia pointed out.

Against this backdrop, and with minimal information about either the power being put out to tender or the reference price, 393 PV plants with a combined capacity of 12.5 GW have been registered for the tender scheduled for October 28. The round also allows for wind power, which has double the participants: 799 registered proposals totalling almost 21 GW.

The tender specifications will not be published until August but, according to ministry sources speaking at Brazil Solar Power, bureaucrats managing the tender are thinking about including other technologies as well. It is worth underlining here that July's canceled tender was expected to attract almost 1 GW of hydropower capacity.

Uncertainty puts sector at risk

Although the industry is confident that the government will answer its call to auction 2 GW this year, uncertainty about the solar power volume contracted from 2016 onwards is putting a brake on the sector's plans. And that not only affects future projects, but also capacity already awarded. Many of the plants contracted in previous rounds had planned to obtain finance from Brazil's BNDES development bank. However, this is linked to compliance with the local content requirements set in the solar power programme. In fact, the vast majority of projects awarded in the 2014 round are

expected to receive BNDES funding, provided at an interest rate much lower than what is available from commercial banks. These plants will have to be operational by the end of 2017, by which date the specifications stipulate 60% local solar module content.

To meet those demands, local manufacturing facilities will need to be in operation. However, if the contracting volume isn't attractive enough, it is likely that some of the many industry support plans announced will suffer.

In fact, several companies awarded contracts in that tender have asked for more time to complete the projects, a request denied by the Aneel electricity regulatory agency in June. What's more, the lack of domestically produced modules isn't the only difficulty developers face - the average energy price stood at BRL 212.5 per megawatt-hour, which, following the currency's devaluation, works out at around $66/MWh.

Given the context, industry representatives have asked for local content requirements to be relaxed, and BNDES won't openly oppose that proposal. "The BNDES is open to dialogue," said BNDES manager Nelson Tortosa. However, for the moment nothing suggests that the request is likely to be granted any time soon. Local newspaper Folha de Sao Paulo even reported in July that the government considers canceling the contracts of almost 900 MW of projects awarded in the first solar auction.

A big enough market?

Without an unequivocal sign from legislators that plans to embrace solar remain unchanged, the industry's commitment is likely to waver. So far, Brazil has five module factories. With the exception of the Globo Solar plant, which has a 180 MW production capacity, all of them are small-scale operations. Nevertheless, plans for major new manufacturing facilities are being drawn up. At the end of April, the BNDES reported it was processing requests to accredit a further four factories under the Finame local content program. Overall, that would be equivalent to 1 GW of production capacity.

Furthermore, several firms have announced they will open new solar power factories. For example, China's BYD plans to start work at a module plant in Campinas in the state of Sao Paulo in the first quarter of next year. It initially intends to make 200 MW modules per year, with a view to raising that to 400 MW.

In mid-June, Canadian Solar also announced it would build a 350 MW capacity module factory in Sorocaba, Sao Paulo, and expects production to start in April 2017. S4 do Brasil has also said it would launch production at a 200 MW facility in Pernambuco by the end of this year.

Enel: a case apart

One company for which plans don't seem to depend on whether or not module factories arrive in Brazil is energy giant Enel. Operating Brazil's biggest power station to date (Fontes Solar, an 11 MW facility awarded in a tender held by the state of Pernambuco), the group's independent approach appears impervious to local content issues.

As it finances its projects from its own funds and so is not subject to the BNDES's local content requirements, Enel Green Power Brasil (EGPB) is the only company to have been awarded capacity that shows evidence of having facilities under construction.

Awarded around 900 MW of PV in the first two auctions, EGPB didn't have much difficulty starting work last December on the 254 MW Ituverava plant. Won in the first tender round held in October 2014, the facility is located in Bahia. Moreover, in April, EGPB started work on its Lapa solar farm in the same state. This 158 MW project was awarded in the second auction, held in November 2015. In early July, the company also announced the start of work on the Nova Olinda power plant. Located in the state of Piauí, at 292 MW, also awarded in the second bidding round, it is currently the biggest facility under construction in Latin America.

Nevertheless, Brazil's solar market has more than enough room for other players. And that is why Absolar President Nelson Colaferro has called on the government to prove its good intentions to the solar PV sector by raising the technology's quota in the next ten-year energy plan. The aim of the last one, the PDE 2024, is to develop 8.7 GW; 7 GW of which correspond to solar. According to Reuters, there are plans to increase solar and wind power's share of the electricity mix from 6% at present to almost 30% by 2050.

Upturn in small-scale facilities

To achieve that, encouraging distributed generation will be just as important as holding big auctions. The small-scale PV segment is perking up thanks to the improvements made last year to the net metering scheme, which came into effect in March. By May, there were already 3,565 systems registered under the scheme, more than twice the 1,675 at the end of the previous year. System capacity has also shot up in recent months, climbing from almost 17 MW at the end of 2015 to nearly 30 MW by May, state Aneel sources. PV plants account for around 80% of net metering capacity.

That growth has been encouraged by improvements in the tax regime that grant net metering producers in the majority of Brazilian states exemption from goods and service tax, and by introducing new nationwide net metering regulations applicable since March. Amendments to the scheme includes an extension of the credit exchange deadline from 36 to 60 months and an increase in maximum system capacity from 1 MW to 5 MW.

Photo: Deutsche Welle/Flickr

A 400 kW solar facility at the Pituacu stadium was unveiled in April 2012, triggering huge interest.

As is the case with the big plants, net metering's biggest obstacle remains finance. The government is considering allowing the FGTS workers' fund to finance solar facilities – a proposal currently being discussed by legislators.

Meanwhile, the same crisis affecting the big solar farms also seems to inhibit the small scale market. "If it weren't for the crisis, there'd be greater growth in net metering facilities," said Solarize's Hans Rauschmeyer. Nonetheless, he's highly satisfied with the amendments to the net-metering scheme in effect since March. "It's still growing," he affirmed. ◆

María Sarado, Blanca Díaz López

Photo: European Parliament/Flickr

Former UKIP head Nigel Farage, left, and president of the European Commission Jean-Claude Juncker interact in Brussels days after the U.K. voted to leave the EU. The uncertainty of that historic vote will persist for months.

A light that never goes out

Brexit: The shockwaves and tumult caused by the unexpected decision by the U.K. to vote out of the EU are still being felt, and will be for a long time. With the dust barely settled, various agencies are already at work maneuvering their policies and outlook, with the country's energy landscape at the sharp end. Solar, and renewables more widely, have opportunities amid the fallout.

The talk of Europe over the past month has been all about Brexit. Politicians, businesses, investors, journalists and, above all, citizens are still trying to figure out what is going to happen to British and European economies and societies as this unprecedented period in European history evolves. Energy policy is not immune from this uncertainty. Analysts of every sort are now offering their predictions on the future of the U.K.'s energy development. However, rather than adding to the guesswork, it is more useful to examine where British energy policy and market development is today and overlay it to post-Brexit dynamics.

Where are we now?

News of recently added renewable energy installations across the U.K. continue to emerge, and solar is still keeping installers busy. The crucial detail, though, is that current renewable energy installations are the result of past policies that are now either defunct or have been significantly altered. In practice, this means that the only existing policy framework for investors to develop large-scale solar PV projects with subsidies in the U.K. is the so-called Contracts for Difference (CfD) mechanism, which awards the successful bids of a competitive tender process a set premium on top of the wholesale energy price.

The inaugural CfD auction was held in February 2015 but a second auction is yet to be announced. The U.K. government had initially said it would announce a second CfD auction months ago. Not that a new auction would trigger huge PV investment, however: the structure of the mechanism tenders PV systems together

Photo: London Public Library/Flickr

Rooftop solar PV is an increasingly common sight across the U.K., with the residential sector proving particularly fertile as customers were attracted by generous FITs prior to recent subsidy cuts.

AT A GLANCE

- Prior to the Brexit turmoil, solar in the U.K. was already facing an uphill battle in the wake of shrinking subsidy support from government.
- Brexit's immediate impact is likely to be felt at the more grassroots, innovative level, with smaller companies already tightening their belts.
- The introduction of the capacity market in 2014 served to centralize the country's energy system, and will likely be strengthened in the short term by Brexit.
- However, the controversial nuclear plant at Hinkley Point C is now unlikely to be built, posing the question of just how this energy shortfall can be plugged.
- Solar and renewables – supported by a bold, U.K.-led carbon reduction target – can hope to gain here, meaning all is not lost.

with onshore wind projects and thus poses significant barriers to solar.

The second existing market route driving solar uptake in the U.K. is the feed-in tariff (FIT). This is only eligible for systems up to 5 MW, the level of tariffs has been largely reduced since January 2016, and installation activity is capped. The present U.K. solar PV activity that generates news of recently added installations stems from the Renewable Obligation (RO) scheme, which is now completely scrapped but does boast a handful of grandfathered projects that ensure a steady drip of new connections will continue for a little while longer.

The hope that once was

Under such a policy landscape, the U.K.'s solar PV stakeholders have turned their focus on to new and innovative business

Photo: Vicente Fernández Rioja/Flickr

With just 52% of the vote – and based on a voter turnout of below 80% – the 'victorious' Leave side has come into criticism for basing their campaign on a series of lies, half-truths and misinformation, triggering anger among Britain's younger population who feel they have had future opportunities taken away.

models that bypass subsidy schemes and make new installations viable. Such models, business stakeholders and industry associations claim at various sector conferences and events, will revolve around specific power purchase agreements (PPAs) with customer-tailored projects. Most often, PPA projects will also include onsite storage to maximize the benefit for the end user and make the business case stronger.

In cases where technical constraints are in place, for example the distribution grid being unable to absorb larger amounts of variable power generation, innovative projects might offer solutions. Such is the case of the "Sunshine Tariff" project in the South West England county of Cornwall. The local Cornish community of Wadebridge and surrounding villages was told they could not proceed with their plan to develop a community solar farm due to grid constraints and the only solution on offer was to change the relationship between power generation and consumption. Thus, the community is now trying to shift the power demand pattern and incentivize daytime power consumption so that the generated power from the solar farm is consumed when generated and does not have to be exported via the grid.

This is where Brexit is having an immediate impact. At the annual event of the U.K.'s All-Party Parliamentary Group for Renewable and Sustainable Energy (PRASEG) that took place in London in July, Sara Bell, founder and CEO of Tempus Energy, an innovative utility that also participates in Cornwall's "Sunshine Tariff" project, told the attendants that Brexit had already left its mark on innovative energy companies and business models.

"To persuade an investor to put money into an early stage innovation company requires them to take an outsized risk," Bell told the conference. "And the reason you need to do that is because so many early stage innovation companies fail. That's the reality," Bell added. "In a safe and calm environment, that is challenging but possible. In the current environment [post-Brexit] it is going to be almost impossible to raise investments for innovation companies," she noted. "In the last week, every innovation company I have spoken to has cut between 20% to 50% of their staff because they know they can't fundraise." Innovative companies cut staff to survive. "This matters," Bell added, "because if we want to move to a zero carbon system at the lowest price for the customers, we need every innovation company out there."

Centralized forces receive a boost

Another area of British energy policy that might be affected by Brexit dynamics is the centralized character of the U.K.'s energy system. As innovative business models in energy lose impetus, the centralized character of energy in the U.K. could, on the contrary, be set to gain.

The victory of the centralized energy system forces was confirmed two years earlier when the U.K. adopted the capacity market mechanism to remunerate existing and new fossil fuel-based and

nuclear power plants. Traditional power market incumbents had argued that their income has been severely cut (partly due to the rise of renewables), leaving them unable to build new power plants or keep operational ones viable. Responding to this, the U.K. government introduced the capacity market, arguing that the country faced a looming energy supply gap as old nuclear plants and many of its polluting coal-fired stations are due to close by the end of the decade. A capacity market will make it affordable to replace them. Otherwise, DECC argued, the country risked blackouts as early as 2018. The U.K. ran its inaugural capacity market auction in December 2014 and a second capacity market auction in December 2015, subsidizing about 49 GW and 46 GW of coal, gas, nuclear and diesel power generation.

The move to a sustainable and decentralized energy future will not come via the energy market incumbents, which most of the time block innovation because it works contrary to their own, established business model, Bell told the PRASEG conference. "Nowhere is this more evident than in the case of the capacity market, where incumbents protected their generation assets at the expense of their customers," she pointed out.

Rather interestingly, Bell added that "we took legal action at the European Court of Justice (ECJ) to appeal the state funding for the capacity market because it is an anti-competitive measure that subsidizes coal assets, nuclear plants and diesel installations. But as a result of Brexit we will not be able to enforce any ECJ judgments, and all of the U.K. electricity bill payers will be paying for the capacity market subsidies."

Not that an ECJ ruling is certain to rule against the U.K.'s capacity market, which had previously been cleared by the European Commission. However, the case is an indicator of the policy dynamics emerging following the U.K.'s departure from the EU. As a member, the U.K. had to comply with European competition laws that play a role in the British renewable sector.

Some believe the argument that the EU competition law might protect the U.K. renewables industry that has grown on the back of public subsidies to be bizarre. But it is not. The U.K. electricity market has stopped being the poster child of the liberalization efforts that it once was, and now relies entirely on public subsidies (mainly via the capacity market and to a lesser extent via past renewables subsidy schemes) to keep the lights on. Every single power generation technology is subject to state subsidies and the state alone decides the generation mix. In the absence of EU competition laws, the U.K. can decide to boost the market incumbents even further without consulting an alternative EU voice.

Targets, what targets?

Last but not least, the EU renewable and emissions reduction targets will no longer be binding. It is true that U.K. has its own ambitious climate change bill in place, and in late June the government also announced a new carbon target for the early 2030s. The U.K.'s Department of Energy & Climate Change (DECC) set the target of reducing carbon emissions 57% by 2030 on 1990 levels, which is tougher than the carbon emissions target it signed up to as part of the EU, which requires a 40% reduction by 2030 on 1990 levels. This is a positive development that was also welcomed by the country's renewable energy associations, including the solar industry. However, a question remains: the new U.K. target, the so-called "fifth carbon budget," is legally binding, but who can punish the state if it is not met?

Think what you wish

Of course, all is not lost. Perhaps the British policy-makers develop a sudden zeal for renewable energy and a decentralized energy system, foster the move to the digitization era and reconsider their passion for nuclear power. Specifically, the latter might happen even if they do not wish for it.

Speaking at the PRASEG event was Jeremy Leggett, Solarcentury founder, who said that "U.K. nuclear energy policy is a fiasco," while the clean energy revolution is unfolding faster than most predicted. The Hinkley Point C nuclear plant expected to be developed by France's EDF, which keeps postponing a final investment decision to build the plant, is certainly not going to be built following Brexit, said Leggett. It was actually never meant to be built despite the massive U.K. state subsidies, simply because the business case does not work, he added. But the risk is even higher following the Brexit referendum result.

So if this proves true, what is going to fill the gap and provide the U.K. with the electricity that it needs? A rational answer, of course, is renewables. A recent report by the National Grid, the company that owns and operates the U.K.'s transmission lines, said that the U.K. could adopt solar, electric vehicles (EVs) and batteries much faster than what was expected only one year ago. The 2016 Future Energy Scenarios report published on July 5, sees up to 39 GW of solar PV installed by 2035, up from around 12 GW today. Two years ago, the National Grid expected as little as 8 GW and no more than 17 GW of solar by 2030. Now, its low scenario is 15 GW.

Photo: Solarcentury

What's bad for nuclear could be good for renewables such as solar, experts claim.

Similarly, the National Grid's expectations for the number of EVs on British roads in 2035 have been increased dramatically, while future scenarios also include, for the first time, a significant future role for battery storage. National Grid is expected to announce the results of its 200 MW frequency response energy storage tender this summer.

All in all, the U.K.'s energy landscape is characterized by its holding on to of the past centralized energy model and Brexit dynamics might boost, at least politically, this direction even further. However, in light of the certain risks that Brexit entails, especially for the nuclear sector, and the constant reduction in solar PV, battery storage and EV technology costs, investors might finally sway towards the latter. Energy incumbents and British establishment politicians will most likely try to block this, and the final battle is going to be won only via technological improvements. U.K. energy policy will merely react to, not shape, the country's energy future. ◆

Ilias Tsagas

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pv magazine IN CONVERSATION SPECIAL

Back again for 2016, this year's In Conversation Special brings you another hand-picked selection of interviews from some of the solar industry's most respected voices and opinion formers, with pv magazine supplying the ammo for a raft of interesting and insightful discussions.

The month of August – in the northern hemisphere at least – tends to be a rather peaceful four-week affair of out-of-office email replies, summer 'Silly Season' stories dominating the airwaves, and quieter-than-normal cities as the world appears to take a collective breather before getting down to business once again in September.

As veterans of the global solar industry, **pv magazine** knows better than most the challenges – and opportunities – posed by such a month. Which is why we have gotten our calls, emails, requests and questions in early to the solar world's industry shapers and shakers before they take a well-earned summer break.

So what does this mean for you, our readers? Well, as you'll no doubt be stuffing this month's issue into your suitcase in preparation for your vacation, it means that you can enjoy a selection of insightful conversations about the current state of the solar industry from those in the know.

And you can do so from the comfort of your sunlounger or hammock, with the soothing sounds of the ocean – rather than the usual cacophony of competing voices found at a typical trade show – as an aural backdrop.

This month's selection of interviews discuss topics ranging from China's large-scale solar PV outlook, to step changes in wafer technology, trends in the inverter landscape and Europe's second solar wave, so there is plenty to get your teeth into. All you have to do is relax, read on, and enjoy!

TALKING SOLAR THIS MONTH...

For more interviews with leading solar lights, be sure to visit the video page on www.pv-magazine.com/video

"Things are starting to recover"

European markets: There are signs of rapid growth in the European storage market, and the PV market on the continent may be turning a corner. Ash Sharma, the senior director solar research at IHS Technology shares this and other insights, including a 10% module price decline looming large in the 2016 marketplace.

Photos: pv magazine/Maximilian Ruegamer

"IHS forecasts a return to growth [in Europe] within the next couple of years."

What is your forecast for what the European PV market is going to deliver in terms of demand in 2016?

We think that the market will be between 8.5 and 9 GW this year. The last couple of years, as you know, have been a little bit depressing in Europe, but we are starting to see a couple of pockets of growth. Things are starting to recover. IHS forecasts a return to growth within the next couple of years.

There are a couple of good EU markets, like the Netherlands and France that are performing well. The U.K. performed well in the first quarter of this year and will still be reasonable for the rest of the year. So it won't be quite as bad as it was a couple of years ago.

The European market is a mature solar market. Solar Power Europe is celebrating the 100 GW milestone in an event in Brussels later this year. What are the opportunities within secondary PV markets in Europe? Will some serious revenue streams be delivered in servicing and repowering PV power plants that are already on the ground in Europe?

I wouldn't say serious revenues but the secondary market will be a significant one. There is a long list of suppliers that have gone bankrupt and are out of the business, meaning those warranties are no longer in place. In those circumstances, someone will have to replace modules and inverters. In some of the older projects the inverters will already be approaching end of life anyway.

O&M is a huge, huge opportunity as the installed PV power plants start to age. It will be interesting for some companies, and there are many that are starting to look at it now.

Intersolar Europe has been located in Europe for many years now, and Germany itself is the center of the storage industry market in Europe at this point. I have heard statistics that something like 70% of new residential PV systems being installed in Germany today are going in alongside a storage system. Would a figure like that surprise you?

That figure is a little higher than I would have expected. Then again, the conditions in Germany are good for storage. Prices of batteries have come down significantly and pretty much every manufacturer at Intersolar Europe are offering a storage prod-

uct. In Germany there is a subsidy program, so it is a promising start and it may spearhead the way for other markets as well.

Should we continue to see cost reductions for storage systems?

Batteries are a big, big market and solar is a very small part of that. Because of this, storage prices are at the mercy of other markets like electric vehicles. But we are seeing costs come down very quickly. It is not only the battery but it is also the power conversion and power management costs that are coming down right now.

What are also falling are module prices. We do know that in the second half of 2016, the PV market could be facing an oversupply situation, if not as bad as was experienced in 2012 and 2013. What are you expecting on the price reduction front?

At the SNEC in May, you may have seen some worried faces at the booths of solar companies as they face some pretty significant oversupply. This is as some major capacity comes online while the Chinese market comes to a halt. So we are expecting around 10% price reductions over the next quarter and we are seeing very sharp reductions in prices in the U.S., where prices are falling very quickly.

Looking at some of the Tier 1 suppliers, they do have some pretty impressive cost reduction roadmaps. This means they could still have healthy margins. But I would say in Q3 and Q4 of this year, things will look very difficult for the Tier 2 and some of the Tier 1 suppliers, selling at a loss.

"O&M is a huge, huge opportunity."

Does that mean we might see some producers stepping out of the market or some bankruptcies?

It is the age-old question in this industry, not many Chinese companies actual exit the market – they tend to get picked up, recycled and refinanced. So I would say that it is inevitable and would have to happen at some point. We are seeing consolidation in some parts of the industry, the O&M side, EPC and inverter supply segments. So it will have to happen at some point as there are too much supply and too many suppliers.

"Trackers are clearly the best way to deliver improved IRRs"

Tracking: Lead by the U.S. market and delivered through maturing technology, trackers have moved into the mainstream. With new opportunities, new market entrants have leapt into the space. Pivoting from CPV solutions, China's Arctech Solar is expanding into the Chinese and international markets with its tracking solution. Guy Rong, the President of Arctech Solar believes it is only the beginning.

How would you describe the Chinese downstream markets at present?

The Chinese downstream market is actually not very stable. For the first half of the year the way a lot of activity, as the FIT came down at the end of June. At Arctech Solar we received a lot of orders in the first half of 2016. This order level will be stable for the remainder of the year.

What role is Arctech Solar in particular and tracking technology more generally playing in the market today?

With the reduction of the Chinese FIT, investors are looking for better IRRs. To do this, they have to find something to improve these returns. So trackers are clearly the best way to deliver improved IRRs. Because of this more and more companies are looking at trackers.

In addition, Arctech Solar takes the market of electricity generation very seriously. As equipment manufacturers, we are aiming to supply a reliable product able to ensure a continuous service. This was the motivating factor behind our special redundancy design that enables zero down time.

So to answer your question, Arctech Solar wants to bring new standards of reliability for a market that needs to ensure a constant service.

International markets are also very important to Arctech. What markets are you finding particularly interesting?

Photos: pv magazine/Dave Tacon

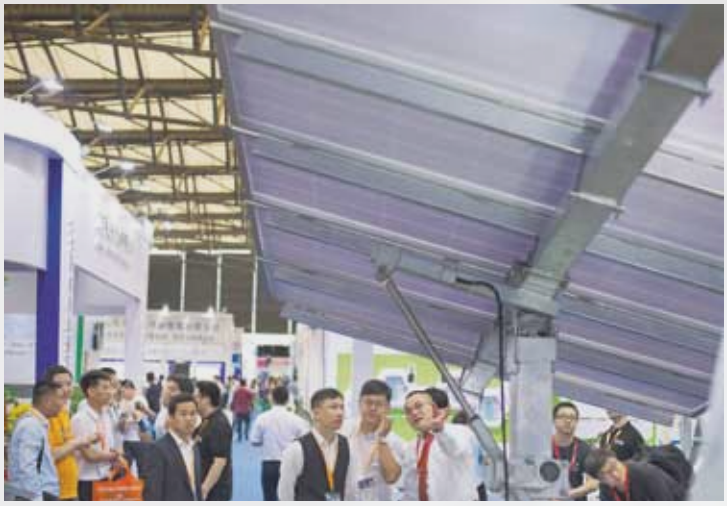
"We think we will have some very interesting results in the U.S. in 2017."

We are working in many countries, but the main focus are three countries: India, Japan and the U.S.

What is the reaction from the market to a Chinese supplier of tracking technology, because in the past, tracker providers have tended to be U.S. and European companies?
You are right, but that is why we have performed strongly in India. In India, there is not so much experience in tracking technology and not a preference for U.S. and European companies. In India, as you know, we won 600 MW of projects for fixed tilt racking systems last year. In 2016, we have received orders for 400 MW of tracking technology. By the end of the year we could possibly reach 600 MW to 800 MW in tracking orders from India alone!
As I mentioned, we are expanding into Japan and the U.S. with our tracking technology. This will take some time, but we are seeing a lot of possibilities in these markets, and we have a lot of leads from the U.S. So we think we will have some very interesting results in the U.S. in 2017.

What is your supply target for trackers globally in 2016?
This year we target 1 GW of tracker orders, and for fixed tilt 4 GW.

How would you describe the dynamic in the tracking market at the moment. From the outside it appears that the tracker market is growing very quickly and additionally there are new entrants. How does that impact on Arctech's strategy?
I can see now that every fixed tilt supplier is now offering and promoting tracking. But we all understand that it takes some time to make a particular tracking technology mature. We actually welcome the new entrants as it will make the tracking market bigger and it will also educate the market. That means it won't only be left up to Arctech to educate the market and our customers. If all the companies can come together to educate the market about the potential for tracking technology, it will be a good sign for the market and be good for everybody.



"We actually welcome the new entrants as it will make the tracking market bigger and it will also educate the market."

What role are solar module suppliers playing in the roll out of trackers?
Most of the module suppliers of the global market now come from China. But we think that increasingly Chinese BoS suppliers will become more visible in the PV market worldwide.
On the other hand, module suppliers are recognizing the benefits trackers can provide to their customers. We routinely work with suppliers to ensure their modules are compatible with our solutions as customers look to maximize the production output.

"We think that increasingly Chinese BoS suppliers will become more visible in the PV market worldwide."

"The scale up has been stunning"

EPC: India's Sterling and Wilson has emerged on to the solar landscape at a rapid pace. Bikesh Ogra, the president of Sterling and Wilson's solar business, says that the company's long pedigree in electrical contracting and service provision has allowed it to grow quickly while bringing solar expertise into the team. Ogra believes that even some of the startlingly low bids in India's solar tenders can be achieved.

Photo: pv magazine/Maximilian Ruegamer

"We have emerged on the solar landscape as an EPC player in a very short space of time."

For those that are not familiar with Sterling and Wilson (S&W), how would you compare the company with other major electrical infrastructure companies?

S&W is primarily a very diversified service provider and has a plethora of business interests. We have historically been in the contracting business and are not a component manufacturer. S&W is focused on services and project based businesses.

S&W has burst onto the solar scene. What is behind the rapid growth and impact on the PV market in such a short time?

You have used an apt word: we have emerged on the solar landscape as an EPC player in a short period of time. I do get this question a lot, and it is not a complicated one to answer considering the pedigree we have as an organization. S&W is almost nine decades in the business. Over this time we have cultivated capabilities in project management, implementation, design engineering and supply chain management. We extended that logically to the solar business. We have a resource base of almost 2,500 people on payroll. Couple that with 3,500 off-roll resources, and it has enabled us to scale the solar business quickly.

The scale-up, as you rightly say, has been stunning, absolutely astonishing. In 2011, Sterling and Wilson had essentially no solar business, and today we have commissioned 1.1 GW of PV power plants and are well positioned to achieve another 1 GW this year. We assumed a leadership position in the Indian solar EPC space over the last three years. We have now been catapulted to the number six spot globally in terms of solar EPCs. This obviously does not happen simply because of our name. To summarize, we have the ingredients built into the company that has allowed us to scale up so quickly, and deliver the projects on time, on budget and with very high PV power plant performance.

How steep has the learning curve been moving into solar?

It has been as steep as the price declines within solar! As an organization our focus has always been to stay ahead of the learning curve. So whatever is happening, whether that is on cost or other parts of the downstream solar segment, our goal is to understand first and then become a leader in implementa-

tion. We have been disrupters within the market and that being said, it is very important for the market to understand that we are uncompromising when it comes to deliverables.

Well, you mention quality. How have you gone about delivering quality projects? This is particularly interesting as S&W came into the solar market as somewhat of an outsider.
Every company has made a start somewhere. It is only a matter of how quickly you adapt to a particular industry and particular business. In order that we don't falter on the quality, we have ensured the blend of our teams is carefully aggregated. Our senior resources for design engineering and supply chain management teams have been in the solar space for almost twenty years. Coupled with our existing execution strengths, we have been able to create a very formidable mix for the complete value-chain.
S&W has created its own quality assurance plan, which is totally independent of component manufacturers. Taking modules as an example, we created a mechanism to map the complete production cycle, end to end. Likewise there are multiple checks and balances on the execution front as well, which add critical value to the plants that we have built.

Does this involve factory audits and the testing of modules?
Factory audits and testing are a given. Testing of modules is not carried out on a random basis, but each and every module and every BoM is verified and vetted by our quality team. The manufacturer then has the S&W stamp of approval. We have been getting some push back from some of the module manufacturers, because we are very stringent and onerous when it comes to quality requirements on our end .

Indian market growth from 2 GW to more than 4 GW in 2016 is outstanding. What is your expectation for India?
Before we talk about the Indian market, let me tell you that of the around 2 GW growth the market experienced last year, S&W commissioned 690 MW alone. So we have contributed to around 25% to 30% of the market's incremental growth.
We are sure that the Indian market will continue to explode. It will no doubt be very challenging to cope with the various complexities associated with this growth. Land acquisition, spiralling tariffs and costs, and foreign exchange risks will always present challenges.
Fortunately, S&W has been intensely focused on all emerging PV geographies. Towards the end of 2013, we started to look at other markets like the Philippines, Egypt and Morocco, and also Africa. We are well positioned to develop 175 MW in Morocco and almost 250 MW in Egypt. South and Central America and MENA markets are also where we are looking to expand. Australia is also very interesting for us.

Back to India, there is talk that some winning bids for tenders are so low they won't be realized. What is your take?
If you had asked me this seven months ago, I would have concurred with your views. Because at that time module prices were $0.47 or $0.48/Wp. Now we are looking at a sub $0.42/Wp price levels. The forecast for next year is even lower. When you talk about that kind of price, then I don't see the tender prices at a non-viable bid level.
That said, we are working with some IPPs that created ripples by quoting very low tariffs. At the time, many had written off those projects. Incidentally, we are currently executing projects for some of those very developers. With current price indicators, we clearly see decent returns for all stakeholders on those particular projects.
Timing is of the essence and can be the difference between a viable or non-viable project. So I have a firm feeling that most of the IPPs that have won bids in the recent past will be realized. Additionally, it is looking like the Indian market is settling, in terms of tender price.

How true are the reports that some projects in India are being built with poor quality components?
This is what disturbs and even upsets me personally, specifically being positioned around India. This, to a very large extent isn't true. Having said that, we are encountering certain projects where what you have mentioned is unfortunately true .This is because some developers and EPCs have built projects owing to very untenable tariffs and EPC prices.
One of the reasons, presumably, being that the assets may be flipped much before the actual life-cycle in order to earn a quick buck. This is unfortunate and can put a dent in India's positioning in solar.

Photo: Sterling and Wilson

Sterling and Wilson was the EPC for this 90 MW solar PV plant located in South Africa.

Looking to the future, what are your expectations for S&W's solar business?
We are very happy and excited to be in this space and our aspiration is to be a global leader in the solar EPC space in the next couple of years. That said, unfortunately, we are all in a rat race as of this moment. We are hoping that sanity sets in fast, for the complete value chain and the recent spate of kamikaze tariffs being bid is a passing phase.
At the end of the day, everyone is in the business to create value and wealth. Therefore there is a pressing need to create a sustainable ecosystem. There is a lot of sun to be harnessed, and we want to harness it in a sane way.

"We are the technology driver"

PV production equipment: Meyer Burger has established itself as one the largest technology providers in the solar space, with a suite of technology offerings across production processes. These include PERC upgrade tooling, SmartWire cell interconnection technology, a heterojunction platform and innovative diamond wire solution. But can the Swiss provider compete against the fast rising Chinese rivals? **pv magazine** spoke to CEO Peter Pauli.

Recently the Meyer Burger DW diamond wire wafering technology, the DW288 Series 3, was recognized by pv magazine, and the independent jury, as one of the winners of the 2016 Technology Highlights award. Why is it that you think this technology is both making an impact in the PV market and also being recognized by industry experts in this way?
With this equipment and with its development Meyer Burger has really made a major stride in terms of technology and improved the utilization of the diamond wire material in a number of ways. The DW288 Series 3 significantly reduces the manufacturing cost per wafer. Parallel to this we have increased the output of the machine significantly, so both the overall capex as well as the opex is reduced for our customers. It is a double edged improvement: lower capex because of higher output and lower opex because of much better wire utilization due to the new tension system.

Photos: Meyer Burger/Dave Tacon

"[The Meyer Burger diamond wire solution] is a double edged improvement: lower capex because of higher output and lower opex because of much better wire utilization due to the new tension system."

How would you describe diamond wire technology's position more widely in the market today? How commonly is it being deployed by wafer manufacturers?
I see that all mono crystalline wafer manufacturers only work with diamond wire -- it is a common technology in the mono field. We are now also seeing more and more customers becoming interested in deploying diamond wire for multicrystalline technology. For this we are doing testing with customers. We have also solved the challenge of texturing the wafers in the cell manufacturing process. So the complete package, a complete solution, is available now.

What impact will that have on the wider market, the deployment of diamond wire for wafer production?
That will be the big question. If the customer is willing and able to invest in additional technology on the multi side, then it will result in an explosion in technology. Multi will become more competitive in the market. But it is a matter of the ability of our customers to invest.

Of course the diamond wire offering is not the only next generation solution that Meyer Burger has on the market today. SmartWire is also a technology that Meyer Burger has been pushing, for cell interconnection, and also the heterojunction (HJT) platform. Can you provide an update in terms of interest from the market for both of these technologies?
Actually, SmartWire and HJT are new technologies. This means that there is huge interest from all players in the market but a lot of existing customers are cautious because it is new. Some customers are risk averse and therefore they don't jump in immediately with the latest technology. For them, it is also about securing their existing investment. That is why many customers first implement a PERC upgrade solution rather than adopting a new technology. However, for new market entrants, it is a huge opportunity to allow them to enter a competitive environment.

You mention PERC. The former Roth and Rau PERC production equipment facility, that Meyer Burger acquired and now operates in Germany, is reportedly running at very high utilization rates due to huge interest in PERC upgrades. How would you describe how that facility is operating to meet the demand?
Our factory is fully loaded. We are very pleased that we were able to make this breakthrough and we had to work a long time to achieve this success. We are very happy that we can now fully utilize our R&D in this field. It is a true success story.

How important is the supply of PERC equipment for Meyer Burger's revenues at present?
It was a strategic investment that we made when we acquired Roth and Rau. Some people said the investment was too expensive at the time, but we made a strategic investment and it has proven to be the right decision. PERC upgrade equipment supply is an important technology pillar for Meyer Burger.

How would you describe the competitive environment amongst technology providers to PV manufacturers at the moment? We are seeing a lot of new Chinese entrants to the market, and they appear to be gaining traction. Where are you positioned?
I think in this situation we are somewhat unique, as we are the technology driver. There is immense interest in what we do. Of course, this also results in some competitors trying to copy the space that we dominate in certain technologies. However, all of the technologies represent a huge investment in terms of R&D costs, so the market splits a little bit. The success is not that big, so it provides us a bit of freedom in terms of our technology.

"If the customer is willing and able to invest in additional technology on the multi side, then it will result in an explosion in technology."

Is a return to profitability on the cards for Meyer Burger on the back of what are growing revenues for Meyer Burger at present?
This year Meyer Burger is aiming to return to profitability, at least on an EBITDA level. That proves that we are on the right path. It is a balance between market growth and expectations in terms of volumes on one hand, and organization size on the other. To ensure we are ready for the future with the costs on the other side is the tricky thing.

"We produce standard wafers directly from the melt"

Wafer technology: The production of PV wafers is a dirty and multi-step process. 1366 Technologies, from outside of Boston, Massachusetts, believes its Direct Wafer technology can simplify and dramatically reduce the costs of wafer production. But step change technology is never easy, particularly amongst the standardized PV landscape. Frank van Mierlo, the CEO of 1366 Technologies, says that the company is well on its way to realizing its ambitious goal.

China remains the heart of the solar module manufacturing sector. At the SNEC trade show earlier this year there were a large number of European and U.S. PV production equipment and materials suppliers. But there were also a huge number of Chinese technology providers. What do you make of the competitive landscape in China today for these companies?

The Chinese have been really, really good at taking a technology that exists and then deploying it and bringing the costs down. I think even the Chinese themselves will admit that the zero-to-one part of development is not something that they are particularly experienced in and I have not seen a lot of examples of that. So, as a supplier, as long as you do something that is truly innovative, then I believe you still can have an edge.

Talking of innovation, step change is one of the terms that has been used in terms of 1366's approach to epitaxial wafer growth. There are numerous challenges to achieving this and to bringing this approach to market. How would you sum up where 1366 is at today with this technique?

Photo: pv magazine/Dave Tacon

"We are making an absolutely standard wafer and we do that in seconds."

If we were doing epitaxial growth then that wouldn't represent such a big breakthrough, but we're not! We make a wafer directly from the melt in one step and we are making an absolutely standard wafer and we do that in seconds – it truly is a breakthrough method. So at the moment we first did a pilot machine, then we did a full scale pilot machine, then we did our first manufacturing machine, our second manufacturing machine and at the moment we have three generation three manufacturing machines up and running. So we can produce sizeable quantities of wafers at our demonstration factory and we are now ready to scale that up.

The method is truly revolutionary in the way that it dramatically slashes the cost. We take today's concept, which involves about four different processes, and we collapse it into one and we are producing an identical wafer much faster and at a much lower cost point. To really hammer that home, the energy we use per wafer is only one third of what the industry is using today. The wafer is, of course, the most energy hungry component in the PV production process.

Technically how are you able to achieve that? I mention epitaxial growth, you say that there is a difference. What is the difference?

The epitaxial growth that you are referring to, there are people creating gases and then depositing that gas very slowly onto an existing crystal structure and slowly growing that. The Achilles heal of that technology is the very slow growth. We don't do that. We take refined silicon, the standard silicon that everybody else is using, then we melt that. The best analogy would be when a lake first freezes in winter and there is a thin sheet of ice that can be pulled off. We freeze the top of our silicon mass, then we pull off one wafer at a time.

What we have invented is a process that is truly unique, nobody else has done this as far I know. We produce standard wafers directly from the melt. So we have standard inputs, Siemens hyper-pure silicon and then absolutely standard output, 6 inch x 6 inch, 200 µm wafers. We can produce thinner wafers, but at the moment we produce 200 µm wafers because that is what most of the industry produces.

Standardization is key, because PV is a very standardized industry. You have achieved some impressive efficiency results in partnership with Hanwha Q Cells, and Hanwha itself is also an investor in 1366. Q Cells has also signed a sizeable supply deal with 1366 over a number of years. What kind of validation of the technology does this provide?

This is something we are very happy with. On the investment front Hanwha did an early investment with us and then recently, after a lot of due diligence with a big team, made another $10 million investment. So there is a lot of due diligence there and the focus of it was on whether there would be a return on the investment. This is a completely different part of Hanwha than the group that placed the order. The group that placed the order carried out purely a technical due diligence. We sent them thousands of wafers every week for the best part of a year, and they carried out lots and lots of different tests and then after this period of testing, they placed a 700 MW order.

Photo: 1366 Technologies

"The energy we use per wafer is only one third of what the industry is using today."

The nice thing now, through this interaction with Hanwha, we have serious validation of the investment group, looking at the financial returns we can generate. And then technical validation, from arguably one of the best technical groups on the planet, because Q Cells' R&D group is very renowned.

That is particularly true when it comes to PERC technology. Do you think there is any danger or risk in getting too close to Q Cells, because 1366 clearly wants to work with a range of cell producers?

We actually are very happy that we are working with one of the industry's best companies. I agree with you that if that was the only company we were working with, that might be a cause for concern, but we will have some positive announcements later on this summer, with some more partnerships that we are currently pursuing.

And Hanwha Q Cells itself isn't concerned that you may be supplying rival producers?

The exact content of the contracts that we have signed is under NDA, but I believe we have signed a very fair deal that is both good for them and for us.

You mention the financing that you have raised, that is for the construction of the first 1366 fab in the U.S. What timeline can you provide as to when that will be built out?

We are a company that has always progressed very methodically. Building the factory in Bedford (Massachusetts) is a step that a lot of companies often skip. Some companies want to go straight from pilot to commercial production. Anybody with a spreadsheet can quickly calculate that having a commercial factory is better than a demonstration factory, because with a commercial factory you can make money. But any engineer will tell you that you skip those steps at your peril.

At 1366 we will continue that tradition of careful, consistent progress and the moment we are ready we will break ground on the factory. At the moment we are already installing utilities and all of that needs to be ready before you can begin breaking ground on the actual building.

"Match product to project"

Inverters: Huawei claims to have assumed the mantle as the world's largest inverter supplier in terms of shipment volumes. William Zhou, vice president of Sungrow Power Supply, begs to differ. Zhou sets out why and makes the case for central inverters in a diverse marketplace.

What is your take on how the Chinese PV market is developing?
There was a change in China's local PV policy on June 30. This meant that in Q1 2016 there was a huge volume of shipments. After June 30 the shipments decreased. But in saying that, 2016 still represents a huge market.

We saw in Q1 something like 8 GW of installations. What are you expecting for the full year in China?
I think the 8 GW is too high, there won't be quite that much. You have to remember that in China it is difficult to collect real installation figures. Some public companies are trustworthy but there are many private companies that report data that is hard to verify, it is very difficult to say what is right and what is wrong!

But what is your impression for how much will be installed in 2016?
For myself, I am not personally so familiar with the Chinese domestic market as I am not in charge of that at Sungrow. But in speaking with my colleagues, they report that the installation figures in China in 2016 will be higher than last year. Total projects installed and connected to the grid in 2015 were around 15 GW – this was announced by the government and this data is very accurate. This year will definitely be higher than that but exactly what the final number will be is difficult to say.

So your responsibilities are focused on international markets for Sungrow. What are the most important markets for Sungrow in 2016?
For Sungrow, the most important foreign markets are divided into four segments. Sungrow started working internationally in Germany, from our base in Munich. This still supplies the EMEA region and we have 30 people in this team. In Germany Sungrow has already achieved an inverter market share of around 25%. The German market is largely supplied by string inverters, because at this stage in the market's development, it is difficult to find large areas of flat land for projects. The next important international markets for Sungrow are India, the U.S. and Japan.

Photos: pv magazine/Maximilian Ruegamer

"In Germany Sungrow has already achieved an inverter market share of around 25%."

At the SNEC in May, Sungrow presented its latest string inverter for large scale PV applications. This provides the ability to monitor plant performance at the string level. How much demand is Sungrow experiencing for large scale string inverters?

For our company, we are seeing very high demand not only for string inverters, but also for central inverters. So our position in supplying different inverters is equal. We like to think in terms of what the developer wants. Developers are looking for a high return on investment. So then it is true to say that when the ground is flat and for a large installation, there is no doubt that developers choose a central inverter. This is because central inverters cost-per-watt is much cheaper.

On flat ground it is safe to say that the yield from a central inverter and string inverter is the same. But the initial investment required for a central inverter is much lower. Central is also easier to install. If a customer chooses a tier one supplier for central inverters, then the quality is very good – it requires almost no service. So for flat ground, there is no doubt that central inverters are best.

For projects where the land has small hills, if it is 50 kW or 50 MW, then string inverters make sense because of MPPT, to increase yield. Our philosophy is very simple for the end customer, and they like our approach. We help the end customer match the product to the project to deliver the highest return on investment. This means that with large projects the central inverter makes sense. For a supplier of string inverters, they need to have a large number of string inverter models to supply the residential market, small commercial, large commercial and for utility scale.

"For a supplier of string inverters, they need to have a large number of string inverter models."

Sungrow has also introduced a 1,500 V inverter into the market. How much demand are you experiencing for 1,500 V?

There are two very important markets for Sungrow: one is China, the other is the U.S. The China market is very big! Only around 10% of Chinese projects choose a 1,500 V because a very limited number of suppliers can provide qualified 1,500 V products. So Sungrow took the decision to launch its 1,500 V inverter in the U.S. along with China. For other regions, due to price declines for lower power rated modules, 1,500 V modules may not be so interesting. In the U.S. it is clear that 1,500 V is becoming mainstream.

Sungrow is working with Samsung to introduce storage products for both residential and utility scale applications. How important is that for Sungrow?

It is important for the future. In the future, all grids will be a microgrid or a smartgrid. For the future, all grids will have to incorporate solar, wind, storage and kinds of renewable sources. For today in Germany, Australia, and some parts of the U.S., storage is already feasible. In some island locations, solar and storage is more competitive than electricity supplied by diesel generation. So the storage market is emerging.

Sungrow is the inverter market leader, so it must also be a leader for energy trends. Sungrow will be the largest microgrid inverter supplier with more than 300 microgrid power plants already – with lithium ion batteries, with flow batteries, with diesel and with hydro power, in fact with all electricity sources that money can buy.

We are excited about this development and we believe it will be the future. Today, battery prices are a little high, but we believe that the trend of battery price declines will be similar to what we have seen with solar panels.

What is the relationship with Samsung?

For Sungrow the core value is still in the inverter. So that is why we have cooperated with Samsung and we have created a JV company with Samsung. This is not an exclusive arrangement, meaning that Samsung can cooperate with SMA or others. We can also work with other battery suppliers like LG, so it is mutually beneficial for both of us. Sungrow has a better understanding of inverters and Samsung has a better understanding of future battery trends.

Sungrow has grown quickly, but so has rival Huawei. Earlier this year, Huawei reported that it had shipped 10 GW of inverters in 2015, surpassing what Sungrow reported. What do you make of this?

I do not think this is true. China has the government National Energy Administration. Going on figures from NEA, Huawei sold no more than 1 GW of inverters outside of China in 2015. That means that Huawei shipped more than 9 GW in China. Again, I don't think it's true. Most of the PV power plants in China are ground mounted and customers are realists and know that only central inverters can deliver the kind of returns they are after.

Our philosophy of honesty with the customer is number one. That is why we supply the right product for the customer's need – not only what benefits myself or my company.

“What we focus on is reliability”

Perovskite: It’s been a buzz technology of the last couple of years, perovskites in PV applications. However, much of the research community has struggled to meet the required material stability requirements of the solar industry. Chris Case, the CTO of perovskite developer Oxford PV, believes that his company has made serious headway.

Photos: pv magazine/Dave Tacon

“We have met or exceeded most of the fundamental IEC 61646 thin film reliability tests.”

The PERC upgrade technology cycle is well established in the PV sector. For next generation technologies, there is a push towards HJT, and then tandem cells come into play. There has been a lot of hype around perovskites, of which Oxford PV is one of the leading developers. Can you provide an update as to where you are at today?

Perovskite technology is relatively new - it has only been in development for a few years. It has shown tremendous capability in just those few years, but our way of introducing it into the market place is as a tandem cell. This means a second solar cell produced on top of conventional silicon.

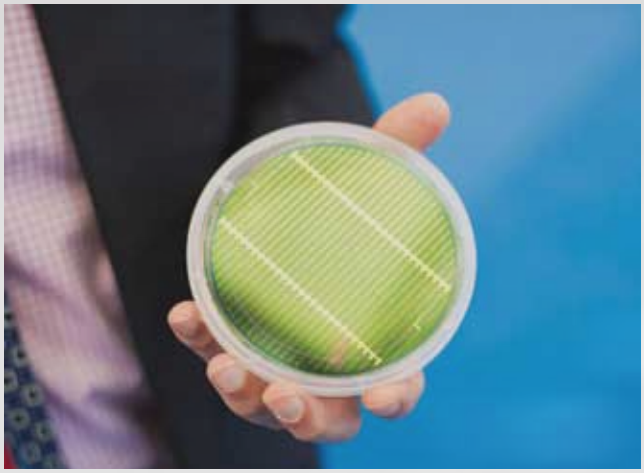
So at Oxford PV we like to think that perovskite could be similar to a PERC upgrade, a manufacturer could do a perovskite upgrade. And potentially the performance enhancement on any silicon solar cell is about 20 to 25% and we’ve already demonstrated taking a silicon cell with 7% all the way up to 22% with this perovskite coating. It is also a relatively inexpensive coating. So you might imagine in the long term, this material could provide a replacement for silicon, but in the short term its use could be as an enhancement to silicon technology. It also needs to be kept in mind that it is not really possible to take silicon much beyond 22 to 23%, and the potential is to produce tandem silicon solar cells with efficiency well above 25%.

And what stage is Oxford PV? Previously I have only seen perovskite applied to a glass substrate, but you are now demonstrating it on a PV wafer and cell.

We have demonstrated perovskite on glass, which is a single junction material. But now we are producing it on solar cells. I even have one of our demo solar cells, a 4 inch or 100 mm cell here with me. This is a commercially produced cell with the perovskite material on top. It is a relatively simple deposition process to add that coating on top of the cell. This had a performance increase of about 4.9% absolute increase over the bottom cell performance. There is nothing else that we can think of, in terms of an improvement on standard silicon technology that can take efficiency beyond 25%.

We are showing the technology to producers and seeking partnerships at this point to take the technology from this prototype stage to a production stage.

"This is a commercially produced cell with the perovskite material on top."



"We will be moving into a new facility in the near future to allow us to demonstrate on customer wafers of standard 156 mm^2 size."

How much interest is there?
There is a lot of interest. If you think of a PERC upgrade, it is very popular right now - it is a capex upgrade of $8 to $10 million [for a standard PERC upgrade], and it boosts the cell efficiency of the silicon cell by 1%. We are talking of boosting silicon efficiency by 5%, for a capex upgrade that will be a little more than that, but not tremendously higher.
As a silicon cell provider, the roadmap runs out of steam at around 23 to 24%, even with HJT, IBC or PERC, and perovskites can put cells and modules beyond 25%.

But of course, PERC, HJT and IBC are considerably more mature technologies. It has been well established that the stability of the perovskite cell is a major roadblock, at least among the research community. What stage are you at with stability?
We don't really focus on efficiency, we don't hold world records for the efficiency of perovskite solar cells. Many academic institutes hold those records, usually on very tiny solar cells. Our interest is not that. What we focus on is reliability. We have achieved a compositional change that changes the bandgap, and remember one of the advantages of perovskite is that you can adjust or tune the bandgap by adjusting the composition. If you look at a bottom silicon solar cell with 1.1eV, to be matched with a second solar cell, that second top cell should by 1.7eV. The standard pervoskite material is 1.5eV, so we have actually changed the composition to raise the bandgap to 1.7eV – the perfect match for a two junction solar cell on silicon.
We could do the same on CdTe, CIGS or even gallium arsenide, but they are not the bulk of the marketplace, so we are focused on silicon at introduction. While raising the bandgap we have also improved the thermal and phase stability of the material and we have met or exceeded most of the fundamental IEC 61646 thin film reliability tests, at least on the scale that we have been developing.

So a cell this limited in size will not show some of the rapid degradation behavior that has been evident in the past?
It meets the IEC 61646 degradation standard. Of course this is a new material, so it does not have 25 years normal lifetime. But it does meet the IEC test to show early failures and recognize problems with the material. Fundamentally, we feel we have addressed the thermal stability concerns of the original perovskite material. Our material is different.

What about transferring the technology to a standard size?
Obviously, what is required is equipment that can handle standard sized cells. We have produced samples on laboratory equipment; it was never designed to handle substrates the size of this sample. We will be moving into a new facility in the near future to allow us to demonstrate on customer wafers of standard 156 mm^2 size, so we can go to a customer and ask them to provide a cell – however it can't be fully processed, we need it before metallization – and we can show them what we have.

Is uniformity an issue?
It really is not. Pervoskite is a very forgiving solar cell material. If it weren't so forgiving, it would not be such a high performance material, with people in laboratories around the world making cells. So all of the technology that appears to be proprietary to us, appears to be relatively easy to do.
CIGS materials, which I began my career on, spent ten years before it broke the 10% efficiency boundary. Today we have 15% efficiency on the module level, but it took a long time to get there. And this material is far less expensive than CIGS will ever be.

Your confident that Chinese manufacturers will be partners to adopt this technology?
They are the likely partners because they make up the majority of the market. We are obviously approaching anyone who does solar cell manufacturers.

How does the bandgap work with CIGS or CdTe semiconductor stacks?
Those are higher bandgap materials than silicon, so the bandgap of the perovskite will have to be moved up even higher. For 1.1eV silicon, the optimum is 1.7eV. For something like gallium arsenide with 1.4eV, the goal would be 1.9eV or 2eV material. We have actually produced material from 1.4eV all the way beyond 2eV. Unfortunately those materials don't show the same performance or the same thermal stability at the moment, but our market focus is on the 1.1eV bottom cell at the moment.

Interviews with Jonathan Gifford

Photo: Aleo Solar

European producers emphasize quality as a key value proposition. But whether that is recognized or a credible claim in the marketplace is debated.

A question of quality for European manufacturers

Module production, Europe: In the wake of the third **pv magazine** Quality Roundtable at Intersolar Europe, **pv magazine** surveys European module manufacturers about strategy and quality. The question is, what makes Made in Europe attractive to buyers looking for modules for a PV array?

Discussions of module production in Europe tend to revolve around trade disputes, import duties and the question of whether mandated minimum prices are justified. How poorly European manufacturers are doing also gets plenty of air time; whether because of the crisis in the German solar market, which began three years ago, or because of Chinese suppliers, who are now three to ten times bigger than European suppliers and can deliver at cheaper prices.

But that is not the topic at hand. **pv magazine** has sought to present a completely different take on European manufacturers. What is being investigated is in what areas EU manufacturers aim to excel, how high a premium they officially place on the quality of their products, and what they are doing to attain it? Additionally, it was asked what they saw as the biggest threats to their strategy, apart from the minimum price issue.

The first step, however, is to take stock of the current situation. Who is actually producing how much? Karl Melkonyan, a senior analyst at IHS, calculates a production capacity in Europe of around 4.7 GW in 2016. That is 20% more than in 2015. But this figure is not very significant without considering utilization. In 2015 utilization was at 50 to 60%. This means that European factories likely contributed less than 5% to global module production.

Nonetheless, manufacturers with production facilities in Europe are still on the IHS list. Most of them are in Germany. These producers occupy the top six slots on the list of European producers.

pv magazine also asked European module manufacturers about their strategies and the role of quality as a unique selling point. After all, that has long been one of the key arguments for why inves-

AT A GLANCE

- IHS calculates that there is a European module production capacity of 4.7 GW in 2016.
- Dual-glass modules are a key product for a number of European manufacturers.
- The BIPV market is also seen as an important opportunity.
- Some European producers function additionally as OEM manufacturers.
- Most EU manufacturers are deploying PERC and even bi-facial cell technology.
- SolarWorld cites environmental considerations as a point of differentiation for its products on the market.
- The "Made in Germany" badge is seen by some producers as setting their modules apart.
- Automation is seen by some as an enabler of quality, but it can reduce flexibility in production.

Photo: Solarwatt

Solarwatt positions itself in the market as a system supplier, including its battery storage system.

tors should spend a few cents more per watt for the Made in Europe label.

Reaching these companies was no mean feat. When manufacturers further down the list were contacted, it was often found that calls were put on hold endlessly, or contact telephone numbers had in fact been disconnected. An Italian manufacturer reported that its plant had just shut down and would not be brought back on line for another three to four months.

Ultimately, it was possible to contact ten manufacturers with cumulative production capacity of some 2 to 2.5 GW. Still, that represents nearly half of the existing capacity and also includes the companies at the upper end of the utilization spectrum: Astronergy, Aleo Solar and SolarWorld.

SolarWorld is in an exceptional position. First, it has the largest production capacity by far. Second, the company is on the frontline in the battle over import duties and minimum prices. Third, the SolarWorld brand has high media visibility due to its legal dispute with Hemlock, where a figure of $770 million, and thus the company's survival, is at stake.

Production back online

With regards to production capacity, only CS Wismar Sonnenstromfabrik – which also participated in the survey – has anywhere near the capacity of SolarWorld. Essentially, CS Wismar's capacity comprises the former Centrosolar production facility, with 525 MW of annual capacity, which was initially taken over by Solar-Fabrik. After Solar-Fabrik also filed for bankruptcy, production was shuttered for several months and has now been ramped up again. Standard modules as well as BIPV and off-grid modules will be produced in the factory. CEO Alexander Kirsch stated that the company will gain access to the market by also producing OEM production for other manufacturers and distribution through wholesalers, and also has the U.S. East Cost in its sights for expansion (see pp. 54 - 55).

Aleo Solar and Astroenergy both have large parent companies in Asia and so are in a different situation to strictly European manufacturers. Solarwatt, which has a similarly large production capacity, is adopting a different tack and specializing in glass-glass modules. This fits with its strategy of positioning itself as a systems supplier and producing its own storage products and platform.

Solarnova is targeting the even smaller BIPV market. Some of its production is produced under an OEM agreement with Sonnenstromfabrik. The company can modify individual modules – by adding a transparent backsheet film, for instance – which sets it apart from the GW-scale producers. Furthermore, BIPV has to meet more stringent standards. Ener-

HOW SUSTAINABLE IS PV MODULE PRODUCTION IN EUROPE?

A number of questions on this issue remain, including:

- As growing self consumption shifts the decision for solar away from the ROI discussion, one question is: How can the self-consumption market be stimulated?
- Many manufacturers in Europe still see their products as particularly reliable. So one question is, how can the awareness of quality be increased?
- Is the assumption correct that low investment costs are the No. 1 driver in module procurement?
- If so, why are low investment costs often overemphasized in comparison with long-term good returns based on low LCOEs?
- How important is 'Made in Europe' for module buyers today, broken down by segment?
- How can PV module fabs in Europe develop better cost structures to compete with Asian companies?
- Can companies in Europe "afford" quality in view of the high price pressure?
- Is the degree of automation among tier one Asian producers really lower than among European producers, such that it could be a distinctive feature?
- How great is the quality advantage arising from automation and how can this be communicated?

Photo: Centrosolar

CS Wismar CEO Alexander Kirsch says that the company will expand through operating as an OEM producer.

getica also focuses on the BIPV market segment.

Manufacturers not specialized in entirely niche segments almost all name PERC and bifacial modules as their field's technological innovation. They also mention glass-glass, 1,500 Volt-, AC- and BIPV-modules.

Under some circumstances, environmental concerns may be a differentiator for European module purchasers, enabling them to command higher prices than the competition. SolarWorld cites the meeting of EU environmental and social responsibility policies as a part of its strategy. Sillia sees reducing its carbon footprint as a field of innovation – and it is not the only French manufacturer thinking along these lines. This may also have something to do with the critical role that CO_2 balance typically plays in the large scale project tender process in France.

Question of quality

Quality was a top priority for all of the companies surveyed. The question, however, is how quality can work as a unique selling point in the B2B business. "No one in the B2B sector buys something because it's high quality; everything is high quality," said Carsten Baumgarth, professor at the Berlin School of Economics and Law and branding expert, in an interview with **pv magazine**.

A large portion of European production not exported to the U.S flows to the end consumer market. Other rules apply

Crystalline silicon module production in Europe (IHS)

Company	Country	Production capacity (IHS) MW	2015 utilization > 50% (IHS)	Included in pv magazine survey
SolarWorld	Germany	More than 200 MW	x	x
Sonnenstromfabrik	Germany	More than 200 MW		
Aleo Solar	Germany	More than 200 MW	x	x
Heckert Solar	Germany	> 200 MW	x	
SolarWatt	Germany	> 200 MW		x
Astronergy	Germany	> 200 MW	x	x
Solaria Energia	Spain	> 200 MW		
Invent	Italy	100 – 200 MW	x	
SunPower	France	100 – 200 MW		
BenQ Solar	Czech Republic	100 – 200 MW	x	
Solsonica	Italy	100 – 200 MW		
Smartenergy Renewables AG	Germany	100 – 200 MW		
Solland (Trina Solar)	France	100 – 200 MW	x	
Solar Cells Hellas	Greece	100 – 200 MW	x	
Bisol	Slovenia	100 – 200 MW	x	
Europe Solar Production	Poland	100 – 200 MW	x	
Photowatt (EDF Energies Nouvelles)	France	< 100 MW		
Sillia Energie	France	< 100 MW	x	x
Alfasolar	Germany	< 100 MW		
Mage Solar	Germany	< 100 MW	x	
arinnia Energy	Germany	< 100 MW		
Azumut	Italy	< 100 MW		
Helios Energy Europe	France	< 100 MW	x	

The data comes in part directly from manufacturers and is partly based on IHS analyses. The total production capacity was approximately 4.7 GW in 2015. The utilization total, according to IHS estimates, was around 56%, with some companies reaching over 80%. Heckert Solar and SolarWorld have plans to expand production. Companies lacking a 'x' in the utilization column may still have > 50% utilization; it could just be that IHS data is missing. In addition to those marked 'x' in the righthand column is a manufacturer from southern Europe that replied but wishes to remain anonymous, and two more not included on the list: Energetica PV and solar Nova. Sillia VL says that since the acquisition of the Bosch Solar site, the company now boasts a capacity of 280 MW. While IHS lists the location of Trina Solar's Solland opeartions in France, the company reports to **pv magazine** that it is in the Netherlands.

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Media Partner: pv magazine group

Photo: Aleo Solar

Aleo Solar says that proximity to market matters when supplying Europe.

there. In the 2015 **pv magazine** installer and EPC survey, 29% of respondents said that the "Modules from Germany" label was a basis for recommending a product to their customers. Quality and reliability was cited by 45%, and 36% said that price was the basis of their recommendation.

But the old dilemma remains: buyers have trouble correlating quality and price. "The key factor is presenting the difference in quality credibly," said Milan Nitzschke, the SolarWorld company spokesman. "We do this with cars. It's even more important for solar modules, since they are expected to last for

BLACK SHEEP IN FOCUS IN THIRD QUALITY ROUNDTABLE

On the second day of Intersolar Europe 2016, (see pp. 16 - 19) **pv magazine** hosted its third Quality Roundtable. The event was hosted in partnership with Initiative Partner DuPont, along with Sponsoring Partners Clean Energy Associates, Multicontact and Suncycle. Some potential "black sheep" cases that had been reported to and investigated by **pv magazine** were discussed, with one Roundtable participant bringing a case, along with photographic evidence of burnt out junction boxes, forward for discussion.

What followed was two hours of debate and the sharing of experiences, in which the experts within the room attempted to get to the bottom of where the faults with the cases lay and at whose feet responsibility should lie.

Representatives from a number of the leading European module manufacturers attended the Roundtable and shared their experiences in ensuring quality and the role market pressures can play.

As engaging as "black sheep" discussions can be, and they are seldom uncontroversial, one key takeaway was that quality issues are an all-too-common feature of the industry and something that is potentially damaging to the reputation of solar PV as an investment and also as a part of the future energy mix.

Being in Europe, the third Quality Roundtable was firmly focused on European cases and experiences. However, the discussion turned at one point towards how the geography of installation can affect quality. One case of a PV power plant in Africa was mentioned, in which poor component quality had seen the park produce only 50% of its expected output after only one year of operation. A video report of the event can be found on **pv magazine's** YouTube channel.

pv magazine will be hosting the fourth installment of the Quality Roundtable series at the Solar Power International trade show in Las Vegas in September.

30 years or more." Customers do not know who to trust to assess quality. What they do understand is that many things have to be done differently in Germany, where wages are significantly higher than in China, and that a higher degree of automation and better selection of materials can positively influence the service life.

Different rules apply to calls for PV project tenders. Many survey respondents emphasized that investors are often only concerned with the lowest price without any consideration of reliability. One reason for this is due to tender criteria themselves. However, this cannot be the only reason. The more general question is, why are the investors not looking for long-term returns? Also if PV projects are to be resold after a short while, the value of the plant should depend on long-term target revenue. Nevertheless, market mechanisms obviously emphasize the very narrow view of low investment costs – that is, "getting in cheap and getting out quick." This contradiction could not be resolved in conversations about the survey.

The reason might be that the investors don't understand the details of the quality discussion, as CS Wismar CEO Kirsch explains. They often use the same degradation values in ROI calculations for different modules. Doing so, the cheapest supplier always wins.

As expected, "unfair competition" was often considered the largest threat to sustainable business development. Policy uncertainty was frequently mentioned as a problem. This was a concern of Detlef Neuhaus, the CEO of Solarwatt. "For me, the question of how high subsidies are is explicitly not the issue." But the mere discussion of the EEG levy on solar electricity consumed onsite created major insecurity, even among those who are not affected or whose profits are not excessively burdened.

With regard to glass-glass technology, acceptance in the market is an issue as the panels are still relatively expensive. According to Neuhaus, marketing and patience are the only way forward. Neuhaus is not concerned that Chinese companies could also begin to reliably manufacture glass-glass modules. "We've built a strong brand," he notes.

Mastering the technology is also no mean feat. In the survey, SolarWorld and Sonnenstromfabrik also said they were committed to glass-glass technology. When asked about the introduction of new technologies, the respondents answered that limited market acceptance for innovations and a lack of financial resources were impediments. They also said that borrowing money to fund technological advances and keep development times as short as possible were further challenges.

Photo: Solarwatt

Automation delivers an increase in throughput and, sometimes arguably, increased quality. However, it can reduce flexibility in production.

Glass-glass modules lack market acceptance, for example. They still cost more than glass-backsheet modules. Still, they can pay off for buyers. Nevertheless, potential customers are often unwilling to stump up the extra money for them. This gets back to the discussion about whether low investment costs may be overrated.

The same discussion surrounds bifacial modules. Kirsch estimates the additional yield with this technology in most use cases to be more than 10%. The additional costs are, according to Kirsch, far below that margin. However, "it is difficult to give an exact number for the extra yield," he adds. "Therefore it is probably not so easy to convince investors."

The discussion also showed that the degrees of automation might not only be a differentiating factor between European and Asian manufacturers, but also between factories in Europe. One question is, which processes need automation for a good quality assurance? Thomas Volz, CEO of Astronergy in Germany, has an interesting and somewhat unique insight. Astronergy factories in China, for example, have a lower level of automation than the company's factory in Germany when it comes to the stringing of cells (see pp. 58 – 61). In all factories the modules are tested for mircocracks using EL testing. "We can not say that the automated soldering is better," says Volz. The automation works more uniformly and was cheaper in Germany, but less flexible. The reduced flexibility in automated lines is also an issue reported by CS Wismar's Kirsch. In this sense, automation is the enemy of innovation. The CS Wismar fab, located in Wismar itself, was planned with this in mind. Intelligent automation is the key. In some processes it has increased quality (e.g. for cell soldering), in other processes it has resulted in decreased flexibility.

Regardless of whether European manufacturers distinguish themselves from the stronger Asian competition through better development, a focus on niche segments or higher quality, there are good reasons to buy European that simply have to do with geography. Christoph Sekura, technical manager at Aleo Solar, sees the proximity of European production to the European market as a competitive advantage: "We have around 250 different items in our warehouse," he said. Companies that merely have a sales branch in the country, or indeed continent, quite simply cannot warehouse this variety of products. ◆

Michael Fuhs

Made in the EU

Module production, Europe: European c-Si module producers do not face a straightforward pathway to success. **pv magazine** has produced five producer profiles to investigate the innovation, differentiation and marketing pathways each is taking. Each profile is organized into five sections: production, strategy, technology, future challenges and quality assurance.

Photo: Aleo Solar

Aleo Solar reports that quality is a key sales proposition as a European module supplier.

Aleo Solar – New technology as a success factor

Aleo Solar has been producing PV panels in Europe since May 2001. For a time, the company was owned by Bosch Solar. Now it is part of the Taiwanese SAS Group.

Production: Aleo Solar has a production capacity of 250 MW. Originally, the company had planned to move from a 3-shift to a 4-shift system. But because the market is not picking up quite as much as forecast, the plan has been put on ice for now.

Strategy: Aleo Solar now belongs to the Taiwanese company Sino American Silicon Products (SAS), acting as the module producer in a group that also manufactures cells and acquired Sunrise for that purpose. The company has already announced that it will establish cell capacity in Germany, at the Aleo site. That would simplify module exports to the U.S., circumventing punitive tariffs. Aleo positions its modules in the market as being high-efficiency, dependable and delivered at competitive prices. Christoph Sekura, the technical manager at Aleo Solar, sees the proximity to the European market as a clear competitive advantage.

Future challenges: "The biggest challenge is that energy policy in European countries is so difficult to predict," says Sekura. A second challenge, he points out, is the damage poor quality installations have done to the reputation of the entire PV sector. Sekura says that it is important to put customers in a position to make rational decisions. If this were achieved, price alone would not be the only purchasing consideration; expected service life would also count: The longer the service life, the lower the LCOE. But this is no mean feat. It would require manufacturers to clearly demonstrate the quality of their products.

Technology: Aleo Solar, like many other manufacturers, produces high efficiency modules incorporating PERC technology. Glass-glass modules are one of the company's key offerings, also for BIPV applications.

Quality assurance: Aleo sees quality as a critical selling point. Sekura illustrates this by pointing out that the materials his company uses withstand load tests that are double that required by standards. Materials are selected based on a long list of criteria. Load tests are not the only selection factor; company financials are also taken into account. "We need reliable suppliers," says Sekura. To achieve high quality, installers also have to be trained. "That is especially important in new markets."

Astronergy – Diverse products for DG and utility scale

In late 2013 Astronergy and the Chint Group, of which Astronergy is a member, took over the former Conergy factory in Frankfurt (Oder). The production facility is highly automated and the plant benefits from the favorable conditions the Chint Group can negotiate. In the German PV market, proximity to the customer is key.

Production: In 2015 capacity was 300 MW and, according to Thomas Volz, the CEO of Astronergy in Germany, the company expanded to 350 MW in 2016. It is important to note that the production facility in Frankfurt (Oder), near the German border with Poland, has always been highly automated. The result is that bottlenecks at certain points cannot always be addressed quickly.

The company recently invested solving potential production bottlenecks and thus increased output. Additionally, the German Astronergy subsidiary has OEM production facilities with an additional capacity of 150 MW. The parent company in Asia has a total production capacity of more than 1 GW and wants to increase this figure to more than 2 GW this year. It produces its own cells and modules.

Strategy: Volz sees the proximity to customers as the main advantage of producing in Europe, but he also sees location as a marketing instrument that improves the image of the entire corporate group. On the purchasing side, Astronergy benefits from its large parent in China. Some of the materials come

Photo: Astronergy

Astronergy sees EU policy as playing an important role in the company's future, however on the demand rather than tariff side.

from there, says Volz, and can be procured optimally through relationships with Asian suppliers.

"It makes life easier" for European project customers to audit the production of their modules here in Europe than in a Chinese factory, Volz says. Another advantage is that warranty claims can be handled more easily with a German manufacturer.

Future challenges: For Volz, the number-one challenge is the debate over anti-dumping measures; not as they relate to modules, but rather in terms of material procurement. For instance, duties make cells and glass more expensive than they are for production facilities outside the EU. In terms of sales, he does not see minimum prices as a big help for European module producers because competitors outside of China also sell cheap modules. Like other manufacturers, he sees market development in Germany as a huge challenge for the company, particularly in the context of the discussion about Germany's Renewable Energy Act, the EEG.

Technology: The plant in Frankfurt supplies two very different markets. First, it supplies installers via the wholesale market. For this segment it has developed a monocrystalline PERC module, which became available last month. It is still difficult to sell this technology for PV power plants because it costs more per watt-peak than standard modules and efficiency per unit area is less critical for large scale projects. Astronergy is therefore developing a module for this market segment. To facilitate the project module's development, Astronergy spoke with project planners and has designed a simpler, less expensive module. In the large scale segment, for instance, homogeneous cell color is less important. What is high-tech about the project modules are their frames. "They are newly developed and consist of other materials," says Volz.

Quality assurance: Astronergy enables purchasers for projects to adapt BoM to their needs, facilitates customer factory audits prior to delivery and analyzes customer satisfaction. When it selects the materials, ease of processing is one of the top criteria. Costs and how materials perform in testing that goes beyond IEC standards rate as second and third priorities, respectively.

CS Wismar – An eye on the U.S. east coast

With more than 500 MW of capacity, the CS Wismar PV fab is the second largest in Europe. The plant is specialized in flexible production, which enables a wide range of different products and contract manufacturing. Looking to markets for

Photo: CS Wismar

In terms of markets, CS Wismar sees opportunities on the East Coast of the U.S., where high overland transport costs present an advantage to European suppliers.

this flexible production, the company's CEO is focusing particularly on the East Coast of the U.S.

Production: Despite the market turbulence of recent years, production was never halted at the CS Wismar fab. The plant was originally built by Centrosolar. Following the bankruptcy of the European arm of the company, the insolvency administrator operated the plant until the end of 2014. At the beginning of 2015, Solarfabrik, a former European manufacturer, used the facility and production lines. Following the bankruptcy of Solarfabrik, the founding team of Centrosolar invested in the new company CS Wismar Sonnenstromfabrik and took over production. It has a capacity of 525 MW.

Strategy: "We're banking on sales through wholesalers and contract manufacturing," says CEO Alexander Kirsch, who was formerly at the helm of Centrosolar. There will no longer be direct sales to installers because the market is too small. Kirsch believes that there is indeed a business model for production in Europe. "We are debt-free and have far more sales markets than Europe alone – for instance America."

There, he has his eye on the U.S. East Coast. "The West Coast is easier to supply from Asia," says Kirsch. "But overland transport is very expensive, which is why the market on the east coast is attractive for European manufacturers."

The OEM business is a key pillar for CS Wismar and it has a tradition in OEM production. Centrosolar has manufactured products for TSMC, Bosch, DuPont and Conergy. It also wants to continue making off-grid modules. That is all possible because the plant is designed to be flexible.

Technology: The really big innovation for Kirsch is glass-glass. "The trend is moving in that direction." Dual-glass modules have a longer service life and a higher mechanical load-bearing capacity and they are well suited for bifacial modules. Kirsch says that bifacial modules actually provide 10 to 20% better yield in nearly every application unless the modules are mounted directly parallel to the roof. "At Centrosolar we were the first to produce glass-glass modules in this plant," says Kirsch. CS Wismar will deploy thin, hardened glass and is only marginally heavier than glass-film modules.

Quality assurance: Quality is also a high priority for CS Wismar. The new company draws on its experience from Centrosolar with a track record of more than 20 years of production. The factory and production plant were developed with experts from the auto industry who had "very clear agreements with suppliers," says Kirsch, which is still not something that can be taken for granted. On the other side, he says that component suppliers are also audited – cell suppliers, for instance, which are only permitted to alter cells after consultation. At one time, Centrosolar had eight qualified cell suppliers, a number reduced to just one single supplier once PID became an issue. At this point, he draws a parallel to LID in PERC cells. For a long while, PID was not discussed, "even though the problem was known." The subtext: even today, it may be that not all module manufacturers do a good job of qualifying suppliers.

Solarwatt – Glass-glass in focus

Solarwatt has been producing solar panels in Europe since 1993. Following the successful conclusion of an insolvency process under its own administration some years ago, the company has a very clear strategic position as a PV system supplier. Its majority stakeholder is Stefan Quant, one of the owners of BMW.

Production: Solarwatt has a nameplate manufacturing capacity of 250 MW. According to CEO Detlef Neuhaus, actual production volume in 2016 was approximately 100 MW, roughly unchanged YoY.

Strategy: Solarwatt is going 'all in' on light weight glass-glass modules. "In the context of our system strategy, we have decided to increase prices for glass-film modules gradually and shift our entire sales focus to glass-glass modules," says Neuhaus. "Here, we can offer a product and performance warranty of 30 years without reservations."

Photo: Solarwatt

Solarwatt believes one of the reasons it has stayed in business is that it has avoided head-to-head competition with Asian suppliers.

Photo: SolarWorld

SolarWorld is the only vertically integrated manufacturer in Europe, from ingot through to module.

"That works well in the residential market," says Neuhaus. "Particularly in markets not driven by subsidies." That applies to Germany, where systems are amortized through self consumption. That is not the case for projects that have to pay for themselves with time-limited incentives or are driven by returns that have to be realized within 10 to 15 years. Accordingly, Solarwatt has deliberate focused on the small-scale segment. Additionally, the challenge in laminating glass-glass modules presents an opportunity. Dual glass markets are also small, meaning manufacturers with GW capacities have little interest in them.

Future challenges: Neuhaus sees uncertainty in the policy framework as the biggest challenge. "For me, it is not about the question of how high subsidies are," says Neuhaus. For instance, he argues, the mere discussion of the levying of the EEG surcharge on electricity produced and consumed within the home undermined confidence, even among those who were not affected by it or for whom returns would not be unduly impacted. With regard to glass-glass technology, market acceptance is an issue since the panels are still somewhat more expensive. The only remedy for that, he says, is marketing and patience.

Technology: Glass-glass is clearly the top priority for Solarwatt, and not new cell technologies like PERC. For the "Solarwatt system strategy," service life is the decisive issue, and not whether an additional 2% of output can be achieved with four-busbar technology. However, Solarwatt also wants to pursue PERC, as in its 300 W glass-glass module, as well as bifacial technology.

The reason is that in subsidized markets, cost per watt-peak is the name of the game, and that can be brought down using new cell technologies. But in the end-consumer market, which is driven by self-consumption, cost pressure is not an issue.

Quality assurance: Like most manufacturers quality is important to Solarwatt. Neuhaus not only allows external audits, he welcomes them. When the auditors come, it gives him a better idea of what is going on as well. However, Neuhaus does not focus on utility scale. The CEO believes that it has been an advantage, since restructuring three years ago, that Solarwatt did not try to compete head-to-head in this segment with the big Asian manufacturers.

Solarworld – Consciously choosing production in Europe

SolarWorld has been producing modules in Europe since August 2000 and is among the best-known manufacturers. This is not least because the company has fought vehemently for customs duties against Chinese producers, which has won it plenty of enemies.

Production: SolarWorld has an integrated production capacity in Europe of about 1 GW. According to figures from IHS, the company leads European manufacturers in its capacity utilization. This year, it plans to expand global production capacity to 1.5 GW.

Strategy: SolarWorld plays in a different league than most other European PV manufacturers. That is also reflected in the fact that the company mentions nearly every technology currently being talked about when defining its strengths and does not concentrate on a particular niche market. Apart from technology, it also considers processes relevant. SolarWorld is vertically integrated and produces everything from ingots to finished modules.

"This plays a major role, because it lets you trace where problems lie should they crop up," says company spokesman Milan Nitzschke. Furthermore, he says that a high level of automation helps. "It lowers error rates and increases service life," he adds. SolarWorld consciously presents itself in Europe as a brand that produces in Europe and proactively markets the image that environmental and social standards, labor productivity and product quality are high on the continent.

Future challenges: To the question of what issues the company considers its greatest threats, Nitzschke responds, as expected, with unfair competition. Another concern is that customers do not base their decisions on what provides the most sustainable returns, but rather consider only the lowest investment cost. "If price alone is the only consideration in tenders, then ultimately investment costs and not LCOE – that is, real power production costs – are all that counts."

Technology: To the question of whether new technologies are essential for the success of the company, Nitzschke answers with an enthusiastic yes. "We always have to stay 18 months ahead of our Asian competitors. The most important current technological fields of development for the company are modules with PERC cells, bifacial modules, and system integration in general. End customers expect SolarWorld not only to supply modules, but also all of the components necessary for a PV system, including home storage and energy management, even if these are purchased from specialized companies. The important thing, he says, is to demonstrate competence.

Quality assurance: SolarWorld puts emphasis on quality. "What is decisive is whether a company can credibly demonstrate a difference in quality," says Nitzschke. As a customer, you don't know whom you can trust when it comes to evaluating quality. But, he adds, consumers understand that in a German plant with significantly higher wages some things are done differently than in China, and that a higher level of automation and better selection of materials can have a positive influence on service life. ◆

Michael Fuhs

Born in the U.S.A.

Module manufacturing, United States: On the back of its booming PV market, solar manufacturing is returning to the U.S. **pv magazine** gives you a look at some of the larger PV makers in the nation, and their position.

Photo: First Solar

First Solar has added capacity, but through technology tweaks rather than additional lines or new facilities.

After a relatively slow start in the first 12 years of the 21st century, the United States' solar market is growing rapidly. In the last few years the nation has grown to the world's third-largest market, and threatens to surpass Japan to become the second-largest this year.

This inevitably brings up the question of where all the PV cells and modules to supply the U.S. market will come from. For most of the last decade, the answer has been overseas – largely from China and Taiwan, but also Singapore and Malaysia. In the larger trend of the United States' place in the world this is not unusual, as the nation has been hemorrhaging manufacturing to lower-cost overseas locations for decades.

However, this is changing. In the last few years many PV makers have expanded their presence in the United States, and others have moved in. But the best part of this boom may be yet to come. In this article, we look at some of the PV makers with the largest presence in the United States.

First Solar – Perrysburg, Ohio 640 MW module

The largest U.S. solar manufacturer by capacity is one of the largest companies in the solar industry, as an integrated PV module maker, developer and construction contractor. First Solar even owns a tracker company and offers operations & maintenance services, making it a one-stop-shop for utility-scale PV.

The core of this is First Solar's manufacturing site in Perrysburg, Ohio, which has the capacity to churn out 640 MW of cadmium telluride thin-film solar PV modules annually on six manufacturing lines in multiple buildings. (see **pv magazine** 7/2016).

This is also First Solar's first manufacturing site, as Harold McMaster founded predecessor Solar Cells Inc. here in the 1980s. Expansions have come slowly over time, however. The latest increases in output have not come from new lines, or necessarily even more modules. Instead, they come from higher wattage in each module, with First Solar's dramatic technical improvements enabling the company to compete with multicrystalline silicon in terms of efficiency.

SolarWorld – Hillsboro, Oregon 430 MW cell, 550 MW module

The second-largest manufacturer by capacity in the United States is in many ways the opposite of First Solar. First Solar is an American company that makes most of its PV modules overseas, whereas SolarWorld is a German company with substantial U.S. manufacturing, which has become the symbol of "Made in the U.S.A."

A further difference is that while First Solar makes CdTe thin film, SolarWorld makes crystalline silicon. In fact, it is one of the few large solar companies that is not under Asian ownership and which does not manufacture in Asia competing in the standard crystalline silicon space.

Finally, First Solar's products are used almost exclusively for utility-scale PV, whereas SolarWorld sells mostly into DG markets.

SolarWorld's factory near Portland, Oregon, has 430 MW of annual PV cell capacity and 550 MW of module capacity, including a new 72-cell module line with the capacity to produce 150 MW annually.

One of the defining features of this factory is a very high degree of automation, and in a factory tour **pv magazine** saw no production processes that are performed manually. SolarWorld presents itself as a leader in quality and reliability, and says that this degree of

Photo: SolarWorld

While most solar PV is still made in Asia, the United States is returning as a manufacturing destination.

automation assists in keeping quality standards high.

All of SolarWorld's cell lines use passivated emitter rear contact (PERC) technology. SolarWorld claims to have been the first company to commercialize PERC, which has since been adopted by most large PV cell makers for at least a portion of their lines.

Finally, SolarWorld has begun production of 5-busbar PV cells on some of its cell lines, and plans to convert its entire production to 5-busbar cells.

Suniva – Norcross, Georgia, and Saginaw Township, Michigan 150 MW cell, 200 MW module

With the two largest solar manufacturers located in the Midwest and the West Coast, the next major PV maker on our list is located in the Deep South, and is a more recent arrival. While First Solar and SolarWorld have decades of manufacturing experience, Suniva was founded in 2007.

AT A GLANCE

- The United States is expected to become the world's second-largest solar market, which will mean an advantage for local manufacturing.
- Currently First Solar and SolarWorld have the largest PV production in the United States, however SolarCity is building a factory that will be larger than either of these when complete.
- GTM Research expects 2 GW of new PV module capacity on an annual basis to come online over the next five years.

Suniva began as a PV cell maker, and its work evolved out of solar PV research at the Georgia Institute of Technology. The company currently hosts 150 MW of annual monocrystalline silicon cell capacity at its headquarters in Georgia, and added another 200 MW of module capacity in Michigan in 2014.

Last August China's Shunfeng, part of clean energy mogul Chen Kin Ming's Asia Pacific Resource Development Investments (APRD), acquired a majority stake in Suniva. Bankrolled by Shunfeng/APRD, the company is currently expanding its manufacturing in Georgia and expects to reach 430 MW of annual mono cell capacity during the fourth quarter of 2016. As part of this expansion, Suniva will premiere its ARTisun Star cells, which incorporate PERC cell technology at efficiencies over 20.4%.

Suniva plans to sell these cells to its global customer base, but also notes that it has an additional 300 MW of annual module capacity available through global assembly partners, should it choose to go that route.

SolarCity/Silevo – California and New York 100 MW + 1 GW under construction

Last November SolarCity began production at a pilot facility to produce PV modules based on Silevo's silicon heterojunction technology in Fremont, California, with a capacity of 100 MW. However, what has attracted headlines is its integrated PV cell and module factory in upstate New York, which is currently under construction and will have the

Photo: Suniva

Suniva is currently in the process of a major expansion of its PV cell capacity in Georgia

capacity to produce 1 GW of of PV modules annually when complete. This will make it by far the largest PV manufacturing facility in the Western Hemisphere.

SolarCity broke ground on the facility in September 2014, after it secured a massive $750 million incentive package from the state of New York. However, the first half of 2016 came and went without the factory ramping production as promised.

In February SolarCity admitted to delays in tool orders and said that it would still be receiving equipment through the second quarter of 2017, which would push ramping of the factory back to the second half of 2017. The company declined to respond to **pv magazine** questions in June about the timeline for commissioning the factory, and SolarCity's market capitalization has suffered due to an ongoing slump in its stock price.

Tesla has made a bid to buy SolarCity, which would address its market capitalization and make new sources of financing available. However, there is no guarantee that this deal will go through, and questions remain regarding when – and possibly if – the Gigafactory will be completed.

Growing attractiveness

Outside these three players, there are a number of smaller manufacturers in the United States. CIGS thin film maker Stion is one of the few companies to survive a wave of insolvencies and acquisitions in this space, and maintains manufacturing in both Mississippi and Silicon Valley.

It is important to note that many companies based in the United States have limited amount of manufacturing here. Both First Solar and SunPower have significant manufacturing capacity in Southeast Asia, and SolarCity currently produces Silevo PV modules in China.

However, the United States is looking better. Since its last report on the subject in 2015, GTM Research has moved the United States from #5 to #2 in its ranking of the nations that are most attractive for PV manufacturing. The company bases this attractiveness ranking on a number of factors, but says that the strongest driver is end-market demand. GTM Research Senior Solar Analyst Mohit Anand describes the extension of the federal Investment Tax Credit as "huge" in this regard.

Other strengths of U.S. manufacturing described by GTM Research are the ease of doing business in the United States, access to finance and a "very robust" supply chain. The company additionally mentions the role of incentives at the state as well as federal level. "States compete with each other to set up the best incentives for manufacturing," explains Anand. This can be seen particularly with the generous tax and incentive packages provided to SolarCity in New York and Stion in Mississippi.

Anand also notes that tariffs on Chinese products have resulted in diversification outside of China, but he says that they have not significantly grown U.S. manufacturing. "You don't need to have U.S. manufacturing, you just have to have non-Chinese manufacturing [to avoid import duties]," notes Anand.

To the future

As a result of these factors, GTM Research estimates that the 2.8 GW of PV manufacturing in the United States will grow by another 2 GW over the next four years. This should position the United States as an important regional hub.

This return of PV manufacturing bucks the larger trend that has played out in previous decades in the United States of "offshoring." However, as a highly automated, high-value industry, PV is fundamentally different from other kinds of production, such as the textile industry, clothing assembly and even other forms of manufacturing, where labor costs are a greater consideration and low-paid labor is the norm.

The presence of highly skilled labor is a strength for the United States. "A big strength is that there is excellent human capital in the country," notes GTM Research's Anand. "There isn't a skilled resource crunch."

But even though PV factories typically employ fewer workers, labor costs are irrelevant. Anand says that the nation's biggest weaknesses are the costs of labor and land, which makes the United States an expensive place to manufacture.

Ultimately, the nation's growing attractiveness is not expected to change the position of Asian nations in solar PV as well as other manufacturing industries. "Global manufacturing remains China-focused, and they tend to only roam a little around," admits Anand.

Regardless, the United States is ready to enjoy a boom in manufacturing; a boom that in the eyes of many is long overdue. ◆

Christian Roselund


THE SOLAR SUPERHEROES HAVE COME TO LIFE AND BATTLED COAL ON THE FLOOR AT SNEC AND INTERSOLAR EUROPE.
WHERE WILL THEY POP UP NEXT?
See the September edition of pv magazine for the latest edition of the Solar Superhero comic.
To create your own Solar Superhero character contact:
sales@pv-magazine.com

Photo: Risen

Manual stringing is becoming increasingly less common, Clean Energy Associates and automated stringer suppliers report.

Adding more strings to the bow

Stringer-tabber equipment: A new generation of stringers are delivering vastly increased throughput on limited fab floorspace. They are also embracing the shift towards four, five and even six busbars. But how can quality be maintained within this crucial process? **pv magazine** investigates.

There's no question the look and feel of the solar industry is always changing. From an immature industry with high levels of process variation last decade, to one in which automation is becoming increasingly common and material variation reduced. The appearance of modules themselves is also always in flux, with a commonly observed transition being the number of busbars connecting cells increasing from two in the past, to three, and increasingly four and five today.

Stringing and tabbing processes play a key role in these observed shifts. The materials and equipment, and indeed the stringing-tabbing process itself, has facilitated the multiplication of busbars, delivering reduced shading, greater conductivity and increased efficiencies on the module level.

But with change comes challenges, and as the stringing-tabbing process has transitioned from manual to automatic and from two to more busbars, so too has the level of complexity both inherent to the process and within the production equipment itself.

What impact this has on quality is a frequently debated topic within module production. While it may seem self evident that machines taking over from humans will inherently increase quality, some reports from producers themselves are that the human touch does not automatically mean poor solders and damaged cells (see p. 49). The providers

of automated stringer-tabber platforms, understandably, beg to differ.

A key step

The stringing-tabbing process itself revolves around the interconnection of PV cells in series along the length of the module into a string using conductive ribbon. This ribbon is soldered at a number of points onto the metal contacts that have been printed onto the cell. These strings are then tabbed together in series at the end of each string along what becomes the width of the module.

Misaligned strings or poor quality solders can seriously compromise the end quality of the PV module, resulting in reduced power output at best and terminal faults like hot spots at worst.

"If you don't have good soldering then you have high resistance, there is not good conductivity, and high resistance is bad because it creates heat and it can have a significantly negative effect," explains George Touloupas, the director of technology and quality at Clean Energy Associates (CEA). "Some of the most frequent quality checks we perform are related to the stringing-tabbing process."

Photo: teamtechnik

Teamtechnik's TT4200 GIGA platform can achieve an annual throughput of 130 MW on the same footprint that a machine with 30 MW could be installed only a few years ago.

Stringing and tabbing is also one of the key processes in the module manufacturing line, which, along with lamination, can dictate the final output of a production facility. Module assembly lines and indeed whole fabs are often designed with either the stringing or lamination process the pull factor within production, where it can be either the bottleneck or the facilitator of higher output.

This results in a dynamic whereby achieving high throughput is key, while

Photo: M10 Industries

Two Kubus units have been shipped to Bangalore, India-based manufacturer Emmvee Solar.

solder and alignment quality must be maintained. It's a catch 22 that leading automated stringer-tabber equipment providers can overcome with well-engineered tools, sufficient training, calibration, optimization and ongoing monitoring and maintenance. For CEA, which has carried out around 125 factory audits in over 25 countries on behalf of developers, EPCs and investors, it is a process that requires close inspection. "Stringing-tabbing is not a stable process," says CEA's Touloupas. "Even the most advanced equipment can face problems, which are due mainly to equipment and material stability." He adds that the nature of the conductive cell paste "is a big factor," while ribbon quality itself may also play a lesser role. Touloupas says that if and when materials change, then alignment and soldering characteristics will change and the soldering process parameters – or recipe – must be adjusted.

"It is a matter of process, standard operating procedures and how strictly the manufacturers stick to them," says Touloupas. "If the equipment is problematic then there are huge issues and I have seen factories that have suffered for long periods of time because of poorly adjusted equipment."

However, while this may paint a somewhat troubling picture for stringing processes and equipment, this was not the CEA auditor's intention. He notes that great progress has been made in stringing technology both in terms of equipment throughput and end quality, and the maturing PV manufacturing sector has resulted in increased material stability and reduced variability.

Competitive landscape

The one-time leading innovator in the stringing equipment space was Germany's Somont, now a part of Meyer Burger. Somont was quickly joined by Japan's NPC, U.S. supplier Komax – now XCell Automation – and Germany's teamtechnik, amongst a number of others and, more recently, a host of Chinese suppliers. CEA reports that in the recent spate of module capacity expansion that took place in Southeast Asia, it is very common to see stringers from Chinese suppliers such as Autowell and to a lesser extent Jinchen Machinery comprising the vast bulk of the machines.

Teamtechnik reports that despite competition from cheaper Chinese tool makers it is currently producing two to three stringers per week at its manufacturing facility in southwest Germany. Sven Kramer, the vice president of solar technology sales at teamtechnik, reports that the competition from China "is getting stronger" but that quality remains a key selling point when it comes to stringer supply.

"When looking at the modules originally with two, then three busbars and now four busbars, it is more critical in handling four busbar ribbons and it can be seen that ribbon placement is not as accurate and this can affect the power output of the module at the end of the day," says Kramer.

Teamtechnik deploys a patented 'Hold Down' component to ensure the precise alignment of the busbars onto the cell. As the number of busbars increase, they get thinner and taller, making positioning more challenging. Three busbar cells deploy ribbon width of 1.6 mm to 1.7 mm,

XCELL AUTOMATION MAKES THE CASE FOR INDUCTION SOLDERING

York, Pennsylvania-based XCell Automation emerged from the former Komax after a management buyout almost exactly two years ago. Its latest stringer-tabber, the X3 employs an induction solder process. XCell Automation's Adrian Gretler says that there is a trend away from conductive soldering – through the deployment of a heating bar – due to machine cleaning requirements.

"There is no such thing as contactless soldering," says Gretler. "Every soldering process needs three basic ingredients to work: a heat source, a hold down force and flux. Both methods [IR or induction] need some kind of hold down device such as hold-down pins, carriers or hold-down wires."

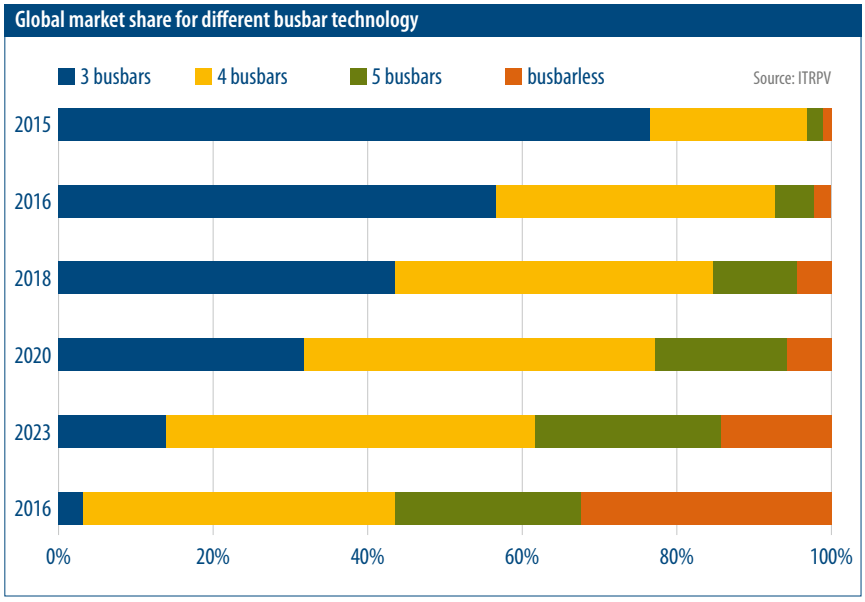
Gretler adds that in Southeast Asia, where manual soldering was more prevalent, he has heard reports that acquiring and retaining skilled staff to perform manual soldering is a major issue.

"In Southeast Asia, salaries are steadily rising. This makes machines such as the Automated X3 Tabber Stringer from XCell Automation more and more attractive."

In transitioning from three to four and then five busbars, XCell reports that a slight yield impact may be incurred by the manufacturer "over the first months" and that increasing the number of solder bonds from six to ten and ribbon spools from three to five that there is a chance for anomalies.

"Nevertheless XCell Automation has taken this trend into account while developing our X3 machine, focusing our efforts especially in these critical areas to ensure a seamless product changeover," says Gretler. "Feedback from the field confirms, after a ramp up time, similar yields than with three bus bar products are possible."

Graaphic: pv magazine/Harald Schütt



with that decreasing to 1.2 mm to 1.3 mm with four busbars.

The VDMA's latest ITRPV Roadmap reports that while around 75% of module production deployed three busbars in 2015, that is forecast to fall to around 55% in 2016 and slightly over 40% in 2018, with four and five busbars consuming the bulk of the remaining share (see graph above).

"Increasing busbars doesn't compromise quality because as a machine builder, we have to ensure this," says Kramer confidently. "It is the combination of the 'hold down,' the vacuum belts and the combination of how we handle the ribbon and how it is unspooled. It builds on the experience we have since we began manufacturing stringers in 2004." Teamtechnik reports to have supplied 650 stringers to the market in that period.

The company introduced two new stringer models this year, the single lane TT2100 and dual lane TT4200 GIGA, which are capable of 65 MW and 130 MW of annual throughput per unit, respectively. Both are capable of six busbar stringing, which Kramer admits is not likely to be commonly deployed for at least "a couple" of years.

New arrival, old heads

A more recent arrival to the stringer supply space is Germany's M10 Industries, located nearby to the renowned solar research center of the Fraunhofer ISE. Emerging onto the scene in 2015, M10's Kubus tool has introduced a number of new features and approaches. And it has placed high throughput on a small floorspace front and center. "With six busbars, the distance between each is 26 mm," explains M10 cofounder and CEO Gregor Reddemann. "Each busbar then is between 0.5 mm and 0.6 mm in width and 290 µm in height. Thin ribbons are challenging, because it means they are taller, but we have tested very thin ribbons that are very tall and it worked quite well."

Reddemann founded M10 Industries along with Reinhard Willi and Günter Schneidereit, who developed and supplied the first high-speed PV soldering tool for pioneering German manufacturer Solar-Fabrik. Willi and Schneidereit went on to found Somont and along with Reddemann have built on that accumulated expertise to engineer the Kubus.

The Kubus tool was formerly recognized this year at Intersolar Europe, picking up one of the technology awards, which Reddemann describes as being welcome recognition both in dealings with manufacturers and also "very good for the team." The Kubus sports a whopping 170 MW of throughput, but unlike the TT4200 GIGA, it does not combine two single-track units, but rather processes six cell strings simultaneously.

"The challenge is to have a homogeneous temperature field, but that can be solved," says Reddemann. "The bottom line is that it is not that difficult. There are six strings instead of one, but we use a tray transport and not a belt or any other transportation system. We have one platform on which we operate and this platform is moving."

The Kubus, as with teamtechnik's TT series, employs infrared (IR) soldering, which the CEA's Touloupas notes is increasingly becoming the industry standard. Different paste and ribbon materials require different soldering parameters, but both companies agree this is a case of optimizing the solder recipe rather than turning to inductive soldering – the method deployed by XCell Automation (see box p. 60).

To optimize the IR solder method, cells are preheated, transported to the solder station and then cooled in controlled fashion post solder. Reddemann argues that an advantage of soldering six cells simultaneously is that with an individual cell, the IR light must run over the edge of the cell, while in the Kubus all six cells can slightly overlap. Reddemann explains: "We can create a very homogeneous temperature field over six cells, overlapping from one cell to the other cell, and then we have a controlled climate," additionally reducing energy loss.

The Kubus' solder cycle time is four seconds, comparing to 1.71 seconds with the latest teamtechnik tools. While a slower solder time may initially conjure up images of reduced tool throughput, M10 suggests it's a luxury afforded by processing six cells at once.

"We have not sped up the soldering time, because this has its limits," says Reddemann. "We take our time. There is no need to rush because we do six cells at once."

Both companies promote the gradual and controlled heating and cooling of the cells through the soldering step as an advantage delivered by their tools – with cell temperature constantly measured in a constant feedback loop. This smooth temperature control has quality implications as it reduces the potential for microcracks to form as a result of thermal stress. And cell breakage, even at the microscopic level, is worth avoiding.

"Remember, every cell costs more than $1, so it is quite expensive," says CEA's George Touloupas. Microcracks may even affect quality many years in the future. Touloupas reports that he is encouraged by what he has seen with recent stringer development, but that with ever-squeezed margins, the pressure for higher throughput is unlikely to let up. "This is a general trend in PV: quality goes up," says Touloupas. "But the situation remains balanced and the pressure on ensuring quality is as big as it has always been." ◆

Jonathan Gifford

Photo: SolarEdge

Module level power electronics are an increasingly common sight on solar rooftop arrays, with DC optimization technology nudging ahead of microinverters thanks, in part, to the flexibility these products offer.

Reasons for optimization

DC optimizers: Module level power electronics are squeezing more energy out of the solar array with every new iteration, with DC optimization a preferred choice for a great many regions and markets. **pv magazine** examines the latest trends and products shaping this space.

The notion of 'premium' products is still relatively new to the solar industry. For much of its brief but booming history, the sector has sought to lower costs at every turn, not heap additional zeros on to the final bill. But amid the many signs that the solar industry has matured into a self-confident, self-reliant sector is the growing appreciation of value for money, and few strands of the industry epitomize this better than module level power electronics (MLPE).

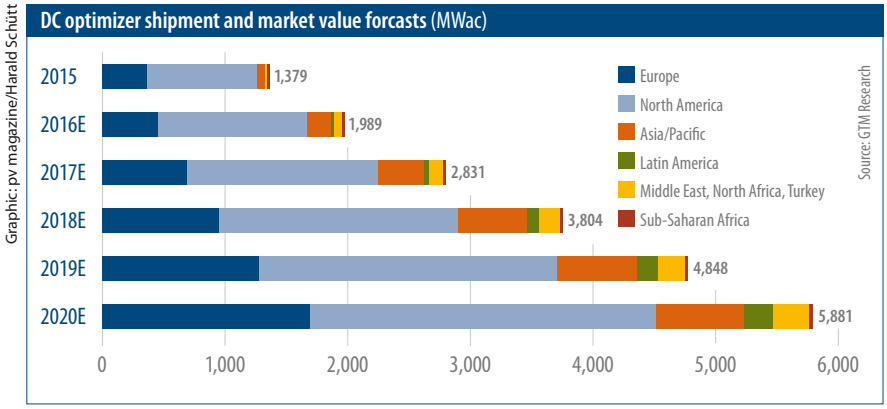
Although representing an additional upfront cost, the MLPE market is growing fast. At the module level there are two leading options for customers to choose when maximizing power output: microinverters and DC optimizers. And regardless of how one views the various merits of each technology, it is DC optimizers that currently have their noses ahead. A November 2015 report by GTM Research titled Smart and AC PV Modules 2015 – 2020 examined the technologies, value propositions and forecasts for MLPE and concluded that, in the short-term at least, DC optimization represented a simpler means of extracting more juice from the panel because both standalone optimizers and embedded cell-level optimizers are possible.

GTM forecasts an average annual growth rate of 63% for smart modules up to 2020. Smart modules come pre-fitted with optimizer technology attached, either on the module itself (SolarEdge and Tigo are the leading proponents in this space) or with cell optimization technology contained within the module (an approach taken by Maxim Integrated).

"Many PV module original equipment manufacturers (OEMs) are now incorporating this next generation of DC performance optimization," Cormac Gilligan, senior solar analyst at IHS, told **pv magazine**. "These are highly integrated power regulators included on each cell string within the module. They basically replace diodes in the module with small chips."

Modules go smart

The attraction of smart, DC-optimized panels for module suppliers is the low price point, which comes in below using standalone power optimizers, while also offering additional flexibility. "The first generation of MLPE technologies required 100% deployment, i.e., on each and every module," said Zvi Alon, CEO of U.S. firm Tigo, which produces mod-



ule-integrated optimizer technology. "This one-size-fits-all approach has fast become unflexible. The next generation of MLPE addresses most of the deficiencies of that first generation while expanding the solutions offered."

Tigo's new Flex MLPE components are offered to the market in two formats: the TS4, which is integrated into the junction box at the module production stage, and the TS4-R, which is a box mounted to the PV module frame that can be added to a new or existing installation.

For Tigo, this more 'flexible' approach offers installers and module producers a wider range of possibilities for optimization. The FLEX TS4 range has five different covers, each representing progressive price points in relation to added functionality, which basically gives module manufacturers the option to make and market "power, where appropriate" modules, Alon said. "The only way to address challenges to a solar array with MLPE is to deploy full function. Current standalone MLPE is not designed to be adopted to new technologies once deployed, making any kind of retrofit improvement costly. Flex MLPE provides flexibility for evolving conditions."

Hence, installers can choose smart modules based on the level of optimization they require for a certain section of the array, thus deploying appropriate functionality to individual PV modules, which is a more cost-effective solution. "Not all Flex MLPE smart modules are optimized, which is part of the attraction for module suppliers," Alon explained.

The GTM Research report notes how Tigo's OEM path to market, also adopted by Maxim Integrated, is a relatively new

AT A GLANCE

- Among MLPE offerings, DC optimization technology has the brightest short-term future, experts believe.
- Smart modules, those pre-assembled with optimizers, have a good growth opportunity in the U.S. and Europe, in particular for safety and cost reasons, respectively.
- Leading proponents in this field number just a handful, and growth is likely to be driven by stronger partnerships with bankable module manufacturers.
- Standalone products, as well as cell-level technology, are both well-worn and niche avenues for DC optimization growth.

Photo: Tigo

Tigo's TS4 range offers installers and customers up to five different 'covers,' which denote a sliding-scale of DC optimization and are priced progressively with the added functionality: the more expensive versions offer greater sophistication in terms of optimization, allowing installers greater flexibility.

and small portion of an optimization market dominated by Israel's SolarEdge, which currently has just under 95% market share.

The North American market represents opportunities and challenges for smart module deployment, most notably in the forthcoming update to its National Electric Code 2017, which effectively mandates the inclusion of MLPE technologies for future solar arrays under the module-level shutdown requirement. However, smart modules shipped into the United States are subject to additional import tariffs of between $0.02 to $0.05 per watt, depending on the added cost of the DC optimization technology.

GTM Research notes, however, that in Europe, unlike in the U.S., there are no added tariffs for smart modules, and so "the minimum price floor often enables suppliers to sell integrated modules with the artificial module price increase covering a portion of all of the DC optimizers," the report notes. "This creates a strong incentive to integrate the product in the factory rather than in the field."

A question of marketing

Currently, the most direct route to market for two of the three leading DC optimizer suppliers (Tigo and Maxim Integrated) is via partnerships with leading module manufacturers. SolarEdge's broader portfolio and stronger brand image affords them more independence, but for Tigo and Maxim Integrated, much of their success hinges on solid partnerships.

Tigo's DC optimization technology is used by Tier-1 Chinese firms such as Trina Solar, JinkoSolar and JA Solar, and also other producers such as Hansol, Luxor and Recom. Maxim Integrated have partnered successfully with ET Solar, JinkoSolar and JA Solar, while SolarEdge has also dabbled with smart modules via partnerships with ReneSola, JA Solar, Yingli and JinkoSolar, to name just a few. However, SolarEdge draws in the bulk of its sales via the marketing of its standalone optimizers, inverters and its newly introduced HD-Wave technology.

A concern noted by GTM Research is a reticence among module manufacturers and installers to proactively market smart modules. After all, a sale is a sale for these vendors, so whether as much effort as possible is being put into pushing these more premium products is debatable.

Alon, however, believes that Tigo's strong relationship with its partners negates this worry. "We make sure that the message of our product fits their language and way of doing business," he told **pv magazine**. "We constantly train and educate the sales and support teams, and co-host events for our mutual customers. Through this tight hand holding we ensure our partners are comfortable talking about Flex MLPE and its benefit, and don't shy away from 'premium' questions."

The growth forecast for smart and AC modules (those fitted with microinverters) is 1.01 GW by 2020, up from less than 80 MW in 2014, according to GTM data. The market will grow in value to around $600 million by that date as vendors and distributors see economies of scale widen the distribution of DC smart modules and thus lower costs. IHS is even more bullish in its forecast, and expects smart modules alone to reach 1.8 GW of shipments by 2019.

Currently, module manufacturers sell optimized modules with an average premium of 3 – 5%, which makes actual, tangible cost savings quite hard to pin down. The message that leading optimizer proponents need to spread now is one of longer-term savings via improved energy harvest, GTM believes.

Different approaches

MJ Shiao, director of solar research at GTM Research, told **pv magazine** that an interesting facet of the optimizer landscape is that the supplier base has not broadened. Dominated by SolarEdge and then supported by Tigo, Maxim Integrated and Ampt, there are – he says – few opportunities for new players to enter the market, with growth likely to be driven by more fully-embedded or cartridge-based optimized modules produced for

or by bankable companies – the recent investment by German inverter specialist SMA in Tigo being a case in point.

The traction gained by smart modules is in part due to benefits of installation and logistics. Modules pre-assembled with DC optimization technology are quicker to install than modules+standalone optimizers, and also boast simplified packaging, shipping and inventory once assembled. However, a weak link of this supply chain occurs pre-assembly. Most MLPE components are produced in locations different to the module manufacturing process, and this adds cost and complexity to the supply chain.

Furthermore, smart module vendors must rely heavily on MLPE providers for service and troubleshooting, although as partnerships strengthen such concerns are likely to melt away. Maxim Integrated's approach differs from other competitors. The company produces cell-string level optimizers that can be embedded into the module encapsulant along the cell-string buses. This approach enables the elimination of the bypass diode in the junction box and so increases energy yield and flexibility for installers working with shaded or partly-shaded arrays.

"Most implementations incorporate the Maxim cell-string optimizer inside the junction box; the main benefits of this approach are that it is compatible with, and least disruptive to, standard PV manufacturing flows," said Seth Kahn, Maxim Integrated's executive director, solar product line. "Maxim can replace each bypass diode with a DC-DC power tracker, thus enabling PV modules with three distinct regions of optimization, solving problems that have not been addressed: for example, real shadow patterns rarely cover the entire module."

Of the other suppliers to watch, Altenergy Power Systems (APS) has developed its OPT700 optimizer, which is designed for large-scale solar installations to improve system efficiency and ensure greater levels of safety. U.S. company Ampt has also made a series of announcements in the field, most recently partnering with Japanese solar developer Elechs Kyokoto to bring its DC-to-DC converters to the large-scale Japanese market. The products are the V1000-JP, V750-JP and V600-JP, and correspond with common maximum system voltages. Another potentially pivotal development comes from First Solar, which is poised to roll-out its new medium voltage DC (MV DC) architecture as a new feature for certain applications.

"The MV DC architecture utilizes DC-DC boost converters that also perform MPP Tracking at the combiner box scale," First Solar's CTO Raffi Garabedian told **pv magazine**. "The DC-DC converter will take the place of a conventional combiner box." The CTO said that this is set to be a beneficial feature rather than the primary driver of First Solar's value proposition. "In utility-scale systems, module mismatch and non-uniform shading losses are a less significant loss factor than in residential or commercial rooftop systems." The benefits, therefore, include more energy per installed DC watt and lower constructed system costs – the modus operandi of every DC optimization technology provider in operation today. ◆

Ian Clover

SOLAREDGE GROWS PORTFOLIO

The Israeli firm's HD-Wave technology promises a revolution in the inverter landscape, delivering improved performance at smaller, more compact – and hence, easier to install – size. But the company is also upgrading its optimizer portfolio and recently launched a new module-embedded power optimizer at Intersolar North America. This new product replaces the standard junction box on a module, allowing for modular design that simplifies manufacturing and inventory management, ensuring easy serviceability during field replacement.

Photo: Jinko Solar

Long-established as a cost leader, Jinko enjoys the highest gross margins of all of the Chinese c-Si module makers.

Top-c-Si turvy in the Top Ten

Crystalline silicon module ranking: As every year, **pv magazine**, via the analysis provided by IHS Research, has listed the top ten crystalline silicon module manufacturers of 2015. Some have left the ranks, others have joined – and one has taken a dive.

Call it the curse of being number one as the solo king of the mountain. Yingli knows all about breathing the thin air in that lonely-at-the-top spot. For the calendar year 2014, the vertically-integrated Chinese solar company was lord of the hill, the largest module producer in the world with an annual assembly of 3.6 GW.

But for our latest survey on production in 2015 of the top ten crystalline silicon (c-Si) module producers – in other words, excluding thin-film panel makers, **pv magazine** – in collaboration with IHS Research – now has the 2014 leader hanging by its fingertips in the sixth spot. In one year, its module production fell by more than a fourth. And, possibly facing bankruptcy, Yingli will almost certainly tumble again in 2016.

Instead, China's Trina Solar, which played second fiddle to Yingli in 2014, reclaimed its 2013 first place showing. Its 2015 production was nearly 25% better than second place module maker Canadian Solar, a name certain to baffle consumers looking for non-Chinese made modules.

In fact – and unsurprisingly – except for South Korean-headquartered Hanwha Q Cells – all of the top ten panel producers are Chinese owned. This is a country that has suffered for years under U.S. and European import tariffs and duties. "We're expecting the trade dispute to get more and more complicated," says Jenny Chase, the manager of Solar Insight at Bloomberg New Energy Finance (BNEF). "Places like Vietnam may be the next frontier."

Indeed, some Chinese producers have made sure to have production capacity

sited in other countries. On the other hand, China is still by far the biggest world market, and certainly all of its manufacturers are more than happy to have such a profitable market at home to sell their products.

But how long China will be its own best market is being put to the test. While IHS is forecasting 13 GW in China of newly installed capacity on roofs and ground in the first half of 2016, it only expects about 5.6 GW in the second half, as a reduced feed-in tariff is expected to kick in, some describing it as a government brake to slow down the booming market. The end result would only be slightly higher than the 18 GW installed last year – not the growth the solar world has come to expect in China. Edurne Zoco, the senior manager of solar energy at IHS, says her fear is that China's module production in the third quarter could be a "lost quarter."

Photo: Trina Solar

Trina has a debt of $2.6 billion, which the company has been paying off. It enjoys higher margins than some rival Chinese producers.

Production vs. shipments

The manufacturing growth seen in the **pv magazine**/IHS rankings is certain to differ from the results of other analysts. That's because the IHS numbers are based on production, not shipments, sometimes estimated, sometimes calculated via a mix of company announcements and production facility utilization rates.

But the fact is that companies almost never reveal production numbers to investors in their quarterly and annual financial reports – only the more impressive numbers of what the manufacturers ship. The argument that shipments reflect real sales as opposed to inventory sitting unproductively on factory shelves has some merit. Certainly some of this discrepancy is due to home-grown, end-of-year capacity being built up over 12 months. And those capacity increases have been impressive. Of the top five, the smallest amount of build-out capacity was 1 GW, while Hanwha nearly doubled its potential production to 4.3 GW.

Still, the metric of shipments can be misleading. It often lumps in the usually unmentioned amount of outsourced production to original equipment manufacturers – that is, basically rented capacity with just the company logo and name added to modules rolling off another factory's line. And the difference can be huge. In 2015, the shipment of the top five companies was 29% higher than production (35% if factoring out Hanwha). If the top ten rankings were based on shipments rather than production, fourth-placed Jinko Solar would be holding down the second spot, while third-ranked Hanwha would have switched positions with fifth-placed JA Solar, each dropping down a rung. And the disparity has been increasing – shipments among the top five were only 12% higher than production in 2014 and just 6% in 2013.

AT A GLANCE

- The curse of market leader has plagued both Yingli and Suntech in recent years. Trina appears to have avoided it, retaining the number one spot.
- BNEF expects solar trade disputes to get even more complicated, affecting major producers.
- Untangling shipments vs. production figures can be tricky, with OEM an apparently permanent feature on the PV producer landscape.
- While Kyocera and Renesola have slipped out of this year's top 10, Risen and Eging represent new arrivals.

What's the score?

Is this a case of production facilities being left dormant or shuttered? At Yingli, the answer is almost certainly yes. For the others, it is unclear. "When the manufacturers find they've got more orders for their tier one, super brand stuff," says Chase, "it makes sense to get someone else to make them for a 'white label' rather than doing expensive expansion."

This is especially true if you are trying to save money. Bloomberg uses the Altman Z score, a ratio of financial metrics to rank manufacturing prowess. "It's a good predictor of bankruptcies," says Chase. Above 2.6 is the safe zone, where companies are more likely to have leeway to borrow money. Unfortunately, this year's gang of the top ten companies are all below the cutoff Bloomberg uses, which means debt. And the best way to pay that off debt? "Lose less money," Chase deadpans.

Here are the 2015 top ten, one for each finger on the hands of a CEO, some of whom have been able to ward off losses, with others surviving the best they can in hopes of living the good PV life down the road.

And the winners are …

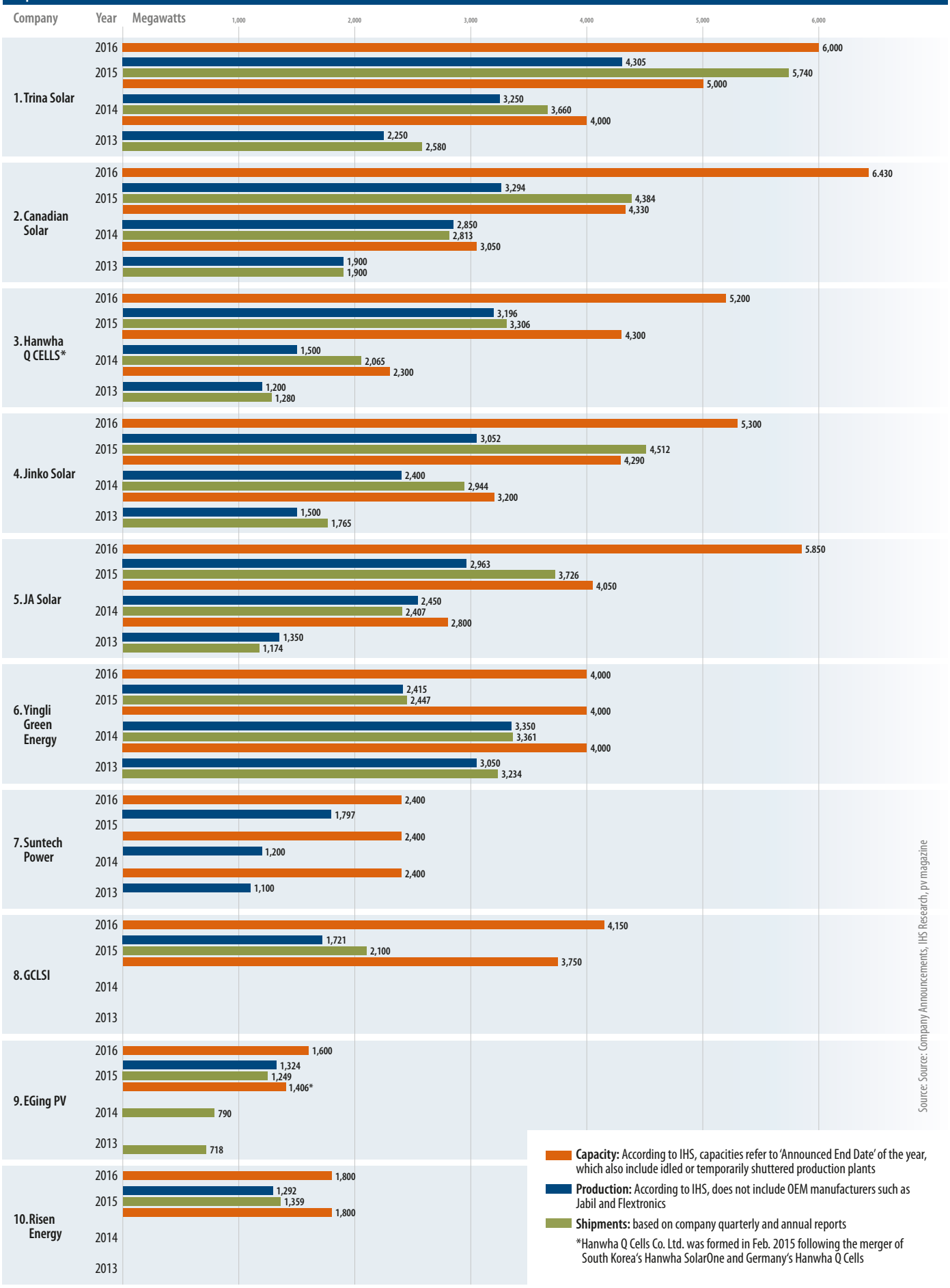
1: Trina Solar

With 4.3 GW of production, China's Trina Solar climbed up one spot to the top in 2015, equaling its leading position two years earlier. According to IHS' Zoco – who, in full disclosure, notes she worked for Trina for eight years – the company's margins have been better than those of others players, as it has been expanding outside to Malaysia and Thailand.

In its 2015 annual report, the company said it had "made progress" with production facilities in Malaysia and Viet-

Graphic: pv magazine/Harald Schütt

Top 10 c-Si module manufacturers



Source: Source: Company Announcements, IHS Research, pv magazine

Capacity: According to IHS, capacities refer to 'Announced End Date' of the year, which also include idled or temporarily shuttered production plants

Production: According to IHS, does not include OEM manufacturers such as Jabil and Flextronics

Shipments: based on company quarterly and annual reports

*Hanwha Q Cells Co. Ltd. was formed in Feb. 2015 following the merger of South Korea's Hanwha SolarOne and Germany's Hanwha Q Cells

nam. Bloomberg notes that Trina is net-income positive with a debt of about $2.6 billion, which it has been paying off. Zoco says that the 100% private firm has a "good cost structure" and has been able to secure financing for capacity expansion in China and elsewhere. Jade Jones of Greentech Media Research (GTM) says Trina could add 500 MW of capacity in China and the same amount in Thailand. As to technology, Trina announced a p-type monocrystalline module called the Honey Plus in the 2nd quarter last year aimed at Europe, with a worldwide launch sometime this year.

Photo: Yingli

The emerging Chinese DG market will potentially assist in delivering higher margins than race-to-the-bottom project pricing.

2: Canadian Solar

Like Trina, China-headquartered Canadian Solar moved up one level in 2015 with a production of 3.3 GW. Downstream project development helped increase profitability, says Zoco at IHS. Still, while the company announced revenues of $721 million in Q1 2016, this was down 36% compared to Q4 2015. In Q1 2016, the company's total debt level reached a new high at $2.4 billion, of which 60% was short-term debt.

According to Jones at GTM, Canadian, which as the name implies has some production capacity in Canada, plans to increase capacity in 2016 by about 870 MW in China, 300 MW in Brazil and about 930 MW in the Asia region. In March, the company launched its PERC-based Quintech SuperPower monocrystalline modules.

3: Hanwha Q Cells

South Korea's Hanwha Q Cells, with a 2015 production of 3.2 GW, more than doubling the previous year's mark and ascending from 6th to 3rd place, was tantalizingly close to Canadian's figures. And like Canadian, Hanwha announced last year it is making moves to set up in Malaysia with 800 MW of capacity, although there is still no date for when production would start.

In addition to its current module capacity and production in Qidong and Lianyungang, China, Hanwha is setting up 1.5 GW of cell and module production in Eumseong, Korea. But in May 2016, as part of a move to optimize its "cost structure," Hanwha Q Cells announced a plan to sell the facility for $57 million to Hanwha Q Cells Korea Corp, described as "an affiliate" which owns and operates a gigawatt-scale PV cell factory in Jincheon. While IHS puts the company's end-of-year capacity at 5.2 GW, in a May 2016 Hanwha brochure for investors, Hanwha claimed as of Q2 its module capacity was already 5.5 GW. According to a spokesman, all the Korean lines are "Q.antum ready," a reference to its new black frame Q.antum module line.

In 2015, the company merged Hanwha SolarOne and Q Cells to form Hanwha Q Cells. From a profitability aspect, says IHS, the company's margins have improved since Q1 2015, ultimately becoming profitable in Q3 2015. The company has increased its leverage level to over $1 billion since Q1 2015. The total debt was $1.1 billion at the end of Q1 2016, of which about 40% is short term.

4: Jinko Solar

After a drop to 5th place in 2014, Jinko Solar has again, as in 2013, occupied the 4th place, this time at 3.1 GW, just behind Hanwha. Jinko had the highest gross margins of all Chinese module suppliers in 2015 and Q1 2016, notes IHS, and is the first Chinese module supplier to have profited in ten consecutive quarters, with an average gross margin since Q3 2013 above 20%.

The company's liabilities-to-assets ratio has remained around 70 – 80% in the past two years. Total debt was over $1.6 billion in Q1 2016. Although the IHS numbers are lower, GTM's Jones says that in addition to production capacity in Malaysia and South Africa, Jinko will add 2 GW of capacity in China this year.

5: JA Solar

Switching ranking place with Jinko, JA Solar dropped to 5th place in 2015, but maintained a neck-and-neck race with its rival Jinko with less than 100 MW separating them. JA has kept a strong balance sheet, compared to other Chinese suppliers, says IHS, holding onto stable margins, even during the industry's downturn in 2012. The company's total equity has also stabilized during the past two years, and at 60%, it has had the lowest liabilities-to-assets ratio among Chinese players over the past four years. According to GTM, the Shanghai-headquartered company, which opened a 1.5 GW module capacity plant in China in May, plans an overall capacity increase in China of more than 2 GW and, like Canadian Solar, will add 300 MW in Brazil.

JA Solar has implied that a 400 MW multicrystalline cell facility, opened in Malaysia in October 2015 and promoted as the company's "first manufacturing facility" not located in China, will also produce modules, noting that the cells will "primarily" be used to manufacture JA modules outside of China for "certain overseas markets." However, this could be a reference to Brazil where, like Canadian Solar, the company plans to add 300 MW of module capacity. Interestingly, in May, seven months after the Malaysia announcement, JA Solar opened a 1.5 GW module plant in China, a sure indication it expects the home country to remain its bread-and-butter market. The company expects an overall capacity increase of more than 2 GW for 2016.

Photo: Risen

Risen is one of the new entrants to the ranking this year, with an increase from 1.3 GW to 1.8 GW of module output.

Last August, JA Solar announced the production start for a double-glass multicrystalline module.

6: Yingli Green Energy

The only thing Yingli Green Energy appears to have gained over 2014, when it was listed as the world's top module producer, is debt. Its production fell by nearly 1 GW to 2.4 GW in 2015, while capacity remained static at 4 GW, almost certainly meaning an increase in idle production lines. Bad timing saw it signing costly long-term contracts for polysilicon just before the industry low point between 2011 and 2013, as well as investing in new manufacturing. "Part of the reason that Yingli is going to hell is that it just went for volume," says Bloomberg's Chase. "It had to, since it built all these bloody factories." And that also meant it had to be the lowest cost provider, she adds, with "a pretty severe loss on every sale." Amid all its trouble, in May Yingli announced it had "successfully commercialized" a high-efficiency dual-glass module – less than two weeks after it reported missing a series of deadlines for huge repayments on medium-term notes, without mentioning the possibility of bankruptcy,

Yingli listed its financial options as either finding "strategic investors," locating new creditors to grant "new borrowings," or selling off "long-lived assets."

7: Suntech

The fact that China's Suntech, with 1.7 GW of module production, held the 7th ranking in 2015 (up from 8th place the year before) – let alone that it was in the top ten at all – is as inscrutable as the history of the company itself. Once the biggest thing in PV that could seemingly do no wrong, it fell into bankruptcy and was then bought up at a bargain-basement price by a mysterious Hong Kong businessman and solar novice, who proceeded to piece together other solar acquisitions. Then in June, an announcement came that it was to be sold off by its parent company of two years, Shunfeng – a Chinese word that literally means "tail wind," but can also be translated as "bon voyage." Will its "goodbye" to Suntech be the "hello" for another investor? Will the 2.4 GW of module capacity continue production? Will there even be a Suntech to vie for the top ten in 2016? Stay tuned.

8: GCL SI

Since China's GCL Group, the world's leading polysilicon and wafer producer, took over the ailing cell and module maker Chaori Solar in 2014 to complete its vertical integration in the supply chain, its module arm, GCL Systems Integration (GCL SI), quickly entered the top ten in 2015 with an 8th place ranking on a module production of 1.7 GW. While IHS is forecasting a module production capacity of 4.15 GW in 2016, GLC SI says it has plans for 6 GW (interestingly the same amount as top ranked Trina Solar). The goal is probably the result of it taking over two companies in late 2015 – Jiangsu Dongsheng PV Tech and Zhangjiagang Qichen PV Tech. The GCL Group, which says it is "committed to becoming the world leading solar energy company," could be setting the stage for its subsidiary to make a run for this year's top rank. Ironically, the cells and modules would almost certainly use GCL wafers, which could exacerbate the current shortage of multicrystalline substrates, a potential weak link in the supply chain for its module competitors.

9: Eging

The vertically-integrated Chinese company Eging Photovoltaic Technology entered the top ten for the first time in 2015. Bloomberg's Chase gives Eging the best rating of all the top companies with an Altman Z score of 2.56, just shy of its 2.60 level for what it considers the "safe zone" for manufacturers. While much

smaller than the other companies in the list, it produced 1.3 GW of modules on a capacity of 1.4 GW, according to an annual report, for a utilization capacity of about 94%, the highest among the top ten in 2015. IHS says its end-of-year capacity in 2016 should be 1.6 GW. The company says it is doing research on PERC cells and glass-glass modules. Eging's revenue was listed as $757 million with a net profit just under $36 million in 2015.

10: Risen Energy

Rounding out the top ten is Chinese manufacturer Risen Energy, which, like the lexicological root of its name, is on the rise as a new entry. IHS puts the 2015 production at 1.3 GW on a capacity of 1.8 GW with no expected build out in 2016. The company reported a 2015 net income of about $48 million, claiming this was a 382% increase over 2014, on sales revenues of about $788 million.

Photo: Jinko Solar

Jinko is adding some 2 GW of additional manufacturing capacity in 2016.

Goodbye and hello?

Japan's Kyocera Solar, at #7 in 2014, dropped out of the top ten, as did China's ReneSola from its #9 spot. At #10 in 2014, Singapore-headquartered REC Group moved down to 13th place. The closest a German maker got to the top ten in 2015 was SolarWorld at #14 with 1.1 GW. And SunPower was at #12 with 1.6 GW of module production, the nearest a U.S. company could get to the top 10.

Not exactly. The U.S. manufacturer First Solar would have been the #6 ranked producer in 2015 – except that it makes thin-film modules, not the subject of this survey (see **pv magazine** 7/2016). Still, with 2.5 GW of production, according to Chase at Bloomberg, it has an Altman Z score of 4.07, putting it well above the 2.6 safe zone cutoff and making it healthier than any of the crystalline producers.

Health is definitely not a word that crops up when the subject of the erstwhile module leader Yingli is mentioned. But bankruptcy is. Chase puts Yingl's Altman Z score at an amazingly low -1.81. "Being first is the last place you want to be if you want to make money," she says. "That's the thing with Yingli. The more it sells, the more it loses." As an employee of BNEF, she is forbidden to speculate on the future of companies she covers. But it doesn't take a genius to see that with its financial woes. Yingli, once looking down god-like from the Everest of PV, could soon be a fallen angel gazing up from the nadir of solar's Dead Sea. ◆

William P. Hirshman

Photos: ARENA

U.S. tracking provider Nextracker supplied the self-powered dual axis system at the DeGrussa mine. The trackers will have to tolerate extreme temperatures and dry and dusty conditions.

Mining with sunshine

Offgrid PV+storage: Over 30,000 modules mounted on dual axis trackers sit above the iconic red earth in remote Western Australia. With the closest town of 1,000 people 150 km away and the nearest sizeable city 900 km, the project is about as off-the-grid as it gets. But it could be pointing the way forward for industrial solar+storage applications in Australia and beyond.

Ray Wills is a man of considerable intellect and endless enthusiasm. Based in Western Australia, he has advocated the opportunities for solar and storage in supplying remote mine sites with reliable and clean electricity for a number of years. "Gigawatts of opportunities," is how he describes it, having crunched the numbers.

Wills is familiar with wearing a number of hats, having been an academic, renewable association head, solar developer and lobbyist. He therefore knows both the energy and political realities facing the state when it comes to the ongoing support of its invaluable mining sector.

While way out west and separated from the population centers of Sydney and Melbourne by thousands of kilometers, the vast state of Western Australia (WA) is the center of Australia's mining industry. From bauxite to iron ore, diamonds, mineral sands and natural gas, if something is of value and can be dug out of the earth, there's a good chance WA has got it.

Over 90% of the state's population of some 2.5 million people live in the southwest corner of the state, with much of the mining taking place in the sparsely populated inland or northwest. This makes manning mining operations a "fly in, fly out" affair, and additionally presents major challenges to the miners in supplying their operations with the vast amounts of power needed for the accommodation and facilities required, and to drive extraction and processing equipment on site. Much of this power comes in the form of piped natural gas or trucked diesel, which are neither cheap nor is their supply particularly reliable.

Given the extreme weather in the form of sporadic flooding and extreme heat that can affect the remote mining regions, long energy supply lines can be stressed, and an explosion at a natural gas facility last decade brought the reality of these fragile supplies into focus.

"We know that there is at least 700 – 800 MW of demand in diesel alone, so there is at least that much and that is just for the miners," explains Wills. "And then there are some of the remote towns that are operated by [regional utility] Horizon Power and they too will be up for the challenge of converting to solar as well."

Located adjacent to the open cut and underground mine, the solar+storage array will be able to supply the operation completely with power during daylight hours.

Utility role

Horizon Power itself has performed a remarkable about face when it comes to renewable deployment in recent years. The state-owned utility supplies power to remote communities and some of the larger population centers outside of the main southwest grid. Much of this has been supplied by diesel and gas fired generation, and some remote households and communities have been supplied literally at the end of extremely long and unreliable electricity lines. This approach required large subsidies, either directly from the government or through increased retail electricity prices paid by customers in the state capital Perth.

As renewable LCOE has fallen and at the behest of state Energy Minister and Treasurer Mike Nahan, a former colleague of Wills, Horizon Power is now embracing solar+storage in a range of both distributed and mini-grid applications. "New technology in the renewable and distributed energy space is presenting multiple opportunities and threats to energy utilities so I am delighted that Horizon Power is at the forefront of exploring these new opportunities," said Horizon Power MD Frank Tudor, when announcing a new 2 MW battery array development to reduce the role of gas and diesel-fired spinning reserve in the town of Canarvon.

However, the uptake of solar has been slow at mining operations in WA, and elsewhere in Australia. While Chile has raced ahead in terms of solar deployment for mining, the Australian resource sector has taken a more conservative approach, unwilling to deploy anything that might detract from the core business of digging, processing and shipping. Short mine lifetimes, at least on paper, and the unstable nature of commodity prices have also further undermined solar deployment in the mining sector Down Under, with multi-year PPAs difficult to sign.

All of these factors make the AU$40 million ($30.5 million) DeGrussa solar+storage project in remote WA all

The remote location added to the labor and logistics required on the installation, a factor other EPCs may underestimate, says juwi Australia.

the more exciting. The 10.6 MW solar and 6 MW storage project at the DeGrussa mine site reached full operation in May of this year. The copper and gold mine is operated by Sandfire Resources. On completion, the solar+storage array immediately achieved a number of records: the largest offgrid PV project in Australia, largest offgrid diesel-solar hybrid globally and the largest solar array to provide peak power at a mine site globally.

Germany-based juwi Renewable Energy was the developer and EPC on the project and secured government subsidies. It deployed 34,080 BYD modules and self-powered single axis tracking technology from U.S.-based Nextracker.

The 6 MW lithium ion battery system has been coupled with the PV array and integrated with a 19 MW diesel generator to supply the underground mine and mining processing operation. juwi selected French developer Neoen to provide the equity financing and secure some of the debt financing. Australian government bodies also played a significant role in the project's realization with a AU$20.9 million ($16 million) recoupable grant from the Australian Renewable Energy Agency (ARENA), and AU$15 million ($11.45 million) in debt financing from the Clean Energy Finance Corporation (CEFC).

Market impact

"Because DeGrussa is being funded by the ARENA, that data will become public," says Wills. "Once that data is public I think that many mine sites will start to move very quickly."

Wills notes that the sharp decline in the Australian dollar in 2014 and 2015, which pushed up the cost of imported solar components, coupled with a fall in some key commodity prices, may have delayed the uptake of renewables by mining operators, but he says the financials for such projects pencil out regardless.

"And at a time when miners are hurting because costs are high, even though the price of diesel has fallen, it has not fallen relative to the Australian dollar and solar is still competitive," Wills notes.

Thomas Hillig is the founder of the renewables consultancy THEnergy, specialized in the industrial offgrid market segment. Hillig says that while DeGrussa "helps erase doubts on the technology side," in proving that solar+storage can power a mining operation fully during daylight hours, he cautions that a battery system of this size is not yet commercially viable.

"Today, I see that most renewable energy projects under development in mining are planned without or with small-scale storage solutions," says Hillig. "However, the DeGrussa project prepares the ground for the future." Hillig adds that the falling diesel price globally has undermined somewhat the business case for solar+storage at mine sites.

"When storage prices come down or diesel price go up again, we will see many similar configurations," Hillig notes. "At that time, DeGrussa will serve as a proof of concept for high-penetration solar+storage concepts in the mining industry." Until then, Hillig sees "renewable ready uninterruptible power supply" solutions as having "better chances."

STORAGE EXPANDS PROJECT AND POSSIBILITIES

There is little doubt that the incorporation of the 6 MW battery system on the DeGrussa project has increased its cost and the LCOE it delivers. However, as a trailblazing project supported through some recoupable government funding in the form of debt and a repayable grant, it has demonstrated at scale battery storage technology to the mining sector. The Clean Energy Finance Corporation (CEFC) provided AU$15 million ($11.5 million) in debt financing for the project and CEFC's CEO Oliver Yates noted the important role the storage system played.

"DeGrussa has delivered a unique combination of an offgrid high capacity solar power array and battery storage fully integrated with an existing diesel-fired power station," said Yates. "Soon remote communities and mines will be able to reduce the need for expensive trucked-in diesel used in dirty generators."

Developer and EPC juwi adds that the battery system can allow for the solar+storage array to provide additional services to the site in terms of the quality of power supply.

"Essentially it allowed us to export more PV power than if we didn't have the storage system," says juwi Australia MD Andrew Drager. "It also allowed the provision of auxiliary services like frequency support and power factor correction."

Juwi looks forward

The DeGrussa project has also pointed the way forward in terms of how offgrid solar projects can reach financial close. While the project was well advanced by the time Neoen stepped in as the equity investor, juwi Australia's Andrew Drager believes it may forge the path for traditional investors to take an interest in similar projects.

"Providing the underlying mine asset is good, then I think we will see traditional financiers start to look at these opportunities," says Drager.

The DeGrussa solar+storage power will sell electricity to Sandfire under a six year PPA and while a relatively short electricity supply contract makes it difficult for the financials to stack up, Drager says that a diesel-tied solar system is competitive today with diesel generation at mine sites over seven or more years in Australia, and less in other countries.

To exploit these opportunities, juwi Australia has entered into a strategic alliance with Pacific Energy Limited's KPS. The companies hope to roll out similar solar solutions to other miners. KPS supplies traditional electricity solutions to mine sites and the two companies worked together on DeGrussa. Building on this an alliance agreement was signed in June which will see large scale solar added to the company's power offerings.

"The experience and expertise of juwi leap-frogs us ahead in terms of delivering utility scale solar," said Pacific Energy MD James Cullen, in announcing the alliance. "Importantly, we have developed the know-how behind successfully integrating and operating the hybrid system in the challenging and changing conditions encountered in mine site operations." KPS operates around 230 MW of diesel and gas fired generation at mine sites in Australia and the companies will be looking to add solar to some sites in Australia and internationally.

In Australia alone, juwi estimates there is around 5 GW of offgrid gas or diesel generating capacity and Drager calculates LCOE around the range of $0.12 up to $0.25/kWh as being typical for this form of generation. Somewhat ironically, while the Australian federal government has scrapped its world-leading carbon tax, which would have made PV deployment more competitive at these sites, it continues to subsidize diesel for farmers and miners through a fuel tax rebate.

"The rebate is the equivalent of AU$0.40/liter in subsidies, meaning diesel is very cheap," says Drager. "Obviously not all of the [mining] sites are suitable [for solar deployment]. But I think the opportunity is there and certainly will increase as costs of solar systems decrease and as oil prices continue to go up, as they have over recent months, and as mining companies become more focused on sustainability and social responsibility." One thing is clear, DeGrussa is leading the way. ◆

Jonathan Gifford

Local construction company OTOC Limited carried out the installation of the project.

Photo: maxx-solar & energie

The winning entry came from Germany's Maxx-Solar Energy, which presented its innovative financing solutions for solar PV in Africa.

And the winner is …

Installation Innovation Award – Europe: presented by **pv magazine** and Hanwha Q Cells, the Installation Innovation Award identified four nominees chosen for their fresh approaches in bringing solar power to a wider audience. But alas, there could only be one winner …

At Intersolar Europe in June, four nominees chosen for the **pv magazine** and Hanwha Q Cells Installation Innovation Award – Europe presented their ideas to an enrapt audience.

Each nominee had a five-minute time slot in which to showcase how they had used solar technology, powered by Hanwha Q Cells, to solve a problem, meet demand, or simply provide a new way of thinking. The presentations were all well received by attendees at the show, and the videos of each pitch were hosted on the **pv magazine** website to give those unable to attend Intersolar Europe the opportunity to have their say and vote on the most innovative solution.

After three weeks of intense voting, **pv magazine** was happy to declare Maxx-Solar Energy as the winner for its inventive project – delivering innovative financing solutions for solar PV in Africa.

Each of the four candidates exhibited refreshing amounts of creativity and a willingness to push the boundaries of what solar can bring to the world, and their messages deserve to be spread far and wide …

Candidate One: Maxx-Solar Energy

Innovative financing solutions for PV in Africa: In 2011, Dieter Ortmann of Germany built a bridge to South Africa and founded a branch office there. "With the goal of bringing training through the newly-founded Solar Academy and becoming a supplier to the installers we train there," says Ortmann, the founder and managing director of the Maxx-Solar Energy Group, which also recruited the Deutsche Gesellschaft für Sonnenenergie to help with training. Now Ortmann is

Photo: Bjarke Ingels Group

Bjarke Ingels Group is a Danish firm that pitched its smart urban living idea to the audience at Intersolar Europe. Powered by solar panels, converted shipping containers are turned into upcycled homes and then clustered together on 'urban riggers', creating a harmonious, sustainable community.

involved in a project that he is so proud of he threw his hat into the ring for the Innovation Installation Award organized by Hanwha Q Cells and **pv magazine**.

Ortmann arranged financing for a PV plant on the Dominican Grimley School; a school for the deaf attended by some 100 children. Ortmann thinks of the undertaking as an exemplary project that can act as a model for further PV installations. After all, even though many people are convinced of the benefits of solar energy, the requisite money is often lacking.

His partners at the school are nuns, some of them more than 70 years old. "I found it fascinating that people of an advanced age have an appreciation for the role of renewables and energy independence," says Ortmann. "Be more independent" is his motto for the project. At the Grimley School, the motto applies both to energy security and with regard to his helping people help themselves.

"Sure, there's plenty of sunshine; it is definitely worthwhile to go there," says Ortmann. "But the financing is often a problem." Ortmann and his team have to link up potential operators with investors and develop a good solution for both. The school is now renting the PV system.

The conditions are right. The location gets approximately twice as much solar radiation as Germany, for example, which makes the power half as expensive. Amortization for off-grid systems therefore follows a similar track. Added to that is the aspect of self-sufficiency, he says, as the power supply is not as dependable as in Europe.

Maxx-Solar Energy implemented the project with a local installer. "All we're doing is helping people to do something for themselves, and we merely act in an advisory role," says Ortmann, explaining his motto. The rental model works much like similar schemes in Germany. The owners are from "our area," and comprise a tax adviser and a South African owner. The first thing to be done is to show how this can work. The school can purchase the system in 12 years for a low price, says Ortmann, for a price of around €100/kW. This price point, however, is often a sticking point. The rental payments cannot be too high, and the purchase price at the end of the rental phase has to be reasonable so that the tenant gets something out of the system. This is the case in the Dominican Grimley School project. The monthly rent is approximately €2,700. At a 70% self-consumption rate, that is already below the cost the school would have paid for the electricity. But the system design is likely to generate a self-consumption rate closer to 100%.

That means that, even in the rental phase, the school will see significant savings month after month – using 90% of the power it produces should save the school some €800 a year according to the figures provided by Maxx-Solar.

It is a 20 kW system producing 33,000 kWh; the school needs 144,000 kWh. "In ten years the system will have paid for itself," says Ortmann. The only thing currently lacking is an emergency power supply. Ortmann is

Photo: Intellisol

This car dealership in Belgium has been fitted with a rooftop PV array by Intellisol, which won the contract by using intelligent modeling analysis to calculate the exact size of the solar system required.

currently exploring options for how to finance that.

Candidate Two: Bjarke Ingels Group

Living Tomorrow Sweden: Bjarke Ingels Group (BIG) is a Danish company that is working on creating a floating neighborhood in Gothenburg, Sweden, called Living Tomorrow Sweden. BIG has been building student housing in inner city areas for many years, and for this project hit upon the idea of placing housing on barges in the river that runs through the city of Gothenburg. One of the key factors for this project, explains BIG's Jakob Lange, was to use shipping containers, thus enabling owners to ship these 'homes' easily around the world.

The containers can be configured together in groups of nine homes – called urban riggers – boasting internal courtyard views and interconnected communities, right there on the water.

Individual riggers can be clustered together to create larger communities. As harbors across Europe and elsewhere become abandoned or fall out of favor, new uses for this type of space are being explored – from offices and retail projects to community and shared spaces. Residential dwellings have long been seen as a desirable option for many post-industrial harbor locations, and BIG wanted to take the concept further – building not just student accommodation, but homes that were zero energy, made from upcycled materials and designed to embrace the opportunities offered by new renewable energy technologies such as solar PV panels.

The riggers produce more energy than they take from their surroundings, using hydrothermal heating that is driven by solar energy. This approach can heat up a complex comprising 16 apartments. The homes are well insulated and made from upcycled shipping containers – a production process that uses one-twentieth of the energy typically required to construct a similar dwelling, Lange said.

The Gothenburg project, once complete, will have a green garden route and also allow inhabitants to fully enjoy the space – including sailing and swimming on and in the water, maximizing the views offered by the harbor's open space, and developing an interconnected energy system whereby each urban rigger can feed or draw energy from their neighbors. The project is expected to house more than 9,000 inhabitants once fully complete and generate many employment opportunities during the course of its creation. Shipping of a prototype urban rigger has already begun, Lange added.

Candidate 3: Solartechnik Mitteldeutschland

Cogeneration tenant project using PV and CHP: The energy transition is a huge challenge; a challenge that Chris Werner of Energy Consulting is convinced he is rising to in an exemplary, if small, way. With Daniel Zschuckelt of Daniel Zschuckelt Solartechnik (Solartechnik Mitteldeutschland), he is equipping not just a single multi-family dwelling in the Passendorfer Schloss residential development with combined renewable energy sources, but several such units, and integrating them into a microgrid. "We have implemented all the major trends needed for the energy transition," says Werner. This will reduce energy costs by 15% over what it would cost to supply the housing units through the local utility, according to his calculations.

The multi-family building comprising 14 apartments, 12 units in a row house,

and six additional residential units are currently under construction and will be supplied starting this fall by an 80 kW east-west PV plant and a 20 kW pellet-fired cogeneration plant. The housing complex also has a smart meter network from Discovergy. "There is real-time consumption monitoring which opens up the black box of energy consumption," says Werner. Some studies show that this kind of transparency makes a critical difference to energy savings and efficiency. In the U.S., successful start-ups like Opower and Bidgely base their business models precisely on that idea. In this case, the concept is being realized not in a single-family home but for residents of a multi-family dwelling.

Photo: pv magazine/YouTube

Solartechnik Mitteldeutchland presented at Intersolar Europe its cogeneration tenant project, which uses solar PV and CHP to reduce energy costs for local utility housing.

In the project, the heat and power supplies are implemented together. In addition, there is a large thermal storage unit that makes use of excess solar power. "There is no need to feed unused solar power into the grid," says Werner. The project is not optimized for electricity or heat, but rather optimized to the energy system as a whole. The PV system acts as the heart of the energy system. The cogeneration plant and heating with excess or unused solar power are controlled based on PV production.

The challenges are in the details. The same goes for regulatory issues, which are not always clear in Germany for new business models. Discussions with regional regulatory authorities preceded implementation of the project. The residents will now receive their own power supply agreement; according to the calculation, 75% of the electricity will be produced onsite and, added to the heat supplied, the system will deliver 85% of the residents' total energy needs. The development could be even more self-sufficient were it not for the fact that the combined heat and power plant will be shut down during the summer to avoid higher costs for residents. To meet electricity demand not covered by the PV system, green power will be purchased.

Because the project not only saves money for those who live in the housing units but also generates returns for its investors, the Passendorfer Schloss residential development could be a model concept for demonstrating how to master the challenges of the energy transition. For one thing, there is broad agreement that tenants in multi-family housing must have the opportunity to benefit from the energy transition and that there must be participation similar to self-consumption for owners of single-family homes. It is also clear that to achieve PV expansion targets, the roofs of multi-family dwellings will have to be used to a large extent for PV, an application for which business models have often been lacking. Werner even sees a possibility of his project serving as a template for a business model power utilities could use.

Candidate Four: Intellisol

Smart solar system for Belgian car dealership: Intellisol has recently connected a solar PV installation at a newly built Mercedes car dealership in Belgium. Herman Daniels explained at Intersolar Europe how Intellisol won the rights to develop a solar PV rooftop system for the group IAM, winning out against four other firms eager for the business. IAM had been looking to establish a new Mercedes car dealership in Belgium, but to do so in a smarter, more energy efficient way. Enter Intellisol.

"They asked us to design a PV installation for this dealership, but nobody knew how much energy this building was going to use, so that was the big difficulty," said Daniels. As a completely new building, unused for one-third of the time, and with a low and decreasing feed-in tariff (FIT) for solar applications, the challenges were vast. "Revenues on the installation were poor, and so we had to stress as much as possible the importance of self-consumption, with storage not yet an option due to safety regulations."

IAM, nevertheless, wanted to cover the entire roof with PV, and wanted a 10% discounted cash flow guarantee. To win the trust of the owner, as Daniels puts it, Intellisol made an in-depth energy profile analysis on IAM's other showrooms, looking at how they used energy generally. The company then made a quarterly hour consumption analysis and projected this on to the new showroom, allied to NASA meteorological data to assess the types of conditions it would be subjected to.

Intellisol also designed an energy usage calculation tool to enable them to strike the perfect balance between energy production, consumption, storage and feed-in. This tool displayed to IAM how a typical dealership uses its electricity, when its peaks are during the day, every quarter hour, and over the course of the year. This intelligent approach to assessing energy usage patterns – and displaying it simply – meant that Intellisol was able to assess that the rooftop PV array needed to only be 81.4 kWp and not cover the entire roof. This system was sized to meet 32% of the plant's energy needs (using 296 Hanwha Q Cells modules) – taking into account the various peaks and troughs of a typical dealership's energy use patterns. Only 35.6% of the energy produced was sent back to the grid, which meant a payback time on paper of 9 – 9.5 years for IAM – with a discounted cash flow (DCF) of 10.2 – 11.4%.

If Intellisol had covered the entire roof with a PV array (requiring 761 modules), DCF would have been just 6.5 – 7.6%, with a payback time of up to 15 years. This is the where, why and how Intellisol won the project, ◆

Ian Clover & Michael Fuhs

Perovskite

Berkeley Lab discovery could push perovskites to 31% efficiency

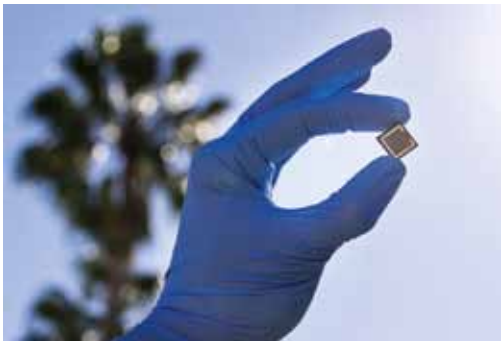


Photo: Rongrong Cheacharoen/Stanford University

A team from Molecular Foundry and the Joint Center for Artificial Photosynthesis at Berkeley Lab has deployed atomic force microscopy to reveal the "bumpy surface" of a perovskite solar cell, indicating that efficiencies vary within the cell dependent on the nature of its surface.

Investigating perovskite solar cells at the nanoscale, the researchers discovered that the cell surface is composed of grains around 200 nanometers. At the nanoscale, the research also revealed that each grain itself has multi-angled facets, like the faces of a gemstone. The photocurrent generation, and therefore conversion efficiency, of the different facets varies wildly, approaching 31% at the highest end, down to low efficiency on others. The facets behave like "billions of tiny solar cells, all connected in parallel," said Berkeley Lab. With current flowing from the good to the bad cell, the overall efficiency of the material is reduced.

"If the material can be synthesized so that only very efficient facets develop, then we could see a big jump in the efficiency of perovskite solar cells, possibly approaching 31%," said Sibel Leblebici, a postdoctoral researcher at the Molecular Foundry.

Leblebici and the Berkeley Lab team performed atomic force microscopy analysis of perovskite material produced by researchers at the Center for Artificial Photosynthesis. The technique allowed for the perovskite surface to be mapped at a resolution of ten nanometers, along with the cells' conversion efficiency, through measuring photocurrent generation and open circuit voltage. The perovskite cells studied were composed of methylammonium lead iodide and were produced without an electrode layer. Eight half cells were packed on to a 1 cm^2 substrate. The microscopy technique revealed that there was a 0.6 V difference in open circuit voltage between facets on the same grain within the perovskite cell. Facets with high photocurrent generation exhibited high open circuit voltage, while those with low generation had low open circuit voltage.

"This was a surprise," said Alexander Weber-Bargioni, in whose lab Leblebici carried out research. "It shows that perovskite cells exhibit facet-dependent PV efficiency."

"These results open the door to exploring new ways to control the development of the material's facets to increase efficiency," added Francesca Toma.

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PERC

Trina Solar hits 21.1% efficiency for mono PERC cells produced in industrial conditions

Trina Solar announced last month that it had achieved a new record efficiency for PERC solar cells. The company said that it had reached 21.1% average efficiency for its P-type monocrystalline cells with passivated emitter and rear cell (PERC) technology, produced in standard industrial conditions on a cell measuring 156 x 156 mm^2 and reaching an output power of 300 W.

However, at this stage the efficiency has only been tested by Trina itself, and thus far has not been independently verified by a third-party testing lab. According to Trina, the P-type mono PERC cell was produced on a large-size industrial boron-doped Cz-Si substrate at the company's golden pilot production line in China using "standard industrial production materials and processes". It is this transition from laboratory to mass production technology that has been the Holy Grail for cell developers.

"We are proud of our latest achievement in attaining an average conversion efficiency rate of 21.1% for our monocrystalline PERC cells that were industrially produced by applying our laboratory world record PERC cell technology," said Trina Solar's VP and chief scientist, Pierre Verlinden.

Trina Solar's director of the State Key Laboratory of PV Science and Technology, Zhiqiang Feng, added that the company's goal has long been to focus on technological innovation and to be able to transfer its best laboratory practices and techniques to commercial production.

"As demand for high-efficiency cells increases," Feng said, "our R&D team's achievement in raising the average efficiency of our industrially produced mono PERC cells will help accelerate the applications of high-efficiency solar products and build a solid foundation for further reductions in the LCOE."

Photo: Phys.org

The competition to drive mono PERC efficiencies to new heights has become fierce in 2016, with Taiwan's Gintech achieving a 21.44% efficiency in January under laboratory conditions, with mass-production expected to follow later this year, while SolarWorld upped its efficiency to 22% for mono PERC cells in January.

www.trinasolar.com

On the road with pv magazine

Where we've been: Intersolar North America, San Francisco

Conflict? In the U.S. solar industry? An industry that has nurtured innovation, expansion and vast profits for the past few years? So it came to pass at the Intersolar North America exhibition, which opened to a rallying cry by the California Solar Energy Industries Association (CalSEIA) labeling solar an "inherent disruptor of the status quo," which has made solar a target to be shot at by those with less enlightened interests. The looming presidential election also weighed heavily on the atmosphere of the event, with the specter of Donald Trump in office causing no little shiver across the show floor. Still, there can be no progress without challenges, and the conflict inherent at the show was viewed in some quarters as a sure sign that solar has the established energy hierarchy spooked – and things are only going to swing further in the direction of solar as invention and affordability are embraced with ever more gusto.

What we've seen: Hanergy's solar-powered car

Photo: Hanergy

Thin-film aspirant Hanergy is set to try its luck in the electric vehicle (EV) space having unveiled in early July four solar-powered concept cars, set for mass production within three years. The EVs are being pitched as "self charge" cars that draw the energy of the sun to power their batteries. The technology used in the prototypes is based on Alta Devices AnyLight, which was initially devised as a way to increase the range of standard EVs. For Hanergy, it hopes that the technology can deliver 80 km of range via the solar cells embedded into the vehicles. These thin-film cells currently have conversion efficiency of 31.6%, and Hanergy is hopeful that it can increase this to 38% by 2020 and 42% by 2025 – at which point the EVs would be fully solar-powered, the company claims. The cars are undoubtedly sleek looking, but whether Hanergy can deliver the technical and marketing advances required remains to be seen. Any further disruption to the EV space, however, is certainly most welcome in **pv magazine's** eyes.

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Renewable Energy India Expo (Greater Noida, Delhi, September 7 – 9, 2016)

Going gaga for gigawatts

Photo: DFID/Flickr

Vast amounts of public and private investment is pouring into the Indian clean energy market, with investors emboldened by the ambitions of Prime Minister Narendra Modi to turn India into a renewable powerhouse and attractive place in which to do business.

The Renewable Energy India (REI) Expo in Delhi is arguably the country's most important clean energy exhibition, and with solar energy dominating the headlines all year, expect PV to be prominent on the show floor once more. New solar installations in India are expected to top 5 GW this year, according to research from Mercom Capital Group, and an even bigger market is on the cards for 2017. The REI Expo will take the pulse of this growth, so expect many international players on the show floor, passionate discussions about the types of applications and technologies best suited to the Indian solar landscape, and presentations examining the challenges facing the Indian solar sector. Those challenges are vast, but not insurmountable. Low bids in reverse auctions have been welcomed in some quarters, but sparked concern among experts that some solar projects may simply be financially unviable. Will the expo serve to deliver a jolt of reality in regards to what is economically feasible? And can international companies use the occasion to get a better understanding of the needs of this incredibly important solar market? These topics, and more, are certain to dominate the proceedings during the three-day event – one that promises to be more pivotal this year than perhaps ever before.

www.ubmindia.in

Solar Power International (Las Vegas, US, September 12 – 15, 2016)

Innovation and collaboration at its core

Photo: Steve Rainwater/Flickr

Powered by the Solar Energy Industries Association (SEIA) and the Smart Electric Power Alliance, the Solar Power International (SPI) event returns for 2016 promising to put innovation and collaboration at its core. The largest solar show in North America, SPI organizers are expecting a bumper event as solar companies from around the world descend on the Las Vegas Convention Center to discuss the U.S. PV market post-ITC extension.

Last year's show drew in excess of 15,000 solar energy industry professional from more than 75 countries, and this year's exhibition should see those numbers surpassed quite comfortably. So what can visitors expect? Aside from the usual networking opportunities and memorable booth displays and parties, SPI will place innovation front-and-center this year, with a focus on smart homes and intelligent buildings, more sophisticated utility and grid integration, smarter finance packages and – of course – a suite of new storage products unveiled exclusively at the show.

Alongside the show floor will be a full series of workshops and conference events, covering a range of topics including megawatt-scale plant design, integrating distributed solar into the grid, special testing for modules in hot environments, calculating good payback for a typical residential PV system and an exploration of the fundamentals of integrating PV and energy storage systems. Education, market insight and more than 600 exhibitors showcasing their products – this year's show promises to deliver the complete PV package.

www.solarpowerinternational.com

2016 PV Taiwan

Taiwan Int'l Photovoltaic Exhibition

Oct. 12-14

Taipei Nangang Exhibition Center, Hall 1

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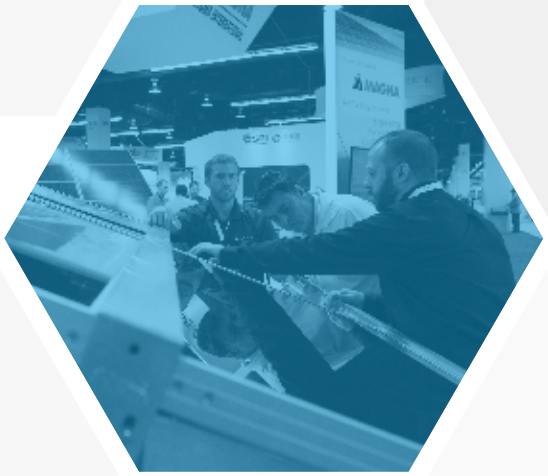

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Preview of issue 09/2016

The next issue will be published on September 1, 2016

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Great White goes forth

Ontario leads Canada's clean energy efforts, and solar PV applications are increasingly shaping the province's future.

Photo: Activ Solar/Flickr

Preventive maintenance

Examining the latest techniques for fleet management and O&M at large scale, using preventive rather than reactive methods.

Photo: Jonathan/Flickr

China's big chill

A surging start to 2016 saw China install 13 GW of PV in the first six months, but is a second-half slowdown on the cards?

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