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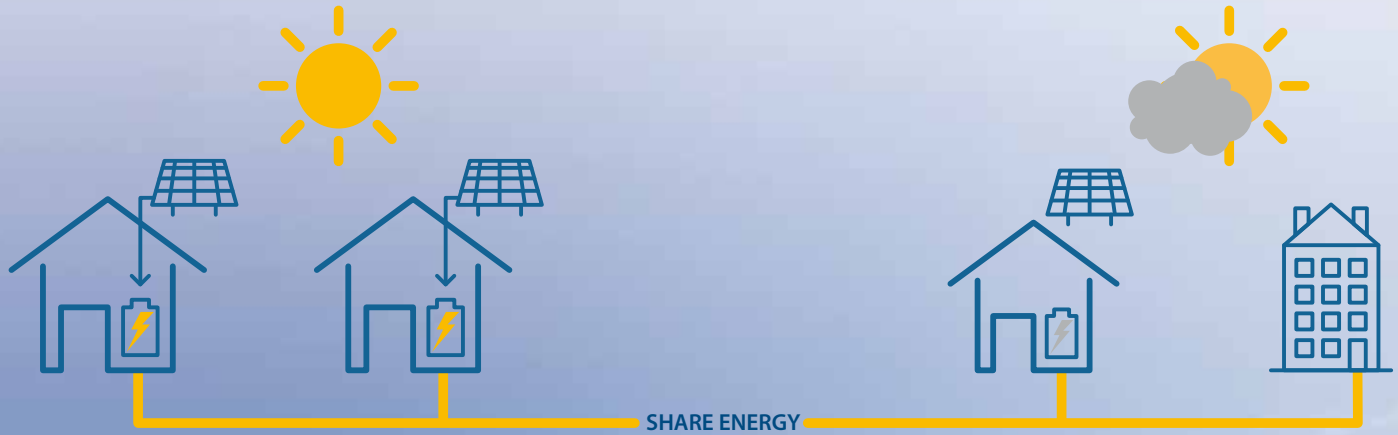

20 Array Changers

The leading components and deployment approaches set to change your array today. *Pages 86 to 95*

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Photo: pv magazine/Patrick Alleyn

pv magazine's Solar Superheroes made their debut at the SNEC show this year. Be sure to keep an eye out for them at Intersolar Europe.

A case of scale

Nowhere does scale quite like China. Aboard a bus, last month, heading towards one of Huawei's inverter manufacturing plants in the southern Chinese city of Shenzhen, the startling growth the city has undergone is everywhere to see.

Sleek new toll roads connect the residential and industrial districts, and apartment blocks under construction rise from all corners of the burgeoning city. From a coastal town of some 30,000 fishers 30 years ago to a genuine metropolis of around 15 million people, Shenzhen embodies the amazing transformation much of China has undergone in recent decades. But it has not come without challenges and skyrocketing accommodation prices, which – as we are faithfully informed by our guide – have far outpaced wage growth in the city.

The SNEC trade show, in Shanghai, has also grown at a startling pace. When SNEC opened its doors for the first time, on May 11, 2007, it welcomed 150 Chinese and foreign exhibitors and covered 10,000 square meters of floor space. In 2016, exhibitor numbers hit 1,500 and the show covered 150,000 square meters. While official visitor numbers have not yet been released, and by the vigilance of the badge scanning at some of the entrances they may not be most conspicuous, some estimates put the number of visitors at this year's show at around 100,000. China's PV industry has come of age.

But that's not to say it hasn't come with any problems. Ongoing curtailment issues, affecting over 50% of renewable production in one province, is threatening the viability of projects, and delays to subsidy payments are demanding deep pockets of developers. According to some industry experts, the short-term outlook for some module suppliers is also looking less than rosy, with very competitive pricing emerging and forecasts of a looming oversupply mounting (p. 8).

But this month, all eyes will be on Europe as the 25th Intersolar Europe opens its doors in Munich. Compared to the breakneck pace of developments in China, European markets are undoubtedly subdued (pp. 22 - 30). However, Intersolar Europe continues to be one of the most international of the solar shows and attendees from the rapidly expanding Indian market (pp. 56 - 59) and the emerging MENA region (pp. 48 - 50 and pp. 52 - 54) are likely to be in attendance.

Intersolar itself is pivoting somewhat this year, embracing the broader energy ecosystem with a focus on the integration of renewable energy into the distribution network, and its role in the emerging smart home and e-mobility sectors. Organizer Solar Promotion has brought together some of these ideas, and companies engaging in the space, in its Smart Renewable Energy section of the Intersolar show (pp. 64 - 69).

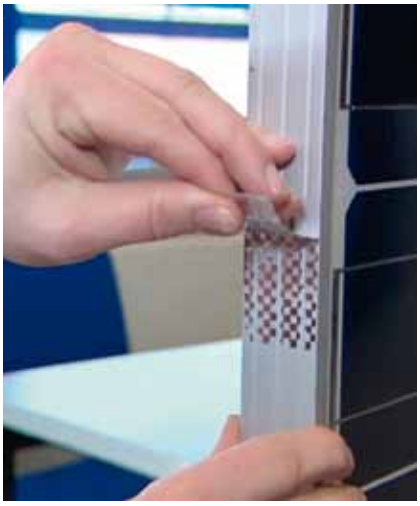
Intersolar Europe 2016 will also see the launch of **pv magazine**'s Array Changing Technologies Award (pp. 86 - 95) and my congratulations go to Sonnen for its Sonnen Community concept, and Nextracker for the NX Fusion, for picking up the inaugural award. The jury members were Elizabeth Mayo from DNV GL, Dirk Morbitzer from Sunrun, the Rocky Mountain Institute's Joseph Goodman, and Geoffrey Kinsey from the U.S. DOE's Solar Technologies Office. The jury selected Sonnen and Nextracker based on the level of innovation displayed and also on the likely market impact not only within solar, but on the global energy transition as a whole. And as Kinsey notes: "I lean towards impact, [in assessing the entries because] from a climate perspective we are running out of time."

It is a timely reminder of the urgency required to roll out our technology at scale with as much alacrity – without forgoing quality – as possible. So perhaps the cracking pace set by China is something not only to admire from afar but to replicate.

To affect such rapid change in a sector such as energy, where inertia is a dominant feature, it often feels that it will require superpowers. So what better way to illustrate the power of the various technologies that are behind the solar's primary unit, the solar module, than in superhero form. Our Superheroes made their debut last month in Shanghai. Next stop, Munich.

Jonathan Gifford
Editor in Chief

Photo: Solar Cells Hellas Group



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Takeaways from SNEC 2016

The 10th annual SNEC trade show in Shanghai attracted vast crowds to booths from around 1,500 exhibitors covering 150,000 square meters. The event saw the debut of the **pv magazine** Solar Superheroes and they were a major talking point as they roamed the trade show floor and performed martial arts routines, representing their battle against their nemesis, Coal. The vast SNEC trade show, much like the Chinese PV market, has grown at a breakneck pace. Its sheer size means that it is very nearly impossible to get through all of the halls, but **pv magazine** did the rounds and spoke to key industry observers to get an overview of key developments.

Domestic market in ascendance

With much of the world's solar manufacturing located in China or at least controlled by Chinese companies, SNEC represents a key global meeting point for the PV sector. However, in 2016 the sheer scale of China's domestic market and the number of attending companies that are focused exclusively on the domestic market was striking. Having achieved around 7.5 GW of installations in Q1 2016, some predictions for the installed market in 2016 at SNEC were are as high as 24 to 26 GW. However, these were the outliers. Given that a FIT digression is set to occur mid-year, particularly in provinces facing curtailment issues, the consensus is that the second half of 2016 could see as little as four to six gigawatts added, resulting in an annual figure of around 16 to 18 GW. This represents a most significant achievement, but short of the runaway boom expected by some and what many of the exclusively China-focused companies were counting on. Bloomberg New Energy Finance's Jenny Chase said that her analysts are not publicly communicating an installation figure for the second half of 2016, given a lack of visibility. "We think that China will build 12 GW in the first half of 2016, which is of course almost over, and that compares with about 18 GW [FY] last year," said Chase. "We have just about no visibility as to what will happen in the second half of this year as we are still waiting for the exact numbers to come out."

Delays in subsidy payments and ongoing problems with curtailment are major challenges facing the sector, but there was much talk of there being sufficient political will to meet them.

Module price pressure 2H 2016

GCL's arrival as a major module manufacturer was evident with the company displaying an array of new modules, from its large format module custom designed for its tracker system, to a glass-glass module that GCL reports is already producing at around 100 MW capacity per quarter. The company also exhibited its 350W Zero White Space module.

GCL was far from being the only manufacturer with new module, and even cell, concepts on display with BNEF's Chase noting that a move towards differentiation through technology is well underway. "I think that after a very strong Q1, some of the module makers here are a bit desperate," said Chase. "We are seeing a lot of bifacial [technology], relatively rapidly put together products, and essentially this is an attempt to differentiate."

Talk of a return to module oversupply was also evident, and perhaps behind some of the moves to differentiate on product. Andy Klump, the CEO of Clean Energy Associates (CEA) said that some aggressive pricing was apparent during the SNEC and that a trend towards downward price pressure is emerging.

"Globally, the tier-1 – and I won't use the entire tier-1 on the BNEF list but rather the top five to seven names – are being a bit more aggressive on price," said Klump. "The goal is to keep placing modules in the key markets. Margins are going to come down, but once again costs are going to come down as well."

Rise of equipment suppliers

Following closely the rise of the Chinese module manufacturers, China's production equipment suppliers are certainly on the up. The number of Chinese equipment suppliers exhibiting at SNEC continued to increase in 2016, as did the level of sophistication of their technology offerings. European, Japanese and U.S. equipment suppliers were definitely present, however it appeared for the first time in 2016, they may have been outnumbered by their Chinese rivals. And word on the exhibition floor was that the quality of the solutions being offered by the Chinese players is also increasing.

U.S. stringer provider Xcell Automation reported that while five years ago it had a leading position in supplying the Chinese market, it has seen that position recede to Chinese rivals such as Wuxi Autowell, that can provide high quality stringers at lower prices. Chinese stringers, Xcell said, can be supplied at one third to half the cost of a U.S.-produced stringer.

Switzerland's Meyer Burger took center stage in the hall in which many of the European production equipment suppliers were present and CEO Peter Pauli said that despite the challenge from Chinese suppliers, its PERC upgrade facility is still running at full capacity to meet surging demand. ◆

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pv magazine news roundup

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

World record-low solar bid

The Dubai Electricity & Water Authority (DEWA) has received a world record-low bid of $0.0299/kWh for the 800 MW third phase of its 5 GW Mohammed bin Rashid al-Maktoum solar project. A total of five bids were received on May 1 for the third phase of the DEWA project, but it was the bid by a consortium led by Abdul Latif Jameel of Saudi Arabia, Fotowatio Renewable Ventures (FRV) of Spain, and Masdar of the UAE that grabbed the headlines. The consortium's $0.0299/kWh bid is 18% lower than the $0.0365/kWh bid submitted by JinkoSolar of China, and it also drastically undercut the $0.0395/kWh tariff submitted by an ACWA Power-First Solar consortium. The two other bids were for $0.04382/kWh – submitted by U.K./French firm Engie and Japan's Marubeni – and $0.04482/kWh, submitted by a consortium comprised of France's EDF and Qatar's Nebras. All five bids came in below the winning bid in phase two, set at a then world record $0.0585/kWh set by Saudi Arabia's ACWA Power and its partner TSK of Spain. The DEWA solar project had an original capacity target of 1 GW, but the authority hopes the park will be 5 GW in size by 2030.

Photo: www.dubaisce.gov.ae

UNSW's 34.5% efficiency record

A new world record for unfocused sunlight-to-electricity efficiency, set by engineers at the University of New South Wales (UNSW) in Australia, has nudged the theoretical efficiencies for solar cells to greater heights. Using a 28 cm^2 four-junction mini-module embedded in a prism, researchers Dr. Mark Keevers – UNSW senior research fellow – and Scientia Professor Martin Green recorded a sunlight-to-electricity conversion efficiency of 34.5% by splitting incoming sun rays into four bands, using a hybrid four-junction receiver to maximize the amount of electricity extracted from each beam.

The result has been verified by the National Renewable Energy Laboratory in the U.S., and is another world record for the UNSW team, which in 2014 achieved a 40% electricity conversion rate using mirrors to concentrate the sunlight (CPV) and then split the various wavelengths.

What is striking about this latest achievement, however, is that it was achieved with unfocused sunlight, making the technique feasibly deployable in standard solar PV cells. The previous record using such a technique yielded a 24% conversion efficiency, set by Alta Devices of the U.S., but over a greater surface area: 800 cm^2 compared to UNSW's 28 cm^2.

The module used by UNSW to set this record-breaking efficiency is comprised of a silicon cell placed on one side of a glass prism, with a triple-junction solar cell on the other. The triple-junction cell is adept at targeting more discrete bands of incoming sunlight using three layers: indium gallium phosphide, indium gallium arsenide, and germanium "There will be some marginal loss from interconnection in the scale-up," said Keevers, "but we are so far ahead that it's entirely feasible."

The researcher added that the theoretical limit for such a four-junction device is around 53%, so UNSW is already two thirds of the way there.

"What's remarkable," added Green, "is that this level of efficiency had not been expected for many years. A recent study by Germany's Agora Energiewende set an aggressive target of 35% efficiency by 2050 for a module that uses unconcen-

Photo: University of New South Wales

trated sunlight, such as the standard ones on a family home."

Argentina to auction 300 MW

One gigawatt of renewable projects is to be assigned at Argentina's first auction in June – 30% is reserved for solar PV. A reference price has not been set, therefore the current price of US$100/MWh is expected. The auction will not be limited to new projects and the World Bank will guarantee payments.

President Mauricio Macri reinforced his commitment to renewable energy with the launch of the RenovAr program. One pillar of the program is the auction to acquire 1 GW from renewable energy sources.

It was originally expected that wind would be the leading technology in the country's first renewable auction, and with 600 MW of capacity set aside, wind will be dominant. However, solar PV has also been assigned 300 MW, while biomass is expected to deliver 65 MW, biogas 15 MW, and small hydro 20 MW.

The published guidelines indicate that participating projects can be either new or existing generation, the minimum capacity is 1 MW and the maximum is 100 MW.

The World Bank will guarantee obligations of renewable energy development bank FODER for contract payments to developers. Earlier this month, the government of the Argentinean Jujuy Province announced that the Interamerican Development Bank (IDB) would finance 100 MW of solar in the province.

100 MW solar plant in Nigeria

Nigerian and American company Motir DuSable has been awarded a power generation license for a 100 MW PV project in Nigeria. The company has signed a Memorandum of Understanding with Portuguese solar firm Martifer Solar to develop the plant. Motir DuSable is poised to invest $200 million into Nigeria for one of the country's first utility-scale solar power projects.

The plant is due to be constructed in Nigeria's southeastern Enugu State, with Motir DuSable now in possession of an energy generation license from the Nigerian Energy Regulatory Commission (NERC) for up to 300 MW. Additionally, the company has completed all of the required technical research for the site, and is in the final stages of a negotiating a 20 year PPA with the Government.

A boost for the project is the addition of established Portuguese solar firm Martifer Solar to help with the development of the project and to provide technical support. Martifer Solar has experience in similar markets, and has worked on solar projects in Africa since 2010. Nigeria's electricity sector is small. The country is aiming for 25 GW of power capacity by 2020, up from 4 GW currently.

PV+storage power island nations

On the Caribbean island of St. Eustatius 23% of annual power demand will be generated by a single system combining PV with storage. The hybrid system has been installed by Germany-based inverter supplier SMA. Using PV elements of 1.9 MW and 1 MW of batteries, it can generate enough power to save 800,000 liters of diesel and 2,200 metric tons of CO_2 annually.

According to SMA, the hybrid system is designed to generate enough solar power to cover more than 23% of the island's annual electricity demand of 13.5 GWh. The company's Sunny Central Storage 1000 battery inverter enables measured solar fraction of up to 88% during sunshine hours and supports the grid with stability functions such as frequency regulation, ramp-rate control for smoothing PV power fluctuations, and optimization of diesel power generation.

The hybrid PV+storage power system on St. Eustatius is the first of its kind in the Caribbean, and SMA expects that neighboring islands will soon also realize the advantage of integrating storage into their energy system. There are also other examples to follow. SolarCity, the largest distributed solar provider in the U.S., is planning to equip its 13 MW PV plant on the Hawaiian island of Kaua'i with a 52 MWh storage system supplied by Tesla. ◆

Photos: SMA

Solar stocks buck growth trend

Geggenheim Solar Index: Energy storage companies and polysilicon producers represent the strong performers, as U.S. solar bellwethers face structural challenges.

In May, the broader stock market experienced three straight months of positive gains. The S&P 500, Dow and Russell 2000 gained +1.5%, +0.1% and +2.1% respectively, compared to +2.6%, +2.1% and +1.7% in April and +6.6%, +7.1% and +7.7% in March.

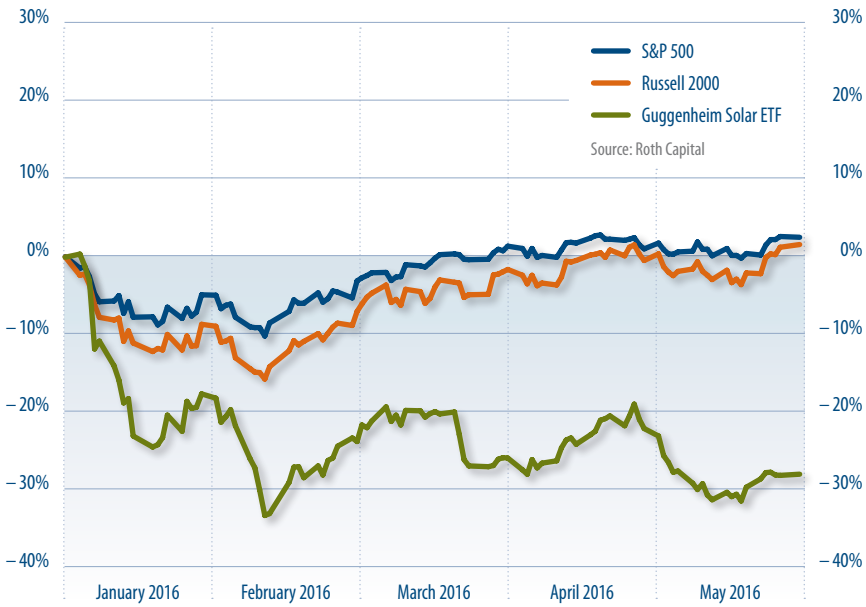
Solar stocks, on the other hand, underperformed this month due to lackluster earnings from solar bellwethers with exposure to the U.S. residential solar market as installation growth is expected to slow. Lower growth from residential solar bellwethers reflect the impact of negative policy decisions (Nevada) combined with a decision to eliminate the more costly customer acquisition sources in a capital constrained environment. One solar company exposed to the U.S. residential solar market almost ended the month as one of the top declines in May, but after it closed a tax equity investment fund with a new investor and an analyst upgrade late in the month (May 27), the stock popped to make it May's second largest U.S. gainer. The Company's competitor completed its first cash equity transaction earlier in May, but ended the month as the worst performer.

Taiwanese upstream solar companies (ingots, wafers, cells) were this month's top gainers due to increased demand as downstream solar companies rush to install projects ahead of the China feed-in-tariff (FiT) installation deadline of June 30, 2016. Polysilicon manufacturers also continue to perform above the average of its solar industry peers.

Global demand for solar modules also continues to remain strong even as demand in China is forecast to slow in 2H16. According to public reports, tier-1 module companies guided to a strong 2Q16 and reiterated 2016 full year shipment guidance. Energy storage companies have attracted interest from large global conglomerates with two major acquisitions in May. According to Energy Storage Association, the U.S energy storage market will grow to $2 billion by 2020. ◆

Jesse Pichel ROTH Capital Partners

Guggenheim Solar ETF (TAN) Holdings



Graphic: pv magazine/Harald Schütt

Company	Ticker	Month close price (in USD)	% change April	% change year to date
Green Energy Technology Inc.	TSEC:3519	21.90	– 3.7%	– 6.2%
Solartech Energy Corp.	TSEC:3561	19.50	– 6.4%	– 3.9%
E-Ton Solar Tech. Co., Ltd.	GTSM:3452	11.45	– 10.7%	– 7.7%
Danen Technology Corp.	TSEC:3686	8.75	– 11.1%	– 20.5%
Amtech Systems Inc.	NasdaqGS:ASYS	7.00	– 3.7%	+ 11.8%
Motech Industries, Inc.	GTSM:6244	33.85	– 16.4%	– 25.1%
Tainergy Tech Co., Ltd.	TSEC:4934	18.10	– 23.1%	– 17.0%
Gintech Energy Corp.	TSEC:3514	24.15	– 13.9%	– 24.6%
Vivint Solar, Inc.	NYSE:VSLR	3.59	+ 26.0%	– 62.4%
SMA Solar Technology AG	XTRA:S92	49.52	+ 0.7%	– 4.3%
REC Silicon ASA	OB:REC	1.88	+ 26.4%	+ 4.9%
Canadian Solar Inc.	NasdaqGS:CSIQ	18.68	– 7.1%	– 35.5%
Sino-American Silicon Products	GTSM:5483	35.80	– 4.2%	– 23.4%
Neo Solar Power Corp.	TSEC:3576	17.90	– 17.2%	– 26.3%
Xinyi Solar Holdings Ltd.	SEHK:968	3.15	+ 11.2%	– 0.6%
Wacker Chemie AG	XTRA:WCH	84.40	+ 8.3%	+ 8.9%
Abengoa Yield plc	NasdaqGS:ABY	17.98	+ 1.4%	– 6.8%
ReneSola Ltd.	NYSE:SOL	1.36	– 4.2%	– 20.0%
Hanwha Q CELLS Co., Ltd.	NasdaqGS:HQCL	12.58	– 16.7%	– 42.7%
8point3 Energy Partners LP	NasdaqGS:CAFD	15.42	+ 7.3%	– 4.5%
JinkoSolar Holding Co., Ltd.	NYSE:JKS	21.74	+ 6.5%	– 21.4%
AU Optronics Corp.	TSEC:2409	9.06	– 2.8%	– 6.9%
Daqo New Energy Corp.	NYSE:DQ	24.87	+ 39.4%	49.4%
GCL-Poly Energy Holdings Ltd.	SEHK:3800	1.11	– 9.4%	– 4.3%
TerraForm Global, Inc.	NasdaqGS:GLBL	2.78	+ 22.3%	– 50.3%

Information upon which this material has been compiled by pv magazine and is based was obtained from sources believed to be reliable but has not been verified. Additional information is available upon request.

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Scant cause for celebration

Module prices: Germany's REA debate reloaded.

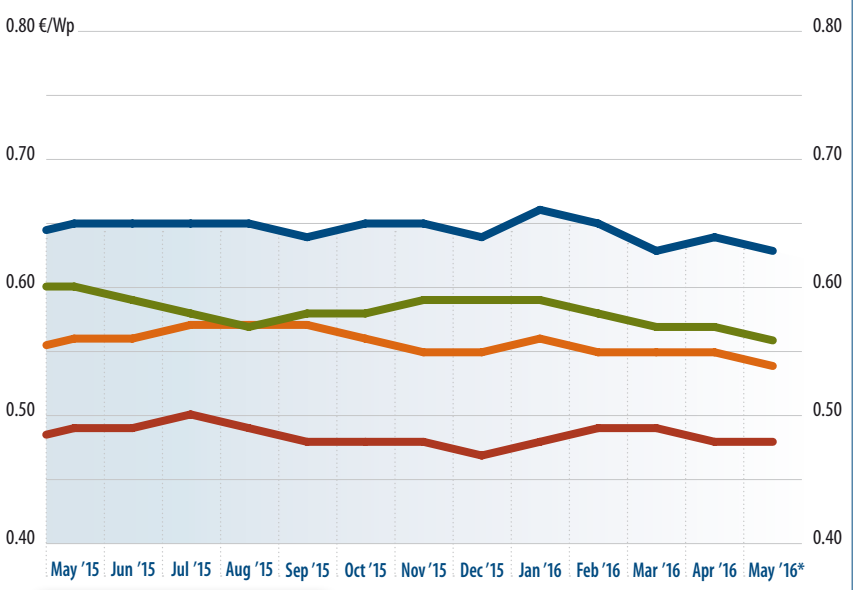
The current state of the European market offers scant cause for celebration. Following a somewhat lively first quarter compared with the same period last year, demand between mid-April and mid-May has apparently dropped off once again. The interest in PV installations is certainly present – what is lacking is decisiveness on the part of consumers and investors. Few new systems are being built and installers are turning to other business segments. Apparently there is little pressure to complete projects in the pipeline: FITs continue to be stable, at least in Germany. Numerous projects already planned are thus being pushed toward the second half of the year. Renewed uncertainty about the revision of the German Renewable Energy Act (EEG) and fear of retroactive cuts is one reason for this.

German Finance Minister Wolfgang Schäuble wants to eliminate the tax exemption for self-consumption of PV. The negative effects of the EEG surcharge on both PV installations and the implementation of innovative direct marketing concepts are still a bitter memory. The recent federal-state special summit on the EEG revision was initially unsuccessful because the individual positions were apparently too far apart. The public tender requirement for wind and PV applies to projects with 1 MWp of capacity and larger, although some would like to see the threshold set at 30 kWp, which would have catastrophic effects.

The progressive transition to the tender model is intended, among other things, to take the wind out of the Commission's sails. Brussels wants to promote tenders in general rather than defined FITs. The EC has been torpedoing the EEG for years. Now the already hotly debated tax breaks in EEG 2012 have been identified as a form of anti-competitive state subsidy, which should have been subject to special approval by the EC. At the same time, the German government is promoting expansion targets for renewable energy that are tantamount to slamming on the brakes at a time when progress is already at a crawl. By 2025, the government is targeting 40-45% of generation from renewables. That means it is allowing a full nine years to increase the current share of 30-35% by just 10%. Because the last German nuclear power plant is scheduled to be taken offline by 2022, the remaining energy demand will be met with coal and gas-fired power plants or imports. While everyone eyes Berlin and Brussels with anticipation, France is releasing expansion targets for renewables. For PV, the plan is to more than triple installed capacity by 2023. The target is 18.2 to 20.2 GW of total capacity. By 2018 there should be at least 10.2 GW of installed PV in France. This would correspond to an annual rate of 1.5 GW. There is also some positive news from IHS: Europe just hit 100 GW of installed PV capacity. ◆

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 April 2016 including changes

Module class	Price (€/ Wp)	Change over prev. month	Description
High efficiency	**0.71**	+ 2.9%	Crystalline modules, 275 Wp and above with PERC, HIT, n-Type, back contact cells, or a combination thereof
All black	**0.59**	0.0%	Module types with black back sheets, black frames and a nominal capacity between 190 Wp and 270 Wp
Mainstream	**0.50**	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	**0.39**	+ 2.6 %	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 of April 2016.

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Innovation loves a challenge

PV industry supply transition: The hurdles facing the solar industry are not always technical. In recent years markets have waxed and waned on the whims of government policy and mandates, and the current climate is just as restless, with manufacturing hubs increasingly fluid and footloose.

Globally the solar industry seems it's always experiencing growing pains. Markets emerge, mature and slow, typically driven by government goals and incentives. Leading manufacturers come and go. Currently the countries that comprise Asia, Southeast Asia and West Asia possess 95% of the global capacity to manufacture crystalline and thin film cells, and consume 60% of module production. China has been the leader in annual shipments of modules since 2009 and appears determined to also establish leadership in concentrated solar power. Does this mean that manufacturers from other countries should accept what appears to be the status quo? No, innovators love a challenge and innovation thrives in adversity.

The U.S. was the manufacturing leader up until the mid-1990s and a pioneer in the development of PV technology. In 1995, the U.S. supplied more than 52% of global demand, while consuming 25%. In 1997, the first year that global demand for PV installations reached 100 MWp, the U.S. supplied 42% of modules while consuming 12%. Manufacturing of cells and modules in the U.S. reached its peak market share in 1995, with its share of global shipments slipping each year. Currently, the U.S. has 2% of global capacity to produce crystalline and thin film cells.

Throughout the height of its FIT-driven demand, manufacturers in Europe were, in the main, unable to take advantage of the strong local market. PV cell and module manufacturers in Europe had the leading share for shipments in 2007 and 2008. Currently, however, manufacturers in Europe have 2% of global capacity to produce crystalline and thin film cells.

Figure 1 (right) presents the supply and demand shares for the countries in Asia, West Asia and Southeast Asia for 2015. Shipments refer to the manufacture and sales of photovoltaic modules. The countries in Asia include Japan, China, South Korea, and Taiwan. The countries in West Asia include India, Nepal and Pakistan. The countries in Southeast Asia include Indonesia, Vietnam, Malaysia, Thailand, and the Philippines.

Supply leadership in the global PV industry has changed from country to country for various reasons. Price domination fueled a shift to China as the supply leader in 2009. China has been the supply leader from 2009 through 2015 and will be the supply leader in 2016.

Currently another shift in manufacturing is happening and this one is driven by tariffs – the type of tariff that penalizes an activity, not feed-in tariffs, which reward activities. Manufacturers in China and Taiwan are starting up cell manufacturing and module assembly activity in Malaysia, Thailand, Vietnam as well as in Brazil, the U.S. and Canada. This section will focus on startup activity in Asia and Southeast Asia.

PV cell and module manufacturers in China and Taiwan are responding to tariff pressure by establishing manufacturing in other countries. Though expansion plans are global, the strongest cell expansion plans are in South Korea, Malaysia and Thailand. Module assembly expansions are taking place in Asia and Southeast Asia in South Korea, Malaysia, Thailand, Indonesia and Vietnam. All of these countries offer incentives to locate facilities there, including low labor costs, and are currently not subject to tariffs from Europe and the U.S. Concerning the latter – manufacturers beware: Today's tariff-free manufacturing location is tomorrow's tariff-scarred assembly location. Table 1 (p. 15) offers a view of shifting crystalline and thin film manufacturing over time.

What now?

It's an old refrain but it is worth repeating: 99% of solar deployment relies on some form of government intervention, including mandates. A renewable portfolio standard (U.S.) is a mandate. In China, a government goal is a mandate. In countries and regions with no mandates, incentives or subsidies, solar deployment is either low or unprofitable.

The global solar industry's reliance on government-created instruments to stimulate demand has created an addiction to these tools. By and large, global solar industry behavior is honed by fear and anticipation of losing an incentive, and surges of relief when incentives are renewed.

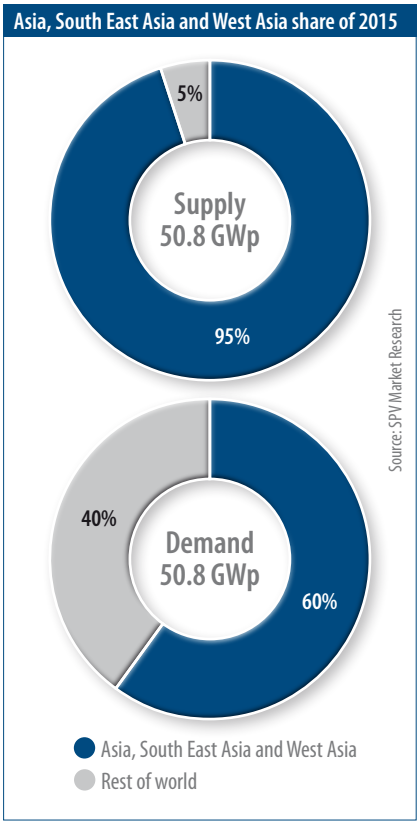


Table 1: Country cell/module shipment shares 2005 – 2015

Year	U.S. Share	Europe Share	Japan Share	Phil. Share	Sing. Share	India Share	S Korea Share	ROW Share	China Share	Taiwan Share	Malaysia Share	Ship. MWp	Average Selling Price
2005	9.5%	28.9%	50.7%	1.4%	0.0%	0.9%	0.0%	1.1%	4.2%	3.3%	0.0%	1407.7	$3.03
2006	6.9%	30.8%	44.5%	2.3%	0.0%	0.0%	0.0%	0.0%	10.8%	4.8%	0.0%	1984.5	$3.39
2007	7.7%	32.3%	29.3%	1.9%	0.0%	0.0%	0.0%	0.0%	20.6%	8.1%	0.0%	3073.0	$3.50
2008	7.1%	31.0%	22.4%	3.9%	0.0%	0.7%	0.0%	0.4%	20.4%	11.5%	2.6%	5491.8	$3.25
2009	5.2%	18.5%	15.9%	4.4%	0.0%	0.4%	0.0%	0.0%	31.9%	14.5%	9.3%	7913.3	$2.18
2010	6.1%	14.8%	11.6%	3.1%	2.0%	0.7%	0.1%	0.0%	37.5%	16.1%	8.0%	17402.3	$1.48
2011	3.3%	6.9%	12.1%	2.6%	2.7%	0.4%	0.2%	0.0%	46.3%	17.0%	8.6%	23579.3	$1.37
2012	3.0%	3.7%	12.1%	2.4%	2.7%	1.1%	3.3%	0.6%	44.5%	19.0%	7.8%	26061.8	$0.75
2013	2.1%	3.0%	10.6%	3.0%	2.3%	2.3%	2.8%	0.2%	44.6%	20.5%	8.6%	34011.3	$0.81
2014	1.9%	2.8%	8.6%	3.0%	2.0%	1.1%	3.3%	0.0%	45.0%	23.1%	9.2%	39397.0	$0.71
2015	2.0%	2.0%	6.4%	2.7%	1.4%	1.0%	4.3%	0.2%	48.0%	19.7%	12.4%	50818.3	$0.72

Hope and inevitability also play a role in strategic planning. In general, industry believes that it is inevitable that solar will contribute a major share of global electricity production. This belief is at odds with the daily thrum of incentive-driven anxiety and relief. Manufacturers of PV cells and modules, as well as the sector's suppliers (glass, backsheets, etc.) must make decisions about capacity additions and production levels in this climate.

By the end of 2015, cell/module product from China dominated shipments with a 48% share of a 50.8 GWp market, and China's manufacturers enjoyed a CAGR from 2005 through 2015 of 83%. How did China's manufacturers accomplish this feat? Its manufacturers employed aggressive pricing and enjoyed significant government support. This support allowed China's manufacturers to build rapidly from greenfield to commercial operation.

The U.S., with its current strong market, and India, with its suddenly booming market, may well respond by expanding import tariffs to other countries, particularly those in Southeast Asia.

Tariff activity has not had a significant effect thus far on easing the competitive environment and it is unlikely to have a significant effect in the future. Innovation will continue despite the current highly competitive and low margin realities of PV manufacturing.

It will continue because innovators love a challenge and the PV industry continues to have plenty of challenges to confront. ◆

Paula Mints

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.
Paula's areas of expertise include: Global markets and applications for solar products, cell and module cost and price analysis, system and system component (including inverters, trackers and other BoS components) analysis, and trend analysis.

C&I solar edges towards parity

Grid Parity Monitor: PV energy is improving cost competitiveness in the commercial segment in Europe and LatAm, finds the latest Grid Parity Monitor from CREARA.

CREARA has released a new issue of its Grid Parity Monitor (GPM) series. This is the third issue focused exclusively on the commercial sector (30 kW PV systems), and which analyzes countries in Europe and Latin America (Brazil, Chile, France, Germany, Italy, Mexico, and Spain).

The latest issue of the GPM, sponsored by BayWa, evaluates the cost-competitiveness of photovoltaic technology with retail electricity prices in the commercial segment, and assesses local regulations for self-consumption in each country.

As opposed to residential electricity consumers, commercial consumers can attain a good match between electricity consumption and PV generation (i.e. consumers with peak electricity demand during the day). Therefore, 100% on-site (instantaneous) self-consumption is possible, reducing the need for solutions to manage excess PV generation (such as storage systems or net metering mechanisms).

Although the relevant savings resulting from PV self-consumption can include not only variable costs (avoided costs from grid electricity) but also fixed costs (such as capacity cost reductions), the GPM considers only the former savings. As such, it may offer a conservative stance on grid parity, so the authors of the report stress that a case-by-case analysis is needed to assess the economics of each specific situation.

According to the study, in the last semester of 2015, there has been a mix of developments for PV economics in the countries under analysis:

- The decrease in grid electricity prices seen by several LatAm countries in the past (which reversed in 2014) has been registered again in 2015, especially in Mexico and Chile. This has negatively impacted the competitive position of PV in those countries.
- In the European countries the grid electricity prices have stayed stable or increased in 2015, except for Italy, where they decreased. The LCOE of PV installations has not changed significantly.

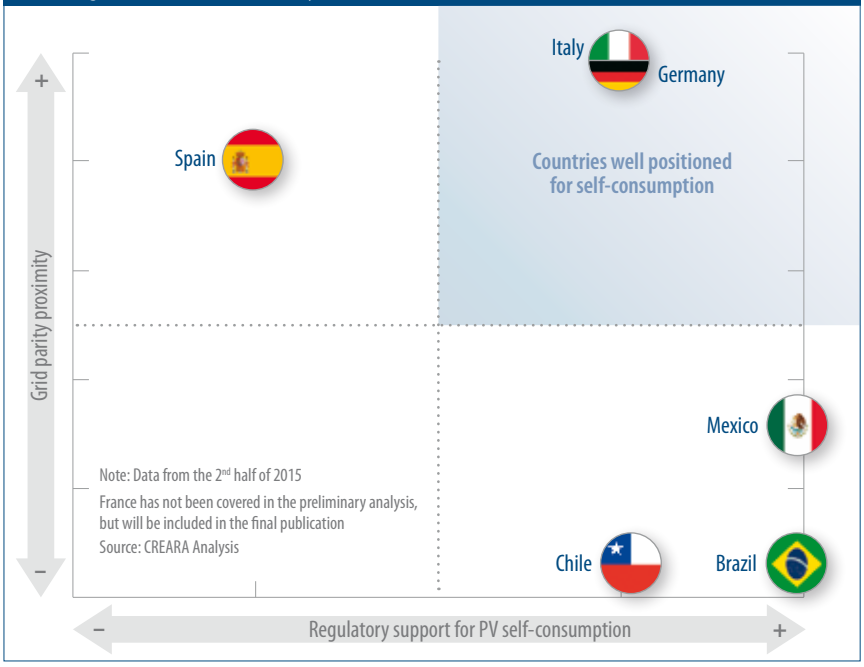
Even if a high self-consumption ratio can be attained in the commercial segment, the regulatory support is still vital for the development of the market. In countries such as Brazil, policies encourage self-consumption. On the other side of the spectrum, poor regulation can hinder the self-consumption market, as is the case in Spain, where the latest law has introduced a fee for on-site self-consumption and no compensation for the excess PV generation fed into the grid, if the excess electricity is not sold to the market through an electricity trader.

The matrix illustrated in the table shows the positioning of each country in terms of grid parity proximity in the commercial segment and regulatory support:

In countries such as Germany and Italy, both at grid parity and with a proper regulation, PV systems for self-consumption represent a viable, cost-effective, and sustainable power generation alternative. ◆

Davide Sabatino

Positioning matrix of the countries analyzed



Graphic: pv magazine/Harald Schütt

The GPM is a series of studies about PV competitiveness against conventional electricity prices in several sectors and countries. The GPM is an independent analysis, which is updated regularly, uses a rigorous and transparent methodology and is available free of charge at: **http://www.leonardo-energy.org/photovoltaic-grid-parity-monitor** | Contact: **gpm@creara.es**

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Photo: Bloomberg New Energy Finance

Bloomberg New Energy Finance founder Michael Liebreich, in his keynote at the Future of Energy Summit, called solar's self-propelled cost reduction the "miracle" that renewable industry watchers have been waiting for.

Energy's solar-shaped future

BNEF's Future of Energy Summit: The theme of Bloomberg New Energy Finance's (BNEF's) annual summit in New York City is the Future of Energy, where one thing was clear: The future will be solar, wind, energy storage and electric vehicles, with some short- to mid-term participation from natural gas.

Solar and energy storage dominated many of the discussions at the 2016 Future of Energy summit, and clean energy – solar, wind and storage – were the main themes of BNEF Founder Michael Liebreich's keynote.

The summit draws from a wide range of perspectives. However, of the 1,000 energy executives, government officials, analysts, and journalists who packed into a hotel in Midtown Manhattan, many were deeply involved in conventional energy sources, including oil, gas and nuclear power.

The presentations by executives from conventional energy and utilities put forward the vision that their technologies will be essential to future energy systems. In an interview with BNEF, Southern Company CEO Thomas Fanning claimed that nuclear energy will be a main component of a future low-carbon grid, and alluded to his company's plans to build more nuclear reactors in the U.S. South. Southern Company is building two of the five new nuclear power reactors to start construction in decades, and it is no accident that the utility is a vertically integrated monopoly whose generation is not subject to wholesale power market dynamics.

Both legacy and new nuclear projects are struggling to compete with cheap

solar, wind and gas, and new nuclear power projects in the U.S. and Europe have been highly controversial due to high prices and cost overruns.

Many in the nuclear industry are pinning their hopes on emerging nuclear technologies such as fusion. However in his keynote, Liebreich noted how far these technologies are from commercialization, and just how expensive the few pilot projects that are moving forward are.

Crisis in conventional energy

The nuclear industry's difficulties are only the beginning of the crisis in conventional energy. With coal use declining in the West and flatlining in China, coal prices have plunged to new lows, and this is putting many of the largest coal companies out of business.

The oil and gas industry is also in crisis, but of a different kind. Record low oil and gas prices are driving smaller producers out of business while oil and gas extraction is at a new high, with the productivity of individual wells skyrocketing.

The global capacity of liquefied natural gas (LNG) terminals is also preparing to boom, particularly in the U.S. This is expected to lead to more uniformity in global LNG prices and potentially higher gas use in nations that are unable to meet demand with supply from pipelines.

Due to these factors, natural gas is strongly positioned to remain a large part of the global energy mix, at least in the short to mid-term.

Solar takes center stage

Despite oil prices collapsing to incredible lows, clean energy investment hit record levels last year, which should put forever to rest the myth of a relationship between the two. And these record investments levels are leading to ever-higher deployments in both wind and solar.

The success of gas is also unlikely to have much of an impact on deployment of clean energy. In his keynote Liebreich briefly articulated his vision of a future of plentiful, cheap energy, and intensified competition between energy sources.

Of these, solar is perhaps the best positioned. While mocking Bill Gates' call for a research-driven "energy miracle," Liebreich pointed out that solar's incredible falling costs are an actual miracle that Gates has overlooked.

In particular, shortly before the summit the results of an auction in Mexico revealed that Italy's Enel Green Power had secured a solar power contract at $36 per MWh, one of the lowest prices reported to date globally. However, it should be noted that trends in investment and solar market growth are highly geographically specific. While investment and deployment are booming in the Americas and Asia, European investment in clean energy has been declining for several consecutive years, as policy sabotage in the U.K. and Germany meets a hangover from feed in tariffs in Southern Europe.

Focus on Latin America

The location of the BNEF summit in New York City echoes the organization's position in former New York Mayor Michael Bloomberg's media empire, as well as New York City's position as a global financial center. However, this year all eyes were on nations to the south. Energy ministers

Photo: Bloomberg New Energy Finance

BNEF's Future Energy Summit still attracted its fair share of fossil fuel industry heavyweights, but the tide was most definitely against them, with solar's falling prices, the emergence of affordable batteries, and the growing adoption of electric vehicles all pointing towards a cleaner, more sustainable energy future.

from Argentina, Chile and Mexico spoke at the conference, as did the director for Brazil's energy planning agency EPE. Solar markets are growing across Latin America, and national auctions are starting to produce some of the lowest prices for solar contracts ever seen.

The region is also showing the way to a future of unsubsidized solar. Chile has deployed more than 1 GW of PV without subsidies. The nation has instead structured national electricity auctions to better support PV by awarding contracts for eight-hour daily blocks, which shows that smart policy support for renewables does not necessarily come with a price tag.

Other nations are further behind. Argentina's new government is struggling to overcome the legacy of an antagonistic relationship with international capital from the previous Kirchner administration.

Brazil is also struggling under an economic and political crisis while it tries to build a large-scale solar market. Despite multiple GW of contracts awarded in several auctions, few of the developers have broken ground on PV projects in Brazil.

Mexico is perhaps the most promising Latin American nation in the short term, as the country has successfully held its first national auctions for renewable projects following on the heels of its far-reaching energy reform.

Batteries and EVs

Another strong undercurrent of the conference was the growth of energy storage, and specifically batteries. Storing energy will be necessary for wind and solar to reach their full potential, and due to growing deployment the day that storage will be needed is approaching with increasing alacrity. Fortunately, the cost of lithium-ion battery storage is also falling rapidly, in no small part due to increasing economies of scale in manufacturing. During a panel discussion, California Public Utilities Commissioner Carla Peterman dropped a bomb by noting that battery storage prices in some cases have become cheaper than that of gas peaking plants.

Batteries in many ways are a superior technical solution than peaking plants, given faster ramp rates. Peterman noted that her office is working on mechanisms to incentivize solutions that specifically support the variable nature of renewable energy, which could be promising for battery deployment. Energy storage will not only be important for supporting renewable sources of electricity, as the future of energy – and greenhouse gas reduction – includes heating and transportation as well.

Here again the timing of the conference closely followed real world events. Shortly before Future of Energy, Tesla announced that it had secured 270,000 reservations for its upcoming Model 3 vehicle in just three days, representing more than $11 billion in value.

In the broader electric vehicle market, cost reductions will be key, and this means bringing down the cost of lithium-ion batteries. BNEF historical market data indicate a positive trend for such cost reduction, and the organization has predicted that EVs will become competitive with gasoline-powered cars on capital costs alone within the next decade. BNEF further forecasts that EVs will represent up to 50% of new cars sold by 2040.

The future vs. the past

While the dinosaurs of the conventional energy industries worked very hard at the summit to convince attendees that the future will look like the past, such claims are increasingly difficult to take seriously.

Many of the factors presented in BNEF's conference – increasing solar and wind deployment, falling prices for solar PV, wind and battery storage, increasing clean energy investment despite low oil prices, and the failure of new nuclear technologies to deliver in the near-term – suggest that solar, wind, battery storage and electric vehicles will dominate the future of energy. And if anything, this future is arriving more rapidly than we expected. ◆

Christian Roselund

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As ever, Europe's solar PV landscape is a mish-mash of growth, hope and contraction, a tangle of legislation and incentives, and a beacon of scientific progress and what-not-to-do for other regions.

Europe's solar forecast: partly shaded

European markets: In a continent seeking ever closer union but ever stronger opposition, solar's ability to stand on its own two feet – free from subsidy – will prove crucial in the coming years, as seen in the disparate approaches many European nations are taking towards PV.

On the eve of summer last year, not everything was rosy in the garden of EU, but few could have foreseen the tumult that was to come. Beginning with the steady drip-drip of refugees and migrants serving to destabilize formerly harmonious border relations, the past year has seen Europe haunted by the specter of a return of old divisions, traumatized by deadly terrorist attacks, and pensive over the direction of many of its leading economies.

With the U.K. due to hold a pivotal In/Out EU referendum around the time you read this, Spaniards being asked to go back to the polls to vote through the deadlock of last December's general election, and the low approval rating for German Chancellor Angela Merkel, it has been many decades indeed since the continent had to face so much uncertainty.

But the onset of summer brings not just sunny skies, balmy evenings and billions of extra euros to the coffers of Europe's poorer – but more popular – nations: It also brings hope of a more unified future. The European Soccer Championship, for example, is currently underway in France: a sporting spectacle that showcases the best in European solidarity, creativity and friendly rivalry. Then, come July, the U.K. could well be doubling down on its efforts to forge a better EU following an 'In' vote, and Spain may have a government in place able to maintain the course of its economic revival.

Which brings us on to the continent's solar market. Perennially a snapshot of Europe's layered nuances, PV has experienced another mixed 12 months in Europe. Rising in places, falling in others, stabilizing in corners of the continent that should, in truth, have more solar installed, and emerging in regions where the sun is something of a stranger, there is no easy way to take the pulse of PV in Europe without breaking it down, nation by nation. Which is exactly what **pv magazine**'s international posse of PV correspondents has done.

Germany: the sleeping green giant

In Germany, newly installed capacity has stabilized at 1.5 GW per year, which is below the stated political goal of 2.5 GW. In the first quarter of 2016, newly installed capacity amounted to just 211.5 MW. Yet the political establishment in Germany is currently doing little to spur demand. The German government is working on a revision of the Renewable Energy Act (EEG), which will change the funding scheme for PV and wind power from a feed-in-based system to one based on a tender process. There are still major disagreements between the German federal and state governments. The plan is to pass reforms in Parliament by summer.

The current draft law stipulates that only ground-mounted or rooftop PV arrays with capacities of 1 MW and up would have to be subsidized through the tender process. All smaller systems would continue to receive incentives through FITs or a merchant basis. The German solar industry welcomes this threshold.

The fear, however, is that in the course of the parliamentary process this limit will be lowered, which will not be without consequences.

Last year saw the first three pilot tenders for ground-mounted systems. In the process, the government awarded 101 contracts for PV plants with capacities totaling more than 500 MW. Another call for tenders was issued in April 2016, which ended with the awarding of contracts for a further 21 solar farms with a total of 125 MW of capacity. In this most recent round of tenders, the value of the contracts awarded turned sharply downward. In April, the lowest successful bid was just €0.069/kWh, and the average value for successful projects was €0.0741/kWh. In the first round of tenders in April 2015, the average price was still at €0.0917/kWh.

So far, all of the tender rounds have been oversubscribed. However, many of the successful projects in the calls for tender have not yet been built. By this spring, only a handful had been completed. This is having a negative impact on expansion because ground-mounted systems are no longer subsidized outside the tender process. "At present, the trend in capacity expansion is pointing toward 1 GW," says Carsten Körnig, Chief Executive of the German Solar Industry Federation. "Whether we reach 1.5 GW this year depends largely on how many tender projects are realized." Once a contract is awarded, successful bidders have two years to build their ground-mounted PV plants. Many investors are speculating on falling prices and will probably not be implementing their projects anytime soon. ◆ Sandra Enkhardt

Photo: Sofos Energia

An example of Spain's self consumption model is seen here, at an 82 kW commercial rooftop installation in Barcelona.

U.K.: Solar's seed is sowed

In 2011, the U.K. installed 223 MW of solar. Last year, that figure was 3,537 MW, according to data published by the Department of Energy and Climate Change (DECC). Cumulatively, PV capacity in the U.K. stands at just over 9 GW, providing 9.1% of all renewable energy output in 2015 – an 86% increase in solar electricity generation in the space of a year, topping 7.6 TWh to boot.

Such naked data would seem to suggest a market that is surging ahead at breakneck speed. Which it was, for a while. In context, however, 2015 is likely to represent a peak for PV installations in the U.K., at least for a few years. Stymied by recent subsidy adjustments, 2016 post-April 1 – when the latest cuts to the renewable obligation certificate (ROC) were enacted – is shaping up to be comparatively moribund, installation-wise.

The U.K. will end the year with around 1.9 GW of additional PV capacity (according to Bloomberg New Energy Finance forecasts), but much of that was installed under pre-cut rush conditions in the first quarter of the year – which suggests what, exactly? The old policy framework that was incorporated by the previous coalition government of the Conservatives and Liberal Democrats was quickly abandoned once the former party took complete control last May. That the Tories are anti-renewables is no secret, but what the maturation of the U.K. solar industry has revealed is that – despite government reticence on solar power – the great British public has taken PV to its heart.

With more than 750,000 residential homes now fitted with rooftop PV arrays, Brits are fast embracing solar. The last

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round of FIT cuts was painful for homeowners – slashed 64% from GBP 0.1247/kWh to GBP 0.0439p/kWh (for systems < 4 kW) – but the advanced warning prior to the cut's enactment (the new rate applied on February 6 this year, and the cuts were announced in September last year) fuelled a 59% increase in FIT-based rooftop installations during that time frame. And even with the reduced FIT rates, a recent study by the Solar Trade Association (STA) found that solar still makes economic sense, delivering homeowners a 5% tax-free return on investment over 13 years, and adding an average of $3,000 to a typical property's value.

At large scale, the early closure of the ROC scheme on April 1 (having also been reduced to 1.3 ROC a year ahead of schedule in 2015) triggered the anticipated rush of installations, with the first quarter of 2016 serenaded to the sound of email pings in **pv magazine**'s inbox announcing the connection of yet another 20 MW+ array somewhere in the country.

With solar panels a common sight on rooftops in British cities, and ground-mounted farms no longer provoking the ire of the NIMBY (Not in My Backyard) set as they once did, the acceptance of PV has grown. DECC's own survey in April found that 84% of the public is supportive of solar energy – the highest backing for any energy technology ever recorded in its Public Attitudes Tracker.

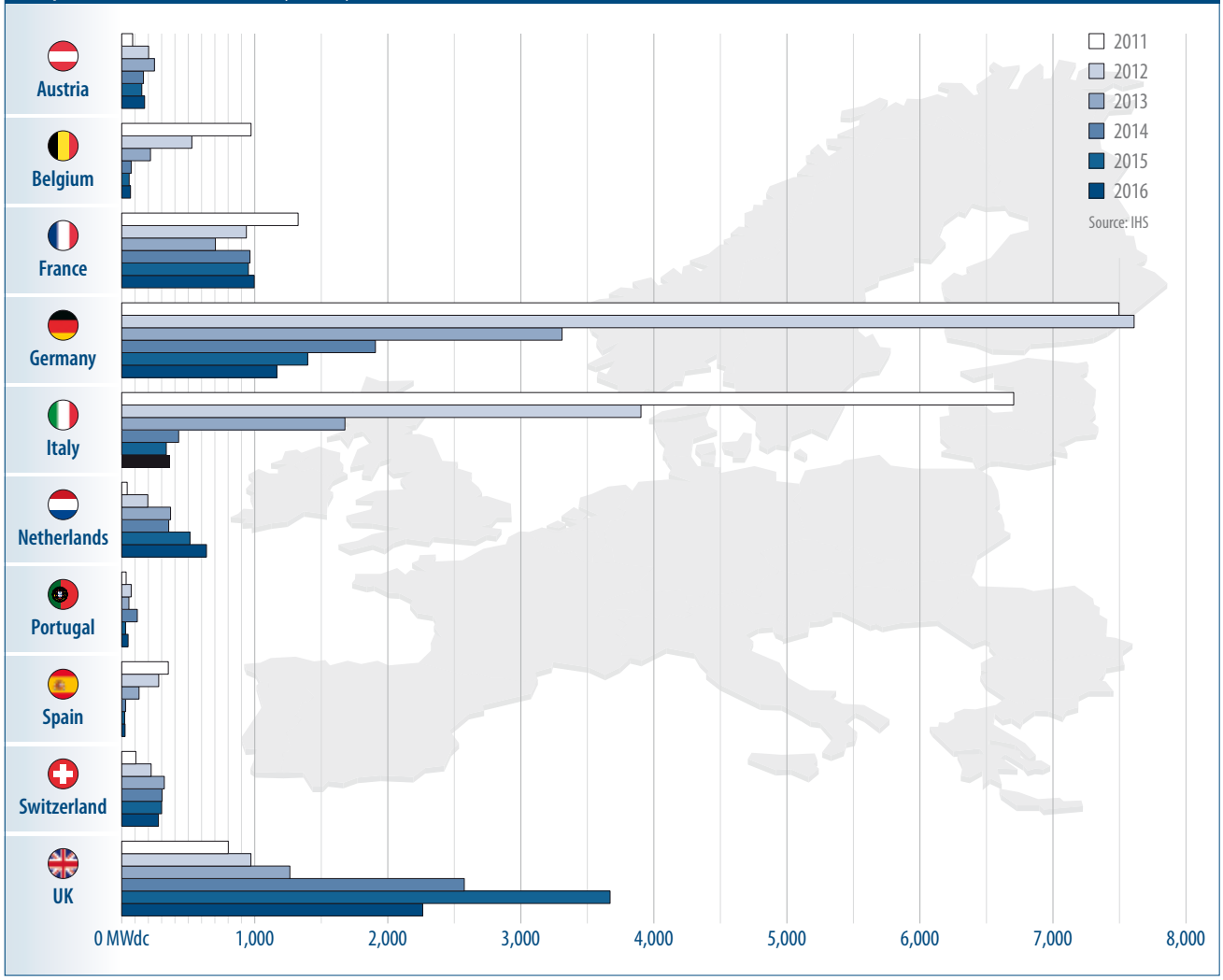
This support should not be underestimated. With the U.K. economy currently one of the strongest in Europe, and Brits eager to play their part in helping the country meet its carbon reduction obligations, solar – despite its near abandonment at top level – enjoys unprecedented support, and its increasing affordability will likely convince more home and business owners to adopt the technology.

There is, however, one major fly circling the ointment: the looming threat of Brexit. Current polls put the 'In' camp ahead on 55%, but the vote is uncomfortably close for many. There are some arguments that suggest a Brexit could, in the short term at least, provide a fillip for the British solar industry. Leonie Greene, head of external affairs at the STA, told **pv magazine** that the issue is complex because, on the one hand the minimum import price (MIP) levied by the EU on components from China is "really hurting the industry," but the bigger picture is one of a longer-term game, she said.

David Hunt, managing partner of clean energy firm Hyperion, is worried what a Conservative government could do to the U.K.'s renewables industry with the EU "shackles" removed. "No MIP for U.K. solar would of course bring a short-term benefit, but that in itself is not a reason to be in favor of Brexit," he said. "There are significant other considerations, not least further weakening of government policy towards renewables with the legal carbon and environmental obligations that come with EU membership.

"We have a government that has already done as much as it can to disadvantage

Europe's solar PV installation rates by country



Graphic: pv magazine/Harald Schütt

the renewable sector, solar in particular. With the EU 'shackles' removed," Hunt continued, "we would likely see a further erosion of the legislation and drivers the industry needs to thrive."

In May a report by Ernst & Young ranking countries' renewable energy attractiveness saw the U.K. slip to its lowest-ever position of 13th, with the government's muddled approach to the sector to blame. "A non-committal approach is putting the attractiveness of the U.K.'s renewable energy on a landslide," wrote Ernst & Young global power & utilities corporate finance leader Ben Warren. A U.K. free from EU regulation on environmental concerns would likely slink further from the progress the country has made in supporting its solar industry. However, despite the harbingers of doom an 'Out' vote could elicit, Prime Minister David Cameron – committed to the EU – could well be out of office come June 24, so who is to say in which direction the country will then go?

As things stand, the U.K. is an EU member, likely (however narrowly) to vote to stay in, and perhaps likely to discover a renewed vigor for backing the EU on matters close to Britain's heart. And if recent evidence is anything to go by, PV is part of that bracket. ◆ Ian Clover

France: steady as she goes

Last year was a positive one for France's clean energy landscape, with several measures favorable to solar implemented. In particular, a decree to be published in the next few weeks and approved by Industry body Conseil Superieur de l'Énergie looks set to triple the current solar PV goal by 2023 to 20.2 GW. The IEA reports that by the end of 2015, PV grew by 879 MW, bringing cumulative capacity to 6,549 MW. Including overseas territories, France reached 6.5 GW of installed PV by the end of 2015 and produced 6.7 TWh of solar energy. According to the Ministry of Energy, Ecology and Sustainable Development (MEDDE), this accounts for 1.4% of electric demand met by PV in 2015. Last March, MEDDE released 2015 solar market figures that showed, in addition to the 897 MW of solar PV installed, a further 559 MW of PV plants have signed interconnection agreements but have not yet been connected.

The policy framework has been evolving in the past few years, thanks to a decisive direction taken by the government towards clean energy. This stance was evident last year with the enactment of the Energy Transition Act for Green Growth and the United Nations on Climate Change Conference (COP21), held last December in Paris. The Energy Transition Act for Green Growth was passed by the French Parliament in August 2015, and creates a new support mechanism for renewables above 0.5 MW (starting 1 January 2017), in which energy will be sold directly on the electricity market at a premium. The multi-year energy plan (PPE), due in July, will set out the specifics.

Several PV promotion policies have also been set up in the country's regional, departmental and municipal authorities. The regions of Alsace, Aquitaine, Guadeloupe, Languedoc-Roussillon, Pays de la Loire, and Poitou-Charentes have issued calls for proposals for PV self-consumption projects. At a local level, Paris is a good example for municipalities implementing eco-district projects: The houses of the new headquarters of the French Ministry of Defense feature an 820 kW array and a low energy building in the 15th arrondissement in Paris was inaugurated in November.

A national policy of FITs is in place in France. The tariffs for purchase of electricity from PV connected to the grid have been lowered in the first quarter of 2016, and the French Commission for Energy Regulation (CRE) published in February the coefficients to calculate the reduction of the FIT rates for rooftop PV systems with a power of up to 100 kW.

Alternatively, PV systems above 100 kW can apply to calls for tenders. They are guaranteed over a period of 20 years and paid for by electricity consumers. Data about the tenders can be found in the 2015 IEA report "Snapshot of Global PV Markets." IEA explains that the CRE launched two calls for tenders. The first was for rooftop systems (100 kW to 250 kW) for a total volume of 240 MW, totaling 80 MW of cumulative capacity.

The list of the 349 winning projects was published in March by the Ministry of

Energy, Ecology and Sustainable Development. The second is for the installation of 50 MW of PV plants (> 100 kW) with storage in non-interconnected territories. The results of the CRE3 call for tenders were released at the end of the year, with a total power of 1,100 MW. Additionally, the ministry published a calendar of new calls for tenders for a total of 4,350 MW between 2016 and 2019. ◆ Anna Favero

Dutch display courage

While promising, considerable uncertainties are undermining confidence in the Dutch PV market. A lack of success in recent SDE+ large-scale renewable tender rounds compounded by a looming review of the residential net metering program has left the sector laboring under an atmosphere of uncertainty.

"In the last few years, there has been incredible growth due to the residential market," explains Cees van de Werken, the Founder of distributor ProfiNRG. "Today, however, there is no visibility as to what the future may be. In 2016 it is crucial that new SDE+ projects get awarded because if there are no new projects that is a huge risk for the market." Large-scale renewables are incentivized in the Netherlands under its biannually awarded SDE+ subsidy program (Stimulering Duurzame Energieproductie/ Encouraging Sustainable Energy Production). The Dutch government allocates €8 billion annually for the program, but the tender process is technology agnostic, with 2015 and the first tranche of 2016 allocating only a small number of successful bids to PV. Wind and biomass/ biofuel were awarded the lion's share, delivering an average kWh cost under the SDE+ program of around €0.12/kWh, a result the Dutch Economic Affairs Minister Henk Kamp welcomed. In such a low tender price environment and with the country's relatively meager irradiation, PV struggles to compete on cost.

"Last month it was reported that 1,200 to 1,300 solar projects applied for the [autumn tranche of] SDE+ but the impression is that no solar projects will be awarded because of the payback time, which needs an SDE+ of €0.128 over 10 years," says ProfiNRG's de Werken. He notes that despite this, some developers will still bid below €0.11/kWh in the hope that falling component prices will allow projects to go ahead.

Dutch PV developers have displayed a degree of inventiveness in pursuing projects, with the lack of suitable and affordable sites for ground-mounted PV forcing successful SDE+ projects to commercial rooftops. Given the small scale of Dutch PV plants, with the largest in the country coming in at only 6 MW, and the high cost of land, ground-mounted projects are uncommon and more expensive to realize than large rooftop arrays. Dutch solar event company Solarplaza reports that the average large-scale PV project size in Holland came in at 1.44 MW by the end of 2015. This is an increase on 790 kW the previous year, but it is still small by global standards. Solarplaza calculates that large-scale capacity has grown from 19.83 MW to 35.9 MW in that period. An additional hurdle for developers is finding a suitable commercial rooftop. While the 2014 SDE+ of €0.14/kWh will be paid for 10 years, a contract must be signed with the building owner to purchase the output of the array beyond the SDE+ period. The government has assumed a spot price of around €0.05/kWh for this period, yet in all likelihood it will be much lower. "A lot of the projects [awarded under the 2014 SDE+] are still not realized because they cannot reach financial close," says de Werken. Under the SDE+, developers have 12 months after winning a project to contract an EPC and then three years to grid connect the completed array.

In 2016, homegrown solar crowdfunding startup ZonnepanelenDelen (We Share Solar) raised €600,000 in financing required for a 255 kW array at the Volendam Football club. ZonnepanelenDelen cofounder Matthijs Olieman founder says that there is a growing appetite for investing in solar projects from the crowd. The startup aims to raise €2 million this year. ZonnepanelenDelen is expanding its platform so that crowdfunded finance can be provided as loans for residential arrays. However, here a threat to the market exists.

Currently the residential segment is underpinned by the country's net metering program, which will be in place until 2020. "Next year the government will decide on what will happen with net metering," says Olieman adding, "2020 is now only a couple of years away and is hanging above the market." The government has previously subtracted an energy tax of €0.025/kWh, including VAT, to the net metered feed-in. Project developer KiesZon Managing Director Frank Heijckmann says that he expects this year's review to result in grid connection fees to be additionally deducted from the solar feed-in rate. KiesZon was allocated around 50 MW in the 2015 SDE+ auction, although it too has experienced challenges in realizing many of these projects.

By the midway point of 2016, Holland's cumulative capacity stood at around 1.3 GW, with Heijckmann and others expecting 400-600 MW in 2016. ◆

Jonathan Gifford

Photo: Solar Cells Hellas Group

This solar farm in Greece stands a sign of the progress the market made in the early years, but solar's recent slowdown in this sun-rich country has been a cause for concern.

Spain pain for self-consumption

Since April 11, every self-consumption facility in Spain has been subject to the country's controversial 'sun tax.' The regulation was first passed last October but granted six months' grace for self-consumption PV systems already in operation. Now that period has come to an end, it is compulsory to enter these systems

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on to the self-consumption facility register and pay the levies established by the new legislation (Royal Decree 900/2015).

Every political party in Spain is against the self-consumption legislation, except the PP (Partido Popular) and the UPN (Unión del Pueblo Navarro). In February, all of the parties bar the PP and UPN signed an agreement committing to amend the self-consumption regulations extensively within their first 100 days in government. Those amendments include exemption from tax on power generated for self-consumption.

Spain's general election in December failed to produce a government, and a new election has been called for the end of June. This time round, left-wing parties Podemos and Izquierda Unida have made a series of joint proposals, including a National Energy Transition Plan. Not only do the two parties advocate exempting electricity generated for self-consumption from taxation, but also propose that electricity fed into the grid "should be fairly remunerated by electricity suppliers." At present, many self-consumption facilities are not permitted to sell excess production, meaning that they have to give it away. Self-consumption is currently Spain's biggest PV market, although there is also some demand for standalone plants. According to the Spanish PV Union (UNEF), last year the sector installed 49 MW of PV. This year, similar capacities are expected. ◆

Blanca Diaz Lopez

Photo: Solar Cells Hellas Group

Large-scale solar plants still have a future in some corners of Europe where land is abundant, but many of the more mature markets are pinning their hopes on rooftops driving installations.

Portugal explores large-scale

In Portugal, and according to the latest provisional statistics published by the country's Directorate-General for Energy and Geology (DGEG), approximately 19 MW of PV were installed in the first two months of this year. That is already just over half of last year's total (which is around 37 MW). In February the country's aggregate installed PV capacity stood at 474 MW. Over the course of this year, additional PV capacity of somewhere between 50 MW and 100 MW is possible in Portugal, experts believe. Currently, market growth is mainly driven by self-consumption schemes that were introduced in 2014, as well as initiatives to encourage distributed generation. Under the latter (which is for systems up to 250 kW), operators are paid a tariff established by tender. This year's awardable power quota totals 19.6 MW. For large-scale PV projects, the European Investment Bank (EIB) this year disclosed that it is considering financing several solar plants in the country. These would comprise a two plant project with a total 100 MW capacity in Alentejo, and a four facility 165 MW initiative developed by Expoentfokus. ◆

Blanca Diaz Lopez

Italy: on the rise again?

At the end of 2015 the IEA released the publication "Snapshot of Global PV Markets." The IEA data showed that Italy reached 8% (25.2 TWh) penetration for solar PV, which is a higher proportion than any other nation. Broken down further, solar PV in Italy now accounts for approximately 55% of total energy produced from renewable sources, which in 2015 reached 17% of the country's energy production. As for total capacity installed, cumulatively solar PV in Italy hit the 19 GW mark at the end of 2015. However, despite this ostensibly positive outlook for PV, the IEA noted a sharp reduction in growth, illustrated by a comparison between total capacity installed in 2015 (300 MW) compared to 2014 (a not-immodest 424 MW).

According to IEA's annual report, Photovoltaic Power Systems Program, the Italian solar sector "has continued to grow, but in a different way than in the past." This refers to the conclusion in 2013 of Italy's "Conto Energia," the feed-in incentive program that had been in place since 2005 and which represented the key driver behind the country's solar boom. The conclusion of recent installation analysis reveals that the Italian solar market has now reached maturity and needs to identify new opportunities.

Financial incentives, such as the introduction of residential tax relief measures, helped aid the development of the rooftop sector, and will continue to do so throughout the year. This small-scale sector performed better than the medium and large sectors, which failed to grow as expected. Furthermore, the IEA data highlighted another small-scale sector success: Off-grid PV applications grew from almost nothing to 14 MW by the end of 2015.

Today, three years after the end of the FIT program, two provisions are in place aside from tax breaks. The first is net metering ("Scambio sul Posto"), which is considered highly successful. Initially, this scheme was only valid for existing plants with a capacity lower than 200 kW. However, this was later extended in 2015 to incorporate new plants up to 500 kW.

The second is called "Ritiro Dedicato" and refers to electricity sales. This regulation allows GSE to retire the electricity according to an agreement based on minimum tariffs set by the energy authority (Art. 7 AEEG 280/07), or on the market prices that fluctuate depending on the time of the day and region.

However, the legislation for solar is perceived as unstable, and resulted in the 17th edition of Italy's Solarexpo being postponed until an as yet unspecified date. The event, scheduled for May 3-5, had attracted more than 10,000 professionals from 56 countries in 2015, and its postponement represented a sign of market decline. Despite the measures in place today, the sector lost many producers whom, without financial support coming from the FIT scheme, had to abandon the market because of severe price reductions. Nonetheless the prospects for the sector are positive, explains the IEA: "Thanks to the know-how acquired during the boom years, Italian PV companies are repositioning in foreign markets, providing interesting development for the future growth of this technology."

To this end, Italy's ENI announced this month its intention to develop a 50 MW solar plant in Pakistan, to be completed by the end of next year. Moreover, the

company is planning to start operating a solar farm of approximately 150 MW in Egypt. Another two companies, Genesis and Dynkun, signed in April a memorandum of understanding (MoU) with officials from Iran's northwestern Qazvin province for an array of PV plants totaling, once finished, 1 GW in capacity.

Furthermore, a national project by Eni called "Progetto Italia" involves the development of 220 MW of capacity to be installed in two phases by 2022 on 400 hectares of unused industrial sites across six regions.

As for technological development, the leading actor in the country for research, development and demonstration activities is ENEA. Most of its activity is on materials, cells and PV systems, but focus is also on innovative approaches for the architectural integration of PV elements in buildings and solar concentrator technologies. The IEA reported that in 2015, ENEA began developing and testing emerging technologies and new strategies for integration in the grid on Lampedusa Island, with the scope of addressing value services for users and distributors. ◆

Anna Favero

Greece: FIT again?

Greece's cumulative PV capacity stands at 2,604 MW, which makes it a significant European PV market. Of this, most was installed in the years 2012 and 2013, while in 2014 and 2015 the country added only 13 MW and 8 MW of new PV systems respectively. Greece had implemented an irrational solar energy policy, which remunerated PV systems with sky-high feed-in tariffs (FITs) leading to projects with internal rates of return up to 40%. Not surprisingly, Greece's PV subsidy bubble created a deficit, leading to retroactive cuts in 2014.

Despite the gloom, there is some good news ahead. According to the EU's Environmental and Energy State Aid Guidelines (EEAG), from 2016 renewable power generators need to sell their electricity in the market, and member states need to replace their FIT remuneration schemes for the support of renewable energy systems with market premiums.

Greece has not yet implemented a new remuneration scheme following the EEAG guidelines, but the energy ministry published in February a preliminary description of such a scheme, and invited stakeholders to comment on it. According to this, new PV systems up to 500 kW will continue to receive FITs. These are 1.1 times higher than the electricity system's marginal price, which leads to about €50 per MWh ($56/MWh). Such a tariff, says the Hellenic Association of Photovoltaic Producers (HELAPCO), is not enough to trigger investment. For systems larger than 500 kW, the ministry said competitive tenders alone will define the FITs, with the first tenders expected to start within the first six months of 2016. Therefore, new tenders are expected to be announced by the end of June. There will be at least two tenders in 2016. Furthermore, the new scheme will exclude renewable energy projects on Greek islands that are not interconnected to the mainland's electricity system. Although the specifics of the tenders have not yet been published, based on the ministry's preliminary plan, and information published in the Greek press, **pv magazine** understands the ministry is going to tender about 50 MW of new PV systems larger than 500 kW. Some stakeholders speak of a first tender for projects ranging from 500 kW to 1 MW, and a second tender for projects larger than 1 MW. The same stakeholders said that there will be a cap on the bids of around €90/MWh.

Greece's energy ministry is preparing an amendment to the net metering legislation to allow for virtual net metering, although this will initally only target specific sectors, such as farming. The existing net metering legislation is sound, but expectations for new net metering PV installations should be kept low due to the restrictions in the flow of capital that the new left wing government imposed last July. ◆

Ilias Tsagas

Austrian aims

The Austrian PV association, Bundesverband Photovoltaic Austria (PVA), expects the PV market to grow by 50 MW in the first quarter of 2016. For the full year, newly installed capacity could amount to as much as 180 MW. The country has a number of different sources of public funding for PV. For small installations with up to 5 kW of capacity, an investment grant is available that covers up to 35% of the total costs. This year, €8.5 million ($9.4 million) has been set aside for this purpose. In addition, systems with capacities of between 5 and 200 kW are eligible to receive a FIT of €0.0824 per kWh. According to PVA, the available budget to mid-December of €8 million has already been depleted. Special investment incentives are available for agricultural and forest product companies in Austria. The budget for this program is

€6.6 million ($7.35 million). Policymakers are also planning major reforms. The Ministry of Economic Affairs is working on a revision of the electricity organization law (ELWOG). The reform would allow PV plants to be used by a number of consumers. Up to now, the use of solar power in multi-tenant buildings or shopping centers in Austria has not been possible. The amendment is expected to the completed by summer.

In addition, lawmakers are considering changing network fees. The PVA says that this change would mean that operators of PV plants who feed excess electricity into the grid would be eligible for an annual compensation payment of up to €30 a year. ◆

Sandra Enkhardt

Switzerland sets its sights

In Switzerland there is an important political decision slated for June that will have a major influence on the further development of the PV market. The government has to decide whether it will increase the surcharge that funds incentives for renewables from CHF 0.013 to a maximum of CHF 0.015/kWh. If the surcharge is raised, it would provide new funding for the second half of the year. If not, the future looks grim for PV incentives.

According to the association Swissolar, between 60 and 70 MW of PV were added in the first quarter. Following the favorable development of the market last year, it is at least holding steady. Operators of PV plants with more than 10 kW capacity can apply for a cost-covering FIT (KEV) or a one-time grant for plants with capacities of up to 30 kW. The funds for the latter incentive are already exhausted, says David Stickelberger of Swissolar. Further plants can only be subsidized if the government raises the KEV surcharge. However, Swissolar does not think that added PV capacity this year will reach more than the 300 MW installed in 2015. "With further funding, we will probably see about 280 MW of installed PV capacity. Without the new funding, the market is likely to stay below the 200 MW mark," says Stickelberger. He also points to a new trend: Instead of building new plants, operators are opting to expand PV plants that already receive the KEV. ◆

Sandra Enkhardt

BRITAIN, SOLAR, AND THE EU

Brexit or Bremain – that is the question. With Brits set to go to the polls on June 23 to decide whether to stay in or leave the EU, pv magazine asked SolarPower Europe CEO James Watson what kind of impact the vote will have on solar in the U.K. and Europe.

A post-Brexit U.K. solar market may be free from MIP, but given that it is likely to be at least two years before EU treaties no longer apply – by which time MIP could be irrelevant – what is SolarPower Europe's view, given current price reduction trends in PV?

James Watson: The argument goes that Brexit would be great because the U.K. could have 5% VAT, no MIP on panels coming in from China, thus making the energy transition much cheaper.

Those are short-term arguments. On VAT, the European Commission has already announced that it will bring forward a review package on the VAT directive in 2017, so at the moment there is no pressure on the government to change the VAT rates. Also, MIP is to be decided by the end of this year. The feeling is that we might well be MIP-free by the middle of next year, so this has to be taken into account – the trading situation with China is likely to improve.

They may sound like seductive arguments, but in reality you have to strip it back and ask: Where did solar's growth in the U.K. come from? The U.K. is now Europe's third largest PV market in terms of installations. That would never have happened without the Renewable Energy Directive, and that came from the European Commission.

We are currently looking at the 2020-2030 period, which will be crucial for the continued deployment of solar in the U.K., and it is hard to imagine a U.K. outside of the EU doing anything to push solar forward.

Investor confidence is being knocked because of the uncertainty and volatility inherent within the U.K. at the moment. This landscape is not attracting investors, they will go elsewhere. But remember, the U.K. is still in the EU; it's true that uncertainty is harmful, but it would be worse if the U.K. was outside of the EU because there are no frameworks. Such behavior while still in the EU means there are frameworks for how solar should develop, which will still scare off some investors, but the ability to attract others will remain. The U.K. is in the EU and has still behaved like this. If you are outside of the EU and behave like that, with no overarching framework, it's going to be worse.

What might the U.K. energy sector look like outside the EU? What kind of relationship could Britain strike with the EU – perhaps something similar to that enjoyed by Norway (which allows it access to the single market but means it has to accept all trade rules, including MIP, and free movement of people) – but if that's the case, then wouldn't that make the reasons for Brexit kind of moot?

You can look at the Norwegian model and see Statoil doing well, sending lots of gas down to Europe. They have their hydro, supplying power to Denmark. The U.K. could go a similar way, creating access through interconnections it has with Continental Europe, and Europe wouldn't want to be without the extra energy the U.K. can provide. So a similar model to Norway's is possible, but the U.K. will have to abide by certain rules, which means that everything Brexiteers think they are gaining in terms of independence, they are not. The U.K. will simply have to adhere to it.

Another idea is to join the Energy Charter Treaty, which basically ensures that you have a certain commonality in the approach to the EU towards energy policy. The irony here though is that most of the countries that are members of that are accession countries that want to enter the EU and want to harmonize their systems with Europe. It's a kind of EEA-lite; all that would be happening by joining that treaty is the requirement to basically do what you need to do to trade freely in the energy market with your European counterparts.

So I don't see much of an alternative from these models, which basically means having to do what the EU wants you to do, but without having a seat at the table.

What about general brain drain? Much of the U.K.'s solar expertise is underpinned by Europeans, many of whom may leave Britain if Brexit happens – is this a concern?

One concern is that the U.K. is the third largest solar market in Europe. There is expertise in U.K.-based companies that want to explore market opportunities in the EU, and these opportunities could be denied them if the U.K. exits the EU. It will be much harder for U.K.-based companies to bring their services and know-how into potential European markets. Poland, for example, could really embrace solar over the next 18 months, and U.K. firms should be well placed to move into that market, but they won't be able to do that as easily outside of the EU. That is a concern.

The lack of access for British companies that have done well during the U.K. boom in Europe is something that needs to be taken on board by voters. 1 GW of investments could possibly disappear – companies across many markets and sectors have made it clear that if the U.K. is outside of the EU, they don't see the value of investing in a market of 60 million people, when there is a market of 450 million just next door.

Interview by Ian Clover


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The Acate PV Plant, 1,597 kW in size, is located in Sicily. Comparatively smaller Italian islands are presenting opportunities today for large scale storage deployment.

Italy examines battery benefits

Italian storage: Italy met 7.8% of its electricity needs in 2015 with solar, and to date the country has installed a cumulative PV capacity of around 19 GW. Yet, despite this astonishing outcome, the rate of Italy's new PV installations has declined dramatically with the majority of solar being added through Italy's net metering scheme. Can energy storage and net metering boost the Italian PV market?

According to the GSE, the state-owned company responsible for the promotion of renewable energy in Italy, the country had installed 18,910 MW of solar PV cumulatively by the end of 2015. This figure is not expected to differ substantially today due to the current anemic growth of the sector. In fact, the number of new PV installations in 2015 was about 300 MW, similar to the rate achieved in 2014.

By contrast, Italy's electricity transmission grid operator company Terna has published some impressive data, revealing that in 2015 the country covered 28.5% of its electricity needs with renewable energy. Specifically, 44,751 GWh of energy came from hydro plants, 24,676 GWh from solar PV installations, 14,589 GWh from wind, and 5,816 GWh from geothermal units. This corresponds to solar PV systems covering 7.8% of the country's electricity mix last year, up from 7% in 2014.

Hence, the energy storage question arises quite naturally due to the high penetration of renewables in the Italian power system. However, another reason why energy storage has emerged in Italy's energy discourse is the large number of net metered installations.

Based on the GSE report, at the end of 2015 there were approximately 520,000 generation plants using net metering, corresponding to approximately 4.47 GW of installed power capacity. Of those 520,000 plants, about 96% are installations smaller than 20 kW, and most of them are PV systems. Furthermore, since FIT payments for all new PV plants ended in July 2013, net metering is currently the only remuneration policy scheme for new PV systems.

Energy storage: policy update

Italy does not currently have legislation regarding the storage of electricity, Carlo Parmeggiani, President of the energy storage group in Italy's energy association ANIE Energia, told **pv magazine**. However, the country's energy market regulator, the AEEGSI, is committed to reform the Italian electricity market and has released two important resolutions aimed at developing the usage of electrochemical energy storage systems. These are resolutions 574 and 642, introduced in 2014.

Resolution 574 defines how storage systems can access and use the electricity grid, and resolution 642 complements the 574 by defining the grid services to be provided by storage systems. Furthermore, the Italian Electrochemical Committee (CEI), which is a private association responsible for the country's technical standardization in the electrochemical fields, has released the technical requirements CEI 0-16 (HV and MV storage applications) and CEI 0-21 (LV storage applications). These requirements define the connection diagrams of the storage systems to the grid, with relative measurement and protection systems, and the grid services required for effective integration of the same. The energy regulator's resolutions 574 and 642 are not policy recommendations, nor legal documents, noted Parmeggiani. Yet they are significant for the development of a domestic storage market because, together with CEI's technical requirement documents, they have set the rules for storage installations. Thus, businesses know where to begin. The AEEGSI resolutions and the CEI requirements "are driving the cost reduction of storage systems," opined ANIE Energia's Parmeggiani.

Small islands, big opportunities

"ANIE Energia is committed to opening up the domestic market for energy storage systems and is actively participating in the debate, which is leading to the reform of the Italian electricity market. In particular, ANIE is working on allowing renewable energy systems coupled with energy storage systems to participate in the dispatching and balancing electricity markets," Parmeggiani added.

However, perhaps the most immediate opportunities lie in Italy's small islands. These are Tremiti, Egadi, Pelagie, Pontine, the Tuscan archipelago (Elba excluded), Ustica and Capri. Spe-

AT A GLANCE

- Flush with solar PV after an initial boom, Italy's clean power landscape is seeking ways to reinvigorate the sector's growth.
- Storage is being touted as one viable option, supporting the net metering scheme that has rooted itself firmly into the renewable landscape.
- Italy's market regulator AEEGSI has introduced new regulations designed to help energy storage systems slot into the energy mix.
- The country's small islands offer large opportunities as testbeds for solar-plus-storage solutions.
- However, Italy's strong energy ties with its neighbors allow it to exchange power almost at will, suppressing demand for storage, at least for the time being.

The Chiaramonte Gulfi PV Plant, located in Sicily, is 4 MW in size.

cifically, following the release of the Law 9/2014 and the Law Decree 91/2014, ANIE Energia is supporting the Italian Parliament in developing the related Implementing Decrees. "The main objective of this legislation is to make the electrical system in the minor islands that are not connected to the grid more efficient both at the distribution and consumption level. Once implemented, it will introduce all the necessary market tools in order to reduce the price of electricity. In detail, it will support the development of renewable energy coupled with storage systems, as well as the wide spread of electrical vehicles with a view to a smart grid," said Parmeggiani. The downside of this is that the implementation of the Law 9/2014 and the Law Decree 91/2014 is part of the wider reform of the electricity market. And apart from some implementing decrees in progress, there are no specific deadlines as to when they need to be fully implemented.

Net metering & storage

The Law Decree 91/2014, introduced in August 2014, also increased the upper limit for net metered systems from 200 kW to 500 kW per installation. Asked about the payback period of net metered PV plants in Italy, Alberto Pinori, President of ANIE Rinnovabili (the renewable energy arm of ANIE Energia), replied that it is difficult to calculate because it depends on the size of the plant, the market value of a plant's components, the electricity price when invoicing net metered systems, the voltage level of the connection, the self-consumption rate, a site's solar irradiation, the decay in performance of PV plants, construction costs, and so on. However, according to a recent study by ANIE Rinoovabili, the net metering payback time can range from seven to nine years, Pinori said.

Pier Francesco Rimbotti, CEO of Infrastrutture S.p.A., an Italian company headquartered in Milan, agrees with Pinori. For residential systems, the current payback period for a net metered system in Italy is around seven years, Rimbotti said. The payback period for a net metered system combined with energy storage on-site is not simple to calculate, "due to the fact that the market is still young in Italy and the product price is still high," Rimbotti explained. "But on the basis of our evaluation the payback time remains around seven years currently. Only when the storage system is perfectly sized and joined with an appropriate and smart management of the energy, the savings procured could pay for the expenses incurred for its purchase in a shorter time." For larger, commercial net metered PV systems combined with storage, the payback times increase significantly, he concluded.

In Parmeggiani's view, Italy's "net-metering [the 'scambio sul posto'] is today more profitable than the usage of the energy storage systems. Therefore, net metering is far the most-used market tool for the virtual storage of electricity."

Given that all three stakeholders agreed that the payback time is closely linked to the consumption profile of each single user, the Italian case is reminiscent of all other countries post solar energy subsidy cuts. So, rather than just installing PV, the sector's business model moves towards a holistic approach that offers energy management solutions, including PV and storage as a component of it.

The 2 MW Giarratana PV Plant, also located in Sicily.

Hop on the storage train?

Infrastrutture S.p.A, has been active in the Italian energy sector for over 50 years, is also investing in Italy's solar PV and wind plants and has recently expanded into Japan. The company now

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plans to enter Italy's energy storage market, according to CEO Rimbotti. "At the moment we are studying [storage] technologies, doing all our evaluation and waiting for the dominant technologies while also looking for potential partners or suppliers," he said.

Certainly though, Rimbotti added, there is potential for energy storage growth in Italy. "We are still in the first stages; there are still lots of doubts about the contribution of storage to the income statement of a PV plant and the payback time is still too long." But in the wake of U.S. and German storage market developments, "there is a stirring, and several foreign operators such as Tesla, Sonnen, SolarEdge and others are betting on the Italian market."

In September 2015, Enel Green Power (EGP) inaugurated Italy's first large-scale solar-plus-storage facility in Catania. The 1 MW/2 MWh battery facility, which uses the Durathon sodium-metal halide technology developed by General Electric, is connected to EGP's 10 MW Catania 1 solar plant, and aims to increase flexibility in management of the power plant, smooth the electricity flows, reduce intermittence and provide auxiliary services to the grid.

"Technologically advanced storage systems like the one at the Catania 1 solar plant will reduce intermittency and enable us to manage the unpredictability of certain renewable sources, thereby helping to ensure the stability of the grid," said EGP's CEO Francesco Venturini at the time of the inauguration.

Two months later, in November 2015, EGP also inaugurated a 2 MW/2 MWh storage facility, comprised of Samsung lithium-ion batteries and located at the 18 MW Potenza Pietragalla wind farm, in the region of Basilicata. By some reports, the system feeds back almost all of the electricity it stores.

"Among the available storage solutions, batteries, thanks to their modularity, make it possible to meet various needs of the electricity system, both regarding generators (deferred feeding of the generated energy or energy shifting) and network operators (uniform feeding or peak leveling and intermittency reduction of non-programmable sources or peak shaving)," said EGP. Speaking at the Energy Storage Update Europe conference held in London in December, EGP's Head of Innovation and Sustainability Riccardo Amoroso told the audience that there are several business models available to storage, for example ancillary services and price arbitrage.

However, such business models need to change per country depending on the regulatory framework of the application, added Amoroso. His view reflects his employer's business strategy. Following the inauguration of the storage facility at the Potenza Pietragalla wind power plant, EGP said its goal is to transfer the know-how it has gained in Italy to its other plants abroad, with applications that vary according to specific business contexts and possibilities.

Pictured above is the 1 MW Monterosso Almo PV Plant in Sicily.

The crucial question that remains, though, is what happens with other Italian stakeholders that do not aspire to invest abroad and would rather focus on the domestic market? Although the Italian regulator's resolutions and CEI's technical standards have set some clear rules, further regulatory work is required for the storage market to become established.

Energy storage competitors

Will Italy's government move forward to establish an adequate energy storage policy framework soon? The answer is far from certain despite its stellar renewable energy success and the plentiful advantages of the storage systems. The reason is that energy storage, unlike power generation and transmission, is not a unique proposition. On the contrary, storage has a lot of competitors, such as electricity interconnections. Italy's geographic position enables it to exchange and trade power with neighboring countries using interconnecting power lines.

Furthermore, in February 2015, Italy's electricity market was coupled with neighboring France, Austria and Slovenia, and will soon link with Switzerland and Greece. Market coupling aims for the integration of power spot markets in Europe by optimizing the allocation process of cross-border capacities thanks to a coordinated calculation of prices and flows between countries. Thus, by using implicit auctions, market players do not receive allocations of cross-border capacity themselves but simply bid for energy on the relevant spot market. The power spot market then uses the available cross-border transmission capacity to minimize the price difference between two or more areas. Eventually, the price coupling of the day-ahead wholesale markets in Europe will lead to a convergence of wholesale electricity prices, providing the right signals for investment.

This is an excellent development, but regulatory obstacles do not allow demand response to take part in electricity markets on an equal footing with generators. Both national and European Union policy frameworks need to adapt to include storage. This serves as another example of why and how storage faces competition. Will Italy move quickly to support it? It depends a lot on its energy agenda. But adding storage to the smaller islands in the short term will help immensely. ◆

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Photo: Havel

A 5 MW solar plant in the village of Kosh-Agach in Altai, Russia' south east.

Emerging from the shadows

Solar and former Soviet states: The PV world is growing bigger, with new markets blooming every year. Yet corners of the globe remain untouched by solar's pre-eminence elsewhere. With almost no information available on the international level, a number of former Soviet states look like Terra Nova for PV. A closer look, however, reveals ambitious solar plans, and even tentative first steps being made.

Post-Soviet countries can no longer be viewed as a single unit, yet they still share historical, cultural and political inheritance that often serves to slow their integration into the wider global energy revolution. Post-Soviet countries lack transparency. Digging up solar news from the region requires busting past disconnected phone numbers, questioning controversial official announcements and disappearing capacities, and dealing with unnecessary confidentiality. And yet, barely noticed globally, large scale PV is slowly emerging in the region.

Ukraine is back in the game

In 2013, shortly before the country was dragged into an exhausting military conflict, Ukraine seemed to be facing a bright renewable future. The country is located in the heart of Europe, and in addition to its high solar irradiation and vast territory was offering a generous FIT for PV of $0.39 to $0.41 per kilowatt hour. Soon after, the political crisis in the country resulted in the FIT being reduced almost eightfold, and left the renewables sector in limbo – until perhaps now.

The Ukrainian legal advice agency DLF, which specializes in renewable project development, reports that since the end of 2015 the number of renewable projects in the country has been gradually increasing. Due to the general economic stabilization, as well as new regulations within the renewable sector, Ukraine's solar market is today exhibiting positive dynamics, Igor Dykunskyy of DLF told **pv magazine**.

"Several solar plants, each under 5 MW, have been commissioned in 2016. Some other projects, which were stalled since 2014, are being revived," he said. "For now, we recommend our clients implement solar projects of up to 10 MW, since this capacity seems to be the most viable in Ukraine at the moment. However, there are several notable projects exceeding 10 MW that are currently under development."

In June 2015, the Ukrainian government adopted new renewable regulations that established compensation of $0.18/kWh for ground-mounted solar power plants and $0.19/kWh for rooftop PV commissioned in 2016. The new regulations also canceled the local content requirements, instead setting up a domestic content feed-in premium system. Renewable plants with 30% to 50% domestically manufactured equipment will receive 5% higher FIT compensation for the produced energy. Those with domestic content of 50% or more will get a 10% higher payment under the FIT.

There are several other potential

changes currently discussed by the Parliament, says Dykunskyy, which aim to simplify the process of land allocation for renewable energy projects. "However, there are still difficulties regarding financing of renewable projects in Ukraine," he explained. "Local banks are usually reluctant to provide necessary financing or may do it only on very unfavorable terms. The restrictions on currency transactions implemented by the National Bank should also be taken into consideration."

To date, Ukraine has approximately 400 MW of installed solar capacity, with about 35 companies active. This number doesn't include the four large-scale power plants totaling more than 200 MW installed in Crimea, the territory annexed by Russia in 2014, which seem to have disappeared from the solar map.

"We have no information on what has happened to these facilities now," admits Dykunskyy. "All we know is that the Crimean plants have not been connected to the Ukrainian power grid since summer 2014."

Russia's solar ambitions

According to Crimean local media, in March 2016 Russian state-owned company Sberbank filed a lawsuit against four solar energy firms, current owners of the four PV plants built in Crimea by Austrian developer Activ Solar. All four companies are registered at the same address in Simferopol, and, according to Sberbank, carry $670 million in debt.

Searching for more details about the case, **pv magazine** spoke to the Russian Solar Association. However, it seems that the fate of more than 200 MW of PV assets remains unknown on both sides of the border.

"At the moment, we have no information regarding the current state of the Crimean plants," said Anton Usachev, head of the Russian PV Industry Association. According to Usachev, to date, Russia has about 60 MW of cumulative installed PV capacity. The country is aiming to install at least 1.5 GW by 2020.

In theory, this goal can be easily achieved, says BNEF's lead solar analyst Jenny Chase: "1.5 GW of PV is hardly anything these days. Our forecast for Russia is 790 MW in 2018, and then there's another two years to go. One complexity is that, because the payments in Russia are capacity-based rather than generation-based, there's no reason why the solar projects should be designed to have high capacity factors." The Russian Energy Ministry reports that about 1,165 MW of PV projects have been tendered within the last three years. Another renewable auction is supposed to see about 300 MW of PV projects approved by the time this issue goes to press.

According to the Russian Solar Association, at the renewable auction last year the average price for solar ranged between RUB 105,000 ($1,570) and RUB 107,000 ($1,600) per kilowatt of installed capacity. The country is expecting about 150 MW of PV to be installed in 2016. However, according to the initial plans, at least 150 MW should have already been completed last year.

Hurdles facing Russia

Nearly the entire pipeline of PV projects in Russia is owned by three main market players. Solar Energy Holding has

Photo: Atmosfera

Rooftop solar is a new trend in Ukraine. This 9 kW system is installed on top of an apartment block in Kherson, southern Ukraine.

Photo: Havel

Pictured: A 100 kW off-grid solar-diesel power generating system in a remote village in Altai, Russia.

the largest portfolio and is said to hold contracts worth 435 MW of PV projects. Hevel, a joint venture of the state-owned Rusnano company and Renova Group, is the second-largest player, with a pipeline of projects totaling 349 MW. The third big player is Solar Systems, the Russian subsidiary of Chinese power equipment manufacturer Amir Sirius. Usachev says that the companies are quite confident in their future plans, even though the existing renewable regulations set domestic content requirements at 70%. This seems like an insurmountable hurdle considering the embryonic stage of national PV manufacturing. Hevel has its own PV manufacturing plant in the country, producing thin film modules, and has placed an order for c-Si technology with Meyer Burger. The initial facility had an annual capacity of 100 MW, which is expected to be increased to 160 MW. A mere handful of other companies across the country have even smaller production capacities.

Aside from some rare exceptions, such as Schneider Electric's inverter manufacturing facility in Siberia, foreign companies do not display much interest in doing business with Russia. "The Russian solar market may in theory be open to everyone, but I'm not seeing much interest internationally," says BNEF's Chase. "The local content rules are off-putting: The volumes are not enough to get international manufacturers to set up factories, and although the IRRs should be good, risk is perceived as high."

According to Chase, if Russia wants to make itself more attractive to international investors it should scrap the local content provisions, and make it a generation auction rather than a capacity auction.

"Fundamentally, the whole system would need to be perceived as transparent; international developers and investors would need to believe that they would be treated in the same way as Russian companies," Chase explained.

Theoretically, Russia, the world's largest country stretched across many different time and climatic zones, has potential for even greater ambitions. "There is huge potential for a distributed solar market, for off-grid solar-diesel power generation in remote areas," says Usachev.

Meanwhile, the companies that have monopolized the market, leaving almost no opportunities for outsiders to make use of the country's renewable potential, already seek to expand their business abroad, namely in India, Iran, Africa, and former Soviet republics.

Post-Soviet solar slow-mo

Nearly every Central Asian post-Soviet republic claims to have the highest renewable potential in the region and one of the highest in the world. Renewable futures become a growing part of the political agenda, with new plans being discussed, new goals set, but low numbers of actual projects developed. Large and sunny Kazakhstan is still a blind spot on the international radar, says Chase, although the Future Energy-themed Expo in Astana in 2017 may attract some interest. "The country has 15 year FITs of KZT 34.61/kWh ($0.11), with a very limited local content requirement," she says.

To date, Kazakhstan has two large-scale operating solar plants totaling 57 MW. Last month, KB Enterprises broke ground on a new 100 MW PV facility in the central part of the country. The solar plant represents a total investment of $150 million. It is expected to begin operation in 2017.

Oil-rich Azerbaijan is also seeking to mark its presence on the solar map. At the CISSOLAR-2015 renewable conference in Baku, deputy chairman of the State Agency on Alternative and Renewable Energy Sources (AREA) Jamil Malikov spoke about the country's plans to develop about 2 GW of renewable energy plants by 2020. **pv magazine** was unable to get AREA to set out how this plan is to be realized.

According to estimations by AREA presented at CISSOLAR-2015, Azerbaijan can potentially install some 5 GW of PV. The National Strategy for the Development of Alternative and Renewable Energy Sources in 2012-2020 sets the goal of 600 MW by 2020. By the same token, the country is planning to increase the share of renewables in its energy mix to up to 20%, from less than 1% today. But if the country is still moving ahead with these plans, it is doing so at an extremely slow pace. According to local news, within this year AREA is planning to start operating a new 9 MW solar plant, which has been under construction since 2014.

Across the Caspian Sea from Azerbaijan, Uzbekistan, another former Soviet Republic, is progressing via tenders. "The country has 300 MW of solar projects slated for 2016-17," said IHS senior analyst for solar power, Josefin Berg. Uzbekistan is also building a 100 MW solar farm in the Samarkand region. The project was first launched in 2013. About a year ago, the owner, state-owned utility Uzbekenergo, announced that it would choose a developer for the project by September 2015 and complete the plant by 2020.

However, in May 2016, a spokesperson for Uzbekenergo told **pv magazine** that the developer has not yet been chosen, and no new information regarding the future of the project is available. ◆ Adilya Zaripova

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Photo: Luxor

Poland's solar appetite has ebbed and flowed in recent years, but the forthcoming RES act appears to give PV the cold shoulder. Pictured: a 5 kW community array from Luxor, installed in the town of Rowne.

Putting the squeeze on solar

Poland RES act: The amended Renewable Energy Sources (RES) Act will introduce an auction mechanism into Poland's clean power landscape, but the proposed terms are not favorable to solar PV nor wind, writes Piotr Mrowiec, associate partner at Rödl & Partner.

Investors in Polish renewable energy must have nerves of steel. Shortly before the end of last year the government postponed the implementation of the auction system for another six months. The Ministry of Energy admitted that it was not just a technical move but a step to gain time to prepare a revised act that would overhaul the support scheme before the auction system starts. Admittedly, the Ministry of Energy kept their word and it now seems that the new Act will mark a U-turn in the development of Polish renewable energy.

Auction system

The present government decided to continue the approach of its predecessors, and the auction system as the basic form of support for renewables will eventually see the light of day. The first auction is supposed to be held in September 2016. However, the auctions will not be akin to those in Germany where the bidder specifies the installation size and the price for which they are ready to sell all of the energy produced. Polish auctions will be based on quantities, meaning that the bidder will specify the quantity of the energy they will sell at a certain price over a certain time period (usually 15 years).

Oddly, the auctions will be technology-specific. Although this approach is nothing new and widely used in other countries. What makes the Polish auctions stand out is the unique criteria for the composition of the six technology-specific groups, which are as follows:

1. Group one will encompass renewable energy source (RES) installations with a total electricity output, independent of the source, of more than 3,504 MWh/MW/year.

AT A GLANCE

- Poland's amended RES Act will be implemented this month, having been postponed to allow government time to revise a proposed auction scheme.
- The new auction system will be technology-specific, covering six categories of energy-producing groups.
- A further division is set out, keeping bids for < 1 MW projects and > 1 MW projects separate.
- The Council of Ministers will decide the order of the auctions, meaning technologies deemed unfavorable will be at the back of the line.
- Solar and wind will likely miss out, as the Polish government is favoring co-firing and biogas plants.

2. Group two will include installations that produce electricity from biodegradable industrial and municipal waste of plant or animal origin, including waste from waste processing plants and water and sewage treatment plants, especially sludge, in accordance with the waste regulations on classification of energy recovered from thermal processing of waste.
3. Group three will encompass installations with a total electricity output of more than 3,504 MWh/MW/year whose CO_2 emission does not exceed 100 kg/MWh.
4. Another two auction groups will cover RES installations that belong to members of energy micro-clusters and, separately, macro-clusters. The energy micro-clusters and macro-clusters are civil law agreements of various entities (natural persons, legal persons, local government associations) on shared production of electricity in the area of one municipality (micro-cluster) or one district (macro-cluster).
5. Group six will encompass all other RES installations that cannot be assigned to any of the above groups.

In addition to separate auctions for every group, the lawmakers want to keep the division into auctions for installations up to 1 MW, and installations that are more than 1 MW. This means that for new RES installations alone there may be up to 12 separate auctions in every auction round. At the same time, the legislators have abandoned the requirement of at least 25% share of electricity from installations of up to 1 MW in every auction round, which was the case in the now-suspended regulations.

Another major change is that the Council of Ministers will decide on the order of auctions each time at the request of the Ministry of Energy. The amount of energy to be contracted in all auctions will be set for the entire year. This means that the installations that belong to the group put in front of the line will have the greatest chance of winning the auctions, as there may be no energy left for contracting to the groups further back in the line. The draft act does not indicate which group will be first (this will be set in an executive regulation), but the government has said clearly that it will prioritize stable and controllable sources. Co-firing

Photo: The Danish Wind Industry/Flickr

Wind, like solar, is preparing to battle with Poland's co-firing installations, which will be eligible for renewable funding as per the terms of the new RES act.

and biogas plants will be preferred over wind energy and photovoltaics (which languish far from the stipulated 3,504 MWh/MW/year capacity required). Even the order in which the auction groups are listed in the draft act suggests this preference of the lawmakers.

The first three groups include exclusively stable sources. Additionally, the legislators have decided to relax the eligibility rules for the controversial co-firing installations and have enlarged the group of hydro power plants that may participate in auctions from those with up to 5 MW power to 20 MW. The goal of the present government is to meet the minimum EU climate targets in order to avoid severe cash penalties, and buying green energy under the statistical transfers from countries that have RES surplus. It seems that those goals can be achieved by co-firing installations as all they need to do is burn more biomass. This means that the growth of wind farms and PV in Poland will essentially halt.

Support for micro-generation

Photovoltaics stands little chance for growth under the act in its proposed form, even though it was due to play the leading role in the development of small local RES sources. However, the new act will turn the support scheme for micro-installations upside down, too. The previous act posited the well-known, tested and proven feed-in tariffs for RES producers with a decent amount of aid depending on the installation size and the technology used.

Instead, the draft introduces barter trading in which a micro-producer is entitled to 0.7 kW for every 1 kWh of electricity fed into the distribution grid (with respect to micro-installations of up to 7 kW). In the case of micro-installations with rated power exceeding 7 kW, a prosumer will be entitled to only 0.5 kWh, and if their micro-installation is subsidized (even if it has power of 2–3 kW) – only to a mere 0.35 kWh. Additionally, a prosumer will pay no distribution fee on the energy taken, according to the above rules.

Surprisingly, a prosumer may participate in that scheme for 10 years (counted from the beginning of production of electricity in a given micro-installation), whereas the participation term in all other mechanisms contemplated in the RES Act is generally 15 years.

Whether the new system turns out to be attractive not only for ecologically aware citizens and people passionate about renewable energy will not be known until concrete executive regulations are published. No doubt the lawmakers have simplified the scheme rules and liquidated the unnecessary reporting obligations forced by the previous administration, while making the connection path for micro-installations easier. They have also strengthened the position of micro-producers against power companies by giving them greater consumer rights.

Chapter 4 of the RES Act, which deals with the aid for small and large producers, will be suspended until the end of June 2016. The amended RES Act must enter into force by that time to replace the old regulations. The draft act is currently in the committee stage of the legislative procedure. However, the present government seems determined to implement the modified support scheme and the amended act will become a reality. ◆

Piotr Mrowiec

Photo: Bilfinger SE/Flickr

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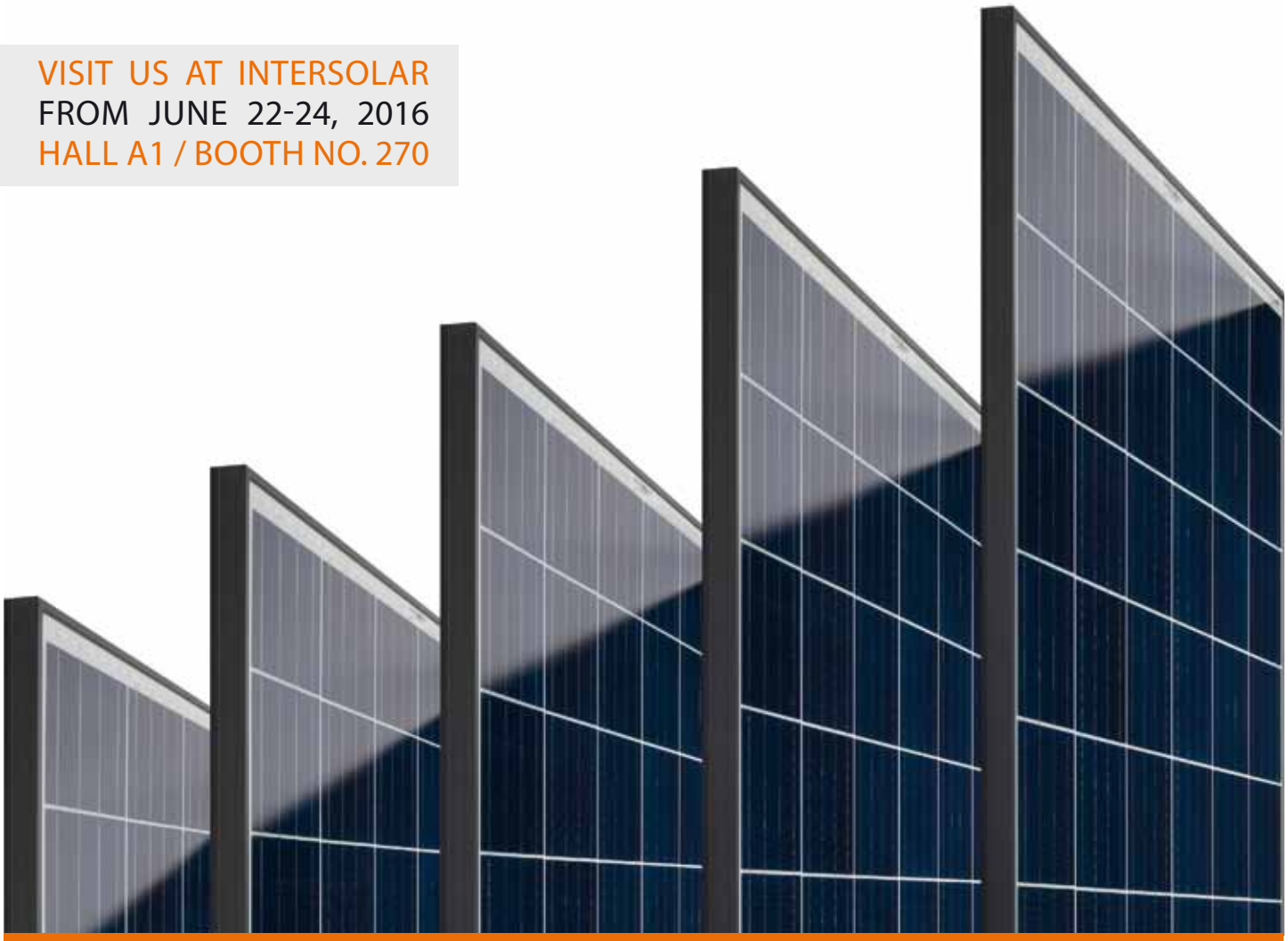

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The P5+1 negotiations delivering the eventual lifting of U.S. and EU sanctions against Iran has resulted both economic development options for Iran, but along with it opportunities for the solar sector.

Untapped and ready to be explored

Iran solar potential: Everybody is talking about Iran. A country that in recent times was cast to the peripheries of the global economy is now being ushered back on to the floor, which has piqued the interest of PV investors worldwide.

For Iran, the recent relaxing of U.S. and EU sanctions acted in tandem with new, less restrictive, renewable energy policies as the catalysts for a renewed global curiosity, in a country where the climate might well have been handmade for solar energy generation.

The breakthrough came last year, when the P5+1 (USA, Russia, China, France, U.K., and Germany) and Iran signed the Joint Comprehensive Plan of Action (JCPOA) agreement. This agreement saw the U.S. and EU lift the majority of their sanctions against Iran, after years of barriers that stifled Iran's interaction with Western economies.

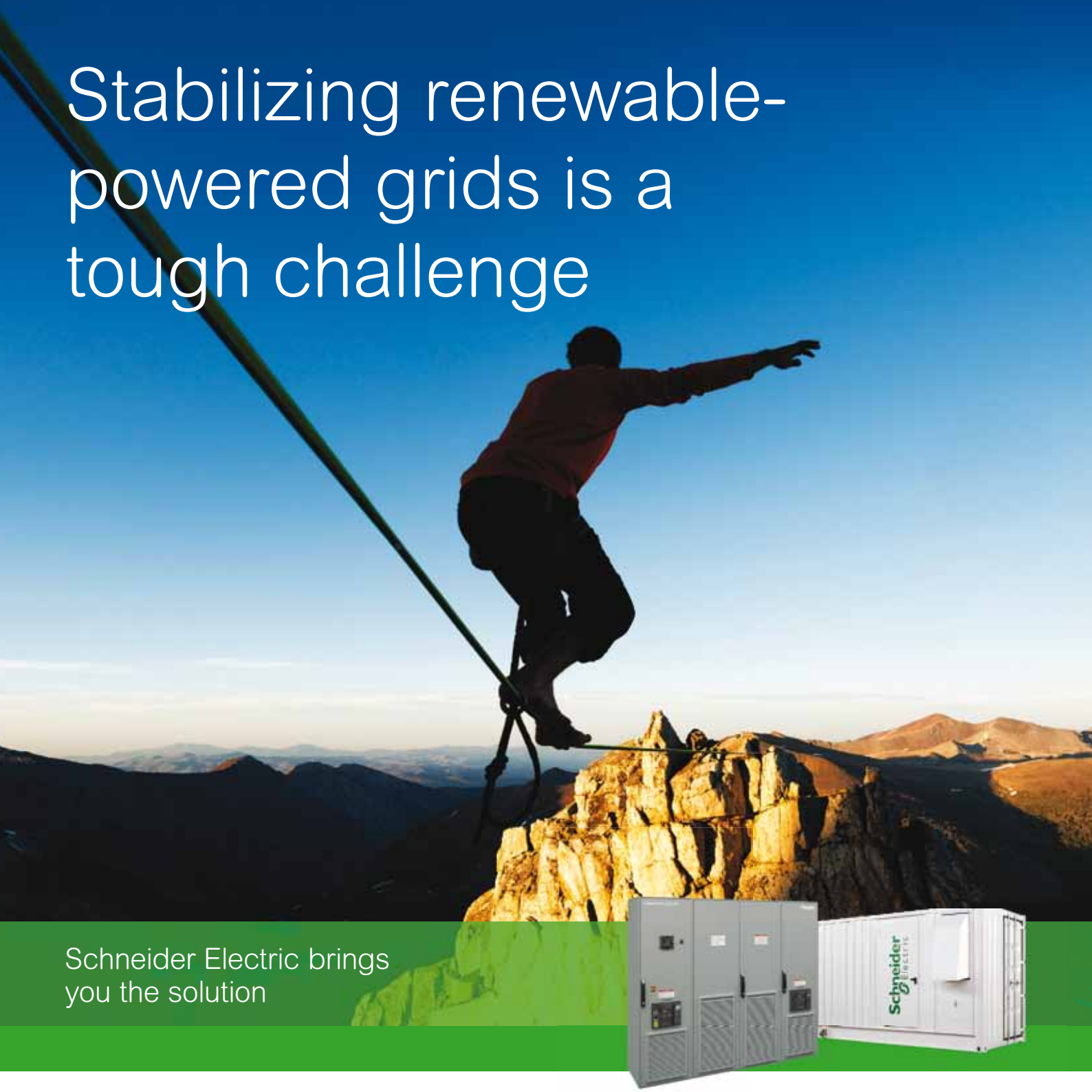
Interestingly, solar PV was never actually covered in the sanctions regime, yet doing business in Iran was still incredibly difficult for foreign companies because of the sanctions that were in place. "Renewable energy was never covered by the trade restrictions; the problem was with the political implications of doing business in Iran, plus with financing, as Iran didn't have access to the international banking system," David Wedepohl, spokesperson for German solar industry organization BSW, explained to **pv magazine**. "Now that the restrictions have been lifted, financing these projects from foreign companies is possible."

Iran's energy story

In a country with the second-most abundant fossil fuel resources of any in the region, it comes as little surprise that Iran's energy mix is heavily dominated by oil and gas. Regardless, there is enthusiasm within the country for a transition to a clean energy economy. This has historically been driven by the Renewable Energy Organization of Iran (SUNA), founded in 1996. However, more recently an independent organization, the Iran-Wind Group, was set up, with the aim of promoting renewable energies within the country.

"I was developing wind farms and solar parks in Iran, but I noticed that there was no chance to succeed, because of the feed-in tariffs, the PPAs, and the lack of budget for renewables," Mohammad H. Ghafouri, the Founder of Iran-Wind Group told **pv magazine**. "So, with the help of others, we gathered all of the renewable energy companies together,

Stabilizing renewable-powered grids is a tough challenge



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and designed four committees to discuss the challenges, and we were successful in influencing decisions. We became the Iran-Wind Group, as there were more wind companies in the committees at the time."

Policies to complement the sun

To unlock the country's solar potential, amiable policies are needed to encourage investment in its PV industry. Up until now, these policies had scarcely existed, but a change in the wind has occurred, making investment more attractive. "With the lifting of the trade restrictions, there is now political enthusiasm and renewed motivation for investment in renewable energy in the country," added Wedepohl.

Iran's Ministry of Energy has set a renewable energy target within its new five year development plan, aiming for renewable energies to make up 5% of the country's installed energy capacity by 2020. This would work out at approximately 5 GW, of which solar is expected to play a big part. To attract investment to achieve this, the country introduced a new FIT scheme for all of its renewables in 2015, and changed the power purchase agreements from a measly five years to an attractive 20 years. The official rates, which were valid until March 21 (the end of the Iranian year), were as follows:

Solar farm > 10 MW: €0.171/kWh
Solar farm < 10 MW: €0.206/kWh
Solar plant < 100 kW: €0.266/kWh
Solar plant < 20 kW: €0.298/kWh

This alone was a major development, considering that this is the first FIT that offers different prices for different renewable energies since the FIT was introduced in 2005. Additionally, there is potential for a FIT rate bonus up to 30%, if the projects use equipment manufactured in Iran.

"We know that stability is important for foreign companies, so six months ago we took the initiative to found a new Industry Association for Renewable Energies in the Chamber of Commerce of Iran," continued Ghafouri.

PV in Iran today

With the political and regulatory climate now favorable for PV capacity increases, a number of foreign companies have begun to work on PV projects in Iran, while steps are also being taken to begin manufacturing solar modules domestically. At the end of April, reports surfaced that Italian companies Genesis and Dynkun signed a memorandum of understanding (MoU) with officials from Iran's northwestern Qazvin province, for 100 PV plants of 10 MW each. The extensive agreement, totaling a gigantic 1 GW, will be funded by foreign investors to the tune of $1.5 billion. "The deal with nine articles is an agreement where Italian partners will build a solar power plant of 1,000 MW nominal capacity during a project defined for 10 years, with the whole project divided to 100 units of 10 MW," said Deputy Head of Qazvin Provincial Investment Headquarters for Services Mohammad Ali Qasemi. "Qazvin has high potential in wind and solar energy, and within recent years we have negotiated to attract investors to the sector."

Another report at the end of 2015 claimed that a German firm has signed a deal to build several solar power plants close to Tehran, with a combined capacity of 1.25 GW. No information has been released about which German company that may be, but there is no doubt that many German companies are well-placed to enter the emerging Iranian market.

"We in Germany, with our experience, are in a good position to facilitate a lot of solar energy in Iran, and to assist in the PV capacity expansion," said Wedepohl. This sentiment would surely be echoed by solar companies across Europe, as the European PV market continues to stutter.

Iran has outlined a preference for the modules to be produced within the county, which is likely to have helped the Industrial Development & Renovation Organization of Iran (IDRO) reach an agreement with German company Schmid Group to open a fully integrated solar manufacturing facility in the country. Schmid Group signed an MoU in May with the IDRO to develop the site, which will cover the entire PV value chain, including the production of polysilicon, wafers, solar cells and modules.

"As an industrial development organization, IDRO is leading establishment of new industries in Iran and has decided upon investment in the solar PV manufacturing value chain," said Deputy Minister of Industry, Mine and Trade & IDRO Chairperson of the board, Mansour Moazami. "Our investment is based on a technology transfer and development framework targeting local and global PV markets."

To help foreign companies make inroads into the renewable energy markets of Iran, Ghafouri founded a consulting company called AYSA. They published the second edition of 'Renewable Energy in Iran: Investment Opportunities' in March 2016. This book gives details of various real world renewable projects, including eight PV projects, which have various permits in place and just need investment to get going.

"A few of the published projects have been approached by German companies and a few joint ventures have been shaped, with the projects now under development," said Ghafouri. The book itself also acts as a guide that outlines how to establish business networks and how to carry out transactions in Iran.

The Iran-Wind Group also mentioned that there was interest and potential for upstream production within Iran, especially for polysilicon purification, and wafer and cell production.

Lingering risks

On the surface, Iran seems like an ideal investment location. However, so soon after the lifting of the sanctions regime, foreign investors have been maintaining an air of caution. There is still a haze of mystery that surrounds the country in the eyes of certain onlookers, as well as the persistent fear that sanctions may be reinforced should Iran fail to implement its commitments under the JCPOA.

On top of this, Iran's relative political instability over the last half century has kept foreign investors conservative in their approaches to the country. Yet, there are structures in place within Iran to protect foreign direct investment against all non-commercial risks. Specifically, investors can register for the Foreign Investment Promotion and Protection Act (FIPPA), which is operated by the Organization for Investment Economic and Technical Assistance of Iran (OIETAI). This guarantees foreign investment against major political risks, such as nationalization or expropriation.

What is certain is that burnt bridges are being rebuilt. Iran is coming round to the idea of change and that a drive towards a significant renewable energy industry could be symbolic. Opportunities have become abundant and it is now up to foreign investors and domestic actors to decide whether they are going to seize them. ◆

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Photo: Tekno Ray Solar

Tekno Ray Solar's Mehmet Özenbaş, the Tekno Group's Altay Coşkunoğlu and EPC partner Enerray's Michele Scandellari at the inauguration of the Konya Kızören Solar Energy Plant.

Turkey's bumpy boom

Turkey: The significant 1 GW cumulative PV milestone looks set to be passed in Turkey this year, although the pathway to this milestone has been littered with obstacles. The government is taking steps to reign in the unlicensed (< 1 MW) market, but needs to see its next round of licensed projects actually be built. A sustainable 1 GW annual market looms, but just how can it be achieved?

Weaving through Istanbul's seemingly impenetrable traffic requires flexibility, patience and innovation. Tekno Ray Solar Managing Director Mehmet Özenbaş takes it entirely in his stride.

Negotiating through the peak hour rush, which lasts much longer than the term suggests, Özenbaş takes unpromising looking backstreets, performs the occasional daring U-turn and at one point winds up driving on the left side of the street, along with a stream of other vehicles. "Don't worry, you're not in England," Özenbaş explains to **pv magazine**. "We'll get back to the right side of the road soon." It's the night before the 8th Solarex trade show in the Turkish capital and organizers are expecting record crowds, with the show floor fully booked and an additional exhibition space added in the form of a canvas tent adjacent to one of the halls. Özenbaş is in an ebullient mood. Not only is he delighted by the genuinely impressive Tekno Ray Solar booth, to which the final touches are being made, but the Turkish PV market itself is finally delivering on some of the promise of previous years. "We will hit 1 GW this year," he forecasts confidently, "but that's in 1 MW blocks. Imagine that, publishing a thousand-page magazine one page at a time!" And he's right.

It does seem perverse that the licensed PV project sector in Turkey, initially tendered for up to 600 MW of capacity and designed to encourage large-scale projects, resulted in prohibitively high fees, and has seen very few projects realized. And in the absence of licensed projects, the industry got to work on developing large projects in many < 1 MW blocks, often with a different owner for each component park, on paper at least.

"Well the licensed tenders were delayed and delayed," explains Tekno Group CEO and President Altay Coşkunoğlu. "With the consent of the authorities [we began] to start solar investments through [the] unlicensed market. It is not very logical, but this is Turkey." Around 300 MW of solar capacity was developed in 2015, the vast bulk of it unlicensed ground-mounted projects. Tekno Ray Solar developed some 50 MW of that, with the Tekno Group providing sites for the arrays, on some occasions, and investing in the parks.

Unlicensed sector

Tekno Ray Solar inaugurated the 18.5 MW first stage of its Konya Kızören 22.5 MW project in May. The company claims that it is the largest PV power plant in Turkey. With the backing of the Tekno Group as investor, Tekno Ray Solar says that it is in a unique position in the Turkish market and reports it is currently working on a 60 MW pipeline for 2016, with that targeted to increase to 150 MW in 2017.

In April, Turkey's regulator (EMRA) introduced new requirements limiting the size of a particular unlicensed project to < 1 MW, however, given the ingenuity Turkish developers have shown in the past, there should be little surprise that their reaction to the changes have been described as being "sanguine." Crucially, the changes prevent the sale of projects to third parties once a "call letter," or approval to construct, has been issued. Previously a large number of projects were in the pipeline, having received a call letter, which the project developer would likely look to sell before construction.

There is a large pipeline of unlicensed projects that have already received call letters – up to 2.6 GW by some reports – however the changes to the sector imposed by EMRA will likely dampen this, if applied retroactively – again an issue causing some debate.

Licensed sector

There are signs that licensed projects will begin moving ahead, at last, this year. Germany's Phoenix Solar plans to complete construction on a 10.2 MW licensed project in Eastern Turkey. It will work with Portuguese firm Asunim's Turkish subsidiary on developing the project. The project is being supported by the European Development Bank. It is a welcome sign given the moves to limit the unlicensed sector.

"The Government is keen to shift the utility-scale activity from the unlicensed to the licensed segment," observes Bloomberg New Energy Finance's Lara Hayim. "To achieve this they are currently doing a balancing act of making large-scale projects more challenging in the unlicensed sector and working on improving the process for the licensed sector for the next round of auctions." Hayim adds that it is crucial for the market that an auction result such as that in 2013 is avoided.

The previous licensed project auction attracted a huge amount of interest and was many times oversubscribed. It resulted in low project bid prices, high project license prices, but very few projects actually being built.

Licensed outlook

"We expect the next round of auctions to put more emphasis on performance and move away from an evaluation based on

ICCI EVENT RETURNS FOCUS TO GROWING SOLAR INDUSTRY

The 22nd International Energy & Environment Fair and Conference, held just weeks after Solarex, delivered another opportunity for Turkey to smooth the edges of its expanding solar sector. The event in Istanbul brought together stakeholders, delegates and businesses from across the energy supply chain, with more than 21 countries represented in the halls.

Although solar's role at the three day event was smaller than some within the industry would have liked, the sector nevertheless displayed its resilience, scalability and – critically – its suitability for the Turkish market.

Among the 278 exhibitors at the ICCI exhibition, around half were concerned with cogeneration and fossil fuels, while wind power appeared more prominent in the renewables hall.

Talk at the opening ceremony fixated on Turkey's need to secure its energy independence. Currently, the country imports 75% of its power needs, much of it natural gas from Russia – a nation with whom relations have become strained in 2016.

Mario Diel, Chairperson of the Energy Council of Foreign Investors called on Turkey to "combine the vast know-how and experience" of Europe with the thirst for energy within the country to drive more foreign investment into the nation's power sector.

The head of the International Solar Energy Society Turkey Section (Gunder), Kemal Gani Bayraktar, suggested that Turkey would likely end 2016 with 1 GW of solar PV capacity installed, from a base of around 400 MW right now. To meet this goal, nearly all capacity will be added in the unlicensed sector, which is comprised of solar projects not greater than 1 MW.

Bayraktar also mentioned the 100,000 rooftops action plan, which is designed to kickstart the Turkish residential solar market, while reiterating targets set by government to install 3 GW of solar PV by 2019, 5 GW by 2023 and 10 GW by 2030.

Afterwards, Sefa Sadik Aytekin of the Ministry of Energy and Natural Resources (ETKB) announced how the Turkish government plans to auction off all of the nation's energy production assets over the next five years in a round of privatizations that the ministry feels will help liberalize the Turkish energy sector. Ian Clover

Photo. Huawei

The deal signed between Halk Enerji and Huawei represents a major deal for the Chinese inverter supplier in the market where string inverters still enjoy strong market share.

Photo: Hanwha Q Cells

Hanwha Q Cells Turkey developed the 8 MW Maras I plant. The company is widely understood to be the leading module supplier in Turkey.

just price," says BNEF's Hayim. "Efficiency of the systems, commissioning timelines and financial reassurance is likely to play a greater role in the next round of evaluations to ensure that projects get built, and get built quickly!" Hayim expects the next licensed project tender to be held in late 2017 for a capacity of around 1 GW.

A number of other licensed projects are expected to be built out in 2016, particularly those that were able to obtain reasonably priced license fees. To clarify, the fees were assigned on an auction basis, with the developer bidding on what it was willing to pay, in the form of a contribution towards a project pre-license. One investor bid and had accepted a fee as high as $0.98/W, while the average was $0.60/W. With such high fees it should come as no surprise that many projects are not moving forward, with the project capex increased by 50% or more based purely on the government fee.

Halk Enerji obtained a fee of only $0.30/W for a 4.5 MW project it plans to build out this year. It has signed supply deals with Hanwha Q Cells for the modules and Huawei for inverters for that and another 5 MW unlicensed project it is concurrently developing.

"It comes as no surprise that the first licensed project that is expected to come online is the one that has paid the lowest contribution fee," observes Hayim.

Turkish manufacturing

Turkey is shaping up not only to be a solar end market, but has made major moves towards manufacturing. The Csun module assembly facility in the country, albeit located in a special free trade zone, is well established and there are a large number of small module assembly outfits.

At the Intersolar Turkey conference, held one day before Solarex got underway, Osman Özberk, the Founder of manufacturer Solarturk, said there were 18 solar fabs currently in Turkey, providing a strong base from which to supply not only Turkey's domestic market, but regional partners in the Middle East and Africa. Others are less optimistic for Turkey's outlook as a PV manufacturer.

"I am often asked whether there is PV manufacturing in Turkey and I reply no," says Tekno Group CEO Coşkunoğlu, clarifying that they are module assembly facilities.

"Their costs are so high that they cannot compete with product coming from China, so what is the point? These manufacturers are now asking for government tariffs, just so that they can survive." (For the full interview see **pv magazine** 5/2016.)

Tariffs and incentives

One of the major talking points during the 2016 Solarex was rumors of antidumping tariffs or duties set to be imposed on Chinese solar modules imported into Turkey. Christian Schmid, the President of the eponymous German production equipment supplier, attended Solarex and told **pv magazine** that he expects tariffsor minimum import prices to be introduced. Schmid has supplied some Turkish manufacturers in the past.

There is no doubt that the domestic manufacturers have some influence over lawmakers in Turkey and there are signs that an incentive program for manufactures may emerge. Reports are that up to 3 GW of project capacity may be allocated to companies willing to establish manufacturing facilities, although it would be for integrated cell and module production rather than pure assembly. Individual companies, so the reports go, could be allocated between 500 MW and 1 GW of projects.

As an additional sweetener, fees would be waived and there has even been talk of free land being provided. Again, details are scarce and as Tekno Group CEO Coşkunoğlu warns, "this is Turkey, things could change." ◆ Jonathan Gifford

Photo: Mecasolar

Mecasolar supplied 4.5 MW of single-axis trackers to the project in Korkuteli, in Antalya Province.

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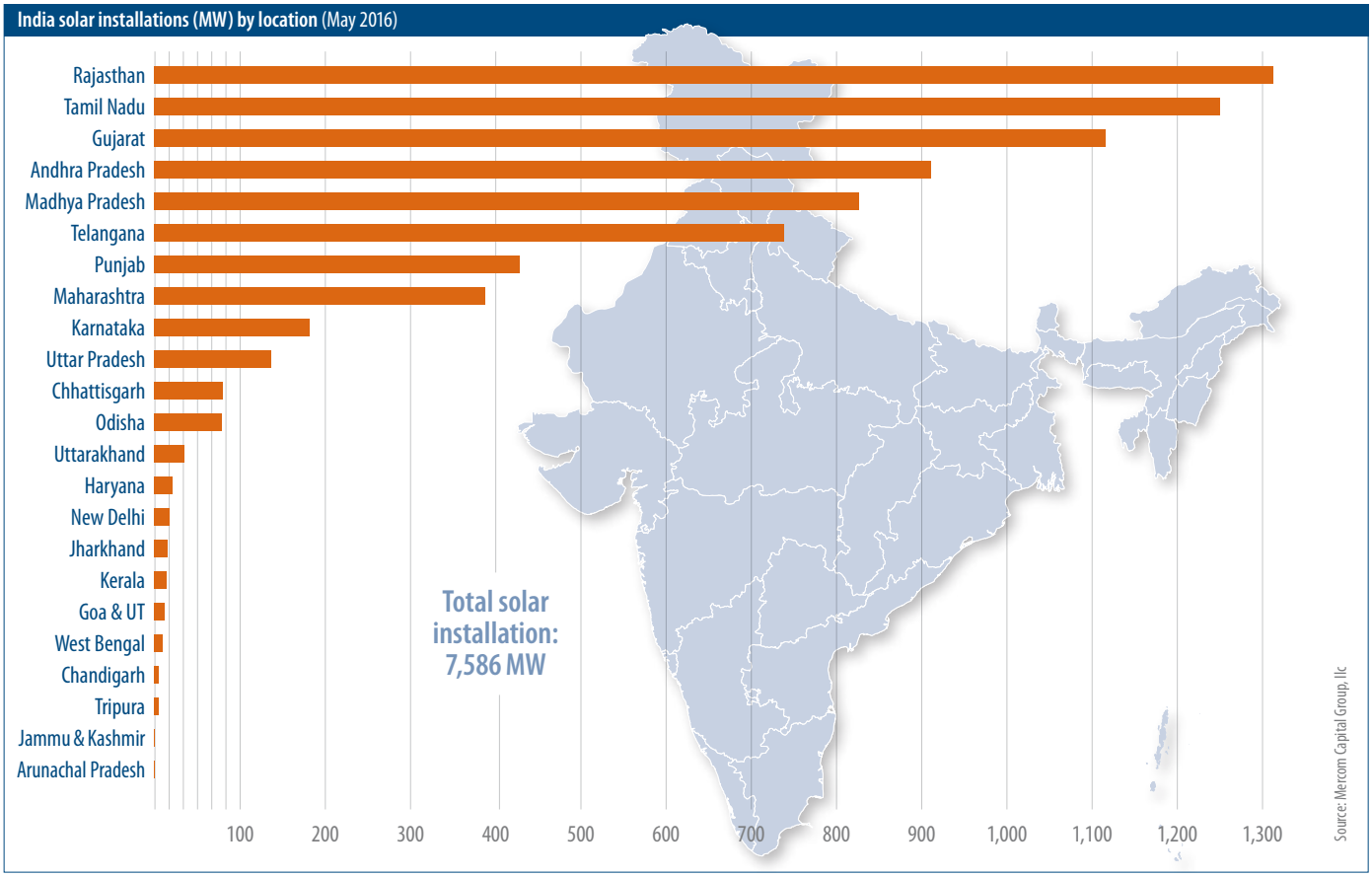


Too much, too fast?

India market update: Raj Prabhu, CEO and cofounder of Mercom Capital Group, proffers a comprehensive update on India's solar situation and notes that falling tariffs are causing concern across the market.

Cumulative solar installations in India crossed 7.6 GW as of May, with approximately 2.2 GW installed so far this year, which is more than all of the solar installations in 2015. India's solar project pipeline has now surpassed 22 GW with ~13 GW under construction and ~9 GW in the Request for Proposal (RfP) process. Mercom Capital is projecting solar installations in India to total approximately 5 GW for calendar year 2016.

The Indian solar market is growing but many challenges remain, which begs the question: Is it too much, too fast? Focusing on the positives first, the solar market clearly is much larger than ever, with more than 21 GW in various stages of development. The government is working hard to achieve 100 GW by 2022. But if we look closely, there are several issues that need to be addressed for the market to continue growing. The big news over the last three months is low bidding in reverse auctions. Mercom reported previously that most banks are unwilling to lend to projects below a INR 5/kWh ($0.0747) tariff. Since then, this subject has been discussed widely, but the fact remains that reverse auctions are driving bids to unsustainably low levels, and lenders are shying away.

Developers are relying on optimistic assumptions to justify low bids but, unless banks can be convinced that these assumptions are realistic, financing will continue to be an issue. In the current environment, a correction may be what the market needs. It may require some projects to fail to execute or reach financial closure in order to give the sector a jolt of reality. At this point, the sector looks underprepared to move from a 2 GW a year to a 10 GW a year market in the space of two years. Government agencies are trying to meet installation goals as ordered, but it does not look like they have the processes and infrastructure in place yet to do so. The auction process is constantly delayed, causing developers grief; evacuation delays - when electricity cannot be exported to the grid because of capacity constraints - are costing developers; land acquisitions have long been an issue and may get worse; there is hype around solar parks, but most are not close to completion; distribution company (DISCOM) finances are a mess; banks

saddled with non-performing assets (bad loans) are risk averse; and, several companies are out in the market looking for buyers for their project pipelines due to deteriorating conditions.

Solutions to improve market conditions

The problems in the Indian solar market are well known. One of the issues from the very beginning has been a lack of technical qualification requirements. The bar is very low when it comes to the required competency and experience for building solar projects: As long as you show the required finances and make the necessary deposits, that will remain the case. There is a lack of incentives for top performers and disincentives for companies that do not execute. It is difficult to imagine a textile company, for example, having the technical knowledge to factor in all the variables necessary to bid in a rational manner (though this can also apply to pure-play developers). All investors are not equal. It should be easier for developers to sell their stakes so that investors who are averse to development risk but who like the steady returns generated by an operating project can come in and take over, making the market more liquid.

Currently, there is a perception in the market that all of the risks have been dumped on to the developers. While developers go through a cumbersome regulatory regime to build a project, they don't feel that the government has done its part to make things efficient. Kudos to the NDA government because the market is growing and projects are being auctioned off regularly. That said, there are several areas that need government attention. **Avoid delays** – some government agencies are overwhelmed and frequent delays are common, which puts unnecessary pressure on developers. **Pay on time** – there is no mechanism to ensure timely payments, which would bring down borrowing costs and reduce risks. A billion dollar fund out of coal cess collections could act as a reserve backstop against non-payments. **Delayed evacuation** should not become a risk to the developer and should be compensated. **Less hype, more execution** – many solar parks are not complete; most of them are just an empty piece of land. Parks need to be 100% complete before the projects are auctioned and costs to develop in these parks must be priced competitively; the initial goal of governments for solar parks was to simplify project development, not make a profit. Many developers feel that solar parks are actually increasing the cost of projects as park fees are quite high compared to what developers get for it.

Policy updates over past three months

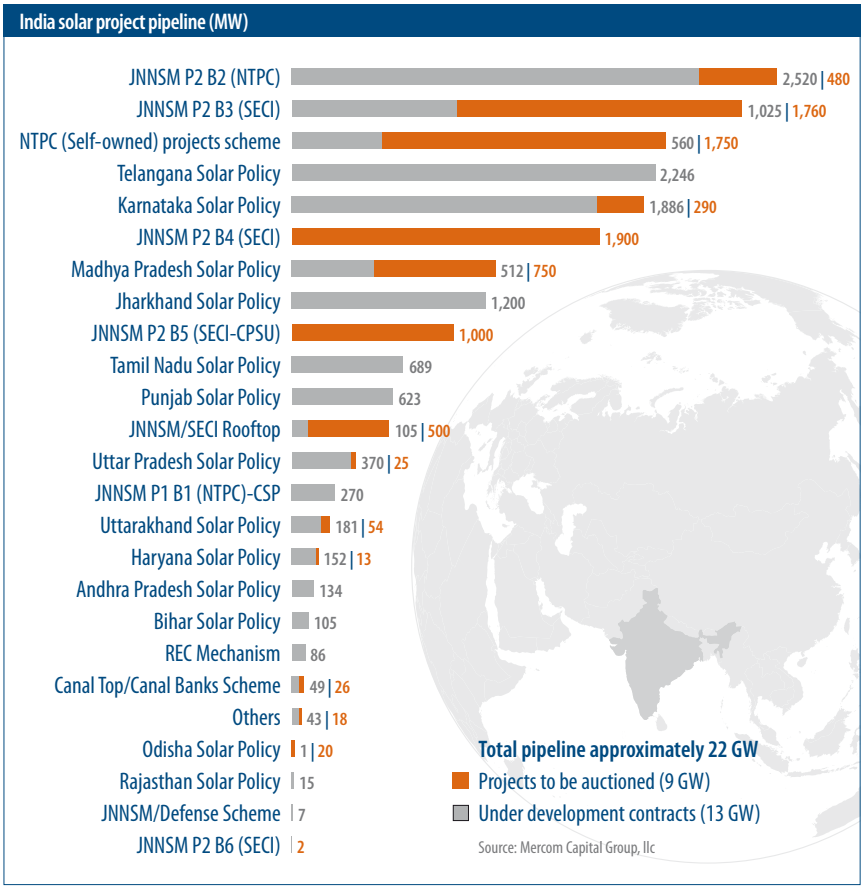
JNNSM – Phase II Batch 1 (SECI): 700 MW of solar projects were scheduled to be completed by May 2015 under this batch. Mercom has confirmation that, so far, 680 MW have been commissioned.

JNNSM – Phase II Batch 2: State Specific Bundling Scheme (NTPC): The Ministry of New and Renewable Energy (MNRE) has called for tenders under Batch 2 for all 3,000 MW of PV projects targeted under this scheme, implemented by the National Thermal Power Corporation through open competitive bidding. The Ministry has been spreading these projects among various states, including Andhra Pradesh, Karnataka, Rajasthan, Telangana, and Uttar Pradesh.

The auction results for 2,520 MW (1,000 MW in Andhra Pradesh, 520 MW in Rajasthan, 500 MW in Karnataka, 400 MW in Telangana and 100 MW in Uttar Pradesh) have been

Utility-scale solar projects in India	
Operational and under development, May 2016	
In-operation	**Capacity (MW)**
Solar PV	7,377.5
Solar Thermal	208.5
Total	**7,586.0**
Under development	**Capacity (MW)**
Solar PV	13,322
Solar Thermal	280
Total	**13,602**

Source: Mercom Capital Group, llc



announced. Of the 2,520 MW, only 300 MW are under the Domestic Content Requirement (DCR) category. Mercom has confirmation that Power Purchase Agreements (PPAs) have been signed for 1,330 MW to date, and these projects are expected to be commissioned in early 2017.

JNNSM – Phase II Batch 3 (SECI): The Solar Energy Corporation of India (SECI) has called for tenders amounting to 2,785 MW under JNNSM Phase II Batch 3, the "State Specific VGF Scheme." Auction results for 1,025 MW of projects to be developed in Andhra Pradesh, Maharashtra and Uttar Pradesh have been announced.

JNNSM – Phase II Batch 4 (SECI): Under this scheme, 5,000 MW of grid-connected solar PV projects with Viability Gap Funding (VGF) benefits will be developed on a build-own-operate basis. The final guidelines were announced in March. A tender for 250 MW of projects to be developed in Gujarat under this scheme were announced. A new tender for 500 MW of projects in Odisha were announced recently. Tenders for another 1,150 MW are expected to be issued soon.

Projects by defense sector

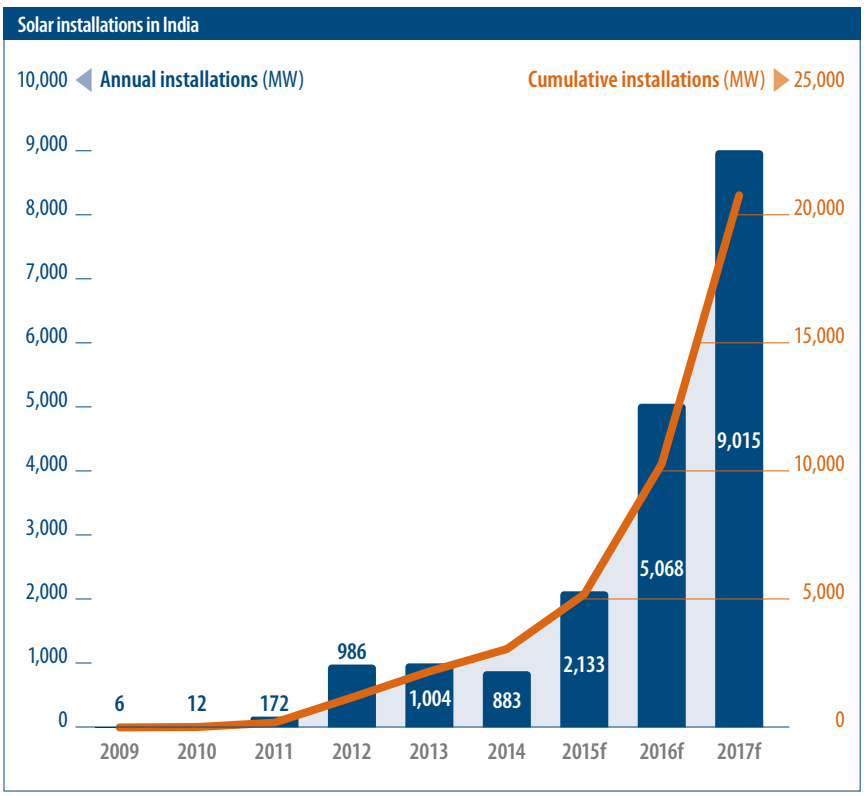
Under this plan, grid-connected and off-grid PV power projects were proposed to be set up by Defense Establishments under the Ministry of Defense with VGF over a span of five years, from 2014-2019. Domestic Content Requirements will be mandatory. According to sources, 340 MW have been approved by the MNRE.

The Ordnance Factory Board is developing 100 MW, Bharat Electronics Ltd. – 50 MW, Bharat Dynamics Ltd. – 25 MW, Hindustan Aeronautics Ltd. – 15 MW and the Department of Defense is developing 150 MW. Auction results for 7 MW to be developed by the Ordnance Factory Board in the state of Maharashtra were announced in March 2016.

State programs

Uttar Pradesh: There are 90 MW of solar projects in operation under Uttar Pradesh State Solar Policy and 320 MW of projects under construction. Of this, 105 MW are expected to be commissioned in 2016, and 215 MW in 2017.

Andhra Pradesh: Andhra Pradesh DISCOMs have signed PPAs to develop 619 MW of projects with first year tariffs



ranging from INR 5.25 to INR 5.99/kWh ($0.0784 – 0.0895) and 3% annual escalation for 10 years. Of these, 506 MW have been commissioned.

Punjab: Phase I: Punjab signed PPAs for 250 MW of solar PV projects in December 2013, with average tariffs ranging from INR 8.20 to INR 8.40/kWh ($0.1225-0.1255). Of these, about 223 MW have been commissioned. Phase II: There were 277 MW of solar projects with signed PPAs in 2015 under three categories: 1-4 MW (29 MW); 5-24 MW (100 MW); and 25-50 MW (95 MW). Another 53 MW of rooftop projects are also estimated to be developed under this phase. Of this, 189 MW, including 12 MW of rooftop projects, have been commissioned. The remaining 88 MW are expected to be commissioned by the end of 2016. Punjab also issued Requests for Proposals for 500 MW of projects in June; five developers have won the bids with tariffs ranging from INR 5.09-5.98/kWh ($0.0760-0.0893). PPAs were signed in December 2015 and the projects are expected to be commissioned early in 2017.

Madhya Pradesh: Rewa Ultra Mega Solar Limited, a joint venture of SECI and Madhya Pradesh Urja Vikas Nigam invited online bids to select developers for the 750 MW (3 × 250 MW) Rewa Ultra Mega Solar Project under the Open Category in Gurh Tehsil, District Rewa in Madhya Pradesh. Madhya Pradesh Power Management Company Limited & Delhi Metro Railway Corporation are the proposed power purchasers while International Finance Corporation is the Lead Transaction Adviser.

Kerala: A Kerala State Electricity Board (KSEB) tender for 200 MW of solar projects through tariff-based competitive bidding for Renewable Purchase Obligation (RPO) of KSEB has been canceled. A new tender is expected in the near future.

Haryana: Haryana Power Purchase Centre on behalf of Uttar Haryana Bijli Vitran Nigam and Dakshin Haryana Bijli Vitran Nigam invited tenders for 152 MW of solar projects. The list of bidders is finalized.

Karnataka: Under Batch 3, PPAs were signed for projects totaling 50 MW. A 23 MW project has been commissioned and the remaining projects are expected to be complete by the end of 2016. Under Batch 4, Karnataka Renewable Energy Development Ltd. signed PPAs for 500 MW in early 2015. These projects are expected to be commissioned by the end of 2016. Under Batch 5, tenders were issued for 1,200 MW. This tender was unique as it sought bids for up to 20 MW on a taluk-by-taluk (county-by-county) basis across 60 taluks in an effort to distribute solar capacity across the state. 100 MW of capacity was reserved for solar cell and module manufacturers located in Karnataka. Letters of Award have been signed for 910 MW by bidders quoting prices up to INR 5.50/kWh ($0.0822) under the general category and up to INR 6.10/kWh ($0.0911) from local manufacturers. The winning bidders have 60 days to sign PPAs.

Telangana: The Southern Power Distribution Company of Telangana invited 2,000 MW of bids on a build-own-operate basis in April 2015. PPAs were signed for 1,988 MW in February and March of 2016. These projects are expected to be commissioned in the second half of 2017.

Tamil Nadu: According to sources, Tamil Nadu Generation and Distribution Corporation (Tangedco), the state utility, has signed PPAs at a tariff of INR 7.01/kWh ($0.1047) with the projects thought to have been commissioned in March 2016. Of the total, Mercom has confirmed that 982 MW have been commissioned. Projects commissioned after April 2016 are expected to receive a tariff of INR 5.10/kWh ($0.0762).

Uttarakhand: The government of Uttarakhand signed PPAs in March 2015 to develop 30 MW of solar projects through a tariff-based competitive bidding process. All of these projects were commissioned by March 2016. Uttarakhand Renewable Energy Development Agency signed PPAs to develop 181.4 MW of projects in March 2016. These projects have a strict deadline of October 2016 for commissioning.

Jharkhand: Jharkhand Renewable Energy Development Agency had issued a tender to develop 1,200 MW of solar projects in December 2015. The Letters of Intent are expected to be issued by the end of May 2016.

Odisha: Green Energy Development Corporation of Odisha invited a tender for the development of 20 MW of grid-connected solar PV projects in Odisha. The last date for bid submission is June 4, 2016. ◆

Raj Prabhu

ABOUT THE AUTHOR

Raj Prabhu is CEO and cofounder of Mercom Capital Group, llc, a clean energy communications and consulting firm with offices in the United States and India. Mercom consults its clients on market entry, strategy, policy, due diligence and joint ventures. For more information, visit: http://www.mercomcapital.com Mercom's clean energy reports can be found at: http://store.mercom.mercomcapital.com/page/.

Photo: RTS Corporation

The Japanese solar industry is coming up to a crossroad, whereby installation pace is likely to increase in the rooftop sector while slowing down significantly at larger scale.

Fog of uncertainty lifts

Japan: Late last month a key piece of solar legislation passed the upper house of Japan's Parliament, opening the potential for a disruptive period of uncertainty for project developers. Izumi Kaizuka, the Managing Director of RTS Corporation, provides her insight into the development and offers an overview of Japanese market trends.

What is the legislation that was recently signed into law?
Izumi Kaizuka: The upper house of the Japanese Diet [has passed] the revision of the Renewable Energy Law [underpinning the FIT]. That revision included how tariffs will be set. Now that the law has passed, the Ministry for Economy, Trade and Industry (METI) can start to design the new tendering program for large scale PV projects.

When will the FIT system that is currently in place expire?
It will not expire, but the process for setting the tariff will change as of April 2017. Now the FIT is set according to market prices. After April 2017, METI can introduce a new way to set a tariff, of which one is the tendering program for large-scale PV and the scheduled reduction of tariffs for smaller solar applications.

How much is METI expected to tender for?
This is not yet decided. Because the FIT revision law has been passed, METI can begin working on the new system. These new systems could include a scheduled [FIT] decline, like in Germany, or new rules for approval.

What do you think will be the new process developed by METI?
For residential PV [smaller than 10 kW], METI will continue to offer a good tariff and include a scheduled reduction to decide the tariff. For the case of large-scale projects, I expect that METI will introduce a tender.

What is your prediction for how much METI will tender for?
I really don't have one. Maybe the tender will be implemented

by the electricity companies on a region-by-region basis because of grid capacity issues. But the decision process will start now that the law has passed. Next month, at the earliest, METI will hold a committee meeting to discuss how to implement the new FIT system. We have been waiting for this law to pass because this Diet session will end on June 1, so if the law had not passed, then the change of the rules would have been extended through to 2018.

What would have happened in that case?
Well the law did pass. If the law didn't pass then project developers would have had no transparency beyond 2017.

Can you provide an update to the current project environment? We know there is still a huge approved project pipeline. Have there been any changes there?
Developers now have to acquire a grid connection contract by the end of March 2017, otherwise the project will be canceled.

What is the size of the remaining project pipeline and how many will not meet the March 2017 grid connection contract deadline?
The pipeline currently stands at around 20 to 30 GW. In Japan there is an approved pipeline of almost 80 GW with 27 GW having already been built and in operation. This leaves a 53 GW pipeline as of the end of January 2016. Among the 53 GW, around 20 to 30 GW will be canceled – although we have to wait and see.

Japan is not a big country and is heavily populated. Are there land supply challenges remaining to find space for new projects?
The market will have to shift to the rooftops. In the Kansai and Chūbu regions, the two electricity companies account for 26% of the generation capacity [on a national basis]. They have the most grid connection capability, but the land price in these areas is very high. That is why it is expensive to realize a ground-mounted project. But there are still plenty of rooftops, of course!

So could we see large-scale projects move onto the commercial rooftop?
The current ground-mounted projects that are approved cannot be moved to the rooftop. I am speaking about new applications for the FIT.

But there is still enough land for 25 GW of ground-mounted projects?
I do believe that is the case, yes.

How does the Japanese PV market look on a macro level?
At the end of 2015, Japan had 34 GW of PV. The government target for 2030 is 67 GW. So already half of that goal has been reached. I think by 2020, the target will be reached. If effective measures are implemented, curtailment is addressed, and an effective use of cross-regional transmission is achieved, then Japan can potentially install 100 GW of PV by 2030.

Looking at Japanese PV module suppliers, what is your feeling as to how they are situated currently?
Sharp advertised recently in a national newspaper that it

Photo: CoCreatr/Flickr

Zero Energy Houses (ZEHs) are poised to shape the future of the Japanese housing and solar markets, with the policy stipulating that all new build residential properties must be fitted with solar PV capacity, either by fixing panels to the rooftop or integrated into the building (BIPV).

will continue its solar business, but we are not really sure what will happen. Sharp's production capacity is very small, and only covers its high efficiency Black Solar, below 200 MW per year. Mostly Sharp is buying PV modules from overseas producers, or importing solar cells from Taiwan. Kyocera is now shifting its focus to the U.S. market. I think Kyocera is a strong company in solar at the moment. And Solar Frontier is also expanding its overseas business in the U.S. For Panasonic, it has relied on the domestic rooftop market, so it is slowing down. But as the entire PV market moves to the rooftop, Panasonic has strong potential.

Can you provide an update on storage in Japan?

The storage market will really begin in 2019, as the first batch of the residential PV FIT program comes to an end. At that time we expect that many people will look to batteries. The centralized battery market is also growing. Right now, these projects tend to be at the demonstration stage, for which the government provides a subsidy.

What is your forecast for the Japanese PV market in 2016?

Our forecast is for 7 to 8 GW in 2016, dropping to 6 to 7 GW in 2017. So it will be a gradual decline. But this is because we believe many projects will survive after the March 2016 grid connection contract deadline. In Japan there is a very stable [annual] residential market of around 800 to 900 MW. ◆

Interview by Jonathan Gifford

Photo: RTS Corporation

IZUMI KAIZUKA BIO

Izumi Kaizuka is the Manager of the Research Division in RTS Corporation based in Tokyo, a PV consulting company with a more than 30-year history. She has been Japan's representative of the IEA PVPS Task 1 (Group for PV strategic analysis and communication) since 2003 as an analyst of PV policy, markets and industry. She is one of the authors of the IEA PVPS Trends Report.
She is responsible for various research projects for the Ministry of Economy, Trade and Industry (METI), The New Energy and Industrial Technology Development Organization (NEDO), and other government organizations.
She also contributes as an advisory member to the Future PV Innovation project and other scientific groups.

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Photo: Alain Herzog

Get smart... or else?

Smart grid products: A preview of Smart Grid-ready products set to be showcased at this month's Intersolar Europe exhibition in Munich, Germany.

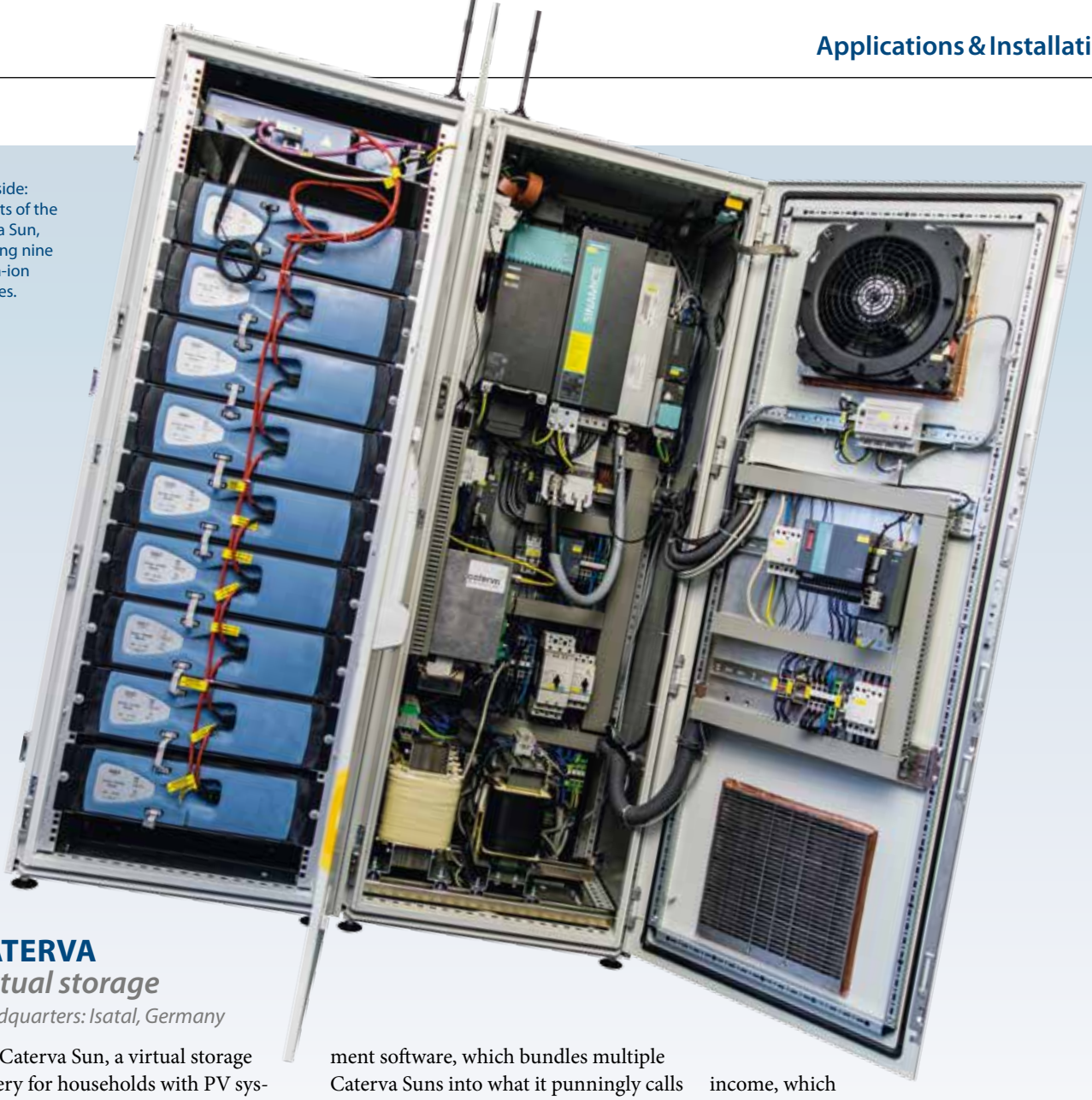
Many in the solar industry are increasingly taking the term "smart grid" to heart. Here could be the hoped-for savior of decentralized PV, damned by utilities and regulators for midday overloading of transmission lines. Can the grid be rewired with artificial intelligence to help make PV a better fit in a stabilized delivery of electricity? Will expressions like "dynamic control," "remote monitoring," "shifted loads" and "communication protocols" become the catchphrases of smart electricity flow? How much will return-on-investment be affected by additional costs of going smart? Can inverters with battery storage restore the promise of PV by knocking down barriers to balanced power?

Such questions on a future of decentralized PV will undoubtedly take center stage at the Smart Renewable Energy Forum, part of this year's Intersolar Europe Trade Fair in Munich from June 22 to 24. And those discussions will be backed up with smart solutions promoted by nearly 80 exhibitors with smart energy products and services. Florent Gaillard is from one of those exhibitors, the Swiss-headquartered lithium-ion battery manufacturer Leclanché SA. For decades, the PV sector has been focused on the growth of installed capacity. But Gaillard thinks that focus needs tweaking. "It is not how many kWh of solar PV are generated," he says, "but how many kWh are actually consumed."

And balancing that give-and-take between consumer consumption and PV production via a smart grid will certainly dominate the forum. Unfortunately, four of its five sponsors – SMA, Siemens, E.ON and Viessmann – did not respond to a **pv magazine** request for details on their smart products. But many exhibitors, mostly smaller, did. We present a preview of what nine of them, each a believer in the IQ of smart PV for a still-dumb grid, have on offer.

William Hirshman

Bank vault: Swiss-headquartered company Leclanché SA covers energy storage solutions for residential and large-scale PV installations.



Sun inside: The guts of the Caterva Sun, including nine lithium-ion batteries.

Photo: Caterva GmbH

CATERVA

Virtual storage

Headquarters: Isatal, Germany

The Caterva Sun, a virtual storage battery for households with PV systems, says it can provide primary control reserve for keeping energy consumption and PV production in balance, as well as stabilizing the grid frequency of 50 Hz "within seconds." Mobile radio communication, updated every 15 seconds, allows Caterva IT management software, which bundles multiple Caterva Suns into what it punningly calls a Caterva Solar System, to buy and sell power on the intra-day trading market, which can be followed on the Caterva App for smartphones. Homeowners sign a contract for what the company grandly claims is "20 years of free electricity." Participation in the market generates an income, which Caterva says it "shares" with homeowners, who also receive a fixed annual amount as a kind of bonus. The Caterva Sun hardware is built by Siemens, based on lithium-ion batteries. The company did not provide information on pricing.

FRONIUS

Smart Grid-ready

Headquarters: Pettenbach, Austria

Fronius claims its inverters are currently "smart grid-ready" and can "meet the requirements that will be placed on PV systems in the future." For example, for preventing a shutdown due to high voltage in just one phase, Fronius says its inverters can reduce this power while feeding more energy into the grid in the other two phases. Through supplying reactive power, its inverters can influence the voltage in the grid without causing energy losses.

Climate change ready: Fronius says its inverters are already designed for a smart-grid future.

Photo: Fronius International GmbH

VARTA STORAGE

Data logging

Headquarters: Nördlingen, Germany

Dubbed a "future-oriented virtual system" for the smart grid and smart home, the VARTA Connect is designed to manage energy production, storage, and consumption in households. PV data loggers are connected to the generating system to provide monitoring, processing and error recognition via an online portal, capable of storing daily, monthly or annual stats for viewing on a PC or smartphone. These include current flows and the charge of battery, presented graphically and numerically. The company claims the VARTA Connect can save PV owners up to 70% of annual costs. Given Varta's 125 year long connection with batteries and energy storage, says CEO Herbert Schein, "It was just natural and logical for us to step into this field."

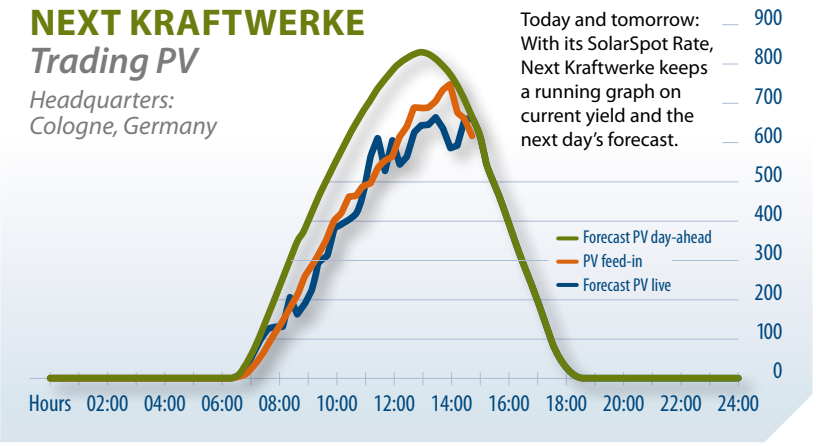
Photo: VARTA Storage GmbH

Storage man: CEO Herbert Schein

NEXT KRAFTWERKE

Trading PV

Headquarters: Cologne, Germany



Graphic: Next Kraftwerke GmbH/Harald Schütt

Next Kraftwerke started a service called SolarSpot Rates for selling PV-generated electricity on the spot market after the German regulations decreed that PV systems installed as of 2016 with a capacity of at least 100 kW have to sell their electricity to the spot market. This requires forecasts of how much electricity plant owners will feed into the grid each day, incurring balancing costs if they do not meet their forecasts. SolarSpot Rates handles the responsibilities for PV customers in return for a fixed monthly fee, ranging from €60 for a system sized up to 150 kW and €110 for systems between 501 and 800 kW. The service is currently only available in Germany. The customers are paid the proceeds from selling their electricity on the market. According to Next Kraftwerke, the SolarSpot Rate service "helps align supply and demand and thus stabilize the grid" by forecasting the solar power influx to the grid and making adjustments through trading on short-term power markets when solar power generation varies. The firm calls the service "an indispensable part of a reliable and efficient smart grid, especially in the long run when distributed solar and wind plants make up the majority of electricity generation."

QOS
Monitoring platform

Headquarters:
La Chapelle Sur Erdre, France

Photo: QOS Energy

Sunny clouds: Based on cloud computing, checking solar performanceanywhere in the world is a click away.

QOS has a renewable monitoring and O&M management platform called Qantum, described as "a flexible, powerful and secure solar monitoring platform that helps solar professionals identify underperforming plants, increase power production and streamline O&M workflows." The energy management software can be used with storage, demand-response, and aggregation aspects for smart grid solar projects. Referring to its analytics as "powerful", QOS says the Qantum platform is helpful in coming up with follow-up intervention plans by using a built-in computerized maintenance management system (CMMS). Data management can be handled via a cloud-based solution anywhere. The company, calling the Qantum an open solution, believes that owners and operators "cannot pretend to be able to manage and aggregate data from all types of PV plants with a locked proprietary solution." While not detailing pricing, QOS says the additional cost is "infinitesimal" compared to the financial losses due to underperforming plants, claiming "the small investment can make millions on large portfolios."

STEADYSUN
Weather predictor

Headquarters:
Le Bourget Du Lac Cedex, France

The Steadysun PV-Forecast API is an eye in the sky, useful for both system owners and utilities in predicting the near-term insolation expectations. It is also an aid for deciding when to consume PV-generated electricity and when to feed it to the grid, and help determine when to send unused PV power to home batteries. Via the API, a client can automatically retrieve solar production forecasts with http queries to Steadysun's server for web-based viewing. A SteadyEye fisheye camera is used for cloud tracking for short-term forecasts of less than an hour. The main technical challenge is evaluating the progression of the cloud cover and its effect on the ground at different locations up to 5 km away. Steadysun hopes that what it calls a "self-learning algorithm" will continually aid in providing ever more accurate forecasts, determined by a combination of weather data (day-ahead forecasting) and a Total Sky Imager (minute ahead forecasting). Currently, Steadysun solar forecasting technologies are deployed at more than 1,400 customer sites in 15 countries, from Panama to Australia. Prices are based on annual subscription fees.

Sky eye: Knowing the future weather is important for balancing the power in a smart grid.

Photo: Steadysun

SCHNEIDER ELECTRIC
Utility scale storage

Headquarters: Rueil-Malmaison, France

The Conext Core XC ES is a grid-connected power conversion system for utility-scale energy storage solutions from the battery to the grid. It includes inverters, MV transformers and switchgear. The energy management system uses smart energy optimization algorithms based on battery status, production forecasting, load forecasting, and/or tariff information. The power plant controller ensures compliance of power delivery to grid code requirements. Schneider says the Conext Core XC ES is able to work with different battery chemistries, as well as flywheels, and can also communicate with battery management systems for smart batteries so that the storage device operates only between set limits. According to Schneider, the Conext Core XC ES meets most grid requirements, allowing it to be installed worldwide. Its smoothing function helps it to reduce the production variability of solar electricity generation, and its energy shifting function allows it to prolong the generation day of a PV plant. From a grid operator perspective, this product can also be used to provide frequency and voltage regulation, and peak shaving. Schneider, which also produces inverters for residential and small-scale commercial systems, declined to give any information on pricing.

Longue vie solaire: One of two Schneider Electric utility-scale systems commisssioned in January on the French island of Corsica to test the lithium-ion battery storage systems for firming and shifting.

Photo: Schneider Electric

SMAPPEE

Watching appliances

Headquarters: Kortrijk, Belgium

The Smappee Solar Energy Monitor keeps a watch over both PV production and electricity consumption, switching appliances on and off automatically via its Comfort Plug. In addition, the Smappee solution is promoted as demand-response ready for switching off appliances during periods of peak demand. Its load disaggregation technology can break the energy consumption down to the appliance level. According to the company, the product is compatible with all types of solar inverters. When it detects that production is outpacing self-consumption, it can be used to power a hot-water boiler, rather than exporting the excess energy to the grid, thus shifting electric loads from periods of peak demand. It can also be used for battery storage. Smappee makes the bold claim that due to making the energy usage more visible via apps for smartphones, iPhones, tablets and laptops, the monitor leads to behavioral changes in consumers, who can save as much as 30% over normal usage. Smappee puts the cost of the solar energy monitor at €299, including VAT.

Photo: Smappee

Smappee happy: The solar monitor could leave smiles on faces of consumers if they find they're saving money.

OUTBACK POWER

Intuitive control

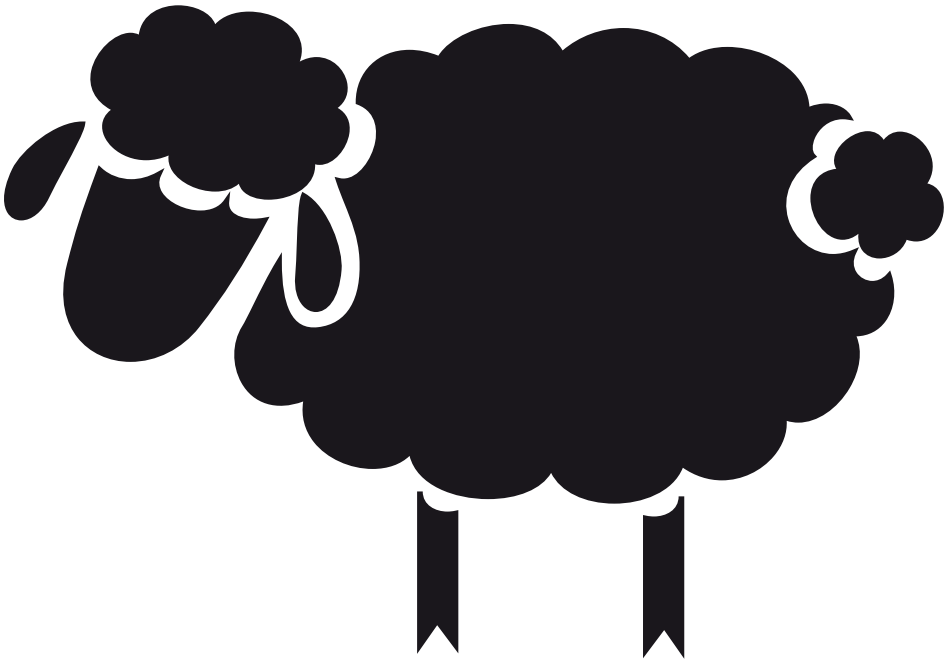
Headquarters: Arlington, Washington State, USA

Despite a name denoting an off-grid emphasis, OutBack also offers a grid-connected inverter with battery backup designed for the smart grid. The OPTICS RE (OutBack Power Technologies Intuitive Control Software for Renewable Energy) is an inverter that the company describes as an advanced software platform that allows users to monitor and control system operation, performance and output from any internet-enabled device remotely. It can send notifications via email, keeping a running log of all system parameters. It shows energy transfer happening at the system level in one-minute increments. A device map includes clickable icons of all devices connected to the system for further evaluation. The upgradeable OPTICS RE, which is compliant with the SunSpec Alliance certification standards, shows graph plotting of historical production information, with data storable up to five years, and is bundled free with the purchase of an OutBack system device.

Photo: OutBack Power

Pretty as a picture: No matter where you are, your devices are ready for screening.

The black sheep of the solar industry



Relabeled: A manufacturer supplies relabeled modules – a case of black sheep or white sheep? **pv magazine** tells the tale of a suspect batch of modules delivered in 2014, in the latest case study examining ill practices in the solar industry.

Imagine the scene: A module manufacturer first delivers panels with a lower wattage rating than ordered. When the replacement shipment arrives, the dealer says that the modules had obviously been relabeled. Old nameplates lying crumpled in the boxes indicate that the modules were neither the watt class nor the type of panels ordered. This rankled both the wholesaler and the end customer. But the manufacturer now refuses to deliver replacement modules.

In the latest case in **pv magazine**'s Black Sheep series, a wholesaler of PV products describes problems with a delivery from a manufacturer. In the summer of 2014, an installation company ordered 680 modules from a reputable dealer, each with a rated capacity of 250 watts, for a 170 kW PV plant. The dealer then ordered the modules from the manufacturer for direct delivery to the installer. Initially, however, only modules with 240 watt nameplates on them were delivered to the installer.

The dealer then complained to the manufacturer about the delivery of the lower-capacity modules, and the manufacturer sent replacements. This is where the story takes a rather strange and unusual twist.

The installer complained to the dealer that: 1) The nameplates on the replacement modules, which now indicated 250 watts, did not stick to the modules properly. 2) The module type was also engraved on the modules, and the engraved information did not match the information on the nameplates. 3) Adhesive residue from old nameplates was visible on the modules. 4) In the boxes, on which the original packaging was no longer intact, were crumpled labels indicating 240 watt panels and a completely different type of module than those ordered.

The installer then began to suspect that the modules had been relabeled with a false nameplate, and so retained a lawyer. The attorney informed the dealer that, among other things, as early as the initial delivery an internal note to the logistics company instructed it to remove the old labels and technical specifications and replace them with new labels indicating 250 watts.

A photograph of the note was submitted to **pv magazine**. In the first delivery this relabeling apparently was not carried out, but the wholesaler and installer suspect that the instructions were acted on for the second delivery.

A subsequent query from the dealer met with little understanding from the manufacturer. Repackaging goods in the warehouse and replacing nameplates was common practice, the manufacturer said, in cases where packaging or labels were damaged during transport from China to Europe, for instance. So far, the manufacturer has not indicated a willingness to send another shipment of replacement modules.

Solutions

Meanwhile, the installer and the dealer have reached a compromise. "The installer is a very good customer," says the dealer, "We didn't have a falling out over this case."

The solution was that the installer agreed to use the modules as delivered but not for the originally negotiated price. The lower price was to compensate for the delayed start to construction, repeated cancelation of sales, and the damage to the installer's reputation in the eyes of its customers and business partners. The dealer agreed to this solution and issued the installer a partial refund of the original purchase price.

"Since then, the case has been closed as far as our customer is concerned," the dealer said.

Between the dealer and the manufacturer the story continues, however. The dealer has demanded compensation from the manufacturer to cover both the legal costs and the additional costs incurred resulting from the compromise with the installer. The wholesaler has not yet filed suit.

"At the moment the case is on the back burner, because we're just not making any progress with the manufacturer," he says. The manufacturer, for their part, does not seem to see the problem. ◆

Mirco Sieg

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Optimizing your O&M

Smart data analytics: The urge to optimize PV plant performance is a natural one, and something every good EPC worth their salt should be thinking of from day one. And while post-installation monitoring and analysis tools vary, there are a wealth of platforms and techniques on the market to assist plant owners, writes Stefan Mau, a senior engineer with DNV GL.

Monitoring systems are implemented in all utility-scale PV plants today. However, the data scope can vary considerably, from mere reporting of the technical assumptions in the financial model to the detection of malfunctions in individual components. Smart Data Analytics (SDA) is a method for delivering key figures for stakeholders, taking into account the design of the PV plant and the physical dependency between individual parameters. There are various SDA approaches and they can be examined using several case studies from operating PV plants where SDA has supported the rapid detection of underperformance and unavailability, prompting and supporting efficient O&M activities. These led to a reduction of downtime and an increase in energy production.

Data quality

Prior to analyzing the operational behavior of a PV plant, the quality of the monitoring data should be verified. This check should include the following steps as a minimum.

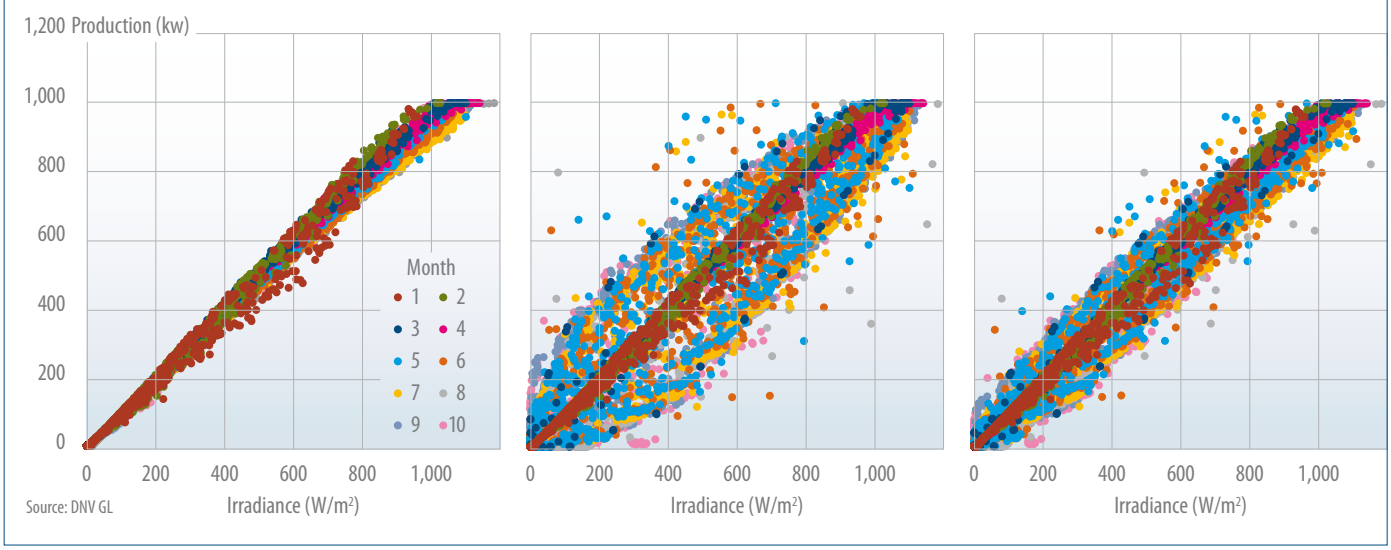
Data availability: Data availability should be checked for individual parameters and missing data points should be identified and flagged. If redundant sensors are available, signals from sensors may be synthesized to patch missing data points.

Data reasonableness: Ranges for reasonable allowed data should be defined for each monitored parameter, and values outside these ranges should be disregarded. However, analyzing these out-of-bound issues may identify required corrective actions related to sensor quality and maintenance. Due to "irradiance enhancement" or "cloud-edge effects," reasonable irradiance data depend on data frequency. Higher irradiance values may be observed when sampled at higher frequencies when clouds are close by.

Synchronized data: All temporal data streams should be fully synchronized. Particular attention should be paid to sensors connected to different monitoring systems or to a change of system time from winter to summer time or vice versa. Changing the time in monitoring systems from winter to summer time is discouraged, as doing so will make data analysis more complicated. Once the data quality is verified, the information can be analyzed in a thorough manner to evaluate the operation of the PV plant and initiate corrective actions if issues are found. The SDA approach compares expected data to measured data. Problems can come from measurement or real performance issues. To illustrate SDA, several examples are presented.

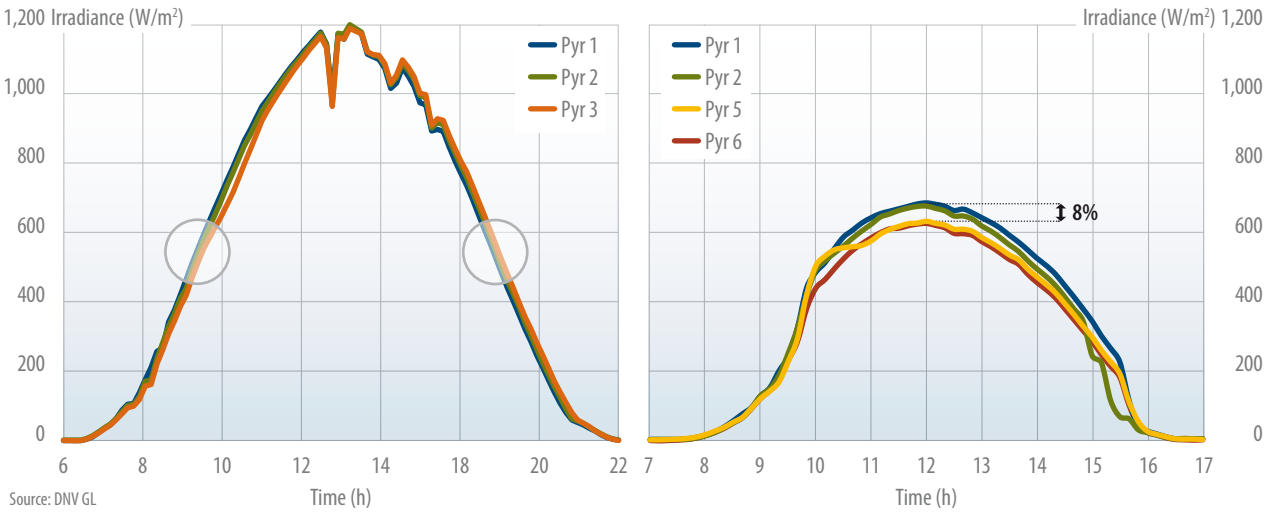
The following example has been taken from a utility-scale PV plant in Europe where irradiance and inverter production data are stored in different databases. Before checking for synchronization issues, the architecture of the monitoring system was reviewed in order to identify parameters that may not be synchronized. The representation of production versus irradiance should always yield a relatively straight line (see Figure 1 below) for a well-performing system. The change from summer to winter time during the summer months causes a more symmetric circular distribution of the data

Figure 1



Graphics: pv magazine/Harald Schütt

Figure 2



Source: DNV GL

points around the straight line (center). Smaller time offsets (30 min, right) result in smaller circular shapes, which may be confused with the normal scattering of the system. It should be noted that there are numerous opportunities for observing similar patterns, i.e. in case the combiner box and inverter measurements are not connected to the same logger (and probably not synchronized) or if the azimuth orientation of the irradiance sensor is not the same as the azimuth orientation of the modules in a plant.

Case study: irradiance sensors

Production and irradiation are often key parameters when compliance with contractual agreements or with assumptions made in the financial model are checked. The energy production is almost always taken from a high quality utility-grade meter in the substation – the accuracy of which is almost never questioned. The situation for irradiation measurements is quite different. After deciding on the type of irradiation sensor, the number of sensors, their location, and orientation must be determined. With large systems that encompass diverse topography and shading conditions, multiple sensors are required to properly characterize the entire site. But even in moderately sized plants, redundant sensors may be very useful, as the following example outlines.

A total of six in-plane irradiance sensors were installed in a 10 MW plant in central Europe. The different sensors were connected to two different communication systems. The sensors were not installed on the module array structure but on separate poles. Visualization of three of the pyranometer measurements versus time (see Figure 2 above) seems to reveal a time offset between the measurements due to the fact that Sensor 1 is the first to measure increasing irradiance in the morning and the first to measure decreasing irradiance in the afternoon.

However, the fact that clouding at noon reduces irradiance measured by all three sensors contradicts this assumption. An on-site inspection revealed that the azimuth orientation of the different sensors differed by up to 4°. The impact on the daily measured irradiance is small (<0.5%), but analysis of the system during the course of the day is hindered as the Performance Ratio exhibits an error of several percent in the morning and afternoon. Note that two of the sensors were connected to a second communication system due to the fact that all input channels of the first system were occupied. The use of multiple communication systems increases the potential for synchronization problems. Comparing the

measured irradiance on a day with clear skies (see Figure 2 above) reveals that at least two of the sensors measure incorrectly. The calibration uncertainty of the pyranometers is roughly 1.5%. Measurement deviations between pyranometers (which are expected to report the same irradiance) of more than 3% indicate that something is incorrect. An on-site inspection revealed that the calibration coefficients in one of the systems were not correct, leading to incorrectly reported irradiance values.

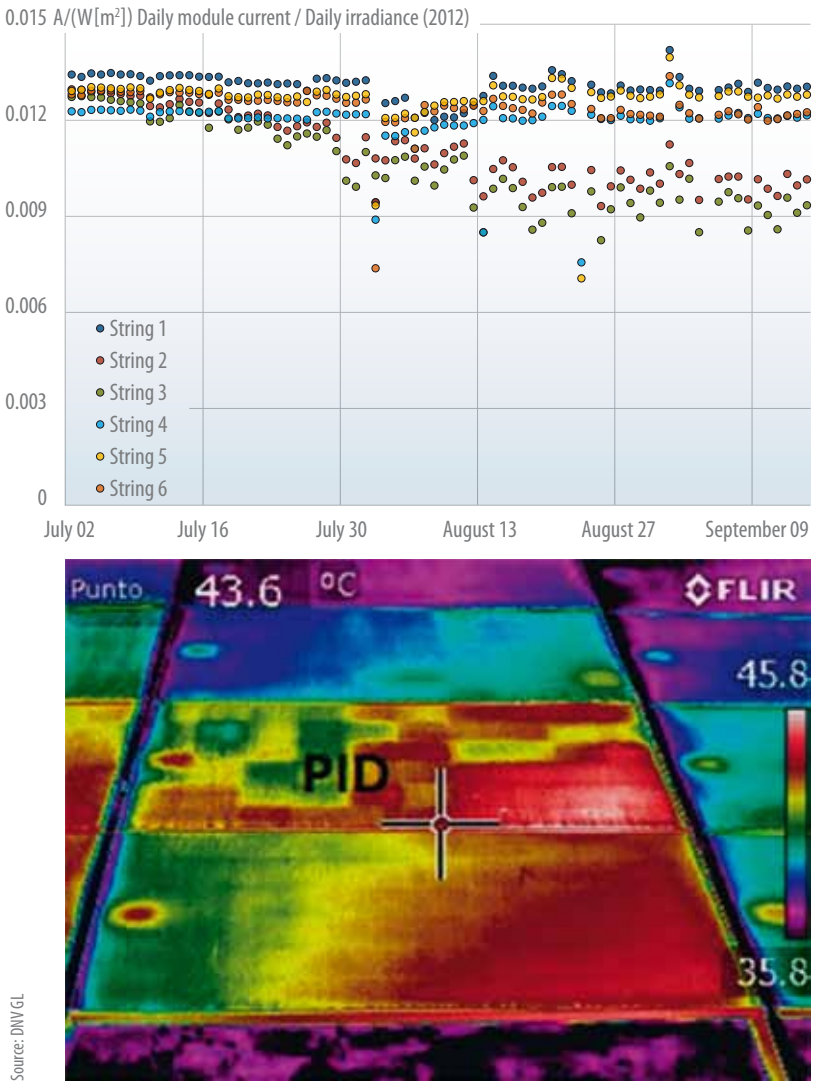
Case study: PID

Potential-induced degradation (PID) refers to the degradation of some commercial PV modules when exposed to high voltages with respect to ground. For PV modules made of p-type silicon solar cells, the voltage has to be negative for this degradation to occur. PID affects the cells within the module individually and may cause considerable degradation of the fill factor (FF) and open-circuit voltage (V_{OC}) of the module. Modules at the negative string end show more degradation than other modules in the strings due to being exposed to higher negative voltages. However, not all modules at the negative string end in one PV plant degrade at the same rate. Meanwhile, in some strings, modules with a performance reduction of 50% may be found, while in other strings modules may still show no measurable degradation. Note that this may be an indication that the small numbers of modules tested according to IEC TS 804 may not be representative of the millions of modules produced.

The fact that not all modules experience PID at the same rate makes it easier to detect the issue via monitoring if measurements at the string level are available. Even though the PID-affected strings show a reduction of FF and V_{OC} due to the parallel connection with other unaffected strings, the affected strings are operating at lower currents.

Knowing this, comparing string currents versus time may help identify strings that are affected by PID. In order to exclude seasonal shading patterns that may be different from string to string, only string currents measured above a certain sun elevation should be considered. Figure 3 shows the comparison of string currents over a period of three months at a plant in southern Europe. Several strings show decreasing production during August and remained at around 80% of the production of the other strings during September. The results of the thermographic imaging and the IV-curve measurements undertaken during an inspection revealed considerable PID of some modules at the negative end of the strings. Figure 3 shows the temperature distribution on the module surface for a module at the negative string end, affected by PID (top), and the module at the positive end of the same string (bottom). The affected module shows the typical variation of temperature for individual cells due to being short-circuited.

Figure 3



Source: DNV GL

Case study: tracking systems

In the boom years prior to 2008, lots of dual-axis tracking systems were installed in Spain. In the meantime, single-axis tracking systems have become the preferred solution in countries with high levels of irradiation. A potential disadvantage of a tracking system is that if the system erroneously remains in the morning or evening position, energy production suffers. Therefore, it is important to detect tracking failures immediately and correct the system operation. If the rotation angle of a single-axis tracking system is measured and stored in the data acquisition system then issues can be detected. With regard to a possible definition of tracking system availability in contractual agreements, a certain range around the theoretical curve may be defined (e.g. 10°), outside which the tracking system should be considered to be unavailable.

The described SDA approach of comparing measured data to expected performance is a valuable and efficient way to make decisions about whether a system is performing well and what corrective actions are appropriate. ◆ Stefan Mau

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Photo: SecondSol

Aware-house: SecondSol head Frank Fiedler (left) checks his warehouse inventory.

From eBay to pvBay – getting used to used PV

Secondhand solar: Could the advent of online bazaars for secondhand PV components mean that PV, after decades of trying to grow its installed capacity, has finally come of age?

Finding a buyer for used items – a dinged desk, a battered bicycle, an old car – was once handled by pinning mimeographed announcements to bulletin boards or buying classified ads in the local newspaper. Then came eBay.

Given the debt SecondSol no doubt owes to the status of that online auctioning website, the Germany-headquartered company could easily be dubbed "pvBay." But SecondSol, founded in 2012, with an online platform serving the second market for PV by connecting buyers and sellers of panels, inverters and other solar components in Europe, has done eBay one better. Unlike eBay's generalized, sketchy pitch for any product imaginable – including PV system components – SecondSol has gone for detail, allowing users to enter all the data a solar trader and a PV bargain hunter could want, be it MPP current, open circuit voltage, or the size of a panel right down to the last millimeter.

The American dream

And now SecondSol is getting ready to export that blueprint to the U.S. The germ for the idea came to SecondSol CEO Frank Fiedler at the U.S. Intersolar North America trade fair in San Francisco last year. In talking with other visitors, he realized that the solar market boom in

the U.S. made it a good prospect for its own national platform. "It didn't make any sense that an American looking for a used module would try to buy a second-market panel in Europe," he says, "or for Europeans to buy panels in America."

The result was that his company set up a U.S. clone in May. A beta version (which at time of print does not accept data input) has been added to the website of SecondSol's U.S. partner Solarado, a portmanteau of "solar" and "Colorado," the U.S. firm's home state. In June, Fiedler says, SecondSol will start a promotion campaign for the Solarado platform. Given the American mentality in dealing with products, he believes the U.S. is ripe for its own PV online marketplace. "If you are in Europe and the module has a scratch, they destroy it," Fiedler says. "But the Americans think, 'Why should I get rid of the panel? It still works."

The fact that a marketplace for second-hand PV components exists at all could be seen as an indication of a maturing industrial sector; that PV has come of age, rather than languishing as a juvenile technology struggling to prove its worth. With a worldwide installed solar capacity of nearly 260 GW at the end of 2015, the PV industry has reached a stage and age where it can support not only the continued sale of new pristine products, but the pre-owned, pre-insulated and pre-sunned variety as well.

And SecondSol is leading the charge. Fiedler says that SecondSol oversees 45,000 modules, including 3,500 different types, kept in three warehouses. He claims that his platform has more than 50 transactions from about 1,000 dedicated users per day. It currently advertises 3,800 items, which he estimates as having a total value of €60 million.

For an industrial segment yearning to become a traditional part of the electricity-generating establishment, the fact that PV has its own eBay-like platform is a big step forward. Until SecondSol, the only formal means ensuring a longer life for all of the materials that went into modules was to recycle the composite parts, mainly via the pan-European legislation on the take-back of solar equipment spearheaded by the Brussels-headquartered PV Cycle association. But instead of recycling throwaways, SecondSol offers the hope of a second life for the whole product, be it with cosmetic flaws or repaired defects.

A change of emphasis

That is how Stefan Wippich sees the development of the sector. As head of Envaris, a German company that assesses defects in PV equipment for insurance companies, manufacturers, residential and commercial system owners, and managers, he is both a user of SecondSol and a SecondSol advisor (Wippich is also listed as the head of the press and marketing department at SecondSol's U.S. partner Solarado). Wippich believes the timing for a service like SecondSol is perfect.

"Before 2010, there was so much money and PV product available (in Europe) that no one cared about the secondhand market," he remembers. But with PV systems continuing their generation of electricity year after year – and following the downturn of the market at the start of the decade after the boom days – the emphasis has changed. "The older the system, the more difficult it is to repair. And tech-

Photo: MDR Journal

SecondSol has started to sell vignettes with QR codes to give module thieves a reason to go straight.

nical advancements are happening very fast. The result is that now for the old PV systems, we need old modules."

He cites an example of a system from 2006 with a broken polycrystalline module, which would have required a time-consuming and complicated search for a panel with similar open voltage, short circuit and nominal power stats, as well as matching the color and size of the remaining array. "Now we can use SecondSol to find a polycrystalline module with nearly the same specifications that looks similar. It can even be from a different manufacturer. If you need to replace a 180 watt module with 8 amperes and 32 volts, we find a module with 200 watts, 8.2 amperes, and 34 volts that will work just as well."

But with utility-scale solar, Wippich says the equation is reversed for his company. Envaris becomes the seller. When modules are damaged, perhaps after a hail storm, Wippich finds it easier to exchange a whole string with completely new modules to repower the park. "But instead of throwing away the old modules, as one might normally, we sell them via SecondSol. So it's the other way round."

A second firm for second market

Another company in the business of a second PV market is pvXchange, which concentrates on large-scale systems. The German solar trader started dealing with new and used PV equipment in 2004. But its Managing Director, Martin Schachinger, soon discovered that his vision of building up an eBay-like platform for PV was ahead of its time.

"Nobody was interested in used modules back then," Schachinger recalls. "Our deals were over 99% for new products."

It wasn't until April 2015, when pvXchange partnered with Adler Solar, an after-sales German company that measures, tests and repairs PV modules and components, that pvXchange got back into the secondhand market – but not for private users. As a B2B trading platform focused on large-scale installations, only licensed business customers can register to use its service. Much of its used-panel business involves uninstalling modules and inverters, in some cases never connected to the grid, from parks in Spain, Italy and the Czech Republic. (Since its partner Adler has a joint venture in Tokyo, pvXchange is in "a testing and research phase" to start service in Japan, he says).

As at SecondSol, pvXchange buyers can expect to save between 20% to 30% compared to new modules. Given that the 25 year module warranties are usually no longer honored, the price has to be low enough for a buyer to gamble on a purchase. "Some customers are dreaming of a world where they can get all of the warranties on the products while paying less money," Schachinger says. "But in reality, the lower the price, the higher the risk they are taking."

Far smaller than SecondSol, pvXchange has an inventory of 10,000 modules and between 400 and 500 types, some acquired from manufacturers selling off surplus stock or from insolvent manufacturers emptying warehouse shelves. Schachinger says he is not worried if he has to wait to sell off the stock pvXchange has accumulated. "At some point, someone will come along and buy exactly what we have – the panel type and brand and specification – and then we can get a lot of money. It's like dealing with antiques or vintage cars."

For Fiedler at SecondSol, the analogy for offering used products available nowhere else – perhaps rebuilt or repaired – is "like buying a good wine." He says his company can even help manufacturers that have sold him surplus stocks "to find their own products" requested by wholesalers or installers.

To catch a thief

Indeed, SecondSol will take almost any module it can get – unless the used item is stolen. As a response to the growing problem of panel theft, be it from utility-scale installations or rooftop systems, two years ago SecondSol started a product called PV-Diebstahl (PV Theft). These are vignettes attached to modules and inverters with owner identification serial numbers registered to an online police database. Any attempt to remove stickers leaves behind scannable QR (Quick Response) codes. Fiedler, who recently sold 160,000 vignettes to one solar farm, says the cost per piece is €0.30 ($0.335) for up to 50 vignettes, dropping to €0.08 ($0.09) for a purchase of more than 50,000. Aside from more peace of mind, users usually get a premium from insurers.

So will the "eBay"-ization of PV continue? Fiedler will probably know more once the U.S. Solarado platform gets off the ground. For now, he estimates that his online platform for trading PV components, with what he describes as "a small fee" per transaction, is growing annually by 10% to 25%. "Five or six years ago, people were laughing at us, telling us, 'Why are you doing this? Anything below 100 watts, it's nothing. It's a joke'." Fiedler seems confident that in a maturing PV world where there is room for brand-new products as well as the second-market variety, he will have the last laugh. ◆

William P. Hirshman

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Photo: SecondSol Group

Frank Fiedler is the CEO of the SecondSol Group.

"The older the PV system, the harder it is to supply spares"

CEO interview: A maturing solar industry needs a thriving marketplace within which system owners, whether new or old, can find competitively priced spare parts for their plants. SecondSol has been a frontrunner in this sector, has now launched its service as Solarodo in the U.S., and CEO Frank Fiedler speaks to **pv magazine**.

pv magazine: What are the services that SecondSol offers?
Frank Fiedler: The SecondSol platform connects customers and traders of solar products, and also service providers. The focus is on all categories of supply: new components, B-grade, and used and repaired products. Using an intelligent search engine, all products can now be found in the U.S. on the Solarodo platform. To provide that feature, SecondSol is using a database with more than 100,000 PV products, which can be found by the user. Furthermore, SecondSol offers service providers new distribution channels and the opportunity to present their service by themselves.

What kind of transaction value has taken place on the SecondSol site in Germany and Europe since launch?
Since SecondSol was launched in 2010, the company has developed into the leading solar PV trade platform in Europe. Currently SecondSol has more than 1,000 visitors from Europe daily. The value of goods offered on the marketplace currently amounts to €100 million ($111 million). In 2015 around 60 MW of both new and used PV modules were traded among users via SecondSol.

PV installation figures for Germany have declined dramatically in the last couple of years, so why is it that there is a still a market for the platform SecondSol provides?
PV in Germany is still big business. Although not as many solar farms are being built today as in the past, the residential market is still active. Since this has always been SecondSol's primary target market segment, we can report double-digit growth rates every year. Furthermore, existing PV systems are a large target group in Germany and Europe. So customers can find a large number of spare parts for older PV systems at SecondSol. Spare parts are particularly required by insurance companies and installers to repair existing systems.

What are SecondSol's plans for the U.S. market?
We would like Solarodo to become the leading online platform for PV products in the U.S. market. Especially for traders, we would like to provide the knowledge we have built up in Europe to help them find products for their customers.
We also would like to make the topic of spare parts for existing PV systems more visible to installers in the U.S. The older the PV system, the more difficult it is in the U.S., and elsewhere, to supply spare parts. Here we see the chance to use the complex experiences from Europe and transfer this to the U.S. However, the marketplace will also be a meeting point at which issues such as cleaning, repairs, maintenance, and more are featured.

Why is it that SecondSol has identified the U.S. as being a good potential market for the Solarodo platform?
Compared to the European market, the U.S. market is a growing market, especially in the construction of new plants, and an overview of the availability of products is required. Furthermore, there is a huge population that is open to the technological progress and can also afford it. In the sun-rich states, solar plays an even more important role regarding independent power production. On the other hand, there is already a considerable number of PV systems installed that are getting older. There are also many farms and communities that would like to provide themselves completely independently with power.

Are similar services being offered in the U.S. at present?
No platform with a similar service in the U.S. is currently known to us, as far as we are aware. In the U.S., there are many exciting online approaches and solutions to make PV more efficient and cheaper . However, there is still no solution to these promising approaches supported in the secondary market. That's where Solarodo comes into play.

SecondSol offers the ability to trade second-hand or "B" modules. How has this market developed?
This market has proven to be one of the most exciting at SecondSol. In Germany we currently operate our own warehouse where we store more than 40,000 modules; second-hand, B-grade modules but also new and old (but unused) stock. This inventory forms the backup for the long-term operation of German PV systems.
A large market for repowering and dismantling of PV systems has developed and an increasing number of used PV modules are traded at our marketplace. This market will also develop in the U.S., where B-grade modules with optical defects will probably become a big topic.
There were times in Germany where new modules with small optical defects were destroyed, although they were technically sound. But thanks to the SecondSol platform, there is no longer such a waste of components. Why dispose of a used module that still works? Also, thanks to new repair technologies, a second life can be given to many modules.

Are there commercial risks in trading these modules?
Commercial risks are always based on the state of the modules. At our warehouse in Germany, we operate our own testing laboratory where we can check the status of the modules. Used modules or B-grade modules are not necessarily broken or do not perform well. Often there are optical phenomena such as scratches or reduced performance due to age. This is why they are cheaper. Sometimes there are also modules that are somewhat more damaged, and then they are sold very cheaply and the risk might increase slightly. In these cases, the buyer simply has to decide themselves whether it is worth it or not. For purchasers of used modules, we provide an information area where buyers can see all existing problems of PV modules.

Beyond modules, how important is the power electronics – including storage – trade on the SecondSol platform? Is there also much trading of inverters and batteries?
This field is growing as the technology has become more mature. Especially with the price decreases that can be observed in energy storage, this segment is getting more and more interesting.

What are the primary benefits in using the SecondSol platform, rather than conventional wholesale channels?
The primary benefit is the huge catalog of products SecondSol has and the visibility it provides as to what is available. Commercial, public and private customers can find the product they are looking for, and the price at which it is offered. The search for specific products is so much more efficient, because you no longer have to be looking at a number of different sources. For retailers, it is the increased web traffic that makes a platform like SecondSol interesting. ◆

Interview by **pv magazine** staff

Photo: Suncycle

Suncycle detects PID directly in the array using electroluminescence testing.

A rogue wave

Potential-induced degradation: The PID wave is still rolling in, says Wolfgang Nasse from service provider Suncycle. Here, Nasse answers 13 key questions concerning the PID phenomenon. Unlucky for some.

1. How relevant is PID in your view?

In 2015, in addition to other projects, we handled about 10 MW of module capacity with suspected PID. The suspicion was justified in about 95% of the cases. PID is often determined by the location of the PV plant. High ambient temperatures, solar radiation and humidity can all accelerate the effect. Conductive deposits such as salt spray in coastal areas also promote PID. Still, our view is that the effect is not limited to specific regions. We have dealt with the problem on several megawatts of PV capacity located far from the coast.

2. Is the PID wave behind us, or is there more to come?

That's hard to say with any certainty; we cannot predict the future. A lot of manufacturers have now shifted their focus to tackling the PID effect. Consequently, they are testing their new products more extensively and initiating countermeasures in production (also see Question 10, p. 85). But a large percentage of previously installed modules will continue to be affected by the problem.

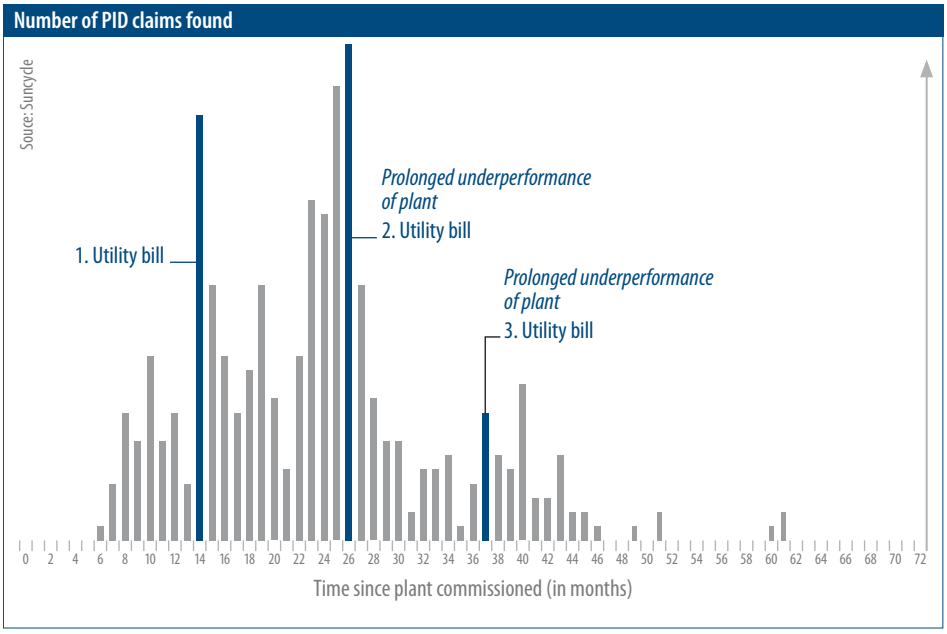
We saw the first wave of PID between the summers of 2013 and of 2014 (see Graph 2, p. 84). After that, the cases declined but only slightly. We do not anticipate a drop in PID-related business. First off, degradation processes progress at different rates in different types of modules. Second, operators always pay close attention as their individual warranty limits approach. Then there is a delay in filing their claims. Also, monitoring processes are getting more and more precise and are being used more frequently, which is why more deviations get noticed.

3. What is the typical sequence of events in determining PID?

Some customers approach us simply because they are dissatisfied with the yield of their plants and are looking for the cause (see Question 13, p. 85). Other customers already have a concrete suspicion because they are using module types known to be susceptible to PID. If the output drops or PID is suspected we conduct a more detailed analysis. Sometimes we find PID by accident during a hail-damage assessment, for instance.

To substantiate suspected PID, it has to be linked to other measurements. In any case, a capacity measurement under standard test conditions is required. This can be done at either the module or the string level. The PID effect can be overlooked in a string measurement, however, because the poorly performing modules may only have a marginal influence on the overall measurement. In such cases a great deal of experience is necessary to properly interpret the measurements.

The more unambiguous measurement on the module level should begin at the negative end of the string because that is where the modules are first and most severely affected by PID. The PID effect can also be determined using electroluminescence (EL) images, although the images do not show the precise degree of the degeneration. The extent of the fault can be seen clearly without a lot of effort by taking images of individual modules in their installed state – we've developed a device (CTUflex) capable of taking such images. Thermographic imaging can also be a good initial indicator.



Graphics: pv magazine/Harald Schütt

Graph 1: Time elapsed between a plant's commissioning and the date Suncycle identifies PID. This chart, like the others, is based on an evaluation of all of the PID cases Suncycle has handled.

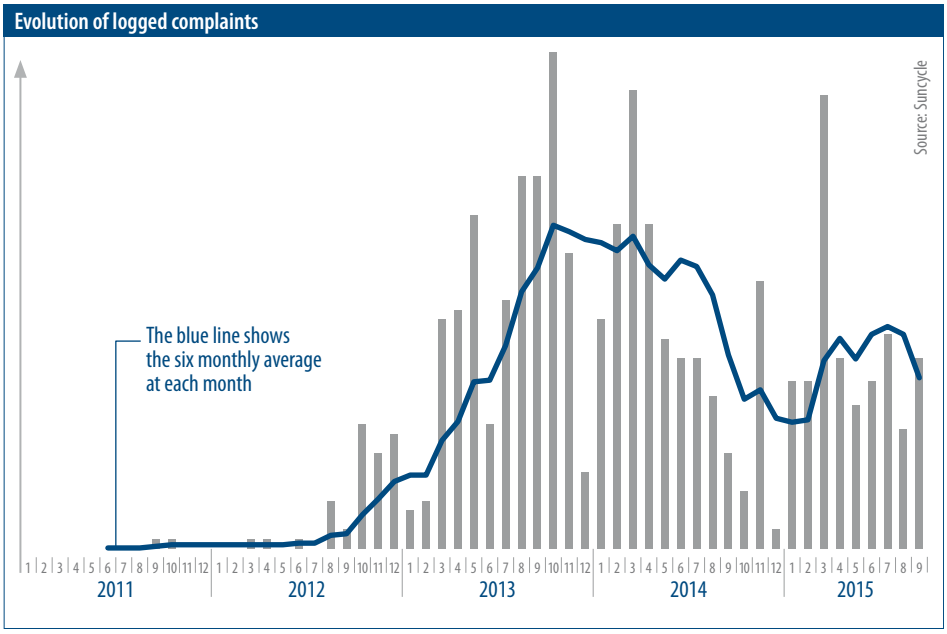
4. Do warranties cover PID, and if so which ones?

You have to distinguish between who contacts whom, and who wants to make what kind of claim. In most cases, module manufacturers offer performance guarantees for individual modules. To file a claim against a performance guarantee, the customer has to supply evidence of the reduced yield at the module level. If an installer has also guaranteed the operator of a plant a certain yield, that company also has to take action in the event that yields are lower than those originally forecast at the plant level. What's more, in such cases the operator is not obligated to prove the drop in performance in every module.

Since about 2012 modules have been sold with "PID free" labels. This marking is always based on certain laboratory test scenarios. The extent to which this assurance is part of a given promised performance or even a performance guarantee is always dependent on the warranty terms and conditions of the respective manufacturer. There is no catch-all legal answer. Basically, in this case, operators can assume that they are covered by the product warranty. If lower yield is detected, the seller should always be informed as quickly as possible. At that point the dealer has to coordinate along the supply chain with the module manufacturer to determine what form of proof is required. This varies so much from manufacturer to manufacturer that it also precludes any catch-all answer. However, many manufacturers today are willing to offer assistance in determining the scope of the problem and finding a solution. It is useful to clarify in advance with the module manufacturer specifically how to prove PID.

5. What are the operator's obligations with regard to PID?

Operators have to keep an eye on the yield and performance of their power plants to



Graph 2: Development over time of the number of PID complaints at Suncycle.

ensure that they comply with deadlines. For instance, some performance warranties specify that claims have to be submitted within a certain period – sometimes operators have just three months after the problem occurs to file a claim.

In cases of PID in particular, this can be critical because the effect becomes more pronounced the longer the condition persists. If, for instance, a PV plant has been in operation for four years and the plant as a whole is only performing at 50% of its original capacity, we can assume that the drop in performance occurred some time ago. In this case, the manufacturer could accuse the plant operator of heel-dragging in filing the complaint.

The pressure to act quickly is compounded by the fact that the PID effect on modules is more pronounced on the negative pole of the strings than on the positive pole. We can thus assume that the modules in the previous example near the negative pole are degraded by more than 50% and have been for a long time.

Regardless of any deadlines for complaints, a half year after the purchase of the components or the commissioning of the PV plant (that is specified in the warranty conditions) the burden of proof shifts to the operator. Because the PID effect within this brief time frame generally has no relevant influence on performance, the shift in the burden of proof almost always kicks in.

Module owners and manufacturers naturally interpret warranties differently. For instance, most warranties rule out liability for the cost of proving PID. For that reason, plant operators who have complaints should establish close contact early on with the module manufacturer and not rack up a lot of expenses too soon. Most manufacturers are aware, within the company, that certain types of modules have a PID problem and will often offer support in determining the presence and extent of the problem. This keeps expenses low for everyone involved and ensures a targeted handling of complaints.

6. Under what conditions are modules generally replaced by manufacturers?

Whether modules are replaced usually depends a great deal on the applicable warranty conditions or supplier contracts. Manufacturers that offer performance guarantees are generally free to decide whether modules should be replaced or repaired.

Even when an operator has a right to module replacement, it sometimes makes more sense to accept a repair. This can be less expensive for the operator in cases where handling and installation costs for the exchange are not covered by the warranty.

In severely degraded modules, exchange is the only effective remedy in the long run because such modules can rarely be regenerated to the extent that they provide the guaranteed minimum output. Suncycle's experience has shown that modules that have lost more than 70% of their capacity can no longer be satisfactorily regenerated.

7. When modules are not exchanged, how effective are anti-PID boxes?

The sooner PID is detected, the lower the assumed degradation of the modules. In such cases the regeneration phase will be brief and there is a high likelihood of complete regeneration.

A number of factors determine whether a module can be fully regenerated. Severely degraded modules with less than 30% of their original capacity usually cannot be fully regenerated. The selection of the regeneration technique also plays an important role. The quality of the grounding, and the amount and duration of the offset voltage are two key factors.

With offset boxes, regeneration occurs rather quickly and then tapers off over time. Using this method, a module that is degraded by 50% can be regenerated to 90% of its original capacity in as little as 30 to 40 weeks (see Graph 3, p. 85).

If anti-PID boxes are not used, other measures can be taken. Whether it is possible to ground the strings after the fact depends on whether a transformer inverter is installed. Our experience has shown that regeneration via the modules' own voltage takes place somewhat more slowly than with anti-PID boxes but that it ultimately has the same effect.

8. What complications and additional operating costs can anti-PID boxes cause?

Anti-PID boxes should generally be approved for use with the inverter installed in the system. We advise against using offset boxes that are not approved for use with the inverter because they not only can cause additional hardware dam-

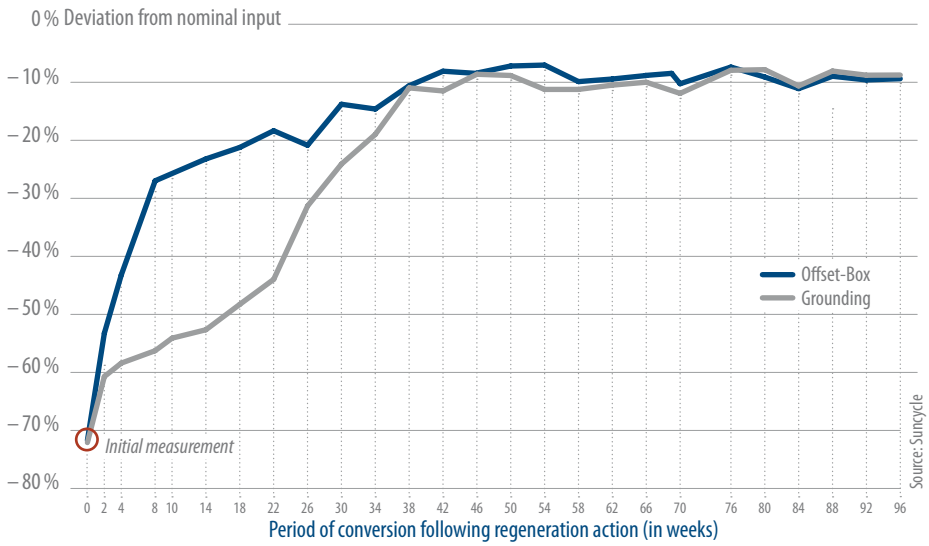
MEET SUNCYCLE

At the third **pv magazine** quality roundtable, held during Intersolar Europe this month, you can meet Suncycle to discuss PID matters.
Where and when?
June 23, Hall B1, Room B13
For more information and to register, visit:
www.pv-magazine.com/roundtable
Also see article on page 136.

age but also void the operating license of the PV plant. One way damage can occur is if the regeneration voltage is too high in relation to the system voltage. Alternatively, the operator can switch to an approved inverter or a grounded transformer inverter. The last possibility is re-stringing the modules to accelerate regeneration. This method can reduce the time it takes to achieve complete regeneration to a period comparable to that achieved with an offset box.

Additional operating costs associated with offset boxes are negligible since the devices draw so little power. However, the function of the boxes should be monitored continuously. For small systems with less than 5 kW of capacity, an offset box including installation can be had for as little as €600-€800 ($680 - 908), by the way.

Impact of PID over time



Graph 3: Regeneration behavior of various PID countermeasures. The graph depicts average degradation data at a PV farm. The modules were 50% to 95% degraded. The development shown in the graph illustrates a trend often seen in the field. The exact sequence differs from module type to module type.

9. How should the effectiveness of regeneration measures be monitored?

Inspection intervals should be set based on the level of degradation and the type of regeneration measure selected. With offset boxes in particular, initial success can already be seen in just a few weeks. It makes sense to carry out as few inspections as possible for the sake of cost effectiveness. We recommend performing inspections at six and 12 months to determine the effectiveness of the regeneration measures.

If the recovery is too slow, conditions conducive to regeneration can be created by repositioning modules in the string. Modules from the negative end of the string are switched with modules from the positive end with less PID damage. This also promotes regeneration during plant operation.

10. What can I do if the module manufacturer will neither replace the modules nor agree to regeneration measures?

Operators who cannot come to an agreement with the module manufacturer can always contact an attorney specialized in PV plant operator issues, or can simply regenerate the modules on their own. But choosing the legal route can take a long time and cost a bundle of money, all for an uncertain outcome. It is nearly impossible to get a bankrupt manufacturer to share costs. Simple solutions are needed for operators who want to regenerate their modules and restore profitable operation of their PV plant. For that reason, measuring techniques that test modules in their installed state should be used to avoid otherwise potentially high handling costs.

11. Different modules react differently to PID. Can this be taken into account when purchasing new modules?

Unfortunately, due to the huge number of module manufacturers on the market there is no clear answer to that question. Our experience has shown that any manufacturer can be affected – the origin and the brand of modules are irrelevant. It is therefore advisable to select a module manufacturer that offers local, experienced customer service capable of handling complaints through a local point of contact.

Customers who decide for a specific manufacturer would do well to talk to industry insiders about their experience. If manufacturers offer characteristics such as "PID free," this promise should be verified both in content and extent in the warranty conditions.

12. Would you say that module manufacturers now have a handle on the problem?

The PID effect is a result of a gradual process. As such, the PID can also come about in newly supplied modules. So we won't really know whether manufacturers have the problem under control for another year, at the soonest. High volume purchasers may have the option of adding a PID clause to the supply agreement. Customers purchasing smaller quantities have to rely on the warranty conditions and the disposition of the manufacturer.

13. What do I have to do to ensure early detection?

Indications of a possible PID effect can be seen particularly well by conducting monitoring at the string level. Ideally, actual values should be compared with target values using solar radiation and temperature sensors. Of course, the latest monitoring solutions at the module level are even better but in many cases the expense can't be justified.

If no monitoring is available at the string or module level, the yield of the entire plant can serve as an initial indicator. If it is less than 10% below the yield forecast, that should be a red flag to have a closer look at the plant. Here, it is important to take into account actual solar radiation levels.

The best way to do that is with a solar radiation sensor. The only way to tell whether a PID effect or some other cause is responsible for a deviation of 10% or greater is to conduct further testing ◆

Wolfgang Nasse

Array Changing Technologies

As an inherently disruptive technology, solar PV is constantly evolving. And as the industry moves from the lab to the field and from niche to a mainstream source of power, a greater focus has come upon downstream technologies to reduce costs, accelerate installation, simplify process and increase yields, as well as to integrate symbiotic technologies such as energy storage.

This is the second edition of **pv magazine's** Array Changing Technologies, which builds on our upstream Technology Highlights series, to look downstream at the leading technologies that have the potential to transform the way that we build, install and integrate solar PV.

pv magazine has assembled a jury of downstream PV experts from industry, non-profits and government agencies to rank entries and select winners from fields as diverse as PV modules, mounting, racking and tracking solutions, inverter technology, and energy storage.

Over the next 10 pages we bring you two winners, two runners up and 16 finalists from our Array Changing Technologies. Modularity and standardization were key themes, with high-powered three phase inverters having a big presence, as well as energy storage enablers.

After review, deliberation and debate, the jury has selected the following winners:

ARRAY CHANGING TECHNOLOGIES 2016 AWARD WINNERS

The SonnenCommunity

Energy freedom and energy community

Nextracker's NX Fusion

An integrated solution for utility-scale solar

RUNNERS UP

Delta M80H Inverter

Quest Renewables' QuaPod

The **pv magazine** editorial team would like to thank all participating companies for submitting entries, and the jury for sharing their time and expertise. Technology is our business, innovation abounds.

Award Jury

Dirk Morbitzer,
Supply Chain Manager, Sunrun

Dirk Morbitzer is responsible for the vendor selection, contract negotiations and quality management at Sunrun. He constantly evaluates new technologies on their impact on cost, reliability and usability. During his more than 10 years in the solar industry Mr. Morbitzer was Managing Director at Renewable Analytics where he advised financial investors on renewable technologies, Director Global Procurement at Trina Solar, and Head of Procurement at S.A.G. Solarstrom.

Elizabeth Mayo
Section head, Solar Engineering and Technology, DNV GL

Elizabeth Mayo is a renewable energy consultant with more than 12 years of PV research and manufacturing experience including device engineering, manufacturing process control, certification, reliability testing and performance monitoring for multiple PV cell and module technologies. She joined DNV GL as an independent engineer in 2014 and currently manages all business operations for DNV GL's Energy Advisory Laboratory Services for PV Module, Inverter and Battery reliability and performance testing.

Geoffrey Kinsey
Technical advisor, U.S. Department of Energy's Solar Energy Technologies Office

As a technical advisor (contractor) for the U.S. DOE, Geoffrey Kinsey is involved in PV R&D, codes and standards and service lifetime. This includes oversight of the Regional Test Centers, codes and standards, PREDICTS2, and building out a new initiative: the PV Lifetime Project. He has over 80 publications and holds a B.S. from Yale University and a Ph.D. from the University of Texas at Austin.

Joseph Goodman
Manager, Electricity Systems Practice, Rocky Mountain Institute

Joseph Goodman is an energy systems engineer with over 10 years' experience in renewables and energy efficiency, which includes extensive experience leading multidisciplinary design teams and bringing new technologies to market. At RMI Joseph is leading the Model T solar program to accelerate the deployment of community solar, which is focused on supporting communities to realize the full potential of community solar.

The SonnenCommunity

Energy freedom and energy community

Inherent in the concept of distributed PV is the dream of transforming our electricity system so that individuals and businesses can generate their own power and share it with their neighbors, as producer/consumers, making large utilities and dirty, centralized generation obsolete.

However, with both the technology and business and regulatory structures that have existed to date, this has been just a dream. On its own solar PV can only generate power during the daytime, meaning only partial independence from centralized electricity structures. Energy storage can provide the technical means to detach from the grid, but only at a high cost.

Enter SonnenCommunity, a new concept by battery storage integrator Sonnen. At the core of the SonnenCommunity is a new software platform to balance supply and demand across a network of users, allowing members to trade electricity from distributed PV and battery systems on the grid through a peer-to-peer network. Sonnen is offering this service at less than the cost of conventional electricity.

SonnenCommunity is only available in Germany at present, however our jurists see potential for this service to come to the United States in the future, particularly in the state of New York which is redesigning the operation of its distribution grid through the Reforming the Energy Vision process.

Sonnen notes that in Germany, it is offering prices around €0.23/kWh ($0.26/kWh), as opposed to standard residential tariffs of €0.28/kWh ($32/kWh).

–

Jurist comments:

"Overall the concept is very innovative in that it allows people to trade directly with each other. The grid is just the means of transportation of electricity and there is a grid fee. Utilities in Europe can't block that."

"This is completely out of the box, and a whole new business model."

"Sonnen's solution links into the community solar sector and sharing infrastructure. There is a tremendous opportunity in that pivoted business model for SonnenCommunity."

Nextracker's NX Fusion

An integrated solution for utility-scale solar inverter with SiC components

The solutions with the greatest potential to transform today's solar PV market are less about perfecting individual components than about designing solutions for systems, with modularity and repeatability being key concepts.

In this regard, Nextracker's NX Fusion was a clear co-winner of our Array Changing Technologies. NX Fusion is a turnkey solar plant solution offering complete power blocks based on 320 watt modules mounted on the company's NX Horizon single-access tracker, combined with DC wiring, advanced string inverters, UPS and piers, as well as monitoring and control systems.

The result is a complete pre-engineered AC power system, with individual components bundled, pre-wired and pre-assembled to work together for faster installation, reduced costs and scalability. The company offers standard blocks of 1 × 90 module rows or compact blocks of 2 × 45 rows, with 18 modules on five strings each, offering a 25 kW AC output.

Nextracker notes that this is the first time that a tracker maker has offered this kind of pre-engineered, complete solution, which it says can accelerate each step of the design, permitting and construction process.

–

Jurist comments:

"Nextracker Fusion is accelerating the marketplace now, in a very timely way. It doesn't come across as just a better tracker, but a better system."

"I lean towards impact, and from a climate perspective we are running out of time, making tracking more valuable across more areas of the industry."

Array Changing Technologies
RUNNERS UP

Delta M80H Inverter
High-powered 3-phase string inverter with SiC components

High-powered three-phase string inverters are the hottest thing in the inverter space. When you add silicon carbide (SiC) semiconductor components, you have an exciting package, which is why our jurists chose the Delta M80H inverter as the runner up for our Array Changing Technologies.

Perhaps the most significant trend in the inverter space at present is string inverters taking market share from central inverters for utility-scale solar projects, based on advantages of greater system design flexibility, fewer losses in the case of failure and lower lifetime costs.

With a maximum output of 88 kW, the Delta M80H is suited for larger commercial and smaller utility-scale projects. SiC semiconductor components allow for the inverter to be used in 400 volt or 480 volt grids, which can minimize losses in AC and DC cabling. The inverter additionally offers a safe DC/AC wire connection box.

A factor for our jurists was not only the performance of this product, but also the future potential of silicon carbide components. While more expensive and hard to fabricate, these have the potential to significantly improve inverter technology.

–

Jurist comments:

"Any company that is spearheading silicon carbide is adding value."

Quest Renewables' QuadPod
Modularity comes to solar canopies

Because we recognize the advantages in terms of simplicity and cost reduction, modular design and standardization are big themes of **pv magazine**'s 2016 Array Changing Technologies.

This is especially true for Quest Renewables' QuadPod, which brings a modular space frame design for solar canopies for carports and other installations.

First, the space frame design means a significant reduction in material usage, with Quest estimating that the product uses only 30% of the steel in a traditional post-and-pier solar carport. This also allows for flexible site design, with one of three substructures for adaption to site variations, and the space frame further results in less site disruption.

Installation speed and labor costs are also reduced by allowing assembly of the rack and the installation and wiring of modules to be done at the ground level.

The advantages of a standardization and modularity has other benefits, including reduction in design costs, simplified sales cycles, and removal of the need for a site-specific third-party analysis – all of which results in lower costs.

Quest Renewables' QuadPod was founded in a DOE Sunshot Initiative-funded program at Georgia Tech, and has been ranked in the top 10% of all SunShot funded efforts. The QuadPod has also undergone wind tunnel testing and UL 2703 certification.

–

Jurist comments:

"Accelerating solar deployment on carports is pretty exciting as it is a largely untapped sector."

Array Changing Technologies AWARD FINALISTS

1 First Solar
Bringing thin film CdTe to a larger format

In many ways Series 5 builds on the strengths of First Solar's existing Series 4 modules, which have seen tremendous efficiency improvements in recent years. The company now produces cadmium telluride (CdTe) thin film modules that rival crystalline silicon PV in efficiency, with the advantages of superior yield, and at the low costs that First Solar has pioneered.

Series 5 offers further advantages by saving balance of system (BoS) costs and installation labor. Series 5 joins together three of the company's 60 × 120 cm PV modules on twin steel rails, resulting in fewer points of interconnection but also making it easier to attach the modules to common mounting and tracking systems. Like the Series 4, First Solar's Series 5 modules are designed to be compatible with 1,500 volt system architecture, which also offers significant BoS cost advantages.

Our jurists additionally gave points to First Solar in the sustainability category. Not only does thin film PV require less energy to manufacture than crystalline silicon PV, but First Solar has launched an industry-leading recycling program that allows it to recover the vast majority of semiconductor material and glass in its modules.

First Solar Series 5 modules will be commercially available in 2017.

2 ABB
TRIO-50.0 inverter

With high-powered string inverters starting to take market share away from central inverters for utility-scale solar projects, it should not be a surprise that ABB's highest-powered string inverter made our list of top downstream technologies.

ABB's three-phase TRIO-50.0 offers a 50 kW rating with increased power density and a two-stage topology with lower minimum input voltage for greater flexibility and energy production yield. It's a product which ABB says offers the performance and price advantages of a central inverter with the flexibility and ease of installation of a string inverter.

The inverter is based on a modular design with three compartments: a main compartment consisting of the inverter and two detachable lateral compartments, one for the upstream DC connection, and the other for the downstream AC connection.

Jurists observed that this design not only reduces weight but makes maintenance faster and less expensive, noting that inverters are not often designed minimize future O&M costs.

3 SMA
Medium Voltage Station

SMA's Medium Voltage Station for Sunny Tripower inverters (MVS-STP) represents the convergence of two trends in component design: the need to reduce balance of system cost and complexity, and the rise of three-phase inverters for larger projects.

As the world's first medium-voltage station for string inverters, the MVS-STP is a big step towards simplification of PV plant designs in a decentralized layout, by bundling a variety of components that previously had to be delivered individually.

The turnkey solution brings together every component needed for connection to a medium-voltage grid including a transformer, a low-voltage distribution board for connection of up to 30 inverters and medium-voltage switchgear. SMA notes that all components come pre-installed, and the three-meter container is suitable for both ground-based PV systems and large-scale commercial roof systems.

Jurists emphasized the MVS-STP's potential for cost reduction, noting that installation costs are a primary remaining source for future cost decreases.

4 SMA
Sunny Boy Storage

It has long been known that energy storage is necessary for solar PV to reach its full potential. However, due to the phenomenal growth of solar PV, that day is coming sooner than many anticipated, making the intersection with energy storage an area of critical development.

SMA is advancing the integration of residential battery systems with its Sunny Boy Storage, a product that claims several innovations. Sunny Boy storage is the first inverter to offer AC coupling for high-voltage batteries, but also the first to combine string technology and AC coupling, and the first transformerless inverter for energy storage.

SMA stresses the cost advantages and the flexibility of the Sunny Boy Storage, which is designed especially for compatibility with high-voltage batteries like the Tesla Powerwall. The inverter offers 2.5 kW charge and discharge power ratings, and SMA says that this is the first-ever AC-coupled storage solution to achieve a maximum total efficiency (PV-battery-grid) up to 90%, which the company credits to its transformerless design.

While jurists note that the Sunny Boy Storage is probably too small for the U.S. market, SMA has announced that it will be unveiling a larger capacity product in the same series.

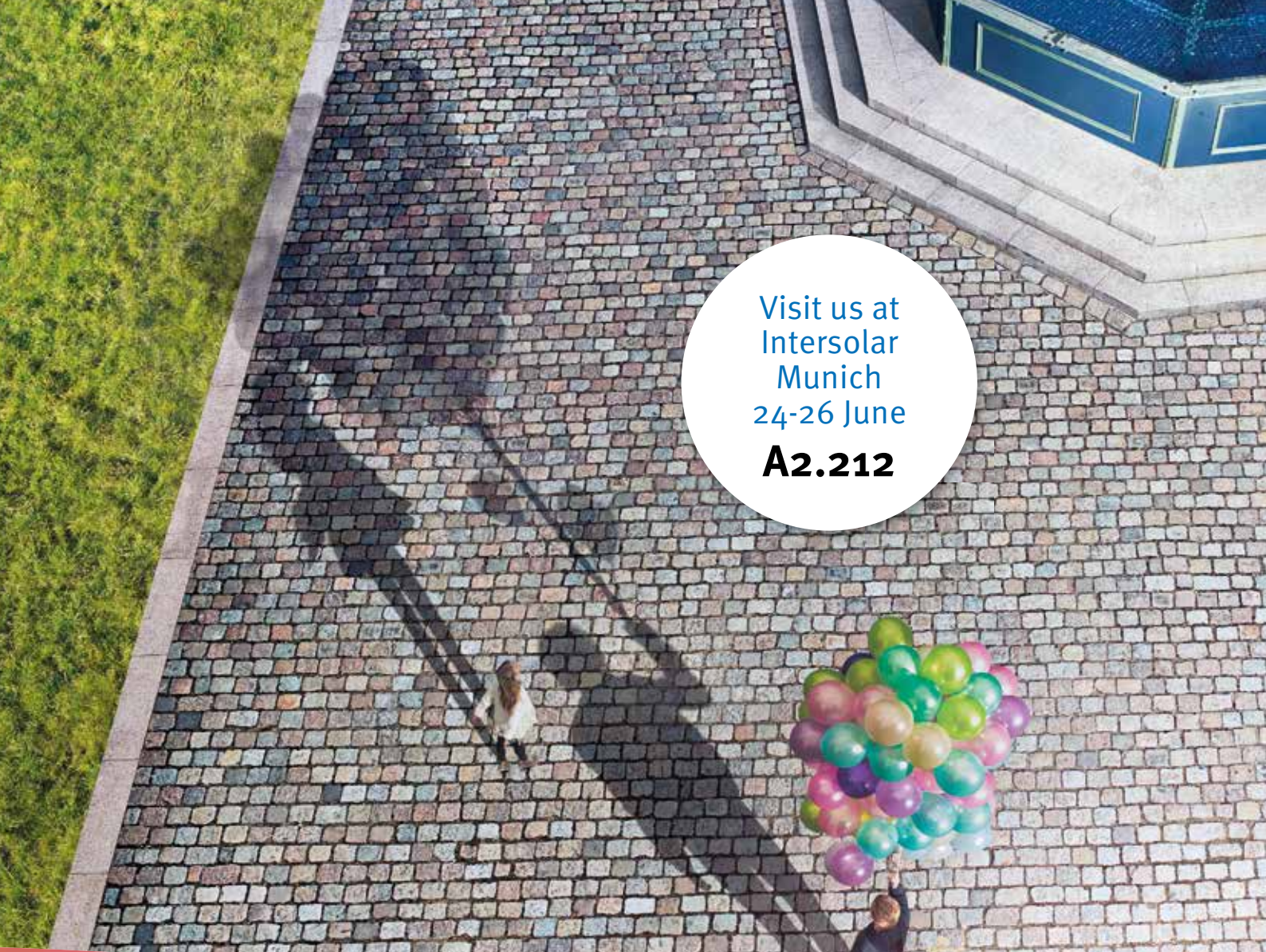
5 Solaria
PowerXT

In the quest to produce more power with PV modules, two areas have received focus lately: improving the interconnection between cells, and removing shading and inactive surface area. The Solaria PowerXT approaches both of those needs with a novel solution featuring cut PV cells linked together in a ribbonless, solder-free connection.

The company claims over 18% efficiency at the module level, and greater power per square meter with this approach versus conventional crystalline silicon technology. Combined with a larger format Solaria is able to produce 400 watt modules in its XT Utility Series.

Additionally the PowerXT module is built with thicker glass and framing to ensure long-term performance, particularly for utility-scale applications.

It is notable that similar approaches have been adopted by large, established PV makers, with SunPower moving to a similar design of overlapping half-cut cells for its P-series. Solaria also notes that its production lines for stringing and lamination can be inserted directly into existing module production facilities.



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6 Ideal Power
SunDial

Some of the more novel products are reactions to not only technical conditions, but also decision-making processes. Recognizing that some commercial PV system owners may choose to add battery storage later, Ideal Power has produced a string inverter which includes an optional bi-directional third port, allowing the integration of energy storage either during initial installation or in the future.

The company says that its three-phase SunDial inverter allows for low-cost plug-and-play integration of energy storage, in a "solar first, storage ready" design. With this optional third port connected to a battery, the inverter is capable of disconnecting from the utility grid and forming a microgrid to provide backup power to critical building loads during outages.

The 30 kW system is based on Ideal Power's Power Packet Switching Architecture, and comes with an integrated PV combiner, disconnects, and a built-in Maximum Power Point Tracker. Ideal Power says that an important feature of the SunDial is a newly designed AC link which provides galvanic isolation from the AC to the DC ports, enabling PV installations which are either grounded or free-floating.

7 Sungrow
SC1000T

More and more, energy storage is becoming paired with solar PV systems at both the distributed and utility scale, as the next step in the evolution of technology. An inverter for battery storage applications, Sungrow's SC1000TL features a high power density and direct parallel connection on the AC side. The inverter can work with a wide input voltage range, including battery systems up to 1000 volts. SC1000TL can support either automatic or controlled frequency modulation.

8 Fronius
Primo Hybrid

Finalist #8 in our Array Changing Technologies also reflects the importance of the nexus between solar PV and energy storage, this time for distributed solar. Fronius' Primo Hybrid is a storage and smart-grid ready single-phase inverter available in power ratings of 3.6 to 11.4 kW, ideal for residential and small commercial PV systems.

The Primo Hybrid offers dual maximum power point trackers, for greater flexibility in system design, as well as simultaneous DC and AC coupling. The system also features an emergency power function, and includes integrated WLAN and ethernet.

The Fronius Primo Hybrid will be launched at the end of 2016 in Europe, Australia and North America.

9 Array Technologies
DuraRack HZ v3

With single-axis trackers increasingly dominating the utility-scale market in the Americas, it is no surprise that several tracker innovations featured among the finalists for downstream technologies. Array Technologies' DuraRack HZ v3 brings the productivity advantages of single-axis tracking with a new passive wind mitigation feature, which allows the tracker to respond to and alleviate high wind loads.

As a passive system, this does not require an uninterrupted power source, additional wiring, or any of the other complications of the active systems deployed in many trackers. Our jurists noted that this feature is expected to reduce project costs, and ATI notes that this is the first system of its kind in the solar industry.

10 Panasonic
Panasonic HIT N330

While the core technology is not new, Panasonic's heterojunction intrinsic thin film (HIT) PV cell and module technology still represents a high-water mark for solar PV design. And while several PV makers have pursued silicon heterojunction designs, none have the experience with the technology or have reached the scale that Panasonic has.

Panasonic's N330 PV module is the latest iteration of this advanced design, which features a monocrystalline silicon layer sandwiched between two amorphous silicon layers. The 96-cell module boasts a peak output of 330 watts, with an enviable 19.7% module efficiency. Along with a superior temperature coefficient, Panasonic's HIT is able to produce significantly greater power per square meter for space-constrained applications.

The N330 also features in-frame water drainage, a pyramidal surface that traps more light, and a three-busbar cell design. Panasonic has recently extended the HIT product and workmanship guarantee to 15 years.

11 Soltec
SF Utility

Soltec's SF Utility is a tracking system designed to bring tracking to a wider variety of terrain. The tracker can work on up to 17% grade north to south and unlimited slope east to west, which the company notes results in less grading and makes more surfaces available for solar PV.

Among the intelligent controls built into the SF Utility is adaptive backtracking, which reduces the degree of shading on tracker rows using an algorithm which considers the distance and elevation of tracker rows.

Soltec's SF Utility has different mounting options including driven piles, screws and concrete foundations for different soil types. Compared to earlier trackers, Soltec has additionally reduced the number of piers used with the SF Utility.

12 Solaria
PowerView

Solaria's PowerView line of building integrated photovoltaics (BIPV) was mentioned by our jurists as the most unique product among the PV module entries. The four products in the PowerView BIPV suite include bifacial modules and three semi-transparent glass BIPV products, which generate electricity while letting light into building interiors.

Unlike many semi-transparent BIPV products, Solaria's PowerView is based on crystalline silicon technology instead of thin film PV technology. The PowerView suite leverages Solaria's cell cutting and assembly technology, and the company cites the higher power density and durability of crystalline silicon.

The transparent technologies feature architectural glass for improved glare control, and are integrated with coating and IGU technologies to achieve lower solar heat gain and loss.

13 Nextracker
NX Horizon

Nextracker is one of only three companies to place two finalists in our Array Changing Technologies. The company's NX Horizon is a self-powered tracker which uses integrated solar power from a small dedicated module, eliminating power and communications wiring to tracker motors. Control is accomplished with Nextracker's proprietary wireless controllers.

The self-powered aspect is supported by a balanced mechanical design, which minimizes power usage. Our jurists commented on the sophistication of the balancing mechanism, which enables autonomous controls for reduced total project costs. Nextracker notes that this also enables plug-and-play installation of each tracker row, and simplifies design, installation and commissioning processes.

14 Smartflower POP

Our 14th finalist is one of the most unusual of the entries, a plug-and-play PV and battery storage solution, which deploys 18 square meters of solar PV in the shape of a sunflower on dual-axis tracking. The aesthetically pleasing Smartflower POP comes in both grid-tied and off-grid options, with different capacities of storage, and the POP-e variant features electric vehicle charging.

Smartflower claims up to 40% more electricity generation than rooftop installations due to the use of dual-axis tracking, and the company additionally notes that back-ventilation keeps the PV modules cool and thus increases output. Smartflower POP is also self-cleaning, as dust is removed when the system's petals open and close.

15 Ideematec safeTrack Horizon

Ideematec's single-axis tracking system incorporates many of the new trends in single-axis trackers, including a reduced number of foundations and backtracking to reduce module shading. Additionally, the safeTrack features a patented steel cord system drive, which it says captures torsional forces. Jurists noted the advantages of this approach for added structural benefits.

Ideematec states that the safeTrack can withstand wind speeds up to 180 miles per hour. Additionally it can accommodate glass-glass modules, which are gaining market share, and notes that its design can be used in sloped terrain.

16 JA Solar JAM6

The JA Solar JAM6 is a "smart module" that integrates a SolarEdge DC optimizer in its junction box for module-level maximum power point tracking (MPPT) and monitoring of output. One of the benefits of MPPT at the module level is a more flexible system design.

The JAM6 incorporates four busbar cells, which reduces cell series resistance and stress between cell interconnections, while improving reliability and conversion efficiency. The module also features automatic shutdown, for electrocution prevention and fire safety.

Revisiting the history books

China's solar story: Charting the birth of the Chinese PV industry is a transparent task, yet misinformation regarding the state's role in supporting the sector persists. Australian expertise, U.S. investment, German foresight and Chinese boldness were all more pivotal in giving China's PV manufacturing base a headstart, argues UNSW's Martin Green.

"Forget the 'dumping-subsidizing-copy-catting' story." This is the advice of Christian Binz from Lund University, one of several researchers currently exploring PV industry development in China. The shift of PV manufacturing to China over the 2005-2010 period (See Chart top p. 98), despite its casualties, undeniably has been the game-changer in bringing PV to international attention as an immediate option for large-scale, low-carbon electricity supply, years earlier than expected.

Another global benefit is PV's positioning for maximum impact in meeting China's increasing energy needs, replacing fossil fuels. There are encouraging signs that internationally competitive PV manufacturing is also possible in India and Southeast Asia, where energy needs are growing the next most rapidly.

The actual story behind the transition illustrated in the chart on the top of page 98 is more interesting. In addition to China, it involves Germany, through the transformational German feed-in tariff (FIT) program, as well as the U.S. where it was investors, not the Chinese government, that largely financed this transition. Australia also played a key role by providing the expertise that seeded Chinese growth.

Wei Zhang and Steven White at Tsinghua University are also researching this transition. They identify the Chinese-Australian joint venture Suntech as the "root firm" from which the industry grew, critical to it in the same way as Fairchild was to the growth of Silicon Valley.

Prior to Suntech's formation in 2001, PV prospects in China were bleak. The Tsinghua researchers note that China was "lacking all the factors representing necessary resources and opportunity," the PV ecosystem was "rudimentary" and technological levels within existing state-owned enterprises (SOEs) fabricating PV in small quantities during the 1990s were "far below international standards."

Echoing this bleakness, the 2000 IEA World Energy Outlook predicted total Chinese installed PV capacity of less than 0.1 GW (sic!) by 2020. The Chinese government was also largely unaware of the PV industry's potential until well past the critical stages of development, suggesting in late 2007 a slightly more upbeat 2020 target of 1.8 GW (the present target is 150 GW).

Photo: UNSW/Martin Green

Martin Green at the opening of Suntech's original 10 MW line in 2002.

Australian seeding

Zhengrong Shi, an Australian citizen, was the driving force behind Suntech, and key to this transition. Zhengrong obtained his training and PhD in PV from the University of New South Wales (UNSW) and subsequent management experience as Deputy Research Director of UNSW spin-off, Pacific Solar. Suntech co-founders were Zhengrong's colleagues from Pacific Solar, Ted Szpitalak and Fengming Zhang, as well as Huaijin Yang, all Australians, and Chengrong Xu. After rejection by the Shanghai, Dalian and Hangzhou governments, the Wuxi government overcame initial hesitation and organized a combined $6 million contribution from seven local enterprises. Zhengrong contributed $400,000 of his savings plus know-how, earning 25% ownership.

Despite this limited budget, Suntech's first 10 MW cell production line was successful, producing sellable cells in August 2002, in time for its gala opening, generating profits by year-end. These financed the installation of a second 15 MW line during 2003, likewise on a minimal budget, with Suntech reporting capital expenditures of $2.5 million in 2002 and 2003 "primarily to purchase manufacturing equipment to expand manufacturing lines for production of PV cells and modules."

Meanwhile, SolarWorld in Europe, opening its first cell line a week after Suntech, reported €40 million expenditure for a 30 MW turnkey capability. Apart from Zhengrong, two other Australians were key to this success: Stuart Wenham and Ted Szpitalak.

Szpitalak had been responsible for procuring largely secondhand equipment and its subsequent commissioning for the

UNSW solar labs since the 1980s. He was then seconded to Pacific Solar as Acquisitions Manager. Szpitalak's acquisition and commissioning experience had a big impact on the Chinese industry, at Suntech and at Sunergy and JA Solar, then finally Sunrise Global (See Chart bottom p. 98).

As soon as Suntech's first line was operational, Wenham, who had set up Australia's first screen-printing line, then made several one to two week visits, in order to fine-tune the processing, and train Suntech engineers in this and quality control. The UNSW "Virtual Production Line" software, developed for UNSW courses by Stuart Wenham and PhD student Anna Bruce, facilitated communication and thoroughly grounded the Suntech engineers in a host of processing intricacies.

The four pioneers

Although Suntech was the first private company producing cells in China, both Trina and Yingli have longer histories (See Chart p. 100), with Canadian Solar (CSI) only slightly younger. The Tsinghua research group notes that the motivation for founding all was not immediate business opportunities but interest in PV's social and environmental benefits. However, only Suntech initially had the technical expertise to capitalize on this interest.

Trina produced its first modules in late 2004 and its first cells in 2007. Yingli sold its first module in early 2003 and began cell production on a small 3 MW line in March 2004, 18 months after Suntech, although dependent on others for cells until a full-sized line was commissioned in mid-2006. These pioneering companies were positioned to quickly exploit opportunities provided by Suntech's success. Sunergy, Solarfun and JA Solar, the three remaining companies earning "top 10" positions via cell manufacturing (See Chart p. 100) were Suntech "spin-offs."

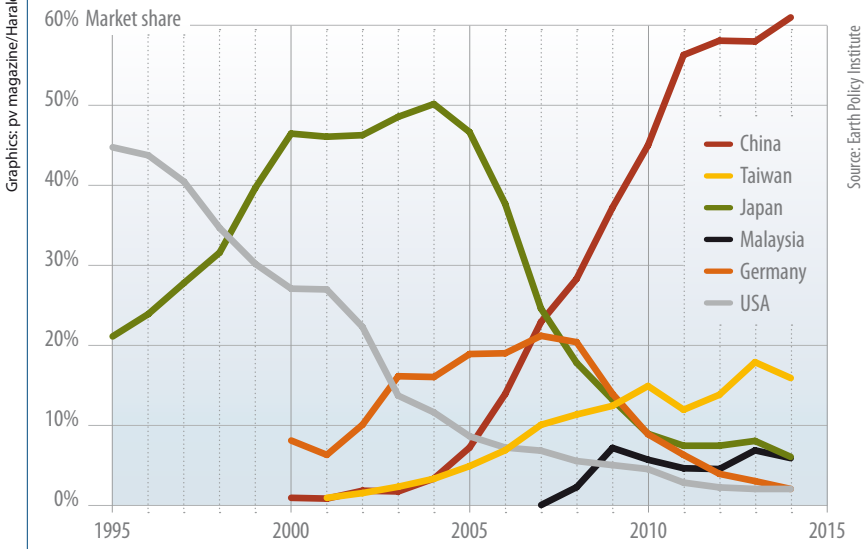
Other pioneering roles

The Tsinghua researchers have documented Zhengrong's additional role in developing local supply chains in polysilicon, ingots, wafers, pastes and processing equipment. Although all of Suntech's 2002 sales were in China, he realized that success depended upon competing internationally and that lower local costs would offer competitive advantages.

Zhengrong gained ISO certification of Suntech's production in 2002 and IEC61215 module certification in 2003. Suntech exhibited in Europe in late 2002, with 19% of 2003 sales to Germany, growing to 72% in 2004. In its 2004 Annual Report, SolarWorld reported concluding "a license agreement with Chinese solar manufacturer Suntech Power Inc. for the production of SolarWorld modules in China in the first quarter of 2005," mentioning volumes of "around €100 million over the next two years." Suntech filings suggest actual volumes of more than $200 million. Given the different costs, Suntech could sell modules profitably to SolarWorld, with SolarWorld then profitably onselling. This endorsement of Chinese product quality undoubtedly contributed to its international acceptance.

Suntech then pioneered capital raising on U.S. markets. In an interview with Christian Binz, Zhengrong reports an approach by Goldman Sachs and Mor-

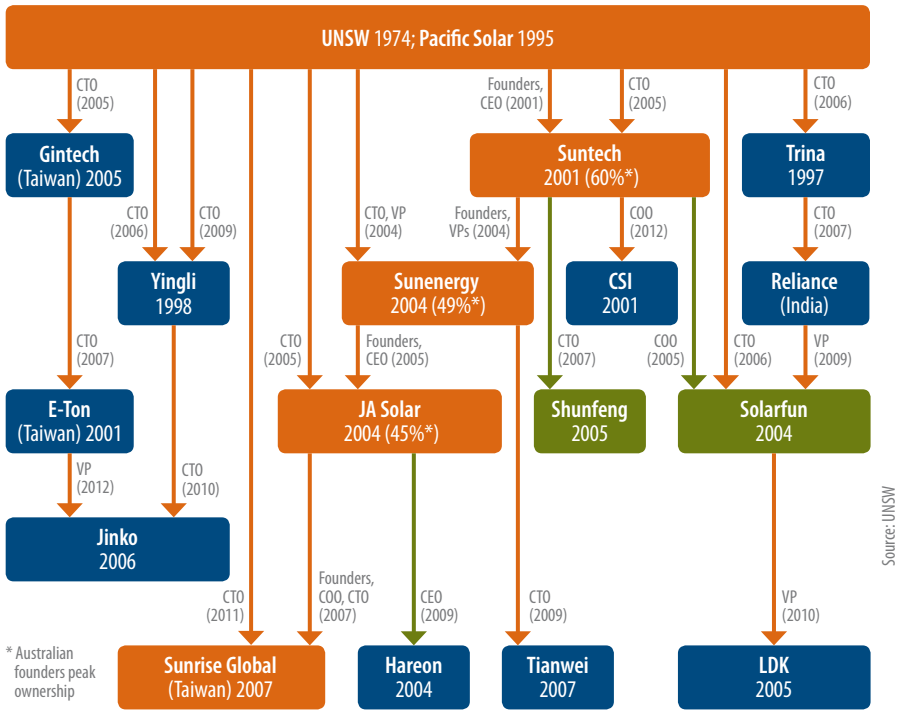
Transformation of PV cell manufacturing over last 20 years



gan Stanley in 2004 with U.S. listing suggested, triggering an effective "management buy-out." Zhengrong emerged with majority shareholding in the reorganized company, subsequently incorporated in the Cayman Islands. From the Chinese perspective, as for the other "top 10" companies, Suntech is a "wholly foreign-owned enterprise" (WFOE).

Cayman Island registration provides a path for foreign companies to operate on U.S. stock exchanges. Zhengrong chose the New York Stock Exchange (NYSE) for listing, the first private company based in China to do so, raising $396.5 million in reportedly the largest technology float of 2005. The other pioneers, Yingli, Trina and CSI, followed largely independent paths, although all appointed Australian-trained staff to senior positions. All benefited from Suntech's pioneering role in developing local supply chains, opening up international markets and pioneering U.S.-investor funding, with all listing within 18 months of Suntech (See Chart p. 100).

Australian links to some of the key firms in the Chinese PV Industry



Orange represents UNSW/Pacific Solar trained or co-founded, green represents "second generation" linkages, and blue "others".

"Second wave" spin-offs

Suntech's initial European success in 2003 and 2004 was probably not widely known outside these pioneers and others with Suntech links. The three other cell manufacturers making the "top 10" had such links, namely China Sunergy and Solarfun, both formed in August 2004, and JA Solar, founded in May 2005.

After Suntech, the next internationally competitive line was commissioned at Sunergy with the first cells produced in June 2005. Suntech's founding team, minus Zhengrong, had moved en masse to help two other UNSW researchers, Jianhua Zhao and Aihua Wang, cofound Sunergy, together owning 49% of Nanjing PV, Sunergy's precursor.

After establishing Sunergy's production, Ted Szpitalak and Huaijin Yang formed another team with Bruce Beilby and Ximing Dai (both UNSW PhDs) to establish yet another line in China at JA Solar, founded in May 2005 as a joint venture with the Jinglong Group, with 45% Australian equity. Market-ready cells were produced in April 2006, around the same time Yingli started full-scale production. Yang and Dai became CEO and CTO of JA Solar respectively. Szpitalak, Beilby and Dai moved on to set up yet another production line at Global Sunrise in Taiwan, a pioneer in commercializing UNSW PERC cell technology. Huaijin later became President, CEO and Chair of Hareon Solar.

Founded shortly after Sunergy was Solarfun, which is now Hanwha Q Cells. While Sunergy and JA Solar were direct Suntech spin-offs, the Tsinghua group describe Solarfun as a "second-generation" spin-off. Wang Hanfei, the first professional manager hired by Suntech, moved to Solarfun, with the company producing its first cells in November 2005.

Another notable "second-generation" spin-off was Shunfeng, with Hui Qu and Caixia Tong leaving Suntech in 2006, becoming responsible at Shunfeng for "production quality and technological management" and "technology and research and development," respectively. Shunfeng was founded in late 2005, producing its first cells in 2007.

MEYER BURGER

Efficiency boost with Heterojunction and SmartWire Connection technologies

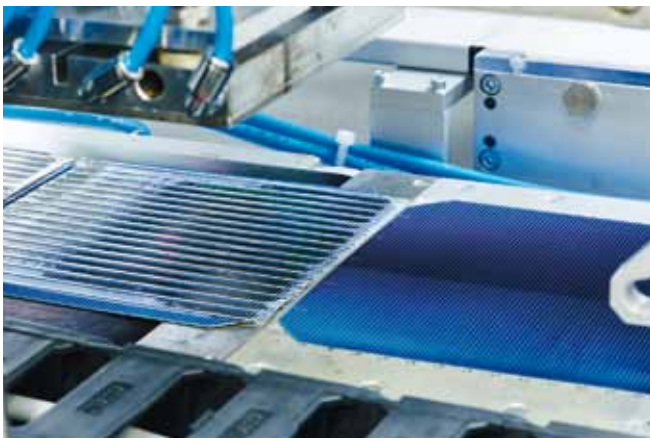
Three to five busbars, heavy silver fingers and a standardized coating process have long been the benchmark in photovoltaics. But those days are coming to an end. Innovative technologies for coatings and cell connections now enable up to 327 watts per module. Welcome to a brief history of records.

It was recognized early on that shorter fingers on solar cells minimize electrical resistance. As a result, the number of busbars was increased from two to three, even five. This brought about a significant reduction in energy losses. The same approach is also taken by SmartWire Connection Technology. Here, busbars are replaced by up to 18 fine copper-based wires on both sides of the cell.

Innovative approach helps boost performance

SmartWire Connection Technology results in a dense contact matrix which reduces the electrical resistance dramatically. This is reflected in the module performance, which is up to 6% higher than with three-busbar technology. This boost in performance can also be attributed to decreased shadowing. In addition, the round copper wires retain more light in the solar cell, and significantly less light is reflected back.

The low silver consumption is likewise record-breaking, as is the greatly reduced risk of microcracks. And because busbars have been eliminated entirely, a 60-cell module needs less than 2.4 grams of silver. Moreover, the wires do not require soldering, as in busbar technology, so that there are significantly fewer cracks. With SmartWire Connection Technology, the wires melt together with the film and the cell surface in the course of the lamination process, which takes place at much lower temperatures.



Dense contact matrix replaces heavy busbars:
Cell connecting station for SmartWire Connection Technology

Perfectly combined with Heterojunction Technology

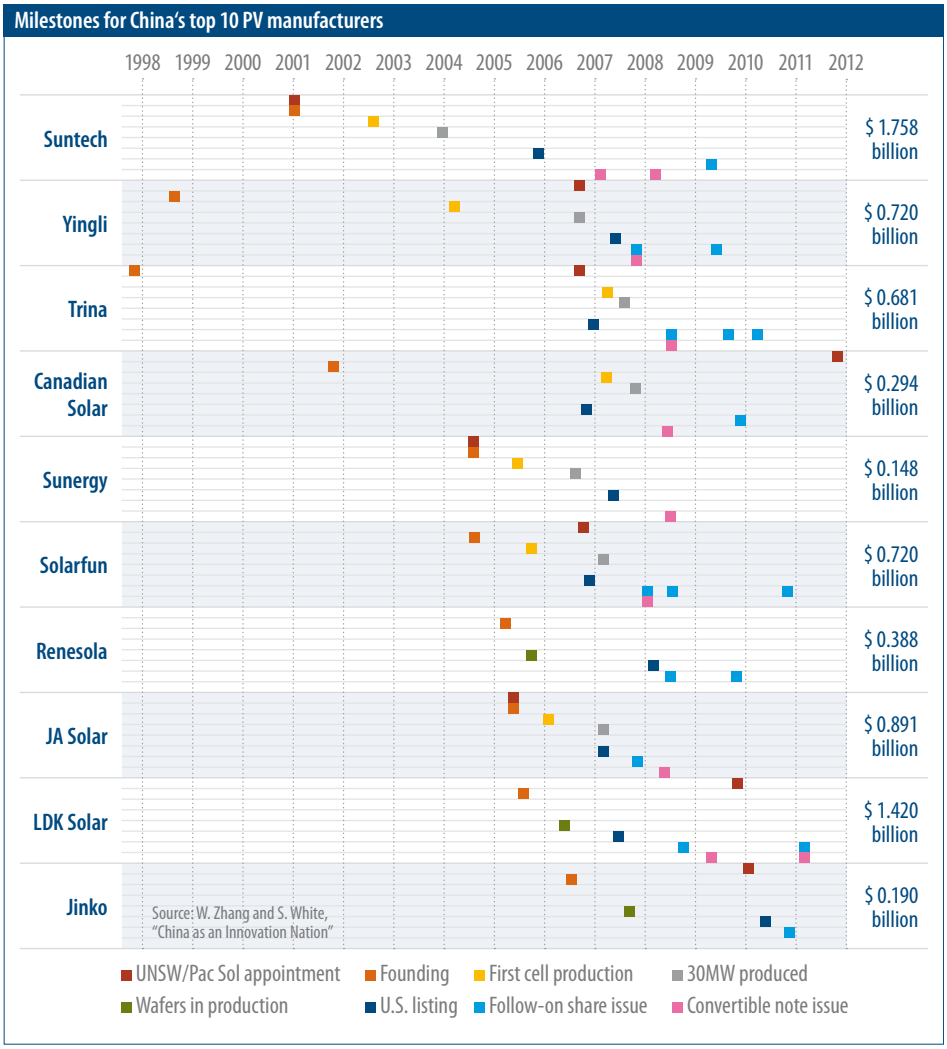
The history of records would not be complete without a mention of Heterojunction Technology. It combines the advantages of monocrystalline silicon with the outstanding passivation properties of amorphous silicon, as is well known from a-Si thin film technology. This approach lifts cell efficiency to a new level. Heterojunction starts at around 22% – the level at which PERC and other technologies are already reaching their limits.

Particularly striking is the unique temperature coefficient of $T_C < -0.25\%/°C$ compared to -0.43%/°C (and greater) for other technologies.

Not surprisingly, Heterojunction has instigated a complete rethink of cell production. Just six worksteps are required from wafer to cell – in contrast to nine when following the standard process.

Moreover, HJT cells have an extremely conductive ITO coating on both sides which electrically protects the cell in the manner of a Faraday cage, thus eliminating the possible efficiency loss of up to 2% which would otherwise be occurred.

Heterojunction and SmartWire Connection technologies are revolutionizing photovoltaics. The first step has now been taken, allowing the history of records to be continued.



Follow the dots: Fund-raising patterns and the route to manufacturing are evident in the various companies' paths to market. As is a correlations between UNSW appointments and U.S. market listing.

U.S. financing

Suntech listed in late 2005, with both Suntech and supporting U.S. venture capitalists doing well. Goldman Sachs' shares increased in value by $200 million beyond their purchase price in the first week. This not only encouraged other PV companies in China to follow suit, but similarly encouraged U.S. venture capitalists to target and groom these to repeat Suntech's success. For firms not already having a senior UNSW appointee, grooming apparently included encouraging this, explaining why multiple companies (Trina, Solarfun, Yingli and Jinko) appointed UNSW CTOs.

By lowering entry barriers through its success, Suntech opened the floodgates for massive U.S. investments in the Chinese PV industry. All but one of the remaining "top 10" companies listed in a 14 month window between December 2006 and January 2008, before the Lehman Brothers' bankruptcy in September when PV share prices fell sharply. Jinko and Daqo, listing in 2010, did not fare as well as hoped, with subsequent low market valuations encouraging both Trina and JA Solar recently to consider delisting.

Capital raisings by the "top 10" over the 2005-2010 period through share and convertible note issues on U.S. exchanges total $7 billion, growing to $10 billion including personnel shares and options. This investment, boosted by profits from European sales, underpinned the 100-fold increase in cell manufacturing capacity in China from less than 300 MW in 2005 to more than 30 GW in 2010.

The third wave

Suntech's listing attracted widespread attention since Zhengrong's shareholding immediately shot above $1 billion in value, attracting international coverage of the "first solar billionaire" during 2006-2007. In particular, companies and local governments within China took note. In a University of Texas Masters thesis, Yu Xia explains how the resulting "uncoordinated, irrational exuberance" led to distorted local government incentives and massive overinvestment.

Fiscal reform in China in 1994 gave local governments increased autonomy in local economic development, thereafter retaining all local and some shared taxes. This gave strong incentives to increase revenue by supporting local industrial development, such as by seed funding, low electricity rates and by establishing industrial parks to provide cheap land. The promotion system for local officials also contributes, since it is based on local economic growth. PV companies had been effective in increasing growth, and advancing the careers of multiple government officials.

Also entering the fray were subsidiaries of large SOEs, Fortune 500 companies, with access to ready capital and ambitious plans for rapid expansion. Tianwei New Energy, formed in mid-2007, invested $1.5 billion to establish 500 MW capacity in wafers, cells and modules by 2010, with plans to expand to 1.5 GW by 2012. Guodian Solar, established in September 2009 as a subsidiary of one of China's "big five" power companies, had similarly ambitious plans, investing $1.2 billion. This third wave pushed PV equipment expenditure to a peak in 2011 (See Chart p. 101). As shown in the insets, there was a major imbalance between geographical origins and use of this equipment.

Massive oversupply created problems for manufacturers inside and outside of China. It benefited users and prospects for PV impact, by driving down prices as companies struggled to maintain cash flows. Only the strongest were able to reduce manufacturing costs to below the new price levels and much of the third wave, including Tianwei and Guodian, withdrew after massive losses.

Dumping-subsidizing-copycatting

Dumping, in the usual sense of selling less expensively in foreign markets than in the home market, certainly does not apply to Chinese PV produce. The local market has long been the market of last resort due to higher prices on foreign markets. World Trade Organization (WTO) rules are based on "normal value" allowing, in some cases, replacement of actual prices by "calculation based on the

combination of the exporter's production costs, other expenses and normal profit margins." This would produce sensible determinations if China were not, until December 2016 at least, classed as a "non-market" economy. This has allowed questionable practices to be used in recent dumping determinations.

Government subsidies have benefited most PV manufacturers globally. PV manufacturing subsidies in former East Germany were probably the most generous, involving cash grants of 35% of capital costs (reported in SolarWorld's 2002 Annual Report), partially offsetting the cost differential between German and Chinese production. Subsidies in China have come in various, normally uncoordinated, forms, with local governments, motivated by subsequent economic benefits outweighing costs.

Commonly the view is that China has hijacked the PV industry through large, low-interest government loans. However, as documented by the Tsinghua researchers: "Not until after 2007... did local governments begin to support the industry through... targeted subsidies and incentives and by establishing solar PV industrial parks… the central government did not provide direct financial or political support to the private solar PV sector before 2009."

U.S. investors largely financed the transformation of the PV manufacturing industry. Debt financing through convertible note issues on U.S. exchanges was clearly more attractive than local loans. Interest rates associated with other debt were not particularly low and, for key players, are explicitly documented in company Form 20F filings.

Photo: UNSW/Martin Green

Suntech's 2005 NYSE listing paved the way for Chinese PV manufacturers to raise capital in the U.S.

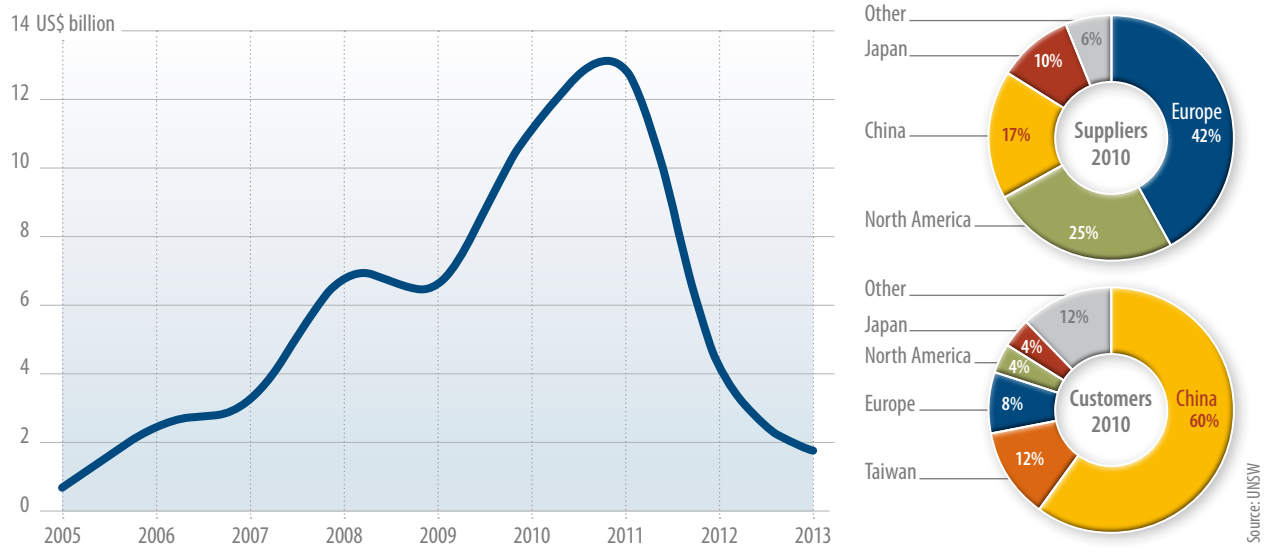
After the event, in 2010, lines of credit totaling over $40 billion were made available to Chinese PV companies, when the Chinese government embraced PV. However, these were not particularly attractive, as documented by low uptake. Recent Chinese market development programs have had a far more significant impact.

Copycatting does not accurately describe how the PV industry took root in China. Early lines at Suntech were not turnkey, but were patched together using the accumulated Australian experience of the founders. Moreover, the Chinese industry has shown a confidence in embracing, developing and commercializing new technology rare in earlier phases of the industry.

The birth of the Chinese PV industry arose from a convergence of key precedents. Among these were the emerging free market in China, the German FITs, an appetite for Chinese stocks on U.S. markets prior to the global financial crisis, and fortunate timing by a team of technically astute researchers driven by the desire to make a difference. ◆

Martin A. Green

Annual PV equipment sales



Using string at scale

String inverters: Heralded by some developers as a way to reduce O&M costs and meet the challenges of optimizing park design, large string inverters for PV power plants have made headway in some markets. And as solar spreads to harsher and more remote regions, string's strength is coming ever more to the fore.

When working in hot and dusty conditions, time is of the essence. It takes a maximum of two trained installers to fit a typical three-phase string inverter on to a row of ground-mounted modules. Depending on the size of the system, this translates to a few hours' work, especially when compared to the heavy duty nature of a typical central inverter install. With shorter DC cables, no need for string combiner boxes and no allocated truck path snaking through the array, the job of installing hundreds – maybe thousands – of string inverters is often far simpler than fitting a single central inverter. And as solar spreads its tentacles into ever more remote regions, it pays to do things quickly and effectively.

Decentralized EPC specialists Asunim speak from a position of experience when they extol the virtues of string inverters at large scale. With a current focus on developing ground-mounted solar systems in Turkey, Egypt and Portugal, Asunim has accrued a weighty scrapbook of dos, don'ts and best practice when constructing solar plants in such regions.

Photo: Huawei

China's Huawei has been a pioneer in using string inverters in large-scale solar installations, developing plants in Germany and other parts of Europe, and is currently working on a 2 GW site in China.

"Large string inverters make our job as an EPC a lot easier," Asunim Group Director Andreas Schuenhoff told **pv magazine**. "By using string, we can install large-scale systems on what would usually be deemed difficult terrain. Even with modules facing different angles, or exposed to different orientations or temperatures, by using a decentralized string inverter solution you can minimize the negative impact of this mismatch."

This tends not to be the case, argues Schuenhoff, with central inverters, which tend to operate to the efficiency of the worst-performing module. "When using central inverters, often the slowest module leads, as it were," he says. "There are smarter central inverters on the market that make accommodations for this effect, but you end up paying almost the same as you would if using string."

And whether an EPC is building a megawatt-scale solar farm in the remotest corner of eastern Turkey, or a large rooftop array in the heart of a German city, cost remains king, with performance and reliability the ever-present prince.

Why string, and why now?

The traditional method for converting the sun's energy into alternating current (AC) at large scale had largely followed the central inverter approach. Large and unwieldy they may be, but once installed a central inverter would operate quietly at the fringes of the array, handling all or half of the entire DC energy produced by the solar modules.

But in recent years smaller string inverters – typically used in residential and commercial-scale applications – have

begun to eat into this segment. As costs have fallen and features have improved, three-phase string inverters have become a viable option for large solar plant owners. "The threshold to what string inverters can achieve at large scale is continuously being raised," said IHS senior solar analyst Cormac Gilligan. "Today, most PV inverter suppliers are very comfortable installing string inverters in an installation up to 20 MW, for example, and really there is no limit – China's Huawei, for example, is currently building a 2 GW solar plant in the country using string inverters."

Asunim's Schuenhoff believes, far from there being a 'sweet spot' for string inverters' efficacy, there is in fact no upper limit, no optimum plant size for string inverters. "I don't see a limit," he said. "People are constantly crunching those numbers, but I would happily build a 100 MW array with string inverters."

Schuenhoff is quick to stress that the situation is not simply one of 'central inverters bad, string inverters good', but rather, as solar installations are increasingly commissioned in more remote areas, logistically and technically it is often easier to ship, install and maintain string inverters rather than central inverters.

Why is this the case? Ask any string inverter manufacturer or EPC and the answer will be the same: A decentralized approach offers greater modularity, design flexibility and scope for innovation. IHS' Gilligan agrees, noting that there is a subset of key benefits that make string inverters an attractive proposition for the large-scale solar market.

"Spare string inverters can be stored in a warehouse or a stockpile on site, allowing rapid and cost-effective replacement of failed inverters," he told **pv magazine**. "In difficult terrain or hard-to-reach locations, this is an obvious benefit. String inverters are also lighter and can be quicker to install, and can now be attached to mounting and tracking systems so that they have a reduced footprint on-site."

Many proponents of string inverters claim that the technology offers more reliability than a central inverter, the argument being less a case that the components themselves are more durable – failure is failure – but that the downtime, i.e., the negative impact of a faulty string inverter, is far less injurious than with a central inverter.

"In the more remote areas in which the solar market is growing, often, as an EPC, you are dealing with sub-contractors that have very little or no solar experience," explains Schuenhoff. "In central Europe or the U.K., the majority of large-scale solar plants have been installed with central inverters. And that's not a problem because the chief suppliers there have 24-hour response times and dedicated, experienced O&M teams close by.

"This is not the case in some of the more emerging solar markets. If we were to install a 10 MW solar farm in eastern Anatolia, for example, not only would we have to deal with customs and face importation issues on spare parts, but we would be dealing with much longer response times from the central inverter manufacturer in the event of a failure."

Schuenhoff believes that a faulty central inverter in locations as remote as this could equate to a realistic downtime of two to four weeks for a typical solar plant – a stint offline that would not sit well with the vast majority of investors.

"With string inverters, failures are swiftly rectified without the need for the customer or EPC to get back in touch with the manufacturer, which is a strong selling point for the technology," said Schuenhoff.

Cost and maintenance

Why install many when one will do? A trump card long held by central inverters at such scale was cost. In 2015, IHS calculated that the average global price for three-phase high power inverters (those larger than 99 kW, i.e., central inverters) was 30% lower than three-phase low-power inverters (<99 kW, i.e., string inverters). Equate that saving over a megawatt-scale plant and central inverters certainly have the upper hand.

But solar installation costs are far more nuanced than the initial capex would suggest. Increasingly, string inverters actually deliver lower balance of system (BOS) costs for the plant owner, and

Photo: Asunim

In terms of post-installation monitoring and maintenance, many EPCs prefer string inverters.

in most of today's markets cost parity between the two has been reached. Factor in shipping, labor and logistics costs in those remote areas that are embracing solar power with such gusto, and the string approach becomes the cost-effective approach.

"You have to look at the full picture of the PV system setup," explains Christian Buchholz, head of product management at REFU Elektronik, the German manufacturer of RefuSol string inverters. "With string inverters you eliminate the need for combiner boxes, but on the other hand you do need AC combiner boxes. However, overall we see that it at least equals out – and not just for the developer. Pro-string arguments account for the customers as well – string opex is taken into account, and the concept of being independent of the manufacturer [in terms of O&M] is attractive."

Exploring that last point, Buchholz remarked that central inverter suppliers typically insist on a maintenance contract with their customer, which is usually subject to an annual fee. "With string inverters," he said, "plant owners can organize their own service as and when required – usually because there is no on-site repair necessary."

From an EPC's perspective, Asunim's Schuenhoff adds that post-installation O&M for solar plants managed by a central inverter can leave plant owners at the mercy of the supplier's cost structure and – increasingly in the volatile world of solar – oftentimes dealing with firms that have either left the industry or gone bust.

"I don't believe that the majority of central inverter manufacturers on the market today will be around in 10 years' time," said Schuenhoff. "The same of course applies to string inverter manufacturers. But let's say you have a 40 kW string inverter in your plant and the supplier goes bankrupt: You can simply buy a comparable replacement product from another supplier. It is not so easy to do this with central inverters."

Schuenhoff cites Asunim's dealings with a central inverter supplier that closed its solar operations but continued to run a lucrative maintenance and spare parts business. "We were completely exposed to this company's price fluctuations. They dictated the price and there was nothing we could do. That is what turned Asunim away from central inverters and led us to explore building megawatt-scale arrays with string inverters."

For innovation, decentralize

Perhaps the strongest argument in favor of string inverters at scale lies in plant design. By decentralizing the solar system setup, EPCs can identify terrain that previously may have been considered challenging. From hilly topography to asymmetrical plots, string inverters can adapt to the most optimum plant design, and not the other way around.

This, believe both Schuenhoff and Buchholz, is string's main strength. "Whether solar panels are installed at different angles, exposed to different temperatures or shading, a decentralized solution minimizes the negative effect. You can solve topographical constraints more elegantly with string inverters because you can basically group modules together," said Schuenhoff. "Let's say you have a square piece of terrain. You can group your string inverters across the field, leading with AC cables to the transformer. And if that terrain has an unusually shaped annex, you simply group those inverters on the extreme side where it leads to your transformer. Sometimes you don't even group the inverters. It's a question of design."

Asunim has calculated that large-scale solar systems it has developed with string inverters consistently deliver a 3% higher yield than central inverter-controlled plants. "This is not a simulated result but actual performance," Schuenhoff stresses, pointing to the extra energy harvested by string inverters boasting multiple maximum power point trackers. "Another point to remember," adds Buchholz, "is that with string you essentially get monitoring for free because you do not need additional smart string combiner boxes because in a multi-megawatt system you have hundreds of string inverters, each monitoring the string input automatically into the portal."

Whether market or technology-driven, or a mixture of both, the trend is apparent. String inverters have proven their worth at large scale, convincing EPCs and plant owners of their efficiency, cost and monitoring benefits. "It's now a virtuous cycle," concluded Buchholz. "EPCs have begun to rethink how they design PV systems, and have adopted a more open-minded approach. Previously their default setting was to use central inverters, but a growing number are now changing their minds and are more open to the possibilities offered by string inverters." ◆

Ian Clover

HUAWEI POINTS THE WAY

Chinese ICT firm Huawei exclusively manufactures string inverters and has already completed a series of large-scale solar farms around the world. Its latest project promises to show that there really is no upper limit to the efficacy of string inverters.

Site size and location: 2 GW once completed, located in Yanchi, Ningxia, China.

Inverters used: Approximately 55,000 Huawei SUN2000-40KTL string inverters will be installed on the site once it is completed.

Benefits of string at scale: "Our string inverters can make real time string detection with a high accuracy sensor at up to 0.5%," said Huawei's Yan Jianfeng. "That is six times higher than what a DC combiner box can manage. Furthermore, the string inverters can detect both the current and voltage.

"Our inverter is simple to install and maintain. There is just one spare part, whereas a typical central inverter has more than 50 possible failure points. Thus, maintenance is simplified.

"The Huawei inverter also allows flexible system design with different panel brands and panel power. It is normal for system owners to replace panels as panel efficiencies increase. By using a string inverter, this process is made much simpler."

航天机电 HT-SAAE

Milky Way[Twin Star]:
Making 1+1=more
than you think

SUSTAINING INNOVATION SINCE THE 1960s

Milky Way Series Product: Twin Star

Existing Characteristics:

- Excellent Low Light Response: Excellent Power Output in dawn, nightfall and overcast period
- Zero Light Induced Degradation (LID): Year 1 LID less than 1 % absolute
- PID Free Module: double 85, -1500v and 96hr test condition, module power less than 2%
- Dual-side Power Generation: 10%-30% additional power generation

2016 New Characteristics:

- 30-year Power Output Guarantee
- 1500V System Voltage: meets 1500V system voltage requirement, reduces system costs by 10%,
- 305W Super High Power Output (based on 60-cell module)

Photos: SolarEdge

For the process of 'potting' its power optimizers, SolarEdge's automated solution yields certain benefits.

SolarEdge's automated manufacturing solution

Inverter automation: Power electronics maker SolarEdge has deployed a new automated line to produce its power optimizers, and says that this will be the future of manufacturing for both power optimizers and inverters.

In a factory in Hungary, a long line of machines is quietly humming. In one end a worker places open plastic boxes with cables attached. Through other access points, printed circuit boards, metal brackets, potting material and screws are added, and at the other end the company's power optimizers emerge to be unloaded by a second worker, roughly one every minute.

This is the first automated manufacturing line for power optimizers in the world, and can produce roughly two million SolarEdge power optimizers annually. This is promising not only for the company, but the entire power electronics industry. And this move says a lot about SolarEdge and changes in the industry.

Rapid growth

Israel's SolarEdge makes inverters and power optimizers. It is the leading company globally for power optimizers, and the fastest growing inverter maker. The company's most recent quarterly results show a 45% year-over-year growth in revenues, and its operating margin has grown to over 15% – an enviable degree of profitability in a space where even leading producers are often barely getting by.

SolarEdge is not merely successful; it is the leading company in a rapidly expanding segment of the power electronics industry. Market research firm IHS has predicted that sales of microinverters and power optimizers, which offer related benefits for solar PV installations, will grow 19% annually through 2019. The company also noted that this segment has not been hit by the deep fall in prices that has impacted the inverter industry.

Demand for SolarEdge's products is growing fast. In six years of commercial production, SolarEdge has shipped more than 10 million power optimizers, and five million of those were in 2015 alone. This presents it with unique challenges that have pushed the company in the direction of automation.

Driving factors

Unlike some other fields such as thin film PV manufacturing, production of inverters and power optimizers is still a manual process, with workers on lines assembling parts, tightening screws and soldering by hand. SolarEdge VP of Marketing and Product Strategy Lior Handelsman notes that there are circumstances where this process is advantageous.

"Manual assembly is good for product lines where you have a high mix – different types of product that are being manufactured – and it is also effective

There are no off-the-shelf solutions for manufacturing power optimizers, so SolarEdge had to design its own bespoke automation system from scratch.

The chief purpose of automation, aside from lower labor costs, is reliable levels of throughput, repeatability and the absences of errors or faults.

when you want to go quickly to market," Handelsman told **pv magazine**.

However, it also has drawbacks. When you scale up, you must hire more workers. These workers must be trained, and this process can be messy. "Even if you have skilled employees, eventually there is a limit to the quality that you can get, because people make mistakes," notes Handelsman. This is particularly true with a higher portion of new employees undergoing training when production is ramped up.

SolarEdge says that a big increase in demand is one of the factors that led it to automation. The company cites multiple advantages to automation including easier repeatability, but one that stands out is the need to maintain and improve quality while rapidly increasing production.

Additionally, while up-front cost of investing in automation is high, this is offset over time by lower wage overheads. SolarEdge estimates that its new automated line means 80% fewer employees, and 80% lower labor costs.

Getting to a solution

But while the factors driving automation are clear, the process of designing and implementing an automated solution is not always easy – especially the first time. SolarEdge notes that as there were no off-the-shelf solutions for manufacturing power optimizers. A custom solution had to be designed, which included tools from the automotive industry.

Not only did the system have to be designed and built from scratch, but its power optimizer products had to be designed for automation. "We designed the power optimizers in advance to be suitable for automatic assembly," explains Handelsman. "But there was a lot of engineering in getting it to run at the high rate, and high quality."

This meant that the parts needed to be added from the top, not the side, as assembly robots are effective in building from the top, but not from the side.

SolarEdge also had to be sure that its automated solution could move from one type of power optimizer to another, which it accomplished by using identical cable connection points and shapes for its printed circuit boards.

Ultimately, SolarEdge deployed a modular solution, with the ability to add tools if new designs require additional manufacturing steps. The company says that this process of design and ramping was the most difficult part.

"The main challenge is to build something that has high throughput, high repeatability, and that every process yields a high-quality product," states Handelsman. "[You need to] get to the point where you can prove that it can do it 1 million times, and every time the quality of the electrical connection is high enough, and that it is repeated."

Going global

SolarEdge began operation of its automated power optimizer line in Hungary last September, and says that it was nearly ramped by the time of writing this article. At full capacity and with only 1.5 hours of downtime each week, the line can produce 2 million power optimizers annually. SolarEdge is shooting for a failure rate of zero parts per million, however it would not disclose what the current failure rate is.

After ramping this line in Hungary, SolarEdge plans to bring this solution to its other power optimizer manufacturing factory in China, which like the Hungary plant is operated through a partnership.

The company notes that automation removes the advantage of low labor costs in nations such as China, making geographical diversification easier. SolarEdge says that this is allowing it to plan more factories and bring production closer to end-markets, including the booming U.S. market. In the process, shipping costs are also reduced. "Eventually all our power optimizer lines will be automated," declares Handelsman.

Automation is the future

SolarEdge is the first power optimizer maker to roll out an automated line, but it expects the rest of the industry to follow. And at some point, the company expects this to spread to inverters as well, although inverter designs will need to be modified. Handelsman notes that current inverter designs still require assembly from the side, not only from the top, which will need to change if inverters are to be produced in automated lines.

For its part, IHS says that a move to automation is supported by inverter market trends. "PV inverter manufacturers are being forced to be highly competitive in nearly all market segments and they are naturally focussed on optimizing costs to maintain their profit margins in today's harsh pricing environment," IHS Senior Research Manager of Solar and Energy Storage Sam Wilkinson told **pv magazine**. "Reducing costs through the automation of manufacturing is naturally a key consideration for them."

As the industry grows, manual assembly as a sole solution will no longer be good enough. "[Automation] is a strategy that eventually everyone will need to employ," states SolarEdge's Handelsman. ◆

Christian Roselund

Photos: LTi ReEnergy

Chris Voet is the Chief Sales Officer at LTi ReEnergy, which is headquartered in Unna, Germany.

"Identifying good partners means screening the market"

Interview: Chris Voet, Chief Sales Officer at LTi ReEnergy, discusses the company's "German heart – local content" approach, which aids entry of its central inverter technology into strong and emerging markets such as Brazil, India, China, and Turkey, as well as other regions with local content requirements and high import taxes.

pv magazine: The LTi ReEnergy slogan "German heart – local content" is more than just a motto. It actually describes the company's business approach. So can you explain in a little more detail the LTi business model?

Chris Voet: If you think of a car, you cannot sell just the engine – you have to sell the whole car. Nobody is really interested in just the engine. That is what we are doing – producing the engine, the black box for the inverter, the PVOne, produced in Unna, Germany, for the entire global market.

We supply the black box from Unna to our partners across the whole world. The black box, the PVOne, can be integrated into a system that can be built here at LTi ReEnergy, or at a related company – perhaps one with experience in building cabinets and other related components. For that we have localization partners who are able to produce a complete inverter solution to our standards. They will source different parts from us, or they can do the sourcing from a Bill of Materials (BOM) list supplied by LTi ReEnergy. We approve the components that they source locally – this could be in markets in India, China, Brazil or wherever our localization partners are – and LTi ReEnergy avoids the transport and logistics costs because these partners are near to where the inverters are being installed. The PVOne, the German Heart, will always be produced and sourced from Germany.

Could you describe the three key benefits of this, rather unique, internationally scalable value chain model?

That we can avoid tax issues is number one because most of our supply is local. Secondly, we can avoid currency exchange fluctuations so we do not have to hedge anything because components are locally bought, locally produced, and locally sourced. Thirdly, of course, we minimize transport costs because do not have to ship big containers, transformers or many other heavy components. Because of these benefits, there is no need to apply any margin on such components – we are able to be as honest as possible in earning money on the components we produce. Last but not least, many upcoming countries prefer larger proportions of local content. This all leads to significant cost reduction for our partner.

Do you have any figures available on the size of the cost reductions you can offer customers in certain markets?

In Brazil, which has high import taxes, customers receive price reductions, often in the double digit percentage range, following our "German Heart – Local Content" model. There are taxes on the products coming from Germany, so the level of localization is based on the amount of the installed components that are locally sourced. The more local components are used, the higher the cost reduction. For Brazil we need the Finame codes that verify a component as locally produced. These are recognized by financial institutions such as local banks. A project needs 60% concerning the local share of the value of the total solution, and a minimum of 60% of the weight, to come from Brazil.

India's solar growth is contingent in no small part on local content. What benefits – in terms of cost and penetration – has this approach brought in India?

Complete turnkey solutions like central inverters in an ISO-container can sometimes be difficult to supply into the Indian market, as it is a rather low cost market. Even with German quality it is impossible to sell at Indian prices if you ship the complete product, which will of course be subject to high import taxes. So people in India expect a locally manufactured product but with the same technology from Germany. We are experienced in working with partners that can produce inverters but also have a pipeline of projects they can complete themselves. Thanks to a combination of production and sales part-

LTi's 'trinity' of applications, its 20 foot ISO container, the PVMaster III and the core PVOne - the 'German heart' of its business concept.

ners, means we are able to rely on our partner's experience in the market – experience of sourcing, and knowledge of the target price required in order to be successful.

Bill of materials costs in India can be reduced by as much as 40% by partnering with local suppliers – can you provide a clearer breakdown of how these cost reductions are reached?
Obviously, labor costs are lower in India than in Germany. There are a lot of orders with big suppliers and good relationships. We can buy, for example, relevant components from leading western suppliers, buy here in Germany or we can buy in India for a lower price thanks to the sourcing we have access to. Our partners may buy the same products at a lower price than we can buy, so we benefit through the contacts they have. Or it is the other way around so that our partners can participate in sourcing from us as part of a large industry group. The bottom line is: it is not a fixed system or fixed price. We try every day to reduce costs further, or to avoid costs that are unnecessary. It's an ongoing competition and the Indian market gives us a good platform to exercise cost reduction for the rest of the world.

How critical is it to identify the right partners: those that can maintain LTi ReEnergy's quality?
It's a bit of a secretive non-secret how we do it! How to identify good partners is simply a case of screening the market. You are not working only with partners that have the possibility to produce but also a pipeline that offers added value. So, it's a win-win situation for both of us. The relationships are based on constant discussions about reducing prices and improving service. The feedback from partners is critical: They might tell us that the price of material has increased locally, so we are on the same wavelength and can adjust accordingly. In the end, they produce the product but we buy it back from them. We keep warranties for our own products, which delivers more confidence to our customers - based on stringent quality control.

How does LTi ReEnergy then ensure that local quality standards are upheld? What levels of checks, due diligence and training/guidance do you offer?
This is a large part of what we do. The localization process will take around three to six months. But prior to that there is a complete program of training people coming to Unna, who build products together with us – cabinets and containers for example – for other markets. So this on-the-job training is actual production, overseen on-site. This is a complete, defined program for after setting up the production.

Does LTi ReEnergy also coordinate post-installation O&M, as well as other aspects of after-sales service?
Of course, this is all part of the program. We offer a huge portfolio of support solutions starting from a helpdesk, technical support to different spare part packages and variants of engineering and application services.

How do markets differ in terms of their priorities?
We are always looking for "the missing piece of the puzzle." We do not enter a new market blindly, without a plan. It is a step-by-step approach: Identify a market, look at potential partners, and then see what is missing in the supply chain. Once that is identified, LTi ReEnergy will support the market by supplying that missing piece, and that is our way in. It is not simply selling a product into a new market, but helping that market to find a solution. These relationships where there is mutual reliance are absolutely key when going to new markets globally. ◆

Interview by Ian Clover

Photo: Eternal Sun Group

"Radically decreasing risks in long-term solar financing"

Technology Highlights Award Winner #1: Last month's **pv magazine** 2016 Technology Highlights Award shone the spotlight on a range of innovations in upstream solar technology, with an independent jury of experts identifying a handful of winners from a very strong field. **pv magazine** caught up with three of the companies recognized for their excellence to gauge what the award meant to them, and to learn a little more about the techniques, investment and R&D that have made it all possible. First up, Eternal Sun CEO Chokri Mousaoui, and CTO Stefan Roest extoll the virtues of the company's winning climate chamber and solar simulator.

What is Eternal Sun's reaction to being chosen – by an independent jury – as one of two Technology Highlights winners, from a field of 38 applicants?

Chokri Mousaoui: We are pleased to see that the industry validates our equipment and innovative character. We would like to share the credit for this piece of unique equipment with Solliance, a research partnership of R&D organizations from the Netherlands, Belgium and Germany specializing in thin film technology.

During the co-development of the equipment, we both delivered the expertise to develop this unique equipment. It confirms clearly to me that co-development and bringing together different areas of expertise is the way for the solar sector to go forward.

What is the advantage of bringing together your sun simulator with a climate chamber?

CM: As more and more substantial investments are being done in large-scale solar projects around the globe, long-term reliability with respect to local conditions needs to be verified. Investors and installers need to be able to understand and assess the reliability impact on ROI.

For this, two things are required: firstly, being able to simulate local conditions, and second, a fast, intensive and multi-stress test, which remains representative of local outdoor exposure conditions.

This piece of equipment is able to perform both, which leads to a combined stress test consisting of sunlight, damp, heat, and electrical load.

This multi-stress test further accelerates aging while causing unique failure modes that are not detected with current separate stress tests of the IEC standards.

How do you envisage the tool being deployed by module manufacturers?

CM: Module manufacturers will have faster and better reliability research results at lower costs that they can use to proof their module quality level, beyond what can be verified with standard IEC tests. As the tests can be customized to local conditions as well, this will radically decrease risk in long term financing of solar projects.

At the same time, thanks to the accelerated lifetime testing, manufacturers are able to shorten their time to market with their newly developed modules.

Are there similar testing products currently on the market? How does the Eternal Sun solution differ from these?

CHOKRI MOUSAOUI BIO

Chokri Mousaoui (*1983) is a Cleantech entrepreneur and founder of Eternal Sun, a spin-off from Delft University of Technology in The Netherlands. Mousaoui is in charge of global business development and sales, with a prime focus on increasing the company's sales pipeline, expanding its business model globally and executing strategic partnerships. In early 2016 he was responsible for the acquisition of U.S.-based Spire Solar. Additionally, he has been an active participant in numerous clean energy forums, and is a regular speaker at global industry summits. Mousaoui studied Systems Engineering at Delft University of Technology in The Netherlands, and followed an exchange program at Harbin Institute of Technology in China.

CM: In discussions with customers and research & development institutions, we learned that it is a unique system that enables combined climate and sun simulation stress testing on cell as well as module size, whereby simultaneous measurements can be done.

What is the advantage for deploying a solar simulator rather than a more common flasher in this solution?
Stefan Roest: A flasher is relevant when you perform a flash test in a fraction of a second to measure the performance of a module.
With the steady rate of sunlight in the climate chamber simulator, you are able to accelerate aging while providing real-time in situ performance measurements.

Are there advantages to testing with a light source sufficiently powerful for more than 1×sun, to further accelerate testing?
SR: We advise caution on this. Research shows that it might trigger failure modes that do not occur in real field conditions.

Why do you say the lamps developed by Eternal Sun are superior to Xenon in terms of durability, and therefore cost? How does that impact on the running of the climate chamber and solar simulator tool?
SR: The patented gas lamps give users a better total cost of ownership. The gas lamps possess a longer lifetime and lower replacement costs than traditional continuous Xenon lamps, which further reduces the costs of reliability testing. ◆

"Significant savings in wafer manufacturing costs"

Technology Highlights Award Winner #2: Identified for its potentially positive impact on the entire solar market of the future, Meyer Burger's DW288 series 3 diamond wire saw won universal praise among the independent jury. Meyer Burger CIO Sylvère Leu reacts to the accolade and discusses in more detail how the tool is an improvement on the market.

Photo: Meyer Burger

While diamond wire for ingot wafering is far from a new concept, the 2016 Technology Highlights' jury was impressed by the series of innovations and market impact of the DW288 Series 3. What does it mean for your team?
Sylvère Leu: The entire team involved in the conception and development of Meyer Burger's next generation DW288 Series 3 was really excited and proud to have won **pv magazine**'s Technology Highlight award for 2016. To be recognized by an independent and international jury comprised of scientific and industry experts really underscores the important technological progress we have made with our diamond wire cutting technology in contributing to the reduction in manufacturing costs for solar wafers.

What demand are you experiencing from wafer manufacturers in terms of diamond wire uptake?
SL: Meyer Burger is very pleased with the response from our customers to the DW288 Series 3, with a good volume of orders already received and other customers in test phases. In the past year we have indeed seen a clear shift in demand from slurry-based to diamond wire-based cutting technologies.

Reports are that diamond wire uptake for mono production is very strong. Have the challenges with multi wafering using diamond wire been overcome?
SL: The outstanding performance with the DW288 Series 3 has indeed been reached with monocrystalline wafers. Meyer Burger has also adapted the process for multicrystalline wafers with a similar level of performance and we are working closely with our customers on the downstream issue of texturing. Meyer Burger already offers a plasma texturing solution but we are aware that most cell manufacturers currently use chemical texturing processes.

You note that the DWManagement System increases performance of the wire by 50%. What does this mean? Can the wires be used for a significantly longer time?
SL: The DW288 Series 3 optimizes the synergies between

reduced diamond wire usage and thickness, and faster cutting time while benefiting from maximized wire management with the Diamond Wire Management System (DWMS). Diamond wire material is a significant cost factor in the production of solar wafers. With Meyer Burger's DWMS, wire wear is reduced and the life of the diamond wire is significantly extended. In combination with the reduced diamond wire thickness, the cutting time has also been reduced from three to two hours and the diamond wire usage decreased to one meter per wafer. The result is a significant savings in the manufacturing cost per wafer.

SYLVÈRE LEU BIO

Sylvère Leu is the Chief Innovation Officer (CIO) of Meyer Burger, and also sits as a member of the Executive Board. Prior to joining Meyer Burger, Leu worked as Chief Operating Officer for 3S Industries Ltd, and before then spent two years as Conergy SolarModule GmbH Managing Director, where he helped to develop the first fully integrated production line for wafer, cell and module manufacturing. Leu studied engineering at the Federal Institute of Technology in Zurich, and also earned a BSc in Economics and Business Administration at the University of St. Gall.

Over what time frame do you envisage the transition to 50 um wires (from today's standard 120 um) and what will that mean, in terms of costs, for wafer producers?

SL: Meyer Burger's research and development team is currently working closely with our customers on testing increasingly thinner wires down to 50 um. Decreased wire thickness alone is, however, not our only focus: The entire process – including cutting time, wire thickness and quality as well as wire usage and handling – must support a wafering process with such thin wires. A forecast on wafer costs is difficult at this point.

Does diamond wire wafering also deliver wafer quality advantages and can you quantify this?

SL: Yes it does. In contrast to standard slurry cutting technology, Meyer Burger's environmentally friendly water-based diamond wire cutting technology results in less erosion on the surface of the wafers. Diamond wire technology uses much thinner wires, which decreases cutting times and enables the manufacture of thinner wafers. This is especially important for downstream high efficiency cell coating technologies such as heterojunction. ◆

Photo: DSM

"Same sun, more power"

Technology to watch: DSM's anti-soiling coating was chosen by the independent jury as a technology to watch. The Dutch company's solar Global Business Director Jan Grimberg offers here the inside track on how anti-soiling techniques are boosting solar plant output.

The industry is familiar with DSM as a supplier of anti-reflective coating (ARC). Anti-soiling coating is a new concept. What can you tell me about the process of developing anti-soiling coating?

Jan Grimberg: Look at PV market projections, by 2020 about half of the newly installed solar capacity will be in areas where the climate is rather arid. Soiling, which has always been an issue with solar parks, will be an even more profound problem. Based on that, it would be great if we could develop a coating to bring down the level of soiling and potentially reduce cleaning costs. There are coatings already on the market that have a certain anti-soiling behavior, but DSM wanted to develop in two directions: to combine ARC with anti-soiling coating, and secondly to produce a coating that lasts much, much longer than one or two years - like we have achieved with ARC.

Durability is clearly key. How would you describe the durability that has been achieved by DSM at this stage?

JG: We have taken the same technology that we developed for ARC, a core-shell structure, and added additional functionality through inorganic components. This means that by default it has long durability. As for performance at this stage, and it was demonstrated in our application for the 2016 Technology Highlights award, there is a minor reduction in anti-reflectivity, but there is a tremendous advantage for anti-soiling.

What kind of testing have you carried out?

JG: It is currently a development project. With our key partners in the PV industry, we are at the stage now that we are testing modules in the field with anti-soiling coating in order to get the field data. Currently, we have seven sites around the world where modules with this coating are being tested and we are collecting data as we speak. More test sites will be added in the near future.

Sand, of course, is not the same in different parts of the

world. You are naturally then testing with different types of sand particles, is that right?

JG: Absolutely. Over the years we at DSM have come to learn that dirt is a science. As you said, dirt at a dry, desert area is different from that from a coastal area and also between different desert areas the size and composition of the dust can differ strongly. It is about the size of dirt, and how it is deposited on the module. We have literally been collecting different types of dirt particles and all of this information went into the development of the current anti-soiling coating. I am convinced that this latest version of the anti-soiling coating will not be the last version, because there will be more diversification down the path.

Recently PI Berlin published findings that robotic cleaning with brushes can damage ARC. What are your expectations for different cleaning methods?

JG: One of the questions that people ask is, 'if the modules are cleaned, will the coating last?' This is particularly true of dry cleaning because there are many places where water is very scarce and you don't want to use it for cleaning modules. We have been working with different cleaning equipment providers and testing with different dry cleaning machines to see what the impact is. Both, our ARC as well as our anti-soiling coating The coating have been exposed to 500 cleaning cycles – representing bi-weekly cleaning for 20 years - at two different equipment vendors, without any measurable damage to the coating. Extended tests are being executed. So far a number of cleaning cycles have been performed, something like 400 to 500, where there are no negative effects. So it is definitely doable.

What is your road map to market?

JG: We are collecting data, because for this coating the real proof point is in the installed product, rather than a flash test. We want to have evidence that our customer gets value. We have our test sites and a few more will be added, and the likelihood is that by next year the product will be commercial.

Do you imagine manufacturers using anti-soling coating for some batches, while standard ARC for others?

JG: That is yet to be seen. I think it is going to be a trade off, because on one side you want the supply chain to be as simple as possible, but on the other hand I can imagine in certain areas where soiling is not a problem anti-soiling coating is less important than ARC. So it will be a diversified application. ◆

Interviews by Jonathan Gifford

JAN GRIMBERG BIO

Jan Grimberg is currently Global Business Director at Royal DSM B.V. and is responsible for DSM's activities in the Solar PV industry. He has a master's degree in Mechanical Engineering, Polymer Processing. Grimberg joined DSM in 1988 and since then has held various technical, marketing and sales, and business positions in both the materials science and life science businesses of DSM. He has lived and worked in a number of different countries around the world.

Photos: pv magazine/Patrick Alleyn

The Solar Superheroes stopped into Shanghai's Bund for an iconic photo call. From left to right, Apollon, Diamond Wire, Flash, Silver Maze, Coal, Inspector Vi, Laminator and Wire Mesh.

The Solar Superhero story... so far

Solar Superheroes: Sometimes the best ideas are born in unlikely settings. Sometimes they happen over freshly squeezed juice.

If you attended SNEC this year, it would have been pretty hard to miss **pv magazine**'s Solar Superheroes. Stalking the aisles, the seven superheroes were mobbed by crowds, posing for selfies, putting on solo, two- and three-way routines and dramatic kung-fu-style battles against the imposing figure of Coal, their arch nemesis. Each superhero was decked out in a colorful costume, and when arriving at a sponsor's booth, the likeness to their comic book form was striking.

Print editions of both Episode I, in three parts, and the first two installments of Episode II, were compiled into a special publication, in both Chinese and English. Copies veritably flew off the stands. It was a welcome addition to the 2016 SNEC and was a frequent talking point among attendees during and long after the event. But how did it all come into being?

Solar Superheroes: the awakening

The idea behind the Solar Superheroes first emerged only 13 months before the 2016 SNEC. From conversation to realization as a comic series and live act is no small undertaking, if we do say so ourselves, but it's been a labor of love.

In many ways, Italian backsheet provider Coveme is to thank for the Solar Superheroes. On the second night of the 2015 SNEC, Coveme hosted a dinner. So well attended was the event that the **pv magazine** was a part of the overflow, unable to get a table at the main event.

Improvising, the Coveme team arranged for a table for attendees unable to be seated in the main hall. It was a happy circumstance as at the table sat representatives of laminating equipment supplier Bürkle, TÜV Rheinland and some other PV module technology providers. And it is fair to say, hilarity ensued.

Putting flesh on the bones

Given the success of the superhero genre in recent Holywood films, the table tried

Wish Mesh struts her stuff at the SNEC trade show. The Solar Superheroes drew vast crowds wherever they went.

to answer the question: what would various solar manufacturing technologies look like, if they were to take superhero form?

It was quickly decided that wet chemical processes would be a rather downbeat character, bringing with it a puddle of water around its feet wherever it went. The factory auditor would be a be-suited engineer, replete with clipboard and certification stickers, that it could throw in rapid succession at its enemies, plastering them into submission. A flasher should be represented as, well, a flasher and so on.

And the enemies? This too would have to be determined. Coal was obvious, and oil of course. Gas, it was con-

Social Media presents an ideal platform for spreading the Solar Superhero message, one selfie at a time.

cluded, would be a malodorous and perhaps lesser evil, and nuclear? Well, much debate followed.

As the evening continued, the bouts of laughter rang out from the spontaneous superhero brainstorm. **pv magazine**'s attempt to procure cold beer to accompany the meal was one source of mirth, with beer orders invariably resulting in a glass of freshly squeezed orange juice: Something the Laminator would not tolerate, the Bürkle team insisted.

The morning after

The morning after the night before can sometimes be full of regret, but in this case, it couldn't be further from the truth. The seed had been planted, and when some of the dinner attendees met again, it was decided that this stupid idea might not be so stupid after all.

It is invariably challenging to convey just how the incremental and evolutionary process of manufacturing improvements, coupled with scale, has delivered the remarkable cost reductions and efficiency increases that have driven solar's competitiveness to the place where it is today. Why not tell the story in a fun, creative and engaging way? But how could the technologies inside and behind solar manufacturing be brought to life?

pv magazine departed Shanghai in 2015 with many questions, but a determination to see the Solar Superheroes take shape.

The search for an illustrator saw a number of overseas options investigated, before a German designer sketched out the first Laminator and we all knew, Stefan Lochmann was our man. Diamond Wire (Meyer Burger), Flash (Wavelabs), Silver Maze (Heraeus) and Wire Mesh (Meyer Burger) all followed, and while in some cases it took some convincing, the amazing Solar Superhero sponsors came on board.

Character development

Jokes aside, developing characters that would both demonstrate the respective companies' technology and brand, and that would engage readers, would require more than a few orange juices between friends. Here the sponsors' embraced the concept.

"We had fun over lunch," reported Wavelabs' founder and CEO Torsten Brammer on providing the input on Flash. "Beard, at least three-day-beard and glasses with a black frame. They can be sunglasses, which makes sense because he [Flash] does not want to blind himself [with his LED flash]," he elaborated. Flash's garrulous humor and amorous advances, often unwanted, towards the female members of the Superhero gang were also stipulated.

"It's the funniest meeting we've ever had among our team," added Robert Gaiser from Bürkle. "Three of four people from the brainstorming team have a bald head, so therefore we decided that he should also have a bald head and a beard when he doesn't wear his helmet." Details, but important nonetheless. Gaiser and the team at Bürkle stipulated that Laminator should have a leadership role, and given their attendance at the evening where the idea first emerged, **pv magazine** acquiesced. However, the overriding theme of cooperation amongst competition prevails throughout the comic series.

A leader?

All superhero groups have their internal tensions and a guiding mentor is a good thing to have. Enter: Professor Green.

With his strong profile among the Chinese PV industry and his and the University of New South Wales' distinguished role in solar research, Martin Green was approached to be the man behind our superheroes.

"Indeed unusual," Green responded to the initial inquiry. "But OK with me."

Launch and beyond

The first Solar Superhero comic was published in the September 2015 edition of **pv magazine** and distributed at the Solar Power International show in Las Vegas and EU PVSEC in Amsterdam. With it came many questions - "What is this? Will you keep going? Just, why?" - but with episodes continuing in the print editions of the magazine and hosted online, momentum began to build.

"I actually now look forward to seeing what the superheroes up to each edition ," **pv magazine** was told at this year's

SPECIAL THANKS TO SOLAR SUPERHERO COLLABORATORS
Bürkle: Michael Essich, Robert Gaiser, Ken Song
Heraeus: Andreas Liebheit, Michael Treutel, Verena Klotz, Gail Strong Heimberger
Meyer Burger: Ingrid Carstensen, Roger Glauser, Ramon Müller, Jose Bautista
3D-Micromac: Mandy Gebhardt, Kristin Schumann, Frederick Bamberg
Victronic: Birgit Voigt, Richard Moreth, Florian Steiner, Bill Wang
Wavelabs: Torsten Brammer, Jason Nutter, Falk Wildgrube, Volker Gutework, Jörn Suthues

SNEC, which was precisely the feedback we were looking for.

Life-sized figures of some of the superheroes were made. Laminator, Silver Maze and Flash were the first, and when it became apparent how in demand they were for photo opportunities, the idea of a live act began to take shape.

New characters were born with Inspector Vi (Vitronic) and Apollon (3D Micromac) joining the Solar Superhero ranks at the start of this year, adding powerful imaging equipment and lasers to the technology mix. Tim Nebel from Hamburg agency WBN also joined behind the scenes, providing invaluable input into taking the superhero concept to the next level. At a meeting of the Solar Superhero sponsors in Berlin the crazy idea of bringing the Solar Superheroes to life at SNEC 2016 was signed off, and work began on the ambitious plan.

The Solar Superhero comics have been published in Chinese, Japanese and English.

To go from two dimensions in the comic to a live act brought with it many challenges, and **pv magazine**'s head of sales, Andrea Jeremias, drew on her experience in theatre production, alongside her boundless enthusiasm, to source costume designers and a choreographer to realize the live acts. Joe Alexander came on board as choreographer and rehearsals began.

What an impact a live act makes. SNEC 2016 saw much of the work behind the Solar Superheroes pay off, and to see some of the sponsor booths decked out with their superhero in living color was an excellent affirmation of the concept. As were the crowds of SNEC attendees. It was hard to follow the superheroes on foot as they were frequently mobbed by crowds, and even Coal picked up a few admirers (he also terrified a small child, as well he should).

Where to next?

Onwards and upwards! The upstream Solar Superheroes are now well established and with each selfie, WeChat, Instagram, tweet, Facebook post, edition of the comic and performance of the 'real-life' heroes, momentum builds. Intersolar Munich will see the live-action Solar Superheroes make their European debut.

As any solar engineer will tell you, innovation is seldom easy, and this also applies to the marketing and communications space. As such, the team at **pv magazine** wishes to thank the people who brought the idea of developing a band of Solar Superheroes forward within their companies (see box p. 116). So I'll see you and the Superheroes in Munich! Until then, make mine an orange juice. ◆

Jonathan Gifford

Photo: Gorkem Soyumer/Enerwhere

Dubai's solar tenders make headlines and capture the imagination. But policy remains crucial to PV's rollout.

Both sides of the PV energy revolution

Policy and investment: While low bid prices grab headlines and herald a new dawn for PV deployment and global energy structures, public policy continues to remain key to the future of solar, writes Gaëtan Masson, the Director of the Becquerel Institute.

Even if the PV industry has become much more professional in the last few years, most of us have been driven by the idea that we are contributing to a better future for humankind. And sometimes, we love to see only the upside of events that are occurring in this industry.

One perfect example is the recent record low bid of $29.90/MWh for phase 3 of the Dubai 800 MW (AC) project. This tender has spread fear and consternation in the conventional power industry. "Finally they made it and much sooner than expected."

In fact, the $58 from phase 2 in Dubai seems rather expensive now. What this and other tenders in South America or India have achieved is that they convince many that PV is now cheap enough to trigger a real energy revolution. And the surprised faces of many observers from the conventional power industry confirm this first feeling. If only it were that simple.

A simple LCOE calculation shows how it is that competitive PV installations should be to reach extremely low electricity prices. Not only capital expenditures must be reduced dramatically (which implies today to sell modules with a reduced profitability margin), but also O&M costs must be kept low, which might trigger surprises in harsh environmental conditions. Finally PV absolutely must deliver the expected yield, simply because the required super-low cost of capital implies little margin for risk management.

Everyone who follows the PV industry these days knows that the electricity prices reached in these tenders are difficult to reach, but could be realistic under certain conditions. Meanwhile, they require the remaining part of the PV market to accept more reasonable prices (in order to provide to component manufacturers acceptable average profit margins). Less competitive utility-scale plants and rooftop installations cannot reach such low LCOEs and represent a major part of the PV market.

The conclusion that PV is developing now independently of financial support or ad hoc regulatory framework is then a completely false and dangerous statement. PV has never been more dependent on policy support. First because the global PV market is still driven by three countries where financial support remains essential (the ITC debate in the U.S. is probably the best example).

Second because the transition of the rooftop market from feed-in tariffs and net metering to competitive solutions based on self-consumption will be complex from a policy point of view and the transition often painful (the German case is there to frighten us all). The question is not to know whether the PV market will grow, it is how, when and at which speed.

Finally the question of decentralized storage, despite the hype of the last two years, is far from delivering on its promises and requires a second layer of regulation and significant price decline to power up. This should also alert us to what we believe as mainstream but remains anecdotal and highly uncertain in the medium term.

Heading to new heights

Most attempts to forecast the PV market in the last few years have had the same limitations: It is impossible to forecast policy. It goes without saying that policymakers have driven the PV market up and down in the first years of its massive

development. Of course, the market today is more predictable, more understandable, and less linked to a limited number of countries where one decision could reverse the course of PV development. But fundamentally it remains subject to policy changes. And the increasing penetration of PV pushes grid stakeholders to put in place measures to control (another way to say "limit") its development. If the sole competitiveness of PV was necessary to unlock markets, 100 countries would have already embraced the PV market and Italy or Spain would be flourishing. The reality is more complex.

Basically the global PV market broke its own annual installation record in 2015, reaching a level of 50 GW in annual installation, no more no less. This represents a 25% market growth, whereas the average annual market growth for the last 10 years was almost 50% year over year.

Optimistic consultancies targeted a much higher number and still continue to believe it. But the truth is always less rosy: The 2015 growth was limited by technical constraints in China, policy constraints in Europe and in the U.S., and a slower than expected growth in emerging markets. For 2016, the perspectives are again showing an upward trend. Emerging countries are starting to significantly influence the global PV market. The paradox is that the slower than expected growth in 2015 has also highlighted a faster than expected growth potential by the end of this decade.

The PV Market Alliance, which targeted 52 GW for 2015 for its most probable scenario, expects this year slightly above 60 GW, and up to 112 GW in 2020 in the most optimistic scenario. The role played by super-competitive tenders in the final market numbers will not be significant enough to modify the global growth trend upwards. They simply represent a (lovely) virtue of what the PV sector is capable of these days, under pressure to destroy its image of a subsidy-driven, expensive industry.

Uncertainties about the future development of PV lie in its ability to become competitive enough without any financial incentive to persuade policymakers to adapt regulations for distributed PV applications. Otherwise its development will remain constrained. Under these conditions, the future might be bright and the 100 GW mark could be crossed on an annual basis. And for the $29.90/kWh in Dubai? Let's wait for the plant to be built first. ◆ Gaëtan Masson

ABOUT THE AUTHOR

Gaëtan Masson is Electromechanical Engineer from the Université Libre de Bruxelles in Belgium, having graduated in Business Administration from Solvay Business School (Belgium). Masson is the Director and cofounder of the Becquerel Institute. After more than 10 years in the financial and IT sectors, he moved to the PV industry and developed the Business Intelligence of EPIA, the European PV Industry Association.

Photo: IIP Photo Archive/Flickr

The U.S. solar industry was on the receiving end of some good news heading into 2016 with the extension of the ITC, but despite the market positivity, financing activity has been relatively weak.

Tough and tumultuous times

Global funding: Mercom capital CEO and cofounder Raj Prabhu delivers an update on recent solar investment, finding a weak fundraising quarter for the sector as corporate funding drops to $2.8 billion in Q1 2016.

Financing activity in the solar PV sector in the first quarter of 2016 was extremely weak, reflecting the general weakness in the public markets over the last few quarters. Only two out of 31 companies across the supply chain were in positive territory in terms of stock price. Public companies in general have had a difficult time raising capital at depressed market valuations. SunEdison's collapse, which began last July and ended in a bankruptcy filing in April, has had an understandably negative effect on the overall solar market, both globally and in the U.S. Yieldcos, which accounted for significant financial activity between the second half of 2014 and first half of 2015, having been especially hard hit.

Global solar installations are forecast to witness another year of positive growth, reaching approximately 65-70 GW in 2016 according to most experts, with installations led by China, the U.S. and Japan, with India set to usurp the U.K. as the fourth most dynamic solar market this year. While air pollution is the impetus for the Chinese solar market growth, the 30% investment tax credit (ITC) extension agreed just before the turn of the year has given a big boost to the United States and, by extension, global markets.

In Japan, renewable installation goals launched after the Fukushima nuclear accident are driving the domestic solar market, and over in India the National

Photo: NREL/Warren Gretz

Solar Mission's goal of installing 100 GW by 2022 is the main catalyst behind the impressive growth of the domestic solar market there.

However, although solar installations have been growing robustly, the corporate funding environment continues its swing back and forth in reaction to the evolution in technologies, policies, changes in financing structures, and other economic changes, both global and local.

The boost the sector received from the ITC extension has been negated by the collapse in yieldco stocks, net metering issues in the U.S., SunEdison's impending bankruptcy, Abengoa's bankruptcy, and solar stocks' decline in lockstep with oil prices.

The SunEdison effect

Last July, SunEdison had a market capitalization of somewhere around $10 billion. The company was valued at closer to $50 million as of April 4.

SunEdison overplayed its hand by accumulating more than $10 billion in overall debt in a relatively short time, as well as creating not one, but two yieldcos - TerraForm Power and TerraForm Global.

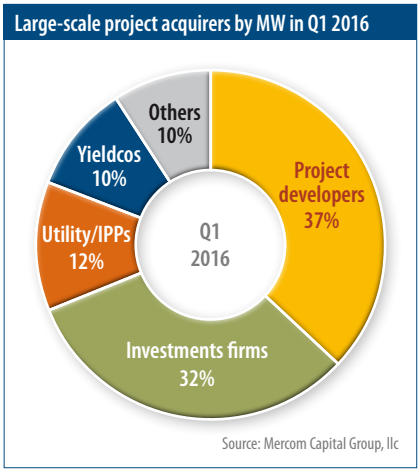
Its downfall began after the Vivint Solar acquisition announcement, from which it was never able to recover. The company has also terminated five of its 2015 acquisitions, and has one filing for insolvency.

TerraForm Global, one of the company's yieldcos, has sued SunEdison for misappropriation of funds. All of the inherent risks of yieldcos and worst-case scenarios have come to bear in SunEdison's case.

SunEdison made the yieldco model popular in the solar sector, but their overzealousness has largely contributed to the negative perception investors now have of yieldcos.

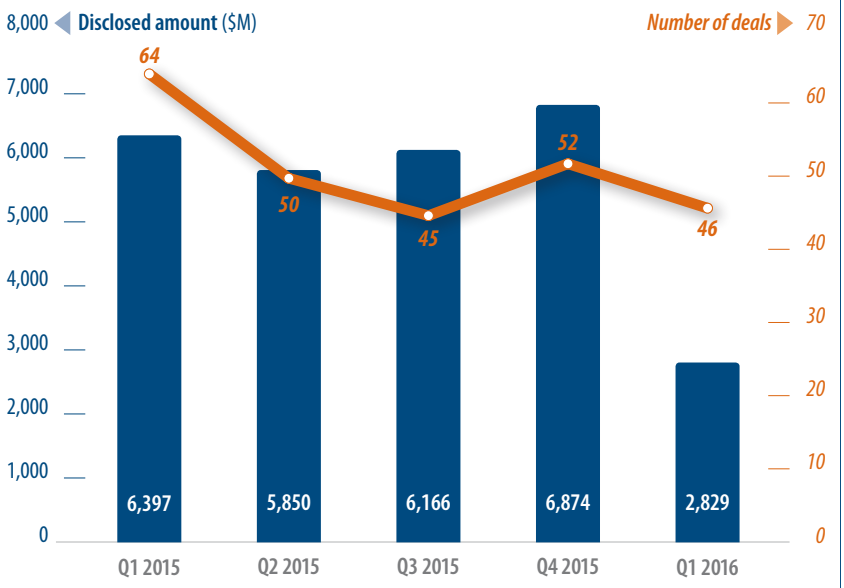
Total corporate funding

Total corporate funding, including venture capital, public market and debt financing in Q1 2016 fell to $2.8 billion



Graphics: pv magazine/Harald Schütt

Solar corporate funding Q1 2015–Q1 2016



across 45 deals, compared to $6.9 billion recorded in 52 deals in Q4 2015, and $6.4 billion invested in 64 deals in the first quarter of last year.

Venture capital funding

Global VC funding for the solar sector started off strongly in 2016 with $406 million across 22 deals. Overall funding fell slightly compared to Q4 2015, when $457 million was raised in 17 deals. Year-over-year, VC funding was up compared to Q1 2015 when $195 million went into 27 deals.

Solar downstream technology companies attracted the greatest amount of funding in the first quarter of 2016, with $333 million registered in seven deals compared to $440 million in 13 deals witnessed in Q4 2015. The solar downstream sector has been a favorite among investors since Q1 2014. The largest deal was the $300 million raised by Sunnova Solar Energy, a provider of residential solar services to homeowners through its network of local installation partners offering long-term leases and power purchase agreements (PPAs), from Energy Capital Partners, a private equity firm.

But with the exception of Sunnova Solar Energy, most of the deals in Q1 raised less than $50 million.

Public markets

Although 2015 was one of the best years on record for public market financing, fundraising activity started to slow in the second half of the year, coinciding with the slide in solar stocks, the global decline in oil prices, and the SunEdison debacle. The fundraising environment has been especially tough in the first quarter this year with only $94 million raised in just four deals. In Q4 2015, in contrast, $605 million went into eight deals. An even starker contrast comes with a year-over-year comparison: In Q1 last year, $1.3 billion was raised in 10 deals. There were no IPOs this quarter.

Yieldco stock performance

Yieldco stocks continued to struggle in the first quarter of 2016 with TerraForm Global (SunEdison's emerging markets yieldco) and TerraForm Power having the worst performance. Troubles faced by SunEdison and its yieldcos have been well publicized. A most worrying development was TerraForm Global's legal action against SunEdison, for breach of contract. While SunEdison was a catalyst in bringing the yieldco model to the solar industry, its complete mismanagement has also led to diminishing yieldco value in the eyes of solar market investors. All of the solar and renewable yieldcos are suffering from the negative perception brought on by SunEdison's actions, immaterial of the fundamentals behind each yieldco.

Debt financing

Announced debt financing fell sharply this quarter with just over $2.3 billion in 19 deals, which is the lowest recorded for a single quarter since Q4 2014. By comparison, in Q4 2015 $5.8 billion was raised in 27 deals. Most of the debt deals were recorded in the U.S., which accounted for $1.2 billion across nine deals.

With most solar company stocks declining, raising debt at lower market values has been a major challenge for solar companies.

Mercom Capital expects the current situation to continue until there is a rebound in valuations. There were just three debt deals by Chinese companies for $295 million last quarter, compared to $4.2 billion in 10 deals in the previous quarter.

Securitization deals

Securitization deals continue to gain

Solar residential/commercial funds announced Q1 2015–Q1 2016

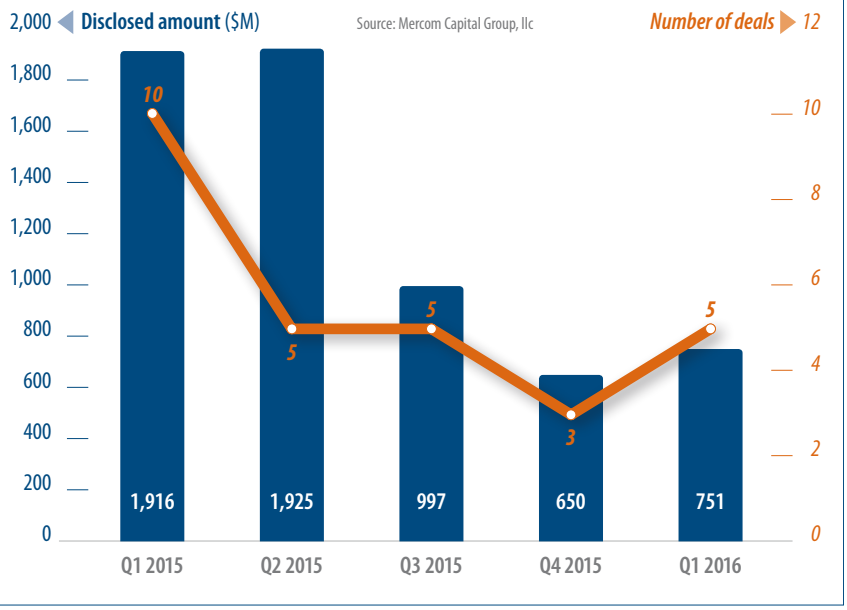


Photo: Solar Frontier

momentum, with three completed in the first quarter of 2016 alone. Mercom Capital expects more deals this year as long as this method of financing continues to represent a lower overall cost of capital when compared to tax equity.

Securitization deals in solar have now surpassed $1 billion globally, a significant milestone achieved over the last three years. Two of last quarter's deals were by U.S. solar leasing provider SolarCity, which raised $185 million through its fifth securitization and its first ever securitization of loan assets. Of this, $152 million was priced at an interest rate of 4.8% and the remaining $33 million was at an interest rate of 6.85%, resulting in a blended yield of 5.81%.

SolarCity also raised an additional $49.6 million through securitization at a yield of 6.25%. Beyond the U.S., and in a first securitization deal from China, Shenzhen Energy, a solar and wind project developer, raised $152 million with interest rates ranging from 3.6-4.5%.

Solar residential/commercial funds

Dollars continue to pour into residential and commercial solar funds, with $1 billion in six deals announced in Q1 2016, compared to the $650 million in three deals registered in the previous quarter.

All of the $1 billion went towards the lease/PPA model. A total of about $18 billion has now gone into residential and commercial funds since 2009.

ABOUT THE AUTHOR

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Corporate M&A

There were a total of 15 solar industry merger and acquisition (M&A) transactions last quarter compared to 13 transactions in the preceding quarter, Q4 2015. The majority of the M&A transactions in Q1 2016 involved solar downstream companies, with 10 transactions.

Solar equipment manufacturers and service providers each had two transactions. There was one transaction involving a PV manufacturer.

Last quarter was dominated by strategic acquisitions that were made for expansion and diversification within the solar market. Furthermore, there were also two distress sales recorded this quarter.

Project M&A

Project acquisition activity held steady in Q1, with 50 transactions registered (of that total, only 22 were disclosed for a total amount of $1.2 billion). Approximately 2.4 GW of solar projects were acquired last quarter. In comparison, in Q4 2015, there were 52 transactions registered (with details of 21 disclosed, for a total of $2.3 billion), with roughly 3.3 GW of solar projects acquired. Project acquisitions by yieldcos have dropped markedly along with the decline in yieldco companies' market capitalization. For more information on the financial activity in the global solar sector, and to learn more about Mercom Capital Group's Solar Funding and M&A Q1 2016 report, visit: http://bit.ly/MercomSolarQ12016. ◆

Raj Prabhu

Photos: Stephan Röhl

Award winners at the recent Ecosummit 2016 in Berlin pose with their plaques while also receiving the plaudits from those in attendance.

Pitch the future

Ecosummit 2016: Now is time for open innovations in the energy market. As consumers become prosumers and begin demanding smarter products and services, big companies are forced to modernize their business and seek support from younger, more dynamic and innovative market players. In April, **pv magazine** attended Ecosummit 2016 in Berlin to discover what products and business models cleantech startups have in mind for our energy future.

This year, Ecosummit Berlin demonstrated that more and more utilities are interested in investing in cleantech startups. "It is a big trend that utilities are looking for external innovations outside of their companies, and are open to new solutions that can be supplied by startups," Ecosummit Founder and CEO Jan Michael Hess told **pv magazine**.

Six European utilities participated in the Berlin event as sponsors and hosts. "We are open to any ideas," said Inken Braunschmidt, Head of Innovation of German energy giant RWE, presenting the company's open innovation and co-investing strategy. For RWE, open innovation is hardly a new trend. In 2014, the company created its Innovation Hub with teams in Silicon Valley, Israel, Berlin, and Birmingham to attract prospective entrepreneurs and develop new business solutions.

E.ON is another German utility with an appetite for cleantech startup investment. One of the companies E.ON is investing in is Thermondo – a Berlin-based startup that sells heating systems online. Inven Capital, a VC of a Czech energy company CEZ, also attended the conference. On the stage the company announced a $20 million investment in Tado, the Germany-based green startup that provides climate control services to households. At the two day event **pv magazine** spoke to representatives of other energy companies, and all of them admitted that the growing trend for open innovations is something that utilities cannot ignore. "It is expected from us today," said EWE's Christina Heilmann. But merging two different corporate cultures is not always easy – unlike large businesses, young companies can react more quickly to the new challenges and opportunities of the rapidly changing energy market.

Storage startups on the rise

Storage is among the main technology trends that inspire cleantech startups today. Some of the Ecosummit presenters have already established themselves in the growing global storage market. Sonnen, a late-stage German startup, is now competing with Tesla in this field. In fact, in the first quarter of 2016, Sonnen sold more products than its more famous rival. At Ecosummit the company's CEO Christoph Ostermann presented SonnenCommunity, a new business model that enables prosumers to sell generated renewable energy to each other.

"Sonnen came to Ecosummit 2012 in Düsseldorf. It was there that they did their first pitch, even before they closed their first funding round," said Jan Michael Hess. "Since then, they have been very successful in VC fundraising. Last year, Inven Capital also invested into Sonnen. And I know that they first discovered the company at Ecosummit 2014." Today, Sonnen is one of the most successful European startups, with corresponding investment appetites: As Christoph Ostermann revealed at the conference, Sonnen is seeking to raise €50 million to accelerate its growth. Fifty million euros seems like a fair expectation for certain energy startups today. The companies that have managed to catch the wave of the booming storage market can now demand investors' attention. Berlin-based grid-scale storage provider Younicos proved as much last year by raising €50 million from Panasonic, First Solar, and Grupo Ecos. This late-stage startup has some 100 MW of installed storage capacity to date. Qinous is another German energy storage provider, and also boasts a rather sleek project portfolio.

Dresden-based Sunfire presented its PowerCore reversible electrolysis system that converts electricity to hydrogen, which can then be stored in a highly compressed form. Early-stage startup Electrochaea is developing a similar power-to-gas solution. Ultracapacitors, famous for their high energy and power density, are another promising storage product offered by Estonia-based Skeleton Technologies. German startup Mobility House is linking storage with electric mobility, another hot trend in the global energy market. The company is already looking to the future; a future in which everyone is driving an e-car, and offering a smart way to use "second-life" EV batteries for energy storage.

Reinvent a solar cell

It is tough for a young company to enter the highly competitive PV market, said Hess, explaining why not that many solar startups made it on stage. However, those that pitched at Ecosummit boasted some startlingly impressive solutions and business strategies.

Klaus Maier of Mobisol demonstrated how the German startup is changing life in remote African villages. Mobisol has installed more than 50,000 PV home systems in Rwanda, Kenya, and Tanzania. Thanks to the company, more than 250,000 people now have access to electricity. "On average, we sell 120 units per day," Klaus Maier told **pv magazine**. Mobisol is not the only startup aiming to make use of enormous business opportunities for off-grid solar in Africa. Berlin-based SolarKiosk is already offering its service in the rural areas in seven African countries.

Startup-reneurs are also looking for new business models that help people go solar, even if they can't install a private PV system. Sven Pluut, CEO of Netherlands-based We Share Solar, said that the crowdfunding platform for collective solar energy projects is seeking to raise more than €1 million to grow internationally. Meanwhile, new startup Prosumergy is planning to bring solar energy to apartment buildings and sell it to tenants.

There is obviously a space for new ideas and out-of-the-box solutions in the solar market, but VCs are not really motivated to invest in PV manufacturing, said Hess: "I don't think that solar startups today should try to reinvent a solar cell. Instead, they should use the concept of open innovation, talk to the big companies and see if there is an opportunity for cooperation."

Late-stage startup Greenergetic is one example of such cooperation. The German firm is offering utilities an online platform where they can sell PV systems to their customers. CEO of Greenergetic, Florian Meyer-Delpho, said on stage that last year the startup sold about 4 MW of residential and small commercial PV systems, and is planning to triple this in 2016.

◆ Adilya Zaripova

ECOSUMMIT AWARD

Ecosummit Berlin is the largest among the Ecosummit conferences – two others are held in Amsterdam and London. This year, the conference presented 83 speakers including 60 startups. The Ecosummit Award is part of the two day event. This year, 11 companies were nominated in the late stage category, and 47 were competing to be named the best early stage startup in Europe. The international jury named Kiwigrid, Mobisol and Kenoby the best among the late stage startups. In the early stage category, the winners were Lumenaza, Ben Energy and Electrochaea.

Photos: Götz Fischbeck/Smart Solar Consulting

Andreas Gutsch, the CEO of Solarwatt Innovation. Solarwatt Innovation was created by German module manufacturer Solarwatt to develop storage solutions for the solar market, and is a spin-off of e-Wolf.

Speed is of the essence

MyReserve system: Unveiled last year, Solarwatt's MyReserve storage system has been met with a strong reception, piquing Smart Solar Consulting founder Götz Fischbeck's interest in the process, and prompting a visit to the firm's Solarwatt Innovation subsidiary to discover more about the system.

At Intersolar Europe 2015, German solar module manufacturer Solarwatt unveiled its MyReserve home storage system. Since then, some 1,000 systems have been delivered to customers around Germany.

We were curious to find out what differentiates the MyReserve storage concept from others in the market, and why Solarwatt remains confident that in 2016 it will eventually make the kind of market impact it had already (prematurely) aimed for last year. We visited the company in May, just days after the new CEO of Solarwatt Innovation, Andreas Gutsch's appointment was announced.

Gutsch had previously held several leading positions at pioneers in the German e-mobility and energy storage industries. Located some 600 km to the west of the corporate headquarters of Solarwatt in Dresden, the team of Solarwatt Innovation are the masterminds that designed Solarwatt's home energy storage system, MyReserve.

e-Wolf: from F1 to EV

In an inconspicuous building next to a highway, tucked away in a small business park west of Cologne, sits the home of e-Wolf, a company acquired by Solarwatt in April this year. Approaching the building from the parking lot, one cannot fail to spot a couple of automatic garage doors, which rather give the impression that one is entering a specialized car tuning garage rather than the design and assembly plant for Solarwatt's MyReserve home energy storage system.

Yet initial impressions are correct. E-Wolf was founded by a small team of engineers that had previously worked for Toyota Motorsport GmbH in Marsdorf near Cologne between 2002 and 2009, back when Toyota had its own Formula 1 racing team. The team members that

founded e-Wolf had been responsible for the development of the Kinetic energy recovery system (K.E.R.S.) for the Formula 1 racing cars. The K.E.R.S. technology provides these cars with additional horsepower for a short period of time, making use of the kinetic energy that would otherwise be dissipated into heat when the drivers hit the brakes before entering a turn.

To a certain extent, K.E.R.S. was an attempt by Formula 1 to demonstrate that they care about energy efficiency, while at the same time serving their main purpose, i.e. making the cars faster and the races more interesting by enabling more overtaking maneuvers.

When Toyota left Formula 1 in 2009, the engineers that founded e-Wolf had struck upon the idea to build all-electrical vehicles with the know-how they had accrued after several years in the demanding Formula 1 environment. They started off by designing e-sportscars and e-sedans, selling more than 50 e-vehicles in the process.

Even to date an e-sportscar manufactured by e-Wolf holds the speed record for electrical vehicles on the famous Nürburgring racing track, located some 100 km south of the development centre. The record is already more than six years old and the car that set it is prominently and proudly on display at the e-Wolf offices.

Most of the cars designed by e-Wolf were built as limited editions of less than 10 models each. The team soon realized that if they were to become economically successful they had to look for further applications of their know-how that were perhaps better suited for mass production. Their first attempt along these lines was the development of commercial vehicles powered by batteries.

The engineers placed big hopes on an e-bus for public transportation that a customer from Turkey found highly interesting. When this deal fell apart, the guys at e-Wolf conceded that the e-mobility market still represented a tiny niche, and figured that it would be difficult to keep the company afloat relying solely on this market.

So in 2011 e-Wolf began exploring the potential of stationary storage systems. It was a time when self-consumption of PV electricity was still supported by generous financial incentives in Germany. There was a growing interest in increasing the proportion of PV electricity being consumed on-site instead of being fed into the grid, with batteries seen as the obvious technology of choice to fulfill this task. So e-Wolf took on the first engineering assignments for stationary storage systems.

Enter Solarwatt

About one and a half years later, Dresden-based PV module manufacturer Solarwatt decided that it wanted to broaden its product offering and viewed energy management and energy storage solutions as a natural extension of its portfolio.

After screening the market for commercially available home battery storage systems at that time, Solarwatt decided that there were none available that fully met their requirements to the extent they felt was appropriate. Instead, Solarwatt's management decided they would take the long route, designing a home battery storage system from scratch, thus enabling full control and ensuring all product criteria were met.

The number one priority on their list was system safety. No compromises were accepted in this respect. Solarwatt teamed up with the Karlsruhe Institute for Technology (KIT) to develop the specification sheet for the new battery system. KIT has long-standing experience in evaluating the security aspects of battery systems and advising manufacturers on how to improve the inherent security levels of their systems. It was Andreas Gutsch, at that time the division head for the battery security test facility at KIT, who suggested e-Wolf as a suitable partner for the storage product development to Solarwatt.

Carsten Bovenschen of Solarwatt takes up the story: "When we decided to get involved in the development of an own home battery storage system under the Solarwatt brand, it was clear from the beginning that there would be no compromises regarding system safety. Our MyReserve system was the first battery system in the market to fulfill all of the security criteria defined in the guidelines for residential lithium-ion storage systems that were established by a consortium of industry experts under the guidance of TÜV, VDE and other relevant industry bodies. In fact we even overachieved on certain aspects."

Bovenschen stressed that security "always comes first," adding: "Our strong commitment towards providing the highest level of security is also reflected in the fact that MyReserve does not require any interaction with the Internet in order to optimize its loading and discharge cycles. Thus it is impossible for any hackers to tamper with our systems through remote access."

Optimum positioning

Besides making sure the battery system would meet the highest security standards, the next objective was to design an efficient system, both in terms of energy as well as cost. This objective led to a system design that is pretty unique among the commercially available systems in the market. The MyReserve battery is coupled on the generator side of the system, i.e., between the PV modules and the inverter.

This concept delivers a couple of advantages. The battery does not require a dedicated battery inverter, and instead is coupled to the DC-string of the modules. Consequently, owners save on inverter costs and spare themselves efficiency losses inherent in every inverter, thus improving overall system efficiency.

Coupling the battery on the generator side also has the potential to improve the lifespan of the inverter, as power peaks from the modules do not impinge directly on the inverter. And

since the battery is positioned between the modules and the inverter, the battery absorbs a significant fraction of the energy supplied by the modules at peak production times around noon in order to charge the battery cells. In the evening and during the night, when the battery gets discharged, this energy that has initially been stored in the battery then gets released and transformed in the inverter. So in the end, the energy flow through the inverter remains unchanged compared to a system without a battery. Having the battery between the modules and the inverter leads to a more homogenized energy flow through the inverter, which equates to less stress being exerted on the power electronics of the inverter.

Another aspect of its MyReserve storage system that Solarwatt believes separates it from the competition are the fast control algorithms implemented within. "High speed is ingrained in the DNA of Solarwatt Innovation," said Gutsch. "The engineers that developed the battery system had previously worked for a Formula 1 racing team, so obviously response times of more than a single second would never have been acceptable for us."

Speed is everything

Gutsch explained how Solarwatt uses high performance sensors specifically developed for the application, and high performance processors to permanently monitor the electrical load and the PV energy supply in the entire system.

"We actually decided to slow down the response of the battery in the millisecond range to make sure that the battery is not being stressed by too steep ramps. So while we believe we have the fastest response time of all currently available batteries on the market, we do not compromise on the longevity of our battery system, which is designed to last way beyond a decade in daily use."

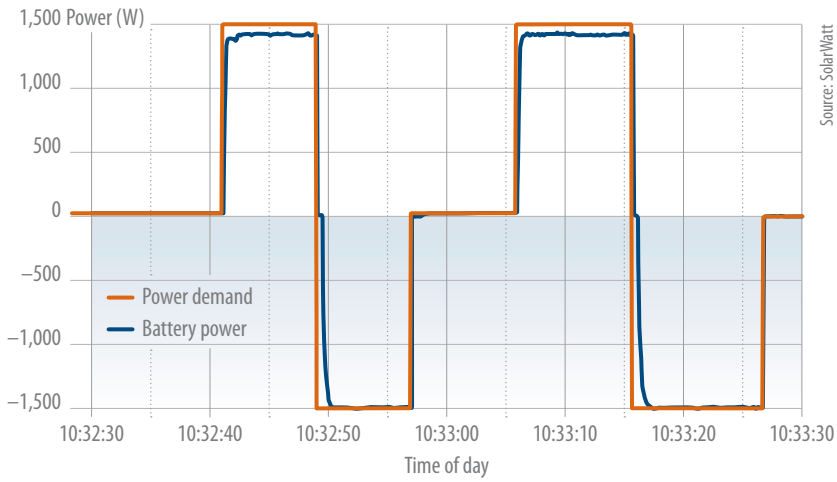
"The longevity of the battery capacity is also assured through our intelligent loading and discharging algorithms," the CEO continued. "They assure that the battery will only be fully loaded shortly before the system switches to discharge mode. Lithium-ion batteries age faster if they are left sitting around at maximum charge levels for longer periods."

Johannes Weniger, a PhD student at the University of Applied Sciences in Berlin who is working on the characterization of PV storage systems, acknowledges as such. "Some commercially available battery storage systems have reaction times of more than five seconds, leading to considerable operational inefficiencies. Over the course of the lifespan of the system these inefficiencies have immediate financial repercussions that can add up to several hundred euros over a 20 year period. As long as some storage systems sold in the market have reaction times in the range of several seconds, we believe it should be mandatory to provide the reaction time constant in the data sheet of the system. Today, one hardly ever finds this information provided in the technical specifications."

Kai-Philipp Kairies of the institute for Power Electronics and Electrical Drives at the University of Aachen (ISEA) supervises the scientific battery storage monitoring program that was put into place to accompany the incentive program for home storage systems administered by the German development bank KfW. In their most recent annual report released at the end of May, ISEA published the first results of their real life monitoring program of residential battery storage systems coupled with a PV system with high temporal resolution.

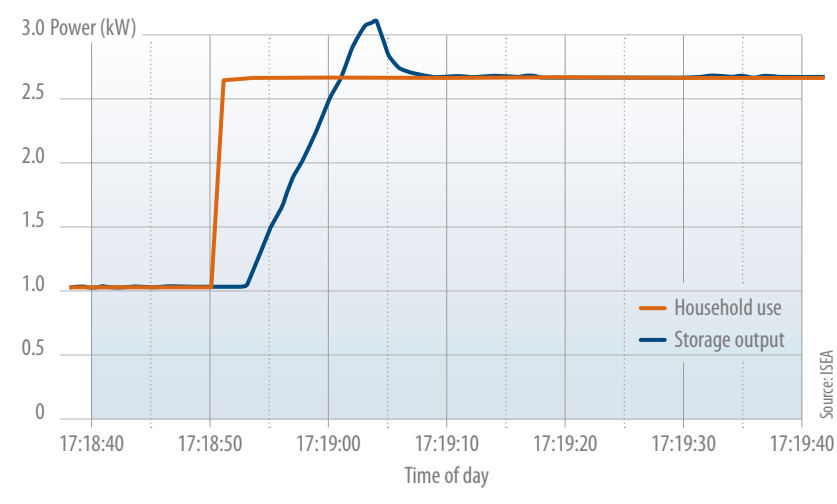
The report charts the dynamic response of a commercial system (see Graph below). It is clear from the measurement protocol reproduced in the graph, the monitored storage system only reacts to the change in load on the local grid with a delay of two seconds. Due to a slow control algorithm it takes this particular system 18 seconds before it has reached the new stable operating condition. Taking into account that a number of typical electrical appliances in the household draw their electricity demand in a pulsed mode, it is obvious that stor-

Dynamic response of the MyReserve system



Graphics: pv magazine/Harald Schütt

Dynamic response of competitor battery system



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age systems with such slow reaction times are not well suited to make the best use of the battery as well as the PV system.

Kairies sees a lot of room for improvement for future iterations of home storage systems as long as slow reaction times are still the norm rather than the exception. "Technologically there is no justification that a home storage system should have such slow reaction times," he explains. "It only depends on the type of sensors and processors used as well as the control algorithms implemented."

Sandra Thiele, Product Manager for MyReserve, highlights another aspect of the system that she believes differentiates it from others on the market. "One of the truly neat features we were able to implement by attaching the battery on the generator side is the fact that we actually improve the performance of the PV system at low light conditions, i.e., after sunrise or before sunset," she said. "The electronics of our battery system stabilizes the voltage in the system, which helps the MPP tracking at low power levels. So with the help of our battery the customer is able to squeeze out a few extra kWh of PV electricity from the modules. This effect relies on the same technical basis that is used by string optimizers to improve the power output at low irradiation levels."

And so to market

With all of these technical features setting its home storage system apart from competing products, Solarwatt was not shy when unveiling MyReserve at last year's Intersolar trade fair in Munich. Solarwatt had built plenty of public anticipation for the product launch, and even German Secretary of Commerce Sigmar Gabriel stopped by the booth to have this new battery concept explained to him by the management and the owner of Solarwatt, Stefan Quandt.

At the press conference, Solarwatt claimed that the MyReserve storage was nothing short of a revolution. The team hailed the many advantages it offers, emphasizing the modularity of the design, an exceptional security concept, a high energy conversion ratio, and an attractive price point.

Detlef Neuhaus, the CEO of Solarwatt, summarized the product introduction by claiming that the battery system was the first one to meet all security standards set forward in the guidelines for lithium-ion home storage systems released at the end of 2014, while also making sense economically. Yet there was one thing that Solarwatt had apparently overlooked. It appears to have underestimated just how much interest MyReserve would garner. While it stated last June that shipments would not begin until Fall 2015, the company had already received a couple of hundred orders within a few weeks of Intersolar Europe.

While conceptually the product was ready in June 2015, the engineers were still optimizing the software and the hardware of the system. Eventually, in October the first shipments of MyReserve began, and by now some 1,000 systems are installed at customer sites. During the ramp-up, Solarwatt realized that the crucial competencies for its new flagship product lay in the hands of a cooperation partner. All the key product development and production steps, as well as the assembly of the battery, were done by e-Wolf. So it was only a logical step that in April 2016 Solarwatt announced the complete takeover of e-Wolf, its battery partner in this undertaking, and renamed the company Solarwatt Innovation.

Perhaps Solarwatt was running at a little too high a speed when it unveiled its storage solution last summer. But after a timely pit stop to even out the glitches, Solarwatt Innovation says it is now ready to fulfill any customer demand, offering short lead times of less than two weeks. ◆

Götz Fischbeck

e-Wolf's office proudly displays the e-vehicle racing car that set the fastest race lap for e-cars on the iconic Nürburgring.

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Photos: GIZ

Many Sub-Saharan African nations have vast regions where reliable electricity supply is lacking. Solar-diesel hybrid systems are a workable and affordable solution for many areas.

Step on the gas

Solar/diesel hybridization: The deployment of solar PV in sub-Saharan Africa severely lags the rest of the world, for many complex reasons. One of these is the proliferation of diesel gensets for off-grid areas, but GIZ's Franziska Kohler explains that, via standardization, PV-diesel hybrids can be made more bankable.

The lack of reliable electricity supply throughout the developing world is by no means a secret. Despite the rise of renewable energies – in no other year has the capacity of renewables increased more than in 2015 – the development of solar PV in Sub-Saharan Africa has only resulted in very conservative numbers. As a matter of fact, growth in the sector has been spearheaded by the U.S., China and Japan, while the go-to back-up option in Sub-Saharan Africa continues to be diesel gensets.

Solar PV technology has long been established, and the costs have dropped significantly, which makes PV a cost-effective alternative to fossil fuel sources. Its modular deployability makes solar a feasible solution for the electrification of remote, off-grid regions in which the transportation of diesel and fuel is expensive and cumbersome. With all these factors justifying the use of solar, why does the deployment of PV in Sub-Saharan Africa continue to lag behind other markets?

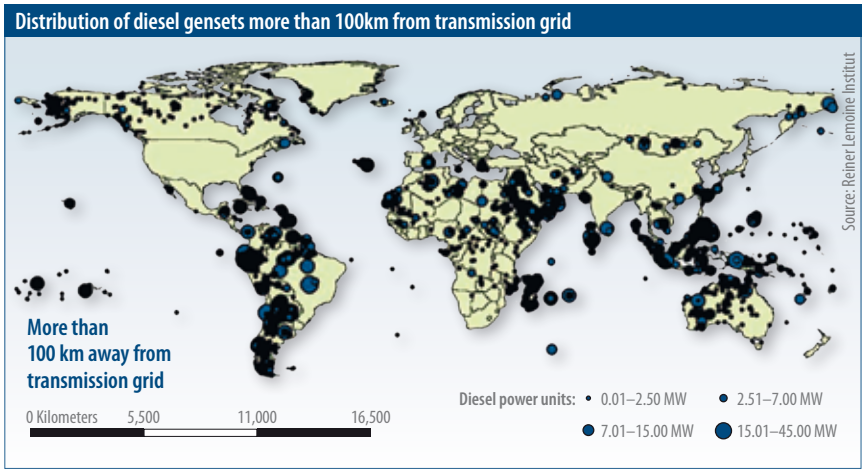
A dalliance with diesel

Diesel gensets located off the national grid are mainly found in island nations as well as countries with large land masses and poor infrastructure. The map presented on the page opposite illustrates the distribution and capacities of such off-grid diesel-powered generator units globally.

Potentially, all of these gensets could be hybridized: Renewable energy sources could be integrated into these existing grids, which would lessen environmental impact, increase reliability of the power supply, and reduce fuel costs at the same time. However, as is often the case, the lack of available financing for hybridizing these grids – i.e. saving fuel through the integration of renewable energy capacity – appears to be the bottleneck.

On the one hand, inaccessibility of financing can be attributed to the lack of familiarity of banks and investors with the technology itself, high risk premiums and payback horizons that are much longer than normal on the African continent. On the other hand, oftentimes proposed projects are not bankable due to weak assumptions: Cash flow, cost structure and pay-back time are based on estimations and 'guesstimates' that lead to increased risk premiums and more reluctance from investors to put money into

Graphics: pv magazine/Harald Schütt



projects. Simon Bittner, Project Manager at Project Development Programme (PDP), deals with such issues on a daily basis. PDP is part of the German Energy Solutions Initiative of the German Federal Ministry for Economic Affairs and Energy (BMWi), providing close, early-stage support to German companies that are taking their first tentative steps in the emerging markets of Sub-Saharan Africa and Southeast Asia.

"German companies tend to be rather risk averse. At the same time, they do not bring the finance for projects with them but are looking for local or international investors instead," Bittner said. "However, investors and banks are not convinced by business plans based on weak or unproven estimations: At this point it is essential to present something that potential financiers will be convinced by – something that speaks their language."

That "something" starts with reliable load measurements; not measurements that mirror a snapshot of a day of operations, but long-term measurements that take daily, weekly, and seasonal fluctuations into account. "Actual experience shows that inaccurate and biased measurements, which often rely on broad assumptions or scarce measurements, lead to improperly designed PV systems that do not meet the actual demand, or even worse, lead to oversized systems and thus to lost revenue and financially non-viable projects," Bittner went on to explain.

"This not only leads to uncertainty for the client and potential investors – it also leads to even more distrust in commercial business models for hybrid power generation plants."

If it is not possible or feasible to conduct measurements for an entire year, the data need to be extrapolated following a thorough methodology. The reliable measurement of electricity consumed is the basis for the dimensioning and planning of the PV system and calculating fuel savings, upon which the cash flow and return on investment of the project depends. Subsequently, hybrid power plants have to be designed to fit the exact actual power demand in order to avoid excessive capital expenditures. The more precise these demand figures are measured, collected and extrapolated, the more effective the subsequent hybrid power plant design will be.

Measurement standardization

After recognizing and setting out to tackle this issue, PDP, in cooperation with the VDE Testing and Certification Institute, and OneShore, the German Berlin-based SME that is specialized in the optimization of PV-diesel systems, have developed a standard for certifying load measurements and fuel saving calculations. "The ultimate aim is to help establish a project's bankability and investability by building up trust between project developers, investors, and financiers," Jonas Brückner, VDE Institute, says about the standard.

The standard describes the specific inputs, outcomes and steps necessary to be taken for load measurements that will serve as an input parameter for the sim-

ulation, which accurately calculates projected fuel savings in PV-diesel hybrid systems.

"The idea is to have a reliable, objective third party – VDE – to certify the measurements and projections of project developers in order to ease their struggle in attaining financing," Brückner explains.

The standard itself consists of four parts: 1) a procedure for load measurements and a methodology for extrapolation; 2) a definition of generator input parameters required for the simulation of hybrid power generation; 3) the definition of input parameters for storage devices (optional – in case these are part of the system); and 4) the fuel savings simulation itself, to which parts 1-3 constitute the inputs used. The accurate and comprehensive measurement of load data is the core of the simulation; therefore, the standard can only be applied to hybridization projects as opposed to greenfield power projects.

Furthermore, neither the standard nor the simulation tool serve to calculate the optimal sizing of a hybrid power project, nor does it certify the financial viability of a business plan or project. Rather, it validates that load measurements and extrapolation (part 1) have been done properly using thorough and complete input parameters (part 2 & part 3). It further ensures that the software used for calculating the fuel savings is capable of processing all parameters and data that have been defined as required in parts 1-3, and follows a defined set of stability criteria when calculating the fuel savings (part 4).

Photo: NREL/Warren Gretz

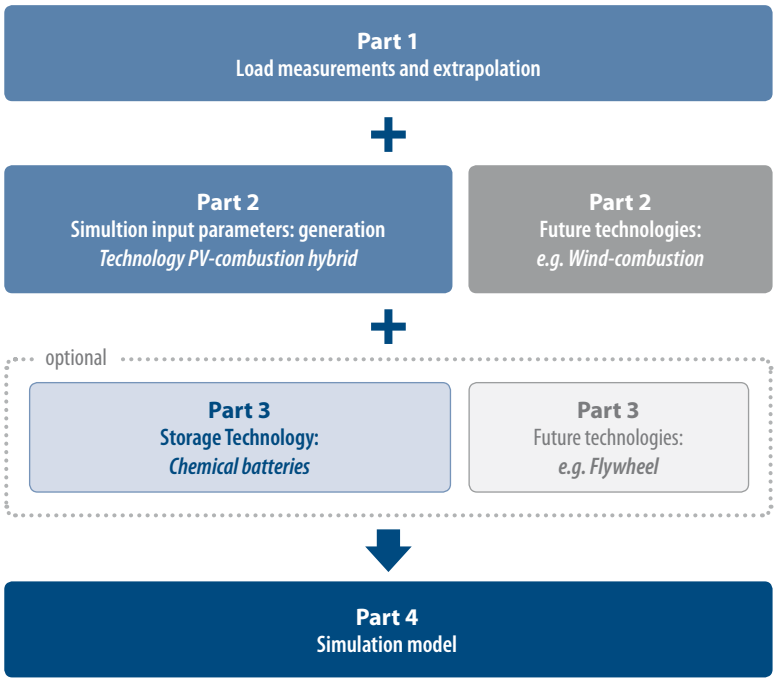
"The key to getting funding for a project is to present a solid case with transparent underlying parameters," Bittner explained, adding: "Especially from an investor's point of view, the issues of non-transparent input data and parameters, undeclared assumptions, and lack of a sensitivity rating for the assumptions made are obstacles in attracting financing for hybrid power generation projects." The basis of hybrid projects are the savings in fuel costs achieved. The standard is supposed to provide investors as well as clients with a transparent set of information, enabling them to evaluate the attractiveness of projects proposed as well as making them comparable to one another.

Because the standard can only fulfill its purpose if it is widely recognized and adopted, PDP is organizing a high-level kick-off event using the platform of the Off-Grid Power Forum of BSW, the German Solar Association, at the Intersolar Europe Exhibition in Munich, Germany, on June 22.

The session will present first project examples that made use of the standards and the experiences gained along the way. Furthermore, the awareness campaign for the standard will involve training workshops for banks located and operating in Southeast Asia and Sub-Saharan Africa. ◆

Franziska Kohler

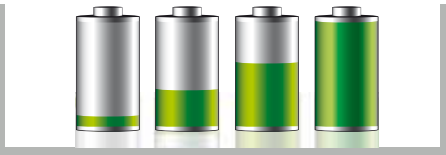
Standard development process



Source: GIZ

THE OFF-GRID POWER FORUM

The Off-Grid Power Forum of Germany's Solar Association, BSW, will be the platform of the launch of a new standard for fuel saving measurements in PV-diesel-hybrid systems. The standard aims to boost trust among clients and investors alike by ensuring proper data measurements, transparency, and comparability.



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pv magazine will once again have a sizable presence at the forthcoming Intersolar Europe exhibition in Munich, Germany: **Please visit our booth in A1, 340**, have a chat with us and enjoy pv magazine LIVE! – **our new video series.** The video output will be going into overdrive in Munich, editors will be out on the floor and interviewing exhibitors, the material will be broadcasted on our huge LED screen!

We are also delighted to co-host Schenker AG at our booth, you are very welcomed to swing by and have a chat with the Schenker crew about logistics!

DB SCHENKER

Innovation in focus: Installation Innovation Award – Europe

pv magazine is teaming up with Hanwha Q CELLS at the 25th Intersolar Europe trade show and conference in Munich this month, to turn the PV industry's attention firmly towards innovation right across the solar value chain.

See the pitching of the award nominees at Intersolar, discuss and help selecting the winner.

The "Installation Innovation Award – Europe" finalists will pitch their projects live at the Hanwha Q CELLS' booth (A1.270) at Intersolar in Munich, with the award winner picking up a trip for two to South Korea and an article featuring the project in the August edition of **pv magazine** global. Be sure to catch the pitches and learn about the power of innovation in serving end markets right across Europe. The winners will be selected by the audience and by online voting.

Highly innovative business models and new trends in the industry will also be brought into focus at the Hanwha Q CELLS' booth. **pv magazine** has curated a selection of presentations from European companies and solar experts boldly pushing the industry in new directions. Holland's ZonnepanelenDelen (We Share Solar) is one of the presenters and cofounder Sven Pluut will be outlining how harnessing the power of the crowd is opening up projects in the Dutch market. "In October 2014 we launched our platform through which we can finance solar energy projects," said Matthijs Olieman, Pluut's fellow cofounder. "So far we have raised €2.5 million for several projects."

Excitingly, ZonnepanelenDelen is beginning to partner with local municipalities, hoping to unlock their many municipal rooftops for solar, through engaging with individual micro-investors.

"We've signed a deal with the municipality of Rotterdam," Olieman explained. "That a municipality is willing to obtain financing from civilians who can also invest in these solar energy projects within the municipality is significant. Rotterdam can multiply by five times the small budget that they have for solar and install way more PV than they could have." Olieman adds that in a promising trend investors are returning to the ZonnepanelenDelen platform to re-invest in additional projects.

For the full overview of innovation presentations check out the Hanwha Q CELLS' booth at Intersolar Europe and also online at: www.pv-magazine.com

pv magazine editors in chief Michael Fuhs and Jonathan Gifford will be the MCs at the event and feel free to pitch your latest project or technology in person!

Photo: pv magazine/Patrick Alleyn

Intersolar Europe

Once again pv magazine will hold its annual, hotly anticipated booth party at Intersolar Europe in Munich on the evening of Wednesday, June 22 from 6 pm at our booth : there will be beer, music from DJ Sebastian Kidd, and an incredible opportunity to network with all of the leading players in the global solar PV industry - and to dance with our Solar Superheroes!

Third pv magazine quality Roundtable at Intersolar Europe

We continue wiping out the black sheep

pv magazine, together with our partners, are organizing another Quality Roundtable on the second day of this year's Intersolar Europe in Munich. We will kick off the Roundtable with a discussion among all participants about two "black sheep" cases. In the second part, the Roundtable will include presentations covering field test results and best practices along the value chain. It is obvious: Those that deliver high quality and sufficient reliability have to consider a range of factors holistically. We will also discuss with module manufacturers what they can contribute to the PV production bases in Europe and form closer ties to investors in the region. During a networking break, you will have the opportunity to meet other participants and personally exchange views on "black sheep."
Join our roundtable and to go into the running to win an Apple Watch.

When?
Thursday, June 23, 3 p.m. to 5:30 p.m.

Where?
Seminar room B13 (Hall B1, first floor) at Intersolar Europe exhibition floor

How?
Register at no cost for one of the 100 seats at: roundtable@pv-magazine.com
MCs: Jonathan Gifford, Michael Fuhs (editors in chief pv magazine)
Language: English

Program

14:45 Entry

15:00 pv magazine survey about strategy and quality as possible distinguishing factor for manufacturers with production in Europe

15:05 Forum 1: We continue wiping out the black sheep

15:50 Networking Break

16:15 Forum 2: How best practice compilations along the value chain can contribute to module quality
There will be a short presentation and panel discussion featuring the following esteemed members of the industry:

Harald Lackner, VP Sales & Marketing, Isovoltaic
Mischa Paterna, Managing Director, Suncycle
George Touloupas, Director of Technology and Quality, CEA
Stephan Padlewski, Marketing Manager, EMEA, DuPont Photovoltaic Solutions
Eric Ast, Head of Global Business Development Photovoltaics, Multi-Contact
*Moderation: Jonathan Gifford and Michael Fuhs (editors in chief, **pv magazine**)*

17:30 Event ends

Initiative partner:

Sponsor partners:

On the road with pv magazine

Where we're going: Intersolar North America (San Francisco, U.S., July 12-14, 2016)

The Intersolar North America exhibition returns once more to San Francisco's Moscone Center to take the pulse of the U.S. solar PV industry.

The 12 months that have passed since the last Intersolar North America gathering have been nothing if not exciting for American solar: From the ascendant rise of solar leasing providers and the emergence of affordable home and commercial storage systems, to the somewhat unexpected extension of the Investment Tax Credit (ITC) and the protracted demise of SunEdison, few could have predicted the dips, climbs and swerves of the U.S. 'solarcoaster.'

As 2016 passes its midway point, Intersolar North America offers the perfect opportunity to assess the first six months of the year and look ahead to what the summer, fall and winter months will bring. Will solar job creation continue to grow? How is the manufacturing landscape shaping up? Which states are looking to offer more supportive solar policies? And which might threaten to lay down even more hurdles for PV to face? These questions and more will be asked, deliberated upon, debated, and answered with the usual passion and aplomb on the exhibition floor, which the organizers say is likely to be busier than last year, which saw some 18,000 people pass through the doors across three days of intense networking.

Photo: Solar Promotion International GmbH

Sidling up to Intersolar North America once again this year will be ees North America – a leading gathering of storage companies keen to exhibit their solutions in what is expected to become a $3.1 billion industry by 2020. As always, the exhibition will be accompanied the three day conference (which runs on July 11-13), offering visitors the chance to attend presentations, roundtables and speeches relating to the current state of the U.S. solar industry, its future challenges, and genre-defining innovations.

www.intersolar.us

What we've seen: Jua's solar solutions

What problem do Jua's solar products solve?

Jua Solar's Matteo Villa: We often use several electronic devices during the day, and often run out of power when we need them most, and you might not always have a plug nearby or spare battery to hand. Jua was created to enable easy recharge and use of electronic devices in any situation, with sunlight.

For which markets are Jua products suitable?

The Jua 5 V USB is suitable for the entire global market through our e-commerce and distributor network. Jua's 5 V USB modularity and design makes it suitable for exterior designers in the U.S., Europe, and the Middle East.

Jua PAYGO 18 V is an off-grid system that provides solar power to autonomous dwellings, some commercial buildings, small colleges and first aid centers and other places that do not have access to electricity.

It removes the up-front price barrier of distributed solar products by enabling off-grid customers to prepay for clean energy in affordable amounts. The system will be rolled out in Ethiopia, Ghana, Nigeria, and Mozambique in the fall, with an innovative remote control system with social integrations to be unveiled next year.

Photo: Jua Solar

What is unique about the product?

Jua Magnetic Photovoltaic Systems are made using premium silicone and next generation cells in order to guarantee long-lasting panels with unparalleled efficiency. The vast majority of similar products consist of a battery that is slowly charged, and when exposed to the sun for several hours will deteriorate prematurely. Jua is battery-free and works anywhere under the sun. The panels come with powerful magnets: They can be easily attached to any metal object, like poles, boards, bikes, and railings. The panels can also be attached to the roof of a car: The magnets are guaranteed up to a speed of 130 km/h. A single panel ensures clean power to 4.2 watts and 6 volts.

To keep up to date with **pv magazine**'s monthly whereabouts, visit: **www.pv-magazine.com**

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The next issue will be published on July 1, 2016

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Mexico auctions

As the Mexican government begins its renewables push, we take a look at the auction process and PV's place within it.

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Tracker market update

The growth of the tracker market promises higher yield and more cost competitiveness in a number of regions.

Photo: Possible/Flickr

PV and storage

Batteries are becoming an ever-greater companion to a variety of solar installations, from rooftop to larger scale.

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