Volume 14
PV POWER PLANT TECHNOLOGY AND BUSINESS
February 2018

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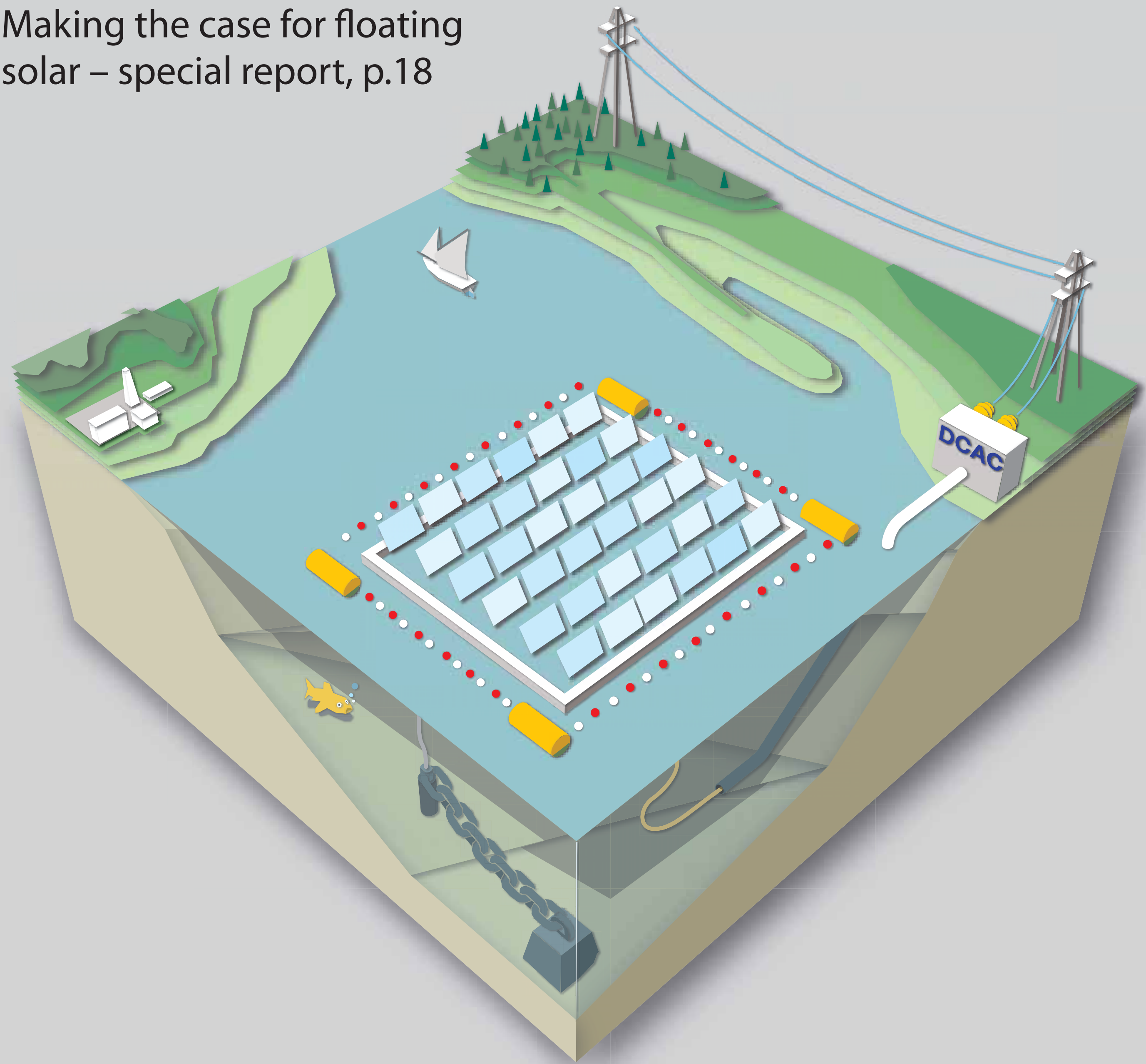

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About LONGi Solar

A world leading mono-crystalline solar module manufacturer for achieving best LCOE (levelized cost of electricity) solutions.

LONGi Solar is a world leading manufacturer of high-efficiency mono-crystalline solar cells and modules. The Company is wholly owned by LONGi Group. LONGi Group (SH601012) is the largest supplier of mono-crystalline silicon wafers in the world, with total assets above $2.7 billion. (2016)

Armed and powered by the advanced technology and long standing experience of LONGi Group in the field of mono-crystalline silicon, LONGi Solar has shipped approximately 2.5GW products in 2016. The Company has its headquarters in Xi'an and branches in Japan, Europe, North America, India and Malaysia.

With Strong focus on R&D, production and sales & marketing of mono-crystalline silicon products, LONGi Solar is committed to providing the best LCOE solutions as well as promoting the worldwide adoption of mono-crystalline technology.

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LONGi Solar

POWER PVTECH

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Introduction

Welcome to the first 2018 edition of *PV Tech Power*. The focus of our cover story is an area that has been exciting the editorial team here at PV Tech Towers for some time. Floating solar presents an entirely new pillar of solar deployment, as discussed at length by the Solar Energy Research Institute of Singapore (SERIS). Having organised the first dedicated conference on the subject and as patrons of a 1MW test site with no fewer than 10 different configurations, SERIS is extremely well placed to put the sub-sector's rapid development in context (p.18). In the pages following SERIS we explore four floating PV case studies from India, Malaysia, The Netherlands and the UK (p.24). It's a subject area PV Tech will be returning to frequently this year, online and in the pages of this journal.

In our Market Watch section we have expert coverage from Apricum of the booming Chinese market, exploring how the country's vast demand, the so-called 'hungry dragon' (p. 32), will be satisfied in 2018 and beyond.

With PV Expo returning to Tokyo this quarter, Japan's RTS consultancy provides an update on a market that, despite its challenges in recent years, continues to represent a multi-GW opportunity (p.36).

Off the back of four years of research, a consortium led by TÜV Rheinland, discusses elective quality assurance (p.70) – specifically how a series of common module faults can impact on the yield and financial performance of a project in the long term. The authors work through some of the key metrics to monitor and the risk mitigation strategies to protect the output of a system.

ISC Konstanz presents a technical paper assessing how to measure bifacial gains and, crucially, how those then translate into real-world system improvements and LCOE reduction (pp. 64). This area is at the crux of the work required to standardise bifacial solar en route to routine bankability.

On the softer side of project development, we look explore an international effort to standardise O&M contracts (p.82). With both parties given a common template to base negotiations around, it is thought that the time taken to agree a deal could be cut from months to weeks.

In our regular Storage & Smart Power section (p.94) we take a look at the growing case for commercial and industrial energy storage projects, a market that has proved elusive for the solar industry in a number of territories.

The PV Tech team will be at all the major industry events in the coming months including our own PV CellTech event in Malaysia where manufacturers will lift the lid on latest cell technology improvements coming down the pipe. We look forward to meeting you there.

John Parnell
Head of content

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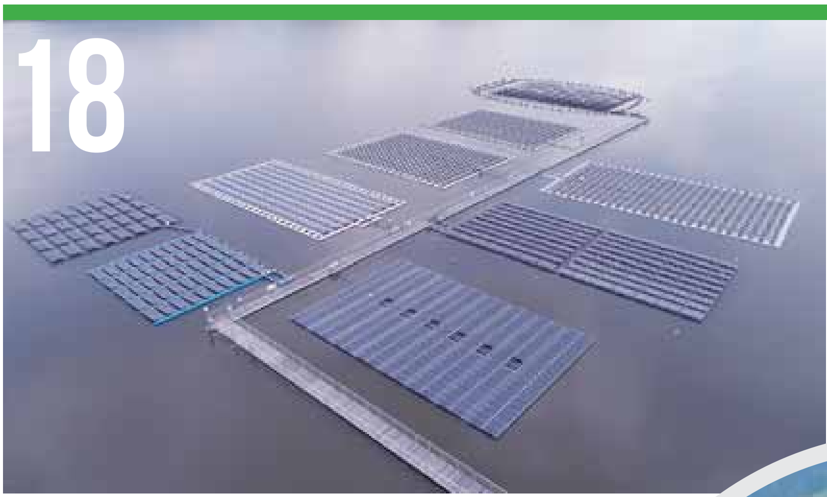

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EUROPE

Tender

France awards 73MW solar 'innovation' capacity and 508MW large-scale

France has awarded 73MW of solar 'innovation' capacity promoting floating solar, new forecasting software, solar greenhouses and bifacial modules, as well as divvying out another 508MW under its large-scale PV programme. The Ministry of Ecological and Solidarity Transition tendered for 70MW of solar innovation back in 2017, as part of a three-pronged 210MW plan. The winners of this first application period had an average price of €80.7/MWh. A second 70MW innovation tender will close on 1 October. Awards were made for new integration designs, component innovations, system innovations, as well as advances in optimization and electrical operation of projects. The ministry also awarded 508MW of large-scale solar to 77 players – the third 500MW allocation out of a 3GW plan comprising six application periods. This time the average price was €61.6/MWh, down nearly 4% from the previous period in July 2017, where the average price was €63.9/MWh. The highest capacity projects in the 5-17MW range had an average price of €55.3/MWh, down slightly from the previous rounds average of €55.5/MWh. More than half of the projects will be located on degraded land such as landfills and old quarries. The fourth large-scale application period for 720MW will take place on 1 June this year.

Credit: Neoen

Module Supply

SolarWorld Industries to supply Turkish EPC with 60MW of mono-PERC modules

Credit: SolarWorld Industries

German-based monocrystalline PERC (Passivated Emitter Rear Cell) PV module manufacturer SolarWorld Industries is shipping a total of 60MW to Turkey-based EPC firm, Inosolar, in the first half of 2018. SolarWorld Industries had initiated an exclusive partnership with Inosolar, which was a former customer of defunct SolarWorld AG. Dr.-Ing. E.h. Frank Asbeck, managing director of SolarWorld Industries GmbH, said: "Inosolar is a loyal and extraordinarily capable partner. We're looking forward to cooperate exclusively with Inosolar to supply the growing Turkish market. Jointly our two companies will contribute to making energy supply in Turkey more sustainable."

First Solar provides modules for one of world's largest thin-film rooftop projects

Credit: Zorlu

Zorlu Solar, an arm of Turkish industrial conglomerate Zorlu Holding, has delivered Series 4 modules from US-based manufacturer First Solar to one of the world's largest rooftop solar project using thin-film technology, located in Turkey. All the thin-film modules were installed on just one roof, making it the largest thin-film rooftop solar project on a single building. The new 10MW project is owned by Tosçelik ERW Pipe Production Facilities and located in Osmaniye Organized Industrial Zone in southern Turkey. EPC firm Smart Solar built the project and connected it to the grid recently. Zorlu Solar delivered 85,000 of First Solar's high-performance thin-film solar modules for the project, which will cover for 30% of the annual power requirement of Tosçelik ERW Pipe Production Facilities.

Shell to become single off-taker of largest solar farm in England

Shell Energy Europe has signed an initial five year power purchase agreement (PPA) with British Solar Renewables (BSR) to take power generated at England's largest solar farm at RAF Lyneham. The utility will become the sole off-taker for the 69.8MW Bradenstoke solar power plant, which generates approximately 65GWh of clean solar energy on an annual basis following its completion in March 2015. It is the largest solar farm to have been developed in England and is second-largest in the UK only to the Welsh 72.2MW Shotwick site, which had been developed by BSR and is now owned by Foresight. BSR, which manages and operates the site on behalf of owner Siem Europe, organised the deal in its capacity as manager of the solar farm utilising its past interactions with Shell to bring the deal together. Shell is also developing a 20MW solar plant at Moerdijk in the Netherlands where it runs one of Europe's largest petrochemicals manufacturing sites. The project, set to include more than 50,000 solar panels, is being developed by Shell New Energies Business. Construction is scheduled to begin this year on an unused land area and Shell Moerdijk, the petrochemical product producer, will offtake power from the plant once completed.

Polski Solar starts constructing 10MW Poland PV project with deer image

Polish PV project developer Polski Solar has commenced construction on a 10MW PV project near Jelenia Gora in southwestern Poland. The Jelenia Gora project will feature the image of a deer by using black colored monocrystalline and blue-colored polycrystalline solar panels. The image was selected as a visual representation for the town of Jelenia Gora, which means "Deer Mountain" in Polish. The installation will be developed over 22 hectares of land and will be comprised of 30,000 solar panels. Once completed, the project can generate enough energy to power 4,500 households. Expansion is already planned for the PV project, with up to 3MW in installed capacity expected to be added to the installation.

TIU Canada commissions 10.7MW PV project in Ukraine

TIU Canada has commissioned a 10.7MW PV projecti n Nikopol, Ukraine. The installation stands as the first investment from the Canadian side under the Canada-Ukraine Free Trade Agreement (CUFTA) in Ukraine, which started in August 2017. Construction on the installation began in late May 2017 and the total investment in the project is tabbed at around US$13 million. The station is comprised of 32,304 solar panels, with 392 inverters installed to manage the power output.

Aquila Capital acquires 170MW PV pipeline in Portugal

German investment company Aquila Capital has acquired four PV projects in central and southern Portugal that will boast a combined generation capacity of 170MW. Construction on the four installations is expected to be completed by the end of 2018. Aquila Capital was attracted to the four projects due to the low costs of the systems and good conditions at the four project sites. As part of the transaction, Aquila Capital entered into a power purchase agreement with a third party for the energy produced by the four installations.

AMERICAS

Projects

Capital Dynamics and Switch team on 1GW PV power plant in Nevada

Asset management firm Capital Dynamics, which has just acquired the First Solar and SunPower solar yieldco firm, 8point3 Energy Partners is to own and operate a planned 1GW PV power plant in Nevada, which includes technology infrastructure firm Switch as a major customer for the renewable energy and is based in the state. "The foundation of Gigawatt Nevada is that Nevada should harness the sun the same way Alaska harnesses its oil to significantly benefit all Nevadans," said Rob Roy, CEO, Switch. "Nevada enjoys the best solar window in the nation and so we Nevadans should not only be using solar for ourselves, but exporting it throughout the Western US to create new jobs, tax revenue, economic diversification, and raise energy independence." Switch noted that the assets would be owned and developed by Capital Dynamics, the second largest owner of solar projects in the country, according to BNEF.

EDF Energies Nouvelles commissions second large PV power plant in Chile

Renewable energy firm EDF Energies Nouvelles said it had commissioned its 115MWp Santiago Solar PV power plant in Chile. The Santiago Solar PV power plant is EDF Energies Nouvelles' second largest in Chile, having completed the 146MWp Bolero plant in late 2017. The latest completed plant is located around 50 km north of country's capital and has deployed around 400,000 PV modules and occupies over 200 hectares of land. EDF Energies Nouvelles said the Santiago Solar plant held a 15-year power purchase agreement (PPA) with Chile's main distributors with an unspecified amount of electricity being sold through Chile's electricity spot market.

SunPower commissions 100MW PV project in Chile

Michelle Bachelet, the president of Chile, and Chile's minister of energy, Andrés Rebolledo, held a ceremony to inaugurate the

Section 201

Timeline of the fallout

Credit: Flickr/Evan Guest

22 January

President Trump reveals 30% tariffs on cells and modules.

The SEIA responds immediately and estimates that as many as 23,000 people could lose their jobs.

23 January

Trump signs the Section 201 orders saying: "We'll be making solar products now much more so in the United States. Our companies have been decimated, and those companies are going to be coming back strong."

GTM and Deutsche Bank analysis estimates a module price increase of 9-10 cents per Watt.

Texas-based Mission Solar announces it will recruit an additional 50 staff as part of an unspecified expansion.

24 January

The start date for the 30% tariffs is confirmed for 7 February.

26 January

As previously threatened, South Korea becomes the first of many countries to complain to the WTO.

29 January

The US confirms the list of exempt countries free to import a collective 900MW annually and no more than 300MW each. NAFTA partner Canada is not on the list.

JinkoSolar announces a 1.75GW US supply deal increasing speculation that it was the company awarded grants to build a factory in Florida.

31 January

Taiwan lodges complaint with WTO.

7 February

China requests a consultation with the US on the tariffs and specifically cites discussions around "compensation". At the time of writing, Chinese-made products were liable for both the safeguard duties and anti-dumping duties.

The EU requests a consultation.

12 February

Singapore joins the chorus of complaints to the WTO.

Canadian manufacturers launch a lawsuit against the US government and insist on an exemption.


Credit: Flickr/Luke Price

100MW El Pelícano solar power plant in the Chilean region of Coquimbo. The project is owned by SunPower and was developed on 186 hectares of land in La Higuera. Now operational, the 100MW PV installation generates enough electricity to meet the energy needs of an average of 120,000 Chilean homes. Electricity generated by the site will be used to support the Metro system of the Chilean capital, Santiago.

Finance

First Solar and SunPower agree sale of yieldco

First Solar and SunPower have agreed to sell their Joint Venture solar power plant yieldco, 8point3 Energy Partners, to energy investment firm Capital Dynamics, Inc., for US$977 million in equity value and about US$1.7 billion in enterprise value in an all cash transaction. First Solar had kick-started the sale of the yieldco after a change in its business focus, back to primarily selling its Series 4 modules and after a transition to its Series 6 modules with less emphasis on its downstream project business. The transaction could be completed in the second or third quarter of 2018, according to management in a conference call to discuss the acquisition by Capital Dynamics, which has an existing portfolio of solar and wind assets. The JV partners said that the search for a buyer through a competitive marketing process resulted in more than 130 parties contacted to find a buyer.

MIDDLE EAST & AFRICA

Finance

Africa Development Bank plans 10GW of solar across the Sahel by 2020

The Africa Development Bank (AfDB) is planning huge developments in grid-connected and off-grid solar to support countries in electrification and mitigating climate change across the Sahel region by 2020. As well as offering to support African countries insuring themselves against weather disasters, the bank will use its Desert to Power initiative to help develop 10GW of solar power projects across the Sahel region. This is expected to supply power to 250 million people, with 90 million of these provided through off-grid systems. The bank has already financed development of a 50MW solar power system in Burkina Faso. As part of that financing, the AfDB is also supporting the North Dorsal electrification project, which will connect Burkina Faso with Nigeria, Nigeria and Benin.

IFC, Canadian government announce partnership to spur renewable energy in Africa

IFC, a member of the World Bank Group, and the government of Canada have formed a financial partnership that will utilise public funding to generate private sector investments to spur renewable energy in Sub-Saharan Africa. The programme, known as Canada-IFC Renewable Energy Program for Africa, will feature the Canadian government contributing US$122 million that the IFC will use to catalyze private sector investment in renewable energy by offering concessional financing mixed with IFC's own account resources to mitigate a variety of risks that can deter private investment in renewable energy.

ACWA Power secures financing for 165.5MW project in Egypt

ACWA Power reached financial close on three solar PV projects under round two of Egypt Feed-in-Tariff program II – with the three installations boasting a generation capacity of 165.5MW. The total project cost is US$190 million – of which 75% is financed through a non-recourse project debt from the European Bank for Reconstruction and Development and the Industrial and Commercial Bank of China. The three projects, located in the Aswan Province at Benban, Egypt, will have a respective capacity to generate 67.5MW, 70MW and 28MW as individual projects. Construction on all three projects will commence in the first quarter of 2018. ACWA also closed on a closing on a 61.3MW PV project that it is developing in the Risha region of Jordan.

Akuo Solar secures financing for 50MW solar project in Mali

The West African Development Bank (BOAD), Emerging Africa Infrastructure Fund (EAIF), the National Bank of Agricultural Development of Mali (BNDA), Green Africa Power (GAP) and GuarantCo have agreed to finance a 50MW PV project in Mali. The financing of roughly US$94.8 million will be used to develop the project, which will be built under a Build-Own-Operate and Transfer (BOOT) contract by local company Akuo Kita Solar SA, a subsidiary of French IPP Akuo Energy.

Procurement

JA Solar's mono PERC panels used in Negev Desert PV power plant

JA Solar was the sole supplier of PV modules to a 35MW PV plant completed in December 2017, in the Negev Desert using its P-type mono PERC (Passivated Emitter Rear Cell) modules. The Ashalim project in Israel is being developed by EDF in collaboration with Israeli renewable energy company, Clal Sun, with Belectric as EPC. The project includes a total of 250MW of solar assets, combining solar thermal energy and PV.

Saudi Arabia

ACWA wins 300MW Saudi project despite being outbid by Masdar

Credit: Flickr/Freestock

Local firm ACWA Power has been awarded the 300MW Sakaka solar project in Saudi Arabia by the country's Renewable Energy Project Development Office (REPDO). Representatives from ACWA Power will sign the power purchase agreement (PPA) for one of the lowest ever solar tariffs of Halala 8.7815/kWh (~US$2.342) with the principal off-taker, the Saudi Power Procurement Company (SPPC), on 7 February in Riyadh. The project is to reach financial close by 28 February 2018 and start commercial operation in 2019. H.E. Khalid Al Falih, minister of energy, industry and mineral resources, said: "The project is expected to involve a total private sector capital investment of about US$300 million and will create job opportunities for more than 400 individuals. When the National Renewable Energy Program was launched last year, we set a goal to make it among the most attractive and well-executed government renewable energy investment programs in the world. After a competitive and transparent tendering process, which saw us receive two world record-breaking bids, we can confidently say that we are well on our way to making that a reality." ACWA and a Marubeni-led consortium were the last two players left in the running, despite Masdar and EDF putting in the lowest ever solar bid during the opening bids last year. There was wide industry speculation that the Masdar bid proposed using bifacial modules and was rejected as the tender rules required proven technology.

NEXTracker supplying trackers to largest PV power plant in Egypt

NEXTracker is to supply its single-axis trackers to the largest PV Power plant in Egypt with a total capacity of 325MW. EPC firm Sterling and Wilson is building the plant at the Benban solar park in Aswan, Egypt. NEXTracker is supplying its NX Horizon single-axis tracker to the project, which will have five blocks of 65MW each.

Credit: NEXTracker

NEXTracker has now shipped 10GW of trackers worldwide.

Recommended 70% safeguard duty would 'derail' India's National Solar Mission

Credit: ReNew Power

A preliminary recommendation from India's Directorate General of Safeguards Customs and Central Excise to impose a provisional 70% safeguard duty on solar cells imported from China and Malaysia was branded as ridiculous and potentially catastrophic, by PV industry members. The proposed duties would apply to cells, whether or not assembled in modules, and would last for 200 days. This is only a very early-stage proposal and it must go through a public hearing and the Ministry of Finance has the final say before being imposed. Industry members expect the 70% to either be reduced significantly or for the proposal to be transformed into some form of anti-dumping duty targeting specific countries. The value of cell imports from China and Malaysia is US¢14-15/W. A 70% duty on this comes to ~10.5 cents. Thus, with the landed cost of imports from Chinese tier-one manufacturers at US¢34-35/W, the final cost will be in the range of US¢45/W. Other nations, including Taiwan, which is under investigation in a separate Anti-Dumping case, will not be subjected to the safeguard duties because none of them individually account for more than 3%, nor 9% collectively, of total imports to India.

Oman

Oman launches 500MW large-scale tender

Oman confirmed a competitive tender for a 500MW PV project. The development will be run on a build, own, operate basis following the independent power producer (IPP) model that has been successful in other regional markets. Private investment of around US$500 million is being sought. The site is in Ibri, 300km west of the capital Muscat. The Oman Power and Water Procurement Company (OPWP) is aiming to award the contract in Q4 2018 with completion targeted for 2021. "The project will be the first in the chain of renewables projects that the company is planning to develop in the coming few years to support the sustainability approach of the country," said Hamdan Ali Al Hinai, chairman, OPWP.

Oman oil and gas firm plans tender for 100MW solar project

Oman's state-owned oil and gas company Petroleum Development Oman (PDO) issued an Expression of Interest (EOI) document for its first renewable energy project, a 100MW(AC) solar farm to be built in the southern region of the country. Once tendered, the successful bidder will be responsible for the design and financing of the project to be delivered at Amin, approximately 210 km north west of Salalah. Following an 18 month construction phase, PDO will become the sole off-taker under the project, with the successful bidder responsible for operation and maintenance of the site for the 23 year term of the power purchase agreement

ASIA-PACIFIC

India surpasses 20GW of solar

India has reached 20GW of cumulative solar installations, with 18.4GW in utility-scale and 1.6GW in rooftop solar, according to Mercom India Research. It is also possible that the milestone was reached earlier. Consultancy firm Bridge to India provided its latest figures noting that up until December 2017 India had installed 19.3GW of utility-scale (17.3GW) and rooftop projects (2GW). Moreover, India had also installed 566MW of off-grid solar as of March 2017, according to the Ministry of New and Renewable energy (MNRE). Adding all of these together, India's installed capacity was very close to 20GW by the end of 2017.

INDIAN TENDERS

Besides a disappointing budget that barely mentioned renewables, India has seen an unprecedented flurry of solar tendering through the end of December and the first two months of the year. They included:

January

- SECI - 2GW of inter-state transmission system (ISTS)-connected solar projects anywhere in India.
- Uttar Pradesh New and Renewable Energy Development Agency (UPNEDA) - 1GW of grid-connected solar projects.
- SECI - 750MW at the Kadapa Solar Park in Andhra Pradesh
- SECI – 200MW at Pavagada Solar Park, Karnataka
- SECI - 275MW at the Uttar Pradesh Solar Park, Uttar Pradesh.

February

- Gujarat Urja Vikas Nigam Limited (GUVNL) - 500MW, with an extra 500MW capacity for those happy to match the lowest tariff
- SECI - 70MW solar project in Assam
- KREDL awards 760MW of solar in auction with lowest price of INR2.94/kWh (US$0.046)

Far East

China's solar market to cool in 2018 as global demand edges over 106GW

Taiwan-based market research firm, EnergyTrend expects Chinese end-market demand to contract slightly in 2018, after posting record installations for several years in a row and accounting for around 50% of global solar installations in 2017. EnergyTrend expects the Chinese market to slow down in 2018 through to 2020. Total annual grid connections, including ground-mounted projects, Distributed Generation, PV Poverty Alleviation and Top Runner projects combined would reach 46.7GW in 2018. China installed 52.83GW in 2017, retaining its dominant position. India was said to have surpassed Japan as the third largest market, installing 9.26GW, compared to Japan's 6.09GW.

Neo Solar Power's mono PERC bifacial modules selected for 100MW PV plant in Taiwan

Credit: Taipower

Taiwan-based merchant PV manufacturer and downstream project developer Neo Solar Power Corporation (NSP) has been selected to provide its 'Glory BiFi' mono PERC bifacial modules to Taipower's ChangHua 100MW solar system project, potentially the largest plant to use bifacial modules to date. State-run utility Taiwan Power Co (Taipower) has held a ground-breaking ceremony for the plant at Chuanghua Coastal Industrial Park, Changhua County, which included the planned installations of around 339,000 solar panels at a cost of approximately US$211 million. Chunghwa Telecom won the bid for the project and NSP has signed an exclusive module supply agreement with the developer, using its bifacial modules, which automatically use the glass/glass format and can deal with the local harsh environment, which includes high salinity and humidity and the sandblasting effect caused by winter monsoons.

Giant 480MW Japan solar plant plans refreshed with five new participants

Plans for a colossal 480MW solar project in Japan have received a boost with the original three developers announcing another five participants. Kyocera, Kyudenko, and Mizuho Bank had been jointly investigating the possibility of the project at on the island of Ukujima, at Sasebo City, Nagasaki Prefecture, since June 2014. They are now being joined by Tokyo Century, Furukawa Electric, Tsuboi, The Eighteenth Bank and Thailand's leading PV developer SPCG. Feed-in tariff (FiT) rights will be transferred to a newly established special purpose company named 'Ukujima Future Energy Holdings G.K.' The new JPY200 billion (~US$1.8 billion) Ukujima Mega Solar Project will include roughly 1.65 million Kyocera high-output multicrystalline PV modules.

Australia

Canadian Solar partners with Photon Energy to develop 1.14GW of solar in Australia

Silicon Module Super League (SMSL) member Canadian Solar has partnered with Amsterdam-headquartered Photon Energy NV to co-develop five utility-scale solar power projects, with a total capacity of 1.14GW in New South Wales, Australia. Under the agreement, China-based firm Canadian Solar will acquire a 51% shareholding in each of Photon Energy's five project companies in Australia, which are working across the projects. They include a 316MW project in Gunning, which is fully owned by Photon Energy, as well as four projects co-developed by Photon Energy and Polpo Investment: 178MW in Mumbil, 165MW in Gunnedah, 286MW in Suntop and 196MW in Maryvale.

Australia on track to hit Renewable Energy Target

Credit: Synergy and GE Energy Financial Services

Australia will meet its 2020 Renewable Energy Target (RET) of 33,000GWh of additional generation, according to the Clean Energy Regulator (CER). CER had originally calculated that to meet the target, roughly 6GW of large-scale renewables capacity would have to be built between 2016 and 2019. The nation is already ahead of schedule. Around 6,532MW of new large-scale capacity has been announced since 2016 (46% of which is solar), with 4.9GW now financed and much of this already under construction or operational. The remainder is set to start construction early this year. There are a further 1.6GW of projects that have power purchase agreements (PPAs) in place that CER expects to reach financial close.

South and Southeast Asia

Besieged regulator causes 'collateral damage' to Philippines solar industry

Filipino energy secretary Alfonso Cusi has euphemistically admitted that the suspension of four commissioners of the Energy Regulatory Commission (ERC) may cause delays in power projects, while the already inert solar sector has seen conditions go from bad to worse. The suspensions have in fact brought the entire power industry to a standstill, not only delaying renewable energy projects, but also impacting a long list of pending policy mechanisms that support alternative energy sources. The ERC is unable to approve any PPAs and even generation licenses until new commissioners are appointed. Such delays are also causing collateral damage to a handful of solar projects as well as to regulations that would supposedly sustain the PV market beyond the feed-in tariff (FiT) that ended in 2016.

Vietnam provinces improve solar environment

Several provincial authorities in Vietnam are developing guidelines for renewables that should improve the country's solar market, but stubbornness from the monopoly utility EVN means that the largest-scale projects remain the preserve of risk-takers. The central government has its own National Master Plan for solar, including a feed-in tariff (FiT) and much-maligned solar PPA template. However, now some authorities have also formed their own renewables master plans, along with guidelines, and adopted regulations for selection of project developers. The provinces of Ninh Thuan, Binh Thuan, Binh Dinh, Binh Phuoc have all started developing their own PV development plans. For example, Thanh Hoa Province has issued a list of four PV projects with total capacity of 280MW that are to be prioritised for development.

Product reviews

Inverter | ABB's PVS-100/120 inverter range reduces PV system capex and opex costs

Product Outline: ABB has introduced a range of cloud-connected, three-phase string inverter solutions that are claimed to reduce both upfront capital expenditures (capex) and operational expenditure (opex).

Problem: PV installers and developers continue to demand cost reductions in both capex and opex to meet the increasing shift to competitive bidding of renewable energy migration. Pressure on reducing the levelised cost of electricity (LCOE) from PV plants remains a priority.

Solution: Overall the new range of PVS-100/120 solar inverters optimises total cost of ownership, to include a 50% reduction in installation and logistics costs as fewer inverters are required to complete the optimal power block and the PVS-100/120 brings to market a solution which is claimed to have the largest power capacity for 1,000VDC string inverters. Greater capacity is provided through its six MPPT input configuration, which increases PV plant design flexibility while preserving yields in complex installations.

Applications: Suitable for both large-scale commercial and industrial ground-mounted and rooftop applications.

Platform: PVS-100/120 solar inverters have smart product design features that include secure access via a cover key, PV quick connectors and configuration via Wi-Fi to eliminate the risk of water ingress and further reduce the installation time for cabling, fuse and SPD checks. Proactive control and management of the solar plant is provided through 'ABB Ability' with remote monitoring capabilities, parameter setting and firmware (FW) updates to improve reliability and operational cost efficiencies with reduced plant complexity.

Availability: February 2018 onwards.

Inverter | Enphase's 7th-generation microinverter uses single hardware SKU worldwide

Product Outline: Enphase Energy has launched its seventh-generation 'Enphase IQ' microinverters for the Enphase Home Energy Solution with 'IQ'.

Problem: A key challenge with microinverters is meeting a multitude of grid requirements that differ around the world, resulting in multiple product platforms and specifications or limited market penetration, which in turn impacts production costs thus limiting adoption.

Solution: The seventh-generation IQ microinverters are powered by Enphase's unique software-defined architecture which results in an efficient design, and a single hardware SKU worldwide. The 'IQ 7' microinverters are claimed to produce 4% more power, and are 19% lighter and 17% smaller than the IQ 6 models. They offer the same ease of installation with only two-wire cabling, and leverage semiconductor integration for higher reliability and better economies of scale.

Applications: Residential, commercial, utility-scale PV power plants.

Platform: The 250W AC Enphase IQ 7 Micro and the 295W AC Enphase IQ 7+ Micro will be followed by a new, high-power 320W AC variant, the Enphase IQ 7X Micro, to address 96-cell modules. Enphase IQ 7X Micros are expected to be introduced in the second quarter of 2018. Greater reliability is achieved via BOM reduction enabled by a new 55nm ASIC chip.

Availability: Enphase IQ 7 microinverter is to be phased into markets around the world through the first half of 2018.

Products in Brief

Ideal Power's 'SunDial' and 'Stabiliti' power conversion products gain UL 1741 SA certification

Ideal Power has said its next-generation 'SunDial' and 'Stabiliti' series power conversion products have met all the safety, performance, reliability and grid support requirements for UL 1741 Supplement A (SA) certification now required by the California Public Utilities Commission (CPUC). Other states with high solar penetration and distributed generation are requiring or expected to require UL 1741 SA or similar regulations. The SunDial and Stabiliti products are compatible with leading battery technologies, providing peak demand management and offering applications for AC microgrids, DC microgrids and backup power.

SMA Solar and Tigo team on TS4 rapid shutdown solution

SMA Solar and Tigo have announced support of a new SunSpec-compatible module-level rapid shutdown unit, the TS4-F (Fire Safety). The new rapid shutdown solution is a cost-effective way to fulfill UL 1741, NEC 2014, and NEC 2017 requirements – especially the stricter requirements for inside the array boundary that will be effective from January 2019. It will be compatible with the power line-based SunSpec Communication Signal for Rapid Shutdown, using the existing DC wires between the inverter and module-level electronics as a communication channel to significantly reduce installation time.

Product reviews

O&M | FTC Solar releases Atlas software solution for centralised PV power plant O&

Product Outline: FTC Solar has released its proprietary Atlas portfolio management software solution. Formerly known as SAM (Solar Automation Module), Atlas provides developers and asset owners with a "one stop shop" solution to manage all solar projects on one centralised platform.

Problem: Solar PV developers and asset owners need one centralised source of 'truth' for project documentation, stage gate approval processes and financial reporting.

Solution: Atlas spans the entire solar project life cycle, from an identified opportunity through project completion and O&M. The software platform allows the user to organise and manage their project portfolio around all critical reporting and tracking functions. Atlas includes programme management, financial reporting and data management modules that enable clear, consistent project execution from early stage development through to commercial operation. The Atlas portfolio management solution can be customised to suit each customer's unique needs and integrate with existing accounting and reporting systems, as well as supporting data import from multiple data sources.

Applications: PV power plant project life cycle management.

Platform: Atlas is available on hosted FTC Solar servers or can be delivered locally on customer managed infrastructure. Atlas organises projects in critical areas: project scheduling/task management, budgeting, cash flow forecasting, demand planning for modules/inverters/structures, and asset management. A project document repository with version control and quick custom reports generation is provided.

Availability: FTC Solar's Atlas portfolio software is available for demonstration and free trial.

Inverter | GoodWe DNS inverters ergonomically designed for higher levels of home safety

Product Outline: GoodWe is rolling out the new DNS series inverters aimed at solar power generation in residential homes.

Problem: Sharp corners and edges are common household hazards that must be taken into consideration, especially when children are around. Conventional sharp-edged inverters also represent a further risk during installation and maintenance, significantly increasing the likelihood of sustaining an injury. Furthermore, some designs are often seen as unattractive or too industrial because aesthetics is not always taken into account when developing a solution for household power generation.

Solution: GoodWe DNS series inverters feature an optimised, ergonomic design

which is not only convenient for installation and service, but also provides a low-profile electrical system that is safer to manipulate and overall home friendly regardless of location. With power categories ranging from 3kW to 6kW, GoodWe DNS series inverters are a perfect match for eco-friendly residential installations thanks to their die-casting aluminum casing, compact size and light weight. They are IP65 rated and can be mounted either indoors or outdoors. GoodWe DNS series inverters also feature a secure plug-and-play installation without opening the inverter and an integrated DC disconnect switch. Low start-up voltage of only 120V and the widest MPPT voltage range of 80-550V provides high flexibility for system configuration.

Applications: Residential PV systems.

Platform: GoodWe DNS series are designed for today's high-output PV panels, enhanced to meet the latest grid compliance standards while providing unprecedented power and dual, independent MPPT.

Availability: Currently available across multiple country markets.

Products in Brief

High-performance harsh environment solar panels from AUO

AU Optronics Corp is offering 72-cell high efficiency N-PERT mono-crystalline module and the 310W P-PERC monocrystalline modules, specifically targeting a range of harsh environments such as high humidity and salt mist. Both of these new products have a 12-busbar design, which enhances power efficiency and higher ability to resist micro cracks within solar cells. The N-PERT mono module has a power output of 395W and is designed for floating and ground-mount power plants. The humidity-resistant capability of the module parts has been raised by over 40%, and salt mist resistance is also claimed to be 12 times higher than the industry average.

GET'S VPC certified lightweight module provides project flexibility

Green Energy Technology (GET) has developed a VPC-certified lightweight module that has advantages of high-efficiency, fire prevention, non-reflection and resistance to severe winds reaching level 17 (Typhoon) and earthquake reaching level 8. The module can be part of the structural support of a building and integrated with lighter steel construction to save materials and costs. Lightweight solar modules can also reduce the temperature of top floors of buildings by 3-5°C, saving about 18% of air conditioning electricity consumption. Other applications include agricultural greenhouses, scaffolding and floating solar.

Product reviews

Inverter | SMA Solar's Sunny Central 2750-EV-US increases power density and integration

Product Outline: SMA Solar has introduced the latest Sunny Central 2750-EV-US inverter, which is said to have 10% more power than previous models enabling maximum power density and integration. The Sunny Central 2750-EV-US has also achieved UL 62109 listing.

Problem: There is a growing trend in the US and other major markets to adopt higher-voltage PV utility-scale systems, which enable longer strings and allow for fewer combiner boxes, less wiring and trenching, and therefore less overall components and installation time, reducing BOM (Balance of System) costs and lowering the LCOE (Levelized Cost of Electricity).

Solution: With an output of up to 2750 kVA and system voltage of 1000VDC or 1500 VDC, SMA's central inverters allow for more efficient system design. An integrated transformer and additional space is available for the installation of customer equipment. The Sunny Central is the central component of SMA Utility Power Systems. In combination with the medium-voltage block, DC technology, power plant controlling system and SMA Service, it is also available as compact platform solution. Utilizing SMA's field-proven central inverter technology with minor component changes, this solution will result in higher power yields and lower specific costs. With superior stack design, the Sunny Central 2750-EV-US offers 1,500V technology for maximum reliability.

Applications: 1,500V PV power plants.

Platform: The Sunny Central has been optimized for outdoor installation. The air cooling system 'OptiCool' ensures smooth operation, even in extreme ambient temperatures creating additional OPEX savings and contributing to the lowest cost of ownership in utility-scale PV. Sand and dust particles are effectively kept away.

Availability: Currently available.

System design | PV*SOL premium 2018 from Valentin Software makes the design of photovoltaic plants easier

Product Outline: Valentin Software's new PV system design software PV*SOL premium 2018 has been enhanced to provide the ability to input object data in different file formats into the software via a new interface. This makes it possible to import realistic and detailed 3D objects created with photos taken from different perspectives (e.g. using a drone).

Problem: The combination of PV, storage and battery systems increases the complexity of a PV system. Greater emphasis is being placed on reducing system design time, therefore design cost.

Solution: Flexibility has been significantly increased with regard to the configuration of the modules, which are automatically placed on an object. The new possibility of polystring configuration allows completely different strings to be connected parallel or in series to an MPP tracker. This is required, for example, to connect an east-west roof parallel to one MPP tracker. Even different modules in a string can now be interconnected, e.g. defective modules that are no longer available which need to be replaced by similar new ones. Modules with different orientations can now also be connected in one string via the integration of power optimisers (e.g. SolarEdge, Tigo). These new functionalities increase the flexibility of the design process enormously and allow even more detailed configuration and simulation of the PV system.

Applications: PV system designs for residential and commercial.

Platform: Other useful additions for the optimisation of a system are the output of the I-V characteristics for each time step of the simulation, as well as an energy flow diagram representing the overall system including the battery system, consumers and also an electric vehicle.

Availability: Currently available.

Products in Brief

BIPV solutions from Linel using Solaria solar modules

Customised architectural glass and metal products producer Linel has team with PV module supplier Solaria to offer a range of BIPV products. Linel can address the architectural community's increasing demand for solar skylights, atriums, clerestories, sunshades, patios and canopies. Linel also offers BIPV sloped glazing systems for architectural solar solutions from building developers and designers producing leading edge plans for new projects. Solaria's 'PowerXT' rooftop solar solutions provide high-performance solar panels that produce up to 20% more energy than conventional modules.

Skytron energy creates new service portal

PV monitoring, control and remote supervision supplier skytron energy has a new service portal that offers quick, direct access to its technical support team. Customers can use the portal to request spare parts, create service tickets and check the status of existing service requests. The portal also allows them to contact support directly with open questions or use skytron energy's newly established wiki. The new website offers developers, EPC firms, utilities/IPPs, investors and O&M providers a clear and concise overview of all solutions.

Inverter | Sineng Electric launches first central PV inverter for bifacial solar modules

Product Outline: Sineng Electric has introduced a new central distributed inverter for bifacial solar modules.

Problem: Bifacial solar modules collect reflected light on the back side of the module as well as the top, generating an additional yield of between 10 to 30%. However, due to the increased current of each string and serious string mismatch, bifacial modules do not always perform perfectly due to the limitations of traditional inverters when light conditions are optimal.

Solution: Sineng Electric's new central distributed inverter comes equipped with the MPPT combination box designed

specially for bifacial modules, capable of supporting an increase in the maximum operating current up to 12.5A and a current gain of over 30 percent on the back side of the panel. The string-level MPPT technology solves issues related to string mismatch caused by an uneven exposure to light on the back side, despite the complex conditions of the surface beneath the solar panel. The power-capacity ratio on the DC side supports extensive and flexible configurations and adapts to the change in capacity on the DC side caused by the difference in current gain on the back side.

Applications: Utility-scale PV power plants specifically using bifacial modules.

Platform: The unit is capable of operating at full capacity at 55 degrees C and addresses issues related to the high current gain on the back side. In addition, the ability to handle long periods of 1.1X and short periods of 1.2X overload capability evenly matches the overload capabilities of the AC-side transformer and boost circuit.

Availability: February 2018 onwards.

Module | OPES Solutions ultra-light flexible solar modules reduces weight by two thirds

Product Outline: OPES Solutions, a supplier of off-grid solar modules for grid independent power supply, has developed O-Lite Plus an ultra-light solar module together with the Fraunhofer Center for Silicon Photovoltaics CSP.

Problem: Integrated solar application modules and the ability to offer customisation services for individual solar needs have been limited as large manufacturers with a high degree of automation cannot serve this segment, while small-scale manufacturers often lack the engineering know-how about innovative modules, investment and quality controls.

Solution: The module backside is made of polyethylene terephthalate (PET) on which mono or polycrystalline solar cells are laminated and is the key to the weight reduction. Compared to alternative lightweight substrates such as fiberglass or PCB, the PET material used by OPES Solutions is even lighter. Since it is easy to process and has similar coefficients of heat and expansion as solar cells, O-Lite Plus modules are also particularly durable

Applications: Their low weight and the ability to be produced in curved shapes make O-Lite Plus modules particularly suitable for weight-sensitive areas of application such as vehicles, boats and small devices, which also place high demands on durability.

Platform: The company develops and manufactures certified modules with outputs from 0.9 to 270 watts, which are distinguished by flexible design, high durability and an attractive price/performance ratio.

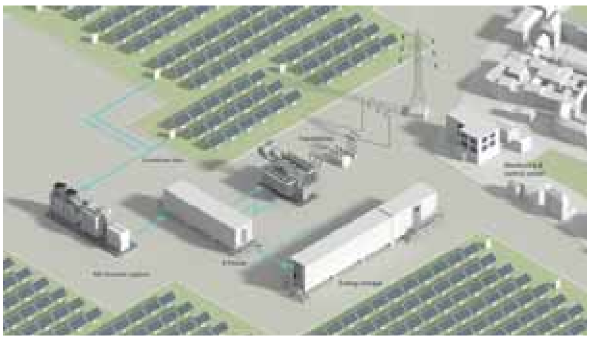
Availability: Currently available.

Inverter | Siemens SINACON PV inverter series achieves high efficiency in harsh environments

Product Outline: Siemens AG has launched a 5,000kVA central inverter that is made in India and is being supplied to utility-scale solar PV power plant projects across the country as part of its new electrical Balance of Plant (eBoP) solution.

Problem: In hot and humid environments inverters need to be designed with high levels of cooling capability to minimise component and system failures and provide high-uptime.

Solution: The SINACON PV inverter is used in medium and large utility-scale photovol-



taic power plants to achieve high efficiency. It is equipped with three-level IGBT modules for input voltages of up to 1500VDC to maximise energy efficiency. The integrated DC and AC distribution makes the SINACON PV inverter cost efficient. Standardised interfaces for easy plug and play reduce engineering hours.

Applications: Utility-scale PV Power plants for harsh environments.

Platform: All the inverter components are enclosed in an outdoor housing. Forced cooling by means of fans and liquid cooling are key features for operating reliably under harsh hot and humid conditions.

Availability: Currently available.

At the heart of floating solar: Singapore

Floating PV | Singapore operates the world's largest testbed for floating PV, comparatively testing and evaluating 10 different floating PV installations from around the world, and held the first floating solar conference globally in October 2017. Writing exclusively for *PV Tech Power*, Thomas Reindl of the Solar Energy Research Institute of Singapore (SERIS) reports on a form of solar power whose huge potential is starting to be realised

Figure 1. Singapore testbed of 10 different floating solar technologies on Tengeh reservoir

The interest in floating solar has grown rapidly in recent years. In many established and emerging markets, such as Japan, South Korea, UK, China and India, floating solar is already considered an attractive and viable option for PV deployment. In October 2016, Singapore launched the world's largest floating PV testbed, with a total installed capacity of around 1MWp. This testbed aims to study the economic and technical feasibility, as well as the environmental impacts of deploying large-scale floating PV systems on water reservoirs. The testbed consists of 10 sub-systems with different types of PV modules, inverters and floating structures. The field experience of operating these systems, and a comparison of their performance and reliability, offers highly valuable learning points for the floating PV community.

Floating solar refers to the installation of PV on water bodies, such as lakes, reservoirs and other often under-utilised water bodies, with PV panels usually mounted upon a pontoon-based floating structure. Floating PV is considered an attractive option due to the following advantages:

- No or reduced land usage. This is important for regions where land resources are scarce or undesirable for PV installations (e.g. when considered competing with agricultural use), but sufficient water bodies are available;

- The evaporative cooling effect from the water (thus lower operating module temperatures) likely increases the annual energy yield of the PV modules. Improvements from 10% to even 25% as compared to land-based PV systems have been reported for some early floating PV projects [1, 2];
- Floating PV is less prone to shading due to the open and flat environment;
- Great potential for complementary operation of floating PV with hydro-power stations due to (i) existing electricity connections, (ii) synchronised operation during day/night time and times with high PV variability (effectively using the reservoir as a "big battery") and (iii) complementary generation patterns in areas with high seasonality, especially with dry and wet seasons;
- Possible reduction in water evaporation losses from the reservoirs, which is of particular interest for reservoirs for fresh water supply and irrigation;
- Expected reduction in algae growth because of less sunlight intake into the water body;
- Potential integration with aquaculture and fish farming.

About the Singapore floating PV testbed

The Singapore floating PV test bed (see Figure 1) is a collaborative initiative by the Singapore Economic Development Board (EDB) and PUB, Singapore's National Water Agency. The Solar Energy Research Institute of Singapore (SERIS) at the National University of Singapore (NUS) is acting as project manager who took complete ownership of design, construction, testing, commissioning and the scientific evaluations of the project.

Inauguration of the world's largest floating PV test bed at Singapore's Tengeh Reservoir was announced on 25 October 2016 by Mr Masagos Zulkifli, Singapore's minister for environment and water resources, at the Joint Opening Ceremony of the 3rd Asia Clean Energy Summit (ACES) and the 26th Photovoltaic Science and Engineering Conference (PVSEC-26).

Figure 2. BBR/Solaris testbed system

Figure 3. REC/Takiron testbed system

Figure 4. Upsolar/Koine testbed system

Figure 5. Sunseap/C&T dual-pitch testbed system

Figure 6. Phoenix Solar/C&T testbed system

Figure 7. Sharp/Sumitomo testbed system

Figure 8. SolarGy/4C+NRG testbed system

Figure 9. Sunseap/C&T testbed system with active cooling

Floating PV testbed participants

Leading PV system integration companies (SolarGy, Phoenix, Sunseap, BBR, Upsolar, REC and Sharp) are participating in the testbed, using a number of tier-one PV module manufacturers (Trina Solar, REC, JA Solar, Upsolar, Sharp, Yingli etc.) to study their performance on water bodies. Floating system products from Ciel & Terre, 4C Solar, NRG Energia, Solaris, Koine, Takiron and Sumitomo Mitsui have been deployed at the testbed. The systems use on-grid solar inverters from SMA, ABB, Huawei and Sungrow. The testbed also features one of the largest floating PV systems with active water cooling.

Figures 2 to 9 show some of the installed Floating PV testbed installations.

Research activities at the world's largest floating PV testbed

The testbed aims to study the technical, economic and environmental feasibility of deploying large-scale floating PV systems on inland water surfaces. The study particularly includes a wide number of testing activities and studies on the performance of PV systems on water bodies, especially by benchmarking the various floating PV systems against each other and against a rooftop PV reference system.

Figure 10. Meteorological station at the rooftop

Figure 11. Meteorological station on the floating pontoon

Figure 12. Module temperature probes

Figure 13. Albedo measurements on water

SERIS has deployed numerous sensors across the test site, including two meteorological stations (one near the floats, one near the rooftop reference system). There are more than 500 parameters measured in real time and transmitted to SERIS' central monitoring system at the NUS campus. Figures 10 to 13 show some of the installed sensors. Others include DC, AC string monitoring and six-degree freedom movement trackers on each floating test system.

Initial results of the research activities

The analyses of the collected data show that the evaporative cooling effect depends on the type of floating structure used. From measured ambient air temperature, wind speed, in-plane solar irradiance level and module temperature, the so-called "heat loss coefficient" of each PV system type is determined, which indicates the effectiveness of module cooling by the environment. The comparison clearly shows a dependence on the way the PV panels are mounted. Higher values of the heat loss coefficient correspond to better cooling, and thus lower module temperatures, leading to a better electrical performance. The floating structures in the testbed are roughly categorised into "free-standing" types (with PV panels open to the water surface), and the "pontoon" types differentiated by the extent of water surface coverage beneath the modules (from "small footprint" to "large footprint").

The module temperatures for the free-standing systems are found to be much lower than those in the rooftop reference system. The heat loss coefficients for those systems are generally in the range of 40 to 50W/m²K, which is about 30 to 60% higher than the typical values of 30 W/m²K for a well-ventilated rooftop system. This is primarily due to lower ambient air temperature and higher wind speed on the water. For floating structures that have PV panels mounted close to the water surface, the cooling effect is dependent on the water footprint as well as module arrangement, as can be seen from Figure 14. Please note that "well ventilated" refers to a rooftop installation that has good ventilation, while an "insulated" system would refer to one with little exchange of heat with its environment (e.g. compact dual-pitch design).

In terms of performance, the performance ratio (PR) of the eight best floating PV systems as well as the rooftop reference system for the past few months of steady operation were measured. The majority of the floating systems reached PR values of well above 80% (see Figure 15), which is not easily achieved in Singapore's hot climate conditions. System G and the reference system use the same modules, showing that there is a slight performance gain for the floating system, despite the installation close to the water surface in this case. It is noted that the rooftop reference system is installed about 1.5 metres above the roof and close to the seaside (next to the reservoir), hence is much better ventilated than a typical rooftop PV system in Singapore's urban environment, and its bifaciality gives it an extra performance boest

One interesting finding is about the albedo and the benefits of using bifacial modules. The albedo from the water surface was found to be much lower than on the rooftop due to low water reflectivity at high incidence angles as well as the light absorption properties of water. Therefore, the bifacial modules generated less power on water than on the rooftop.

With a longer duration of monitoring, SERIS will also assess whether there are accelerated degradation effects for the floating PV modules and systems.

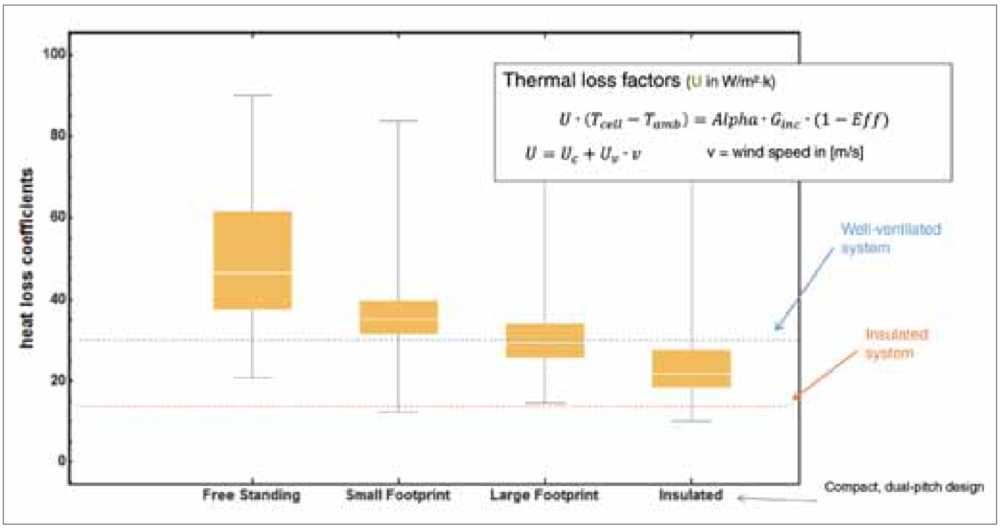


Figure 14. Measured heat loss coefficients in (W/m2K) for different types of floating PV systems. Common values for comparative standard systems are also indicated as dashed lines

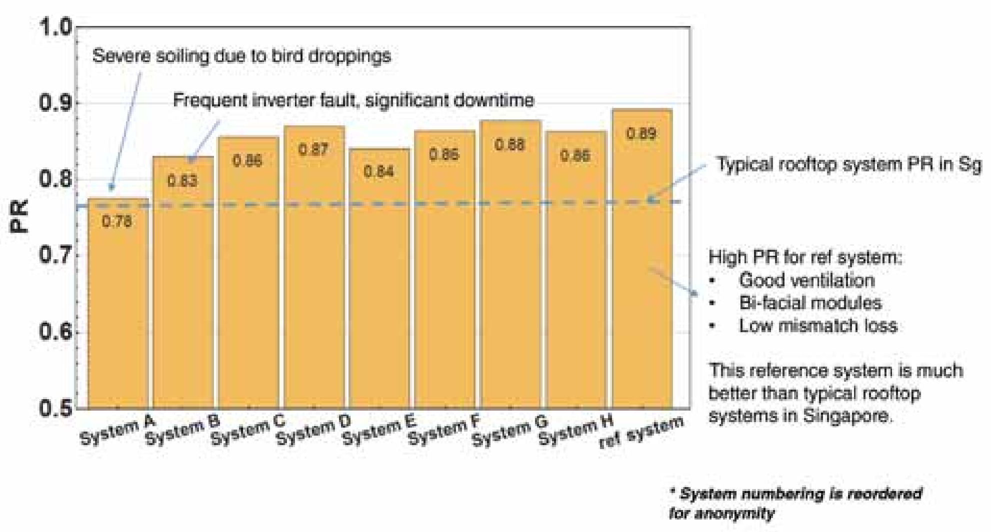


Figure 15. Overall performance ratio (PR) for various floating PV systems and the rooftop reference system. Typical PR for rooftop systems in Singapore is marked as red dashed line. PR values are corrected for DC cabling losses

Other current topics of interest are: electrical ground faults (observed multiple times), loose electrical connections (despite sufficient slack provided), soiling from bird droppings (which can be quite severe at times) and rupture of anchoring lines (occurring at selected systems).

Building a global community - the world's first floating solar conference

The inaugural "International Floating Solar Symposium" (IFSS) was held during October 24-26, 2017 at the Marina Bay Sands Convention Centre, Singapore, under the motto: "Building the global community". IFSS is an integral part of the annual Singapore International Energy Week (SIEW) and the Asia Clean Energy Summit (ACES).

Floating solar is taking the solar industry by storm. Globally, it unlocks 400,000 km2 of potential deployment space on man-made freshwater reservoirs alone, and thereby a new TW-scale opportunity for photovoltaics. It addresses the water-energy nexus through evaporation reduction and opens paths to ultra-low balance of system (BOS) costs.

The fascination with scalability and market potential is palpable: new form factors are being discussed and field tested, and the young industry is charting its way through the options for electrical architectures and unfamiliar environmental considerations. This made it the right time to bring industry players, innovators, developers and other stakeholders together for the very first time.

Jointly chaired by your author and Philipp Schmaelzle (X, formerly Google X, USA), over 100 experts from industry, governments, financing and academia gathered and shared experience in all related fields, such as the latest floating solar technologies, deployment strategies, environmental impact of floating structures, hybrid operation of hydropower with PV and bankability perspectives. The most important learnings and key take-aways from this first floating solar conference ever are highlighted below.

Setting the stage

IFSS 2017 shared the Grand Opening as well as the Solarising Singapore and Asia sessions with the Asia Clean Energy Summit (ACES), before it continued its own track on global market opportunities.

Oliver Knight from the World Bank Group (WBG) highlighted the benefits of floating solar and its great potential globally. He also shared the various funding opportunities for such projects and underlined the interest in lending for WGB, which includes both the World Bank itself and the International Finance Corporation (IFC). Moving on to the leading floating solar market, China, Frank Haugwitz of AECEA highlighted the enormous plans for floating applications there. He cautioned a bit that in China the term literally calls for "solar over water", which also includes installations on piles, such as the 200MWp installation on a fish farm in Zhejiang province. Floating solar solves a number of problems of large-scale solar farms: long transmission lines from Western China to the load centres in the East are expensive, which also leads to severe grid curtailments in certain areas, whereas there are plenty of water bodies in eastern China, which are often not utilised and don't require major permissions. The prime area for floating PV at the moment is Anhui province where water bodies on top of abandoned coal mines are earmarked for installations beyond 1GWp. The largest installations under deployment are in the range of 150MWp. In the meantime, floating PV has also been added to the so-called "Top Runner" programme, with cumulative goals of up to 4.5GWp over the next few years.

India, in contrast, has not really kicked off yet on Floating Solar, although it hides a huge market potential, as Rahul Jain from Renew Power pointed out; this even more so when taking the side benefit of reduced water evaporation into account, especially for irrigation canals and freshwater reservoirs. Similarly, the ASEAN member countries are still at an early stage, but with large opportunities when it comes to the combined hybrid operation of floating PV with existing hydropower stations, such as in Thailand, Cambodia, Laos or Indonesia, according to Badariah Yosiyana from the ASEAN Centre for Energy (ACE).

Keynotes

The IFSS 2017 keynotes were delivered by four highly recognised experts in floating solar. Professor Eicke Weber from UC Berkeley and BEARS (Singapore) made the point that floating PV clearly has the potential to become the third pillar of the PV industry, after ground-mounted and rooftop – this in particular when comparing the sheer areas of all rooftops in the world and the available reservoir surfaces: while covering all rooftops would lead to ~20TWp of PV installations, the reservoirs area could house ~50TWp.

Weber also highlighted the great benefits when combining hydropower with floating solar. If not run-of-river, hydropower stations have a reservoir attached anyway, which is typically not much utilised. In addition, there is naturally an electricity grid connection, which typically also has some spare capacity. The most striking fact he presented, however, was that "more water evaporates from reservoirs than is consumed by humans". If floating solar can reduce the evaporation losses, it

Figure 16. IFSS 2017 was chaired by the author (right) and Philipp Schmaelzle (X, USA)

would have a substantial double benefit for humankind.

It was a great honour to have one of the pioneers of floating solar speaking at IFSS 2017: Bernard Prouvost, the founder and chairman of Ciel & Terre. He shared his impressive journey, but also the pains of being a pioneer. C&T has installed more than 100 floating solar farms, including the largest in operation at 70MWp. The company had enormous growth and manufactures now in 10 countries at a capacity of ~800MWp per annum. C&T's Hydrelio has become a quasi-standard design for floats around the world, although obviously not all of them are manufactured by C&T. Prouvost called for a voluntary charter for "good practices in floating PV", which the chairpersons returned to later.

Torgeir Ulset shared his view from a leading PV manufacturer, REC Solar, which is an early mover in floating solar. The company had already extensively tested PV modules in water bodies a few years ago, both in freshwater, but also in seawater and found no evidence of higher degradation or lower reliability from the presumably harsher environments in floating PV installations. Therefore REC is very committed to the market and extends its warranties to such systems without any reservations.

Co-chair Philipp Schmaelzle gave an overall market opportunity and highlighted the opportunities beyond the current system design, which is largely based on pontoons with conventional solar panels mounted on top. He shared more detailed information on the approach, which X had pursued later in Session 1 (see below).

Session 1 (Architectures for Floating PV Systems and Modules)

The first session saw a great number of presentations about how PV modules can be deployed on water bodies. Veyis Neo Toprak from LG CNS gave a great overview about the various types of installations, but also about the materials, mooring systems and deployment methods. He also highlighted the importance of environmental impact assessments (EIA), which is often neglected amidst the current hype in the industry.

Dr Zhao Lu of SERIS then introduced the world's largest testbed for floating solar and shared first results from it (see details above). Philipp Schmaelzle then showed the work X had done in this area, in particular the development of a novel flexible, self-buoyant floating macro-module that could be manufactured in lengths of up to 100m. This would eventually save all the pontoons and metal structures and hence dramatically reduce the cost of floating PV, once mass-produced. In a similar approach, Tobias Haarburger of Continental proposed the use of rubber-based membranes for floating solar applications. Those membranes are used to cover large-scale reservoirs in areas where evaporation losses are substantial, such as desert areas in Israel.

Moving over to offshore floating systems, Raymond Hudson introduced the SUNdy structure by DNV GL. Although still in the concept stage, he encouraged participants to further develop the technology, especially since the module prices and cost for floating structures have significantly come down since it was first presented in 2011. Børge Bjørneklett from Ocean Sun demonstrated the results from his company's novel floating solar platform, which is based on large fish farming floats, which have been used in Norway for decades. The initial results are very promising and larger testbeds are under preparation. Already commercialised is the offshore floating PV system from Swimsol, as Dominik Schmitz pointed out. It is mostly applied in eco-resorts such as in the Maldives.

Closing the session was Wu Weiwu from Sungrow in China. The company has expanded from an originally pure inverter manufacturer towards a full green energy company, including turnkey provision of floating solar farms. He explained the details about Sungrow's standard 2MWp floating solar blocks, which also include a floating inverter and transformer station. The system is deployed, amongst others, in a 40MWp installation in Anhui province, China.

Session 2 (Enabling Components and Reliability for Floating PV)

The session was opened by Marco Rosa-Clot of Koine Multimedia who wrote the first book on floating solar. He gave an overview of the history and types of floating solar structures, including various tracking and concentrating versions. He also highlighted the importance of wind-loading tests and shared some of his latest developments that are undergoing tests at the moment. Leo Casey from X then gave a more detailed view of the electrical concept of the self-buoyant structure, with a specific focus on the electrical safety of the macro-module. It was not trivial to guarantee highest electrical performance, while maintaining proper grounding and ensuring that the macro-module and its components remain "touch safe" at all times.

Oakland Fu from DuPont then moved on to highlight the importance of suitable component selection when it comes to the packaging materials for solar modules to be deployed in harsh environments such as nearby water bodies. This includes preventive measures for potential-induced degradation (PID). Duncan Harwood of D2 Solar added to that discussion that floating PV installations rank higher in risks with respect to moisture, mechanical stresses and hot spots (e.g. from soiling or bird droppings). He described accelerated stress tests for those three mechanisms that have been applied on the self-buoyant macro-module which X had developed. He presented results of typical failure modes and suitable mitigation strategies.

Adding the views from a certification body, Keith Punzalan from VDE Germany, highlighted that there is an urgent need to develop standards for floating PV modules and systems, against which the certification bodies can then test and certify. At present, there are no such standards and he invited the industry to work with VDE and other certification bodies, probably starting with the testbed in Singapore where multiple floating systems are deployed next to each other.

Session 3 (Operational, Environmental and Financial Aspects of Floating Solar)

This session touched upon issues which are often "left aside", but are increasingly gaining awareness amongst stakeholders, in particular what the impact of floating solar is on the environment and the water body itself.

Jenny Johnson from Ascent Solar gave a great overview of what needs to be taken into account when looking at the environmental impacts of floating PV on water bodies. She differentiated by industrial water bodies (e.g. treatment plants, mines, cooling water) and reservoirs (e.g. for irrigation and flood control, municipal water or hydropower). She then walked the audience through the process of a proper "anti-degradation" strategy.

Geoff Schladow from UC Davis followed on by explaining the potential impact on the water body, introducing the hydrodynamic mechanisms that occur in any lake or reservoir. He presented the results from simulation studies at a hypothetical lake in Freson, CA, concluding that for a mat-like coverage (like the self-buoyant macro-module from X) there is a projected impact on the surface temperature of the lake and the temperature gradient from the water surface. Also the wind boundary layers are affected. All in all, a 10% coverage of a reservoir could theoretically lead to a 4-6% reduction in evaporation. It could also affect the lake circulation pattern, which may have some effect on the environment. More modelling work is required to come to conclusive results, especially since every reservoir is somewhat different.

Moving over to the financial aspects, Monika Bieri from SERIS presented insights from a detailed financial modelling of floating Solar, using today's component prices. Based on a turnkey system cost of US$1.14/Wp, the resulting levelised cost of energy (LCOE) is around 10.4 US$-cents per kWh, but with a wide range from 7.5 to 15 US$-cents/kWh – depending on the assumptions and financial parameters. The LCOE is particularly a function of the country risk and the conditions for debt financing, but in general floating solar is competitive with other LCOEs, also benefitting from the higher energy yield due to the evaporative cooling effect. Similarly, Jan Napiorkowski of ArielRe had no reservations that floating PV farms are commercially viable and, in principle, do not represent a higher risk for their unique PV system output guarantee, which acts as yield insurance for the project lifetime.

At the end of this session, two great presentations were given on the hybrid operation of hydropower with solar PV. Pang Xiulan from SPIC/Huanghe Hydropower Development Corporation showed details of the joint operation of a 1.3GW hydropower plant (consisting of four turbines) with an 850MWp solar farm – which happens to be the largest solar system in the world. The solar farm is ground-mounted (hence not "floating" in nature), but the intriguing issue here is the fact that the control centre operates the solar farm "as if" it was a fifth hydropower turbine. It can even buffer the variability from solar power within minutes and hence can provide a steady and stable output to the power grid. The Natural Heritage Institute (NHI) is applying this concept in a large-scale feasibility study in Cambodia where it proposes to shelve the plans for a potentially devastating hydropower dam across the Mekong River and rather deploy floating PV on a newly built hydropower station in one of the tributaries of the Mekong River. This would not only help save one of the most productive fishery systems in the world, but also, by installing the solar system in stages as demand grows, make the capacity addition more market-compliant and with fewer financial risks.

The day ended with a dinner event under the motto "Building the Global Community", which was also the occasion of the birth of the IFSS – the International Floating Solar Society. More on this to come…

The final day of IFSS 2017 saw workshops on "Electrical and Grounding Architectures for Safety, Reliability and Yield in Floating PV" (by Leo Casey, X) and "Hydro Power Basics & Colocation and Hybrid Operation of PV with Hydro" (by David Wright and Øystein Holm, Multiconsult), as well as the long-awaited site visit to the Floating Solar Testbed.

IFSS 2018 will be held October 31st to November 2nd, 2018 in Singapore as part of SIEW and ACES. It is anticipated that IFSS would also travel to other locations or continents in the future, if the demand arises.

Conclusions

Floating solar is on the best way to become a third pillar of the solar industry. The deployment growth is breathtaking, but certain issues need to be addressed, such as electrical standards and environmental impacts. Singapore has positioned itself as knowledge and know-how hub for floating PV and will continue to drive R&D efforts and work with the industry to develop innovative solutions and suitable standards. ■

The author would like to thank Liu Haohui, research fellow, PV system technology at SERIS, and Zhao Lu, head of PV system technology at SERIS, for their contributions to this article.

References

[1] Choi, Y.-K. and N.-H. Lee. Empirical Research on the efficiency of Floating PV systems compared with Overland PV Systems. Conference proceeding of CES-CUBE, 2013.

[2] Trapani, K. and M. Redón Santafé, A review of floating photovoltaic installations: 2007–2013. Progress in Photovoltaics: Research and Applications, 2015. 23(4): p. 524-532.

Author

Dr Thomas Reindl is the deputy CEO of SERIS and principal research fellow at NUS. He started with PV in 1992 at the SIEMENS Corporate R&D Labs. After holding several management positions at SIEMENS and running one of the leading German PV systems integration companies as chief operating officer, he joined SERIS in 2010 and became director of the Solar Energy Systems cluster. During his time at SERIS, he has won public research grants in excess of SGD20 million, founded two spin-off companies and authored strategic scientific papers such as the "PV roadmap for Singapore". His research interests are high-performing PV and embedded systems, including BIPV and floating PV, techno-economic road mapping and the reliable integration of renewable energies into power systems".

Turn to the following page for our in-depth case studies exploring how floating PV is already being deployed around the world.

Credit: Seaflex

Monsoon rising: An anchor for India's floating PV dreams

Projects | The huge potential offered by floating PV technology is already being realised in a variety of regions. In a series of case studies, Tom Kenning and Liam Stoker explore some of the trailblazer projects and the challenges they faced in execution

India is in the midst of a frantic large-scale solar tender bonanza that seeks to emulate China's colossal PV deployment. Doubters say the plans are ill-timed given the Indian sector's stuttering at the hands of various trade disputes and additional taxes, but the hunger for new capacity could be satiated through a promising new outlet. A 10GW consultation exclusively for floating PV has been issued by the Solar Energy Corporation of India (SECI) and it is conceivable that no such plans would be on cards had it not been for the completion of a humbly sized but strategically significant project in the southern state of Kerala. Given its size and potential, India was a relative latecomer to the multi-gigawatt solar markets of the world stage and its module procurement remains stuck at the low end of product ranges on offer. However, floating solar, the up-and-coming saviour of PV's traditional land constrictions, could turn out to be a technology on which India is amongst the early adopters on a grand scale.

With plenty of hydroelectric reservoirs in certain states and a vast number of manmade ponds used by thermal power plants, there is no shortage of water bodies to keep India's floating pioneers busy. But first, the industry needed proof that such projects could work in India, which is a market seen by many as somewhat tricky.

No doubt under the watchful eye of the central government in 2015, one state utility, Kerala State electricity Board Limited (KSEBL) went about tendering for a 500kW system at the Banasura Sagar reservoir in Wayanad, which now stands as the largest floating PV plant in India following grid connection in late 2017. Local firm Adtech Systems, based in Trivandrum, won the tender and proceeded using modules assembled by Telangana-based manufacturer Radiant Solar and 32kW string inverters made by ABB, a firm that is well established in India and has service support locations in the city of Bangalore, not far from the project location. Two other major contributing firms were Floatels India and Regen Power, which is based in Western Australia.

KSEBL was not primarily looking for payback, says Raveendran T. Nair, vice president, projects, Adtech, because the aim of the floating plant was more to act as a technology demonstrator. As the utility of Kerala, a green and tropical state with plentiful rainfall, KSEBL was also looking to make the most of its many reservoirs. Moreover, as one of India's most densely populated states, Kerala has expensive land, which gave added impetus to the search for viable alternatives to land-based projects. Likewise, Nair believes the utility had no worries about the long-term outlook for floating PV tariffs once the technology becomes widespread in India, given the extreme drops seen in utility-scale ground-mount prices across India in recent years. With this confidence, the stakeholders in the Wayanad project chose to focus on using highest quality materials and components to make it a successful proof-of-concept undertaking. Total project cost was INR92.5 million (~US$1.46 million).

While the surrounding area was scarcely populated before the government procured the land and built a dam to support the Kakkayam hydroelectric power project in 1979, many locals were displaced when the dam project was started. It remains the largest earth dam in India and the second largest in Asia. Regular dams are made of concrete, whereas this is made of an earth embankment that is nearly 100 kilometres in length, adds Nair. Now the site attracts tourists drawn by many surrounding waterfalls and smaller lakes and adventure sports.

To test project viability in this location, a scaled down 10kW version of the system was installed in the same reservoir by Vaatsa Energy, a young start-up company with technical support from Floatels, says M.R. Narayanan, chairman of Adtech Systems and managing director of Floatels India.

Bar a few minor cuts, the next 500kW was completed without accident although Nair says the main challenge was constructing the floating platforms


Credit: Seaflex

due to a lack of suitable facilities on site. Progress slowed down for this period due to the site's lengthy distance from any main industrial base. As a comparatively new reservoir, the soil around it was soft, meaning that mechanised equipment could not be taken near to the shoreline. Such difficulties would be less likely in other locations around industrial or thermal power plants, adds Nair.

The solar plant will not affect the quality of the water in any way, Nair assures, claiming that there are no effluents from the equipment and even forecasting that the structure might improve fishing figures by providing a section of water that is shaded and therefore of a lower temperature than the rest of the reservoir. The environmental effects of floating solar are certainly a concern in the industry and it is not just water quality that causes concern. The impact of a sudden lack of sunlight on biodiversity in these water bodies is often raised as a potential problem, but has not yet been well-studied in the context of floating solar as far as *PV Tech Power* is aware.

The system

The project involves fibre-steel-based floats that were designed with ferrocement, which involves applying reinforced mortar or plaster over layers of metal to create a hollow structure, making the project very stable, says Narayanan. "Our company has been specialised in making


Credit: Seaflex

ferrocement platforms and floating structures for the last 20 years," he adds. "They are guaranteed for a 50-year life."

Unlike similar materials, the ferrocement uses either welded mesh or expanded metal to make the metal to mortar ratio higher, so that if taking a cross-section, the metal content will be higher than in regular concrete. Nair is surprised that it has not become a more popular material since it is thin, lasts well beyond 50 years and requires little maintenance.

"With steel it tends to rust – you have to scrape and bend it and all that, whereas this needs no such maintenance," he adds.

Each floating platform has one string inverter. The 415V from these inverters is fed to the ELT 415V switchboard, which is then transformed to 11kV. An 11kV XLP underwater cable, from major Indian cable supplier APAR, has been laid along the bed of the reservoir to the shore. Many other floating solar designs have the cables above water, but in this case the reservoir attracts many tourists for boating so underwater cabling was required to prevent any hindrance to those activities. Adtech also felt that it was more aesthetically pleasing to have the cables hidden.

Generation benefits

Being located on top of a hydro plant means the solar generation can support daytime peak load and more hydro power can be reserved for the evening peak, says Nair. It's a major opportunity, particularly in Kerala, given that almost all of the state's locally generated power comes from hydro already. The state relies on energy imports from other states for a significant portion of the rest of its power mix.

"The water available in these generating stations in the reservoir is not sufficient for running these hydro generators for 24 hours, 365 days so they have to stop the generators over substantial periods," adds Nair. "So instead of that they can run the hydro plants during night and you can utilise the solar generation during daytime."

The hydro plants also guarantee that transmission infrastructure is already available in close proximity to any co-located floating PV plant. Nair describes this as a "win-win" situation.

From a logisitics perspective, while the Banasura Sagar reservoir is remote, it was still relatively accessible by lorry, being located just 20 kilometres from the Calicut-Mysore-Bangalore road.

O&M

Adtech was awarded the EPC contract for the project by KSEBL as it put in the lowest price bid, and under this contract it must perform O&M services on the plant for a two-year period; subsequently it has to maintain the equipment in case of any faults for another four years.

Cleaning the plant is easy given regular rainfall on location for nearly six months of the year, which naturally washes the panels. Dust, which can cause soiling of the panels, is also minimal at the location. Of course there will still be occasional build ups of sediment on the panels and the two-man team uses long handheld mops to clean them. They brush using rainwater as it falls or pump water onto the panels from the reservoir itself. An ABB remote monitoring system keeps tabs on each string feeding the inverters and can record energy generation statistics.

Tenders

With the successful completion of the project, the government is now scanning the rest of India to see where the opportunities lie and how much appetite there is. Besides hydro dams, industrial units and thermal power ponds are the most obvious targets for now and Nair says they are a multi-gigawatt prospect.

Since the project was completed, Adtech has received enquiries for dozens more megawatts of projects, Narayanan adds, which demonstrates a desire to try out this technology already at this early stage.

To drive the technology further, Nair suspects that KSBEL will now go down the tender route to procure more floating PV, although he expects there to be strict prequalification requirements. ■

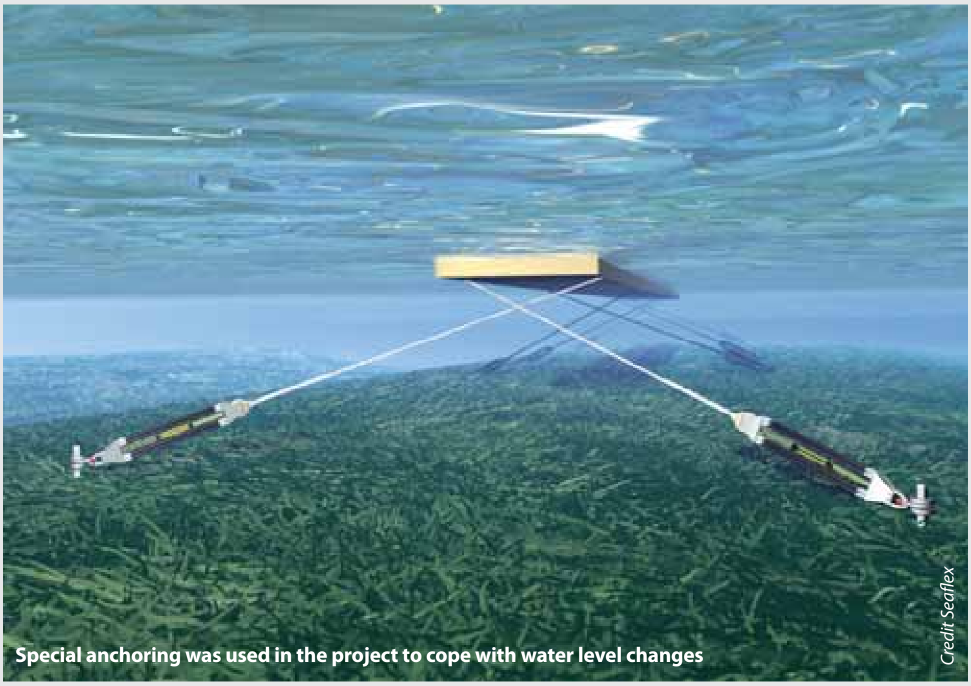
Anchors and huge water level variations

The main challenge for the project was a water level variation of up to 25 metres between summer and monsoon seasons, says M.R. Narayanan, chairman of Adtech Systems, so the firm had to procure and design special anchoring systems to ride the variations as well as high-speed wind conditions while lasting 25 years.

Swedish specialist in mooring and anchorage systems, Seaflex AB, supplied the Wayanad project. Company CEO Lars Brandt says that harbours and marinas from around the world have done business with Seaflex to make use of its floating marine structures. A Seaflex representative visited the Indian project in March 2017 to survey the site and surrounding area. Based on these details Seaflex designed the anchoring system and Adtech installed it.

Withstanding the huge water level variations was a key challenge. For this, the anchoring system uses a patented polypropylene rope assembly where the ropes, tied to the floating structure on the surface of the water above and to the anchors on the bed of the reservoir below, can stretch to roughly 70% of their initial length. A total of eight anchors were used to allow the floats to withstand wind from several directions and the slight stretching of the elastomer rope can alleviate the wind forces.

The depth of the reservoir at the plant location is around 35 metres when full. As the water levels rise and fall with seasonal rains, the ropes can stretch or contract as necessary. The stretching rope means that once assembled, installed, tested and put in place it operates automatically without requiring any external forces.



Special anchoring was used in the project to cope with water level changes

Malaysia's first grid-connected floating PV project: a matter of national security

A reservoir supplying drinking water to the people of the Malay Peninsula was the chosen site for the country's first grid-connected floating solar plant under the feed-in tariff programme. The prestigious location meant that the developer not only had to take the risk of using a relatively young technology, but also had to take care not to disrupt a site of national security.

Local firm Cypark Renewable Energy (CRB), a subsidiary of Cypark Resources, built the 270kW floating PV project at the Ulu Sepri Dam using equipment supplied by specialist French firm Ciel & Terre (C&T), which to date has dominated the floating solar space globally. C&T offered its Hydrelio support, taking charge of engineering the 'solar island' and anchoring system design. The bottom anchoring was designed to meet a maximum depth of 45.6 metres and a seasonal level variation of 17.5 metres.

A total of 900 solar panels were used to cover around 1.5% of the roughly 18-hectare water surface. Bin Ibrahim says Cyparks's in-house research team conducted tests on several module brands and from those it studied performance and several other factors before selecting components. These parts have to last 21 years as CRB signed a 21-year power purchase agreement (PPA) with TNB, the national utility.

"Our company uses equipment from tier-one suppliers," says Achmat Nadhrain Bin Ibrahim, general manager at Cypark, remarking on the chosen 300W modules from China's Bluesun for the project. "We emphasise quality performance and reliability; we also look into the company's position in the market – whether they are financially sound or stable."

This is not the first floating project located on a reservoir used for drinking water. Indeed, UK developer Lightsource's project on the Queen Elizabeth reservoir just south of Heathrow, London, is also above a major drinking water source. However, the Malaysian project is located upstream at the first reservoir which collects all the water before it goes on to a feeding reservoir.

The Malaysian project took close to three years to obtain a permit because of the stringent compliance rules at what is a national security location. To assess environmental impact, Bin Ibrahim says the company did its homework and had to produce plenty of data to comply with the wishes of the authorities.

Inverters from Germany-based supplier SMA were chosen for the project, says Bin Ibrahim, and they were placed on land rather than on the floats given the relatively short distance between the solar island and the shoreline. Moreover, the company felt that managing risk as well as managing O&M of the inverters would be easier on land.

Cypark's other floaters

Cypark had already been a frontrunner in the Malaysian large-scale PV market, having secured EPC contracts in the first Large-Scale Solar (LSS) auction and bagged more floating PV contracts in the second, most recent LSS round. From this second tender, the firm is developing a 30MW(AC) floating project at the Terip Dam and has been awarded an

EPC contract by Cove Suria for another 30MW(AC) floating PV project at the Kelinchi Dam in Negeri Sembilan, which is also on the Peninsula of Malaysia.

Cypark also built what was at one time the largest solar project in the country standing at 13MW under the feed-in tariff (FiT) programme. The firm looks forward to participating in many more solar tenders, which it believes the government will be rolling out on a regular basis to meet its renewable energy targets. As well as being a fully fledged turnkey EPC contractor and project developer, Cypark offers financing for developers so they do not have to come up with securities or conventional finance tools themselves.

The Ulu Sepri floating project did pose some unique challenges compared to CRB's previous ground-mount endeavours. Logistically, getting equipment to the site was straightforward but launching the floats onto the lake was troublesome since the launching site was particularly small, says Bin Ibrahim.

"It's very similar to floating solar projects around the world," he explains. "The challenge is the same, but every site poses a unique challenge or concern. In this case, the launching site was small, so we had to adapt to what land was available to construct the plant."

Even so, Bin Ibrahim believes that the company's experience with land-based solar still helped it execute the floating project with great efficiency.

Malaysia-wide

The overall opportunity for floating PV in Malaysia is significant, says Bin Ibrahim, with plenty of dams, hydroelectric projects and recreational lakes available, but getting approval is hindered by the fact that different locations have different authorities and there are no standard requirements for this technology.

"That's expected because nobody has done this before," he adds.

Nonetheless, CRB found advantages in using the technology. For example, the module efficiency gains recorded by C&T in a water-cooled environment were also confirmed by Cypark's own research and the project's performance to date has been in line with such expectations.

Bin Ibrahim also speculates that the floating structure of the Ulu Sepri project could be used to rear fish in the future, citing companies in Scandinavia that have managed to combine similar floating structures with raising salmon.

It's not the first time Cypark has considered dual-use for a solar project. Indeed, it was a pioneer in agricultural solar when it built a 1MW solar system across 2 hectares of land also used to grow various crops including rock melons and chillies. There were challenges in securing the land, says Bin Ibrahim, and this drove Cypark to go down the unconventional route of applying to use the land for both energy generation and farming.

Cypark has clearly been an innovator in Malaysia, but the LSS auctions have attracted plenty of international attention.

"We worked hard to get this position," adds Bin Ibrahim. "But when you are leader, where you are ahead of the train, there's a big lorry with a bigger carriage following behind you." ■

Europe's floating PV pathfinder

Lightsource and Ennoviga Solar partnered to install more than 23,000 panels on floating pontoons, covering the Queen Elizabeth II reservoir near Walton-on-Thames. At the time of completion it was not only Europe's largest floating solar project, but also the world's first to be installed on a deep water reservoir. The system has a capacity of 6.3MWp, covering 9% of the reservoir.

The array was several years in the planning before it was connected in 2016. Formal plans first surfaced in 2013, with Thames Water – the benefactor and off-taker – successfully claiming it to fall under permitted development rights. This quirk in UK planning law means the system did not require formal planning and, by extension, a full environmental impact assessment.

The system was made achievable by the two developers bringing in Ciel et Terre International. The French floating PV pioneer supplied the floating pontoons for the project in what was the company's largest outside of Japan at the time of completion in 2016. Lightsource managed the installation of the project with Ennoviga, Thames Water's frequent solar EPC.

A total of 23,046 panels are kept afloat by a platform consisting 61,000 floats, held in position by 177 anchors which were secured during its installation by professional divers.

The project was borne from Thames Water's ambition to generate one-third of its own renewable energy by 2020, a significant increase from the 12.5% it achieved in 2014/15. While the water utility currently has solar on 41 of its sites across its operating area, the QEII floating solar array represented the largest single PV installation Thames Water had invested in to date.

Power generated by the site is supplied directly to Thames Water's private network under a power purchase agreement entered into with Lightsource, meeting roughly 20% of the water treatment facility's total energy demand throughout the year. Thames Water noted that water utilities are amongst the UK's most energy intensive industries, accounting for 2% of overall energy consumption each year.

In its first year of operation, the array was generated roughly 5.8MWh of electricity.

But maintaining the site has required new skillsets, techniques and procedures which Mark Turner, managing director at Lightsource's O&M division, says had been developed for the "challenging environment".

"Even on inland, fresh water floating solar can present a range of challenges for O&M providers such as access, soiling, corrosion and stress from continual flexing. These challenges should first be addressed during the design, specification and construction phase," he adds.

The 6.3MWp floating array built for Thames Water on the Queen Elizabeth II reservoir in Walton-on-Thames was Europe's largest when it was completed in 2016.

Credit: Lightsource

One floating PV installation – double the benefits

Credit: SolarEdge

When the De Krim Resort on Texel Island in the Netherlands decided to become more energy independent, its main requirements were the generation of green energy and an installation that would not be visible from street level.

The tender was awarded to Texel4trading because of its proposal to place floating PV modules on the rainwater reservoir used to irrigate the resort's golf course. This novel approach resulted in a number of benefits for the resort, and the installation also qualified for an incentive programme from the Dutch government (SDE+). The resort outputs the solar power it generates to its local public grid provider.

Floating installation – cost-effectiveness and increased yield

The placement of PV modules on the reservoir means revenue is generated from a property asset that would otherwise have had no financial yield. By repurposing the reservoir for the PV installation, the resort eliminated the need to allocate any other costly land and maintained the beauty of the surrounding environment. And, because the PV modules cover most of the surface of the reservoir, they reduce the amount of direct sunlight hitting the water, bringing an added environmental and financial benefit.

When fresh water is protected from direct sunlight, there is a two-fold effect. First, there is a reduction in the plant and algae growth on the water surface, which, if untreated, can cause costly damage to the pumps in an irrigation system. And second, there is a reduction in water surface evaporation, resulting in a preservation of valuable fresh water. As a consequence of this effect, the resort expects to reduce fresh water losses by up to 30%.

Based on a predicted PVsyst performance ratio of 0.9, the installation is expected to generate 700MWh per year; however, placing the modules on the reservoir produces a natural water cooling effect which should improve PV system performance.

Texel4trading manager Nicol Schermer explains: "This cooling effect has been shown to produce greater energy generation and, based on results from previous installations, Texel4trading expects that the floating solar installation will generate between 770MWh and 800MWh per year, some 10-15% more energy compared to a similar ground-mounted installation. This will offset the additional costs of installing a floating installation. We are seeing growing interest in installing floating solar parks to conserve fresh water, including at hydroelectric plants and especially in arid countries."

Meeting the challenges of a 'floatovoltaic' installation

Floating PV installations come with a great deal of benefits, but also have unique design and maintenance considerations. Modules and components require planning for attaching on to concrete pontoons or plastic floats. The fact that the modules are located on water makes on-site monitoring and maintenance of the installation, and the safety of maintenance personnel, potentially more challenging due to location and access issues. SolarEdge power optimisers monitor the performance of modules and communicate performance data to the web-based SolarEdge monitoring platform, reducing the number of actual site visits needed and the time spent on-site in each visit.

Design flexibility and reliability

When working with SolarEdge inverters, SolarEdge power optimisers maintain a fixed string voltage, allowing installers even greater flexibility with longer strings and strings of different lengths in order to design optimal PV systems. Modules positioned at different tilts and orientations cause energy losses when connected in a single string to traditional inverters. With the SolarEdge solution, energy yield from each module is optimised independently, eliminating these energy losses.

As the De Krim Resort is located in close proximity to the sea, protection of the PV installation from the effects of the salt mist corrosion and other harsh environmental conditions was an important consideration when p lanning the installation. To this end, SolarEdge optimisers and inverters were installed together with modules resistant to salt-mist and humidity mounted on saline-resistant frames on concrete pontoons in the reservoir. Having long warranties, SolarEdge inverters and power optimisers are designed to respectively meet IP65 and IP68 ratings for water and humidity resistance and are suitable for saline environments. ■

Credit: SolarEdge

The hungry dragon: explaining China's 50GW+ PV market in 2017

China | In 2017 China's domestic PV market surpassed 50GW. Meishi Tan asks whether such astonishing levels of deployment can be sustained and, if so, what the future drivers of growth will be

Credit GCL

At the beginning of 2017, the big question regarding solar in China was whether the stunning ~35GW performance of 2016 could be repeated. Yet, over the course of the year, the question transformed, quite surreally, to whether China would hit the 50GW mark in 2017 – essentially, the sum total installation of the rest of the world combined. The Chinese National Energy Administration (NEA) official figures eventually put 2017 new-built capacity at 53.06GW.

In this article, we will address some questions that have been on everybody's mind, namely: what exactly is causing the growth surge? With such rapid growth, are the economics of China PV projects today compromised? What could sustain this gargantuan, feed-in tariff-fattened domestic industry in 2018 and beyond? Is 50GW+ the new normal?

What drove the 2017 surge?

To give some context for the discussion, we can characterise the Chinese PV market in 2017 as having four key segments with distinct growth drivers, approximately broken down as shown in Figure 1 and explained as follows:

Utility-Scale FiT: Pure commercial utility projects that before 2016 made up almost all of the domestic market. Projects in 1H 2017 receive 2016 FiT tariff rates and projects in 2H 2017 receive lower 2017 tariffs; annual new build capacity is theoretically capped by annual "Build Plans" issued by the NEA, but in practice many states fill the FiT quotas on a first-completed-first-served basis, leading to massive overbuild, particularly in June, the month before the deadline.

Top Runner programme (target 5.5GW). Competitively tendered projects utilising modules and inverters that fulfill more stringent Top Runner performance requirements – Round 2 was awarded in 2016 and slated for completion mostly by September 2017, but many were delayed. Price makes up only ~30% of the evaluation criteria and

China's domestic solar industry looks set to remain the bellwether for global PV trends

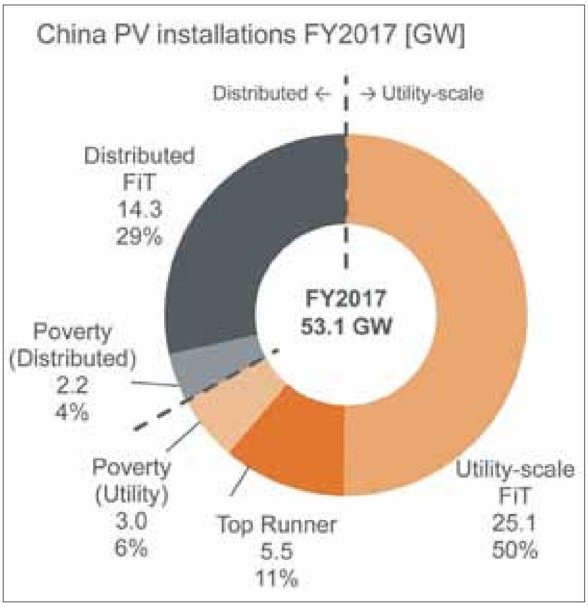


Figure 1. China PV installations FY2017 (GW). Source: National Energy Administration (NEA), local news reporting, Apricum analysis. Note that there are no official numbers available for exactly how much has been installed under the Poverty Alleviation and Top Runner programmes – the figure shows the maximum allocated under the respective programmes

any excess over the local wholesale rate is still subsidised by the government.

Poverty Alleviation programme (target 5.2GW). Utility-, village- and household-scale projects to specifically benefit households with no employment ability, including the disabled. Projects are funded by debt from state banks and equity from state social support funds and private investors. Regarding how the "poverty alleviation" works, for utility- and village-scale projects, dividends accruing to the state-funded equity share are distributed amongst households over the project lifetime, approximately CNY3,000 (US$465) per year; for residential projects, households simply receive the installations for free.

Distributed FiT. FiT-supported projects under 20MW that have priority over larger utility-scale projects in receiving FiT disbursements; new build capacity is not capped under the Build Plan and segment is thus heavily exploited by utility-scale developers building ground-mount projects under the 20MW limit.

As evident from Figure 1, despite expansion of the Top Runner and Poverty Alleviation programmes in 2017, and the growing awareness of such in the international community, both segments in reality contribute only a small percentage of the annual demand. Of the 5.5GW planned for the Top Runner programme, reportedly only ~2GW had been completed as of October 2017, despite the deadline being 30 September for most projects. Progress on the 5.2GW Poverty Alleviation programme allocated in 2016 is likewise slow: while statistics are not published on a national level, Henan province, for example, had completed only 35% of their target as of October 2017, and Gansu only 44%.

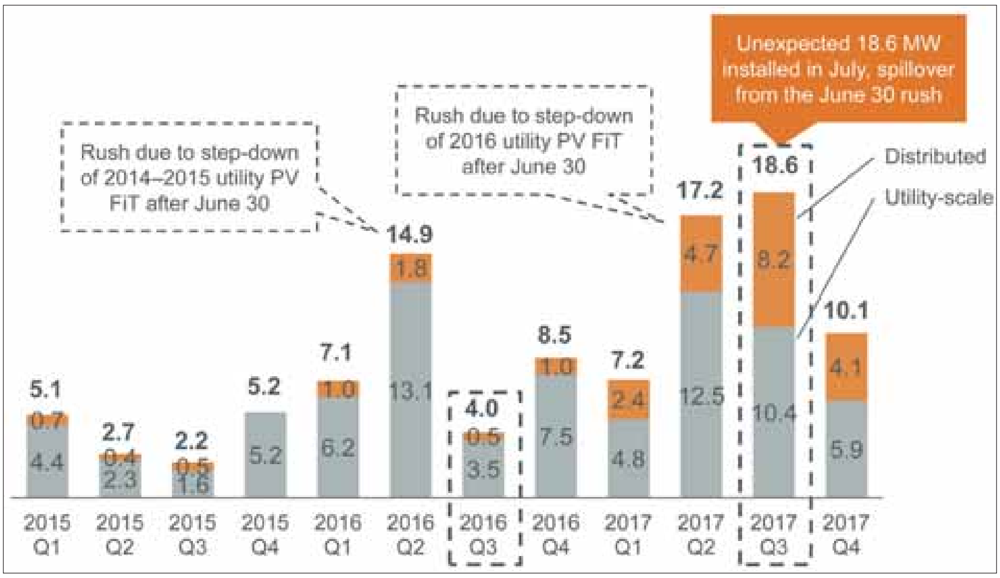
The 2017 market is thus still primarily driven by pure-commercial utility-scale (>20MW) FiT projects. Subtracting the Top Runner and utility-scale Poverty Alleviation maximum capacity allocated from the 33.6GW total utility-scale projects built in FY2017, we estimate the volume of pure-commercial utility-scale FiT projects to be 25.1GW, making up half of the installed capacity.

To fathom why such massive volumes are being installed in China but not elsewhere in the world, recall that projects in 1H 2017 were installed at 2016 FiT rates of CNY0.80–0.98/kWh (US$0.12-0.15) at locations with solar irradiation upward of 1,300-1,600kWh/m^2 (equivalent to e.g., Brazil); projects in 2H 2017 were installed at stepped-down, but still very healthy, 2017 FiT rates of CNY0.65–0.85/kWh (US$0.10-0.13). On top of this generous national support, many regions still offer further province-level and city/local-level incentives in the forms of tariff increment or investment subsidies. If there are any questions about how Chinese component manufacturers are able to so easily outcompete international counterparts, one may look to see if margins in their home market are in fact supporting their overseas growth.

But while vanilla utility-scale FiT projects may be the workhorse of the industry, the dark horse of 2017 is distributed FiT. According to NEA statistics, by and large the Chinese solar market behaved in line with expectations for the first half of 2017, with June seeing the same installation rush as last year from the FiT deadline. But whereas Q3 last year saw a deep market slump as the pipeline emptied, Q3 2017 exceeded the Q2 peak, driven by a spillover from the 30 June 30 utility-scale FiT rush and the – literally – exponential growth of the distributed PV segment.

Although distributed PV amounted to only 4.2GW in the full year of 2016, the market grew more than 4.5 times to 19.4GW in 2017. Distributed PV FiT, unlike utility-scale FiT, is not subject to any (however weak) caps by regulators, and thus developers have *carte blanche* to develop as many projects as they can – the incentive is even greater when considering that in some regions and consumption models distributed projects enjoy higher remuneration rates, and that distributed projects have priority over utility-scale FiT in receiving the oft-delayed FiT disbursements. ("Distributed PV" in fact turns out to be a misnomer, as developers are using this scheme to build 20MW projects en masse, which would be classified as utility-scale anywhere else in the world.)

Figure 2. China PV installations breakdown by utility/distributed. Source: NEA, Apricum analysis



What are the economics of PV projects in China today?

On 22 December 2017, the NEA announced the 2018 FiT rates, which incorporated a cut to both the utility-scale and distributed PV rates. Although the utility-scale FiT is typically cut every year, this would be the first cut to the distributed PV FiT rate since it was announced in 2014.

Utility-scale projects under the 2018 FiT (to be built presumably before June 2019) will receive between US$0.10-0.13/kWh – an embarrassment of riches in today's global PV market. However, the cash flow for the first few project years is subject to risk, as there have been significant delays in the disbursement of the FiT subsidy as the state Renewable Energy Subsidy Fund is severely backlogged to the tune of CNY60 billion as of end-2016. Projects currently backlogged receive only the wholesale rate and not the tariff subsidy.

The remuneration model for distributed PV projects is slightly more complicated. There are two possible models: "net metering" and "100% feed-in".

Under the net metering model, only the portion of the electricity not consumed onsite is sold to the grid at a rate of CNY0.42/kWh + a "air pollution pass-through tariff" rate, which is levied onto consumers on a per kWh basis for treatment of sulphur and other pollutants generated by conventional coal. A commercial PV installation in Hangzhou city in Zhejiang province in 2018, for

[tariff/kWh]	Region[a]	2018		2017		
		CNY	USDc	CNY	USDc	Small-scale[c] PA projects will continue to receive 2017 FiT
Utility-scale	I	0.55	8.59	0.65	10.15	
	II	0.65	10.15	0.75	11.71	
	III	0.75	11.71	0.85	13.28	
Distributed		0.37	5.78[b]	0.42	6.56[b]	

Table 1. China 2018 FiT rate cut, assumed exchange rate of US$1 = CNY6.40. a) solar resource region; b) distributed PV FiT is supplemented by other tariffs; c) meaning household- (~5-7kW) and village-scale (~300kW). Source: National Energy Administration (NEA)

example, would receive 0.37 (national FiT) + 0.4153 (air pollution pass-through tariff) + 0.10 (provincial FiT) + 0.10 (city FiT for first five years) = CNY0.985/kWh, or 15.5 US dollar cents/kWh for the portion sold to the grid.

The remuneration model for the 100% feed-in model was more complex previously but from 2018 onwards this was simplified, and they would be remunerated like a commercial utility-scale PV plant.

Village- and household-scale poverty alleviation projects will continue to receive 2017 FiT rates, evidence of the strong political support for the programme.

The million-dollar questions: will China be able to sustain an annual 50 GW+ market? What drives the future of China PV?

A study published by the China National Renewable Energy Centre (CNREC) in November 2017 recommended that China raise its official 2020 PV installation target from the current 105GW – already surpassed – to 200GW. Assuming that China reached 130-140GW at the end of 2017, this target translates into an average of 23-30GW of annual new build, or in other words, a collapse of the domestic solar industry as it currently stands.

From an economic stability point of view, and considering that PV is one of very few "technology of the future" industries in which China leads globally, a position it very much wishes to be in, there is little chance that regulators would allow a drastic slowdown of the domestic PV industry. As such the relevance of such excessively low targets to mid-term China/global PV demand should be viewed with a healthy dose of scepticism [1].

So, will China be able to sustain growth at 50GW a year? While this figure may seem unreasonably high, it has to be put in the context of China's gargantuan power demand. The 13th Power Five-Year Plan targets total installed power capacity of 2,000GW (including renewables). If the PV market sustains growth at 50GW/year over the next three years, it would put PV at ~300GW, or 15% capacity penetration. While this is not exceptionally high in comparison to other industrialised countries (e.g., Germany 20%, or Italy 16%, in 2015), the ability of the grid to absorb this level of variability differs vastly across regions, favouring of course installations closer to population-dense demand centres.

We do believe that 50GW per year is sustainable, at least in the mid-term, and that this would increasingly be driven by the distributed PV segment. We see three key risks that may inhibit PV growth: land scarcity, curtailment risks and the inability of the increasingly-burdened Renewable Energy Fund to pay out the promised FiT – for all three of these risks, distributed PV has the clear upper hand over utility-scale installations. Distributed PV has the distinct advantage of utilising smaller pockets of land, which are more readily available than large land parcels; being built closer to demand centres – as installations shifted east this year, the overall national curtailment rate in the first nine months of 2017 has actually declined 3.8% year on year; and a potential to soon access more diversified sources of compensation via private PPAs.

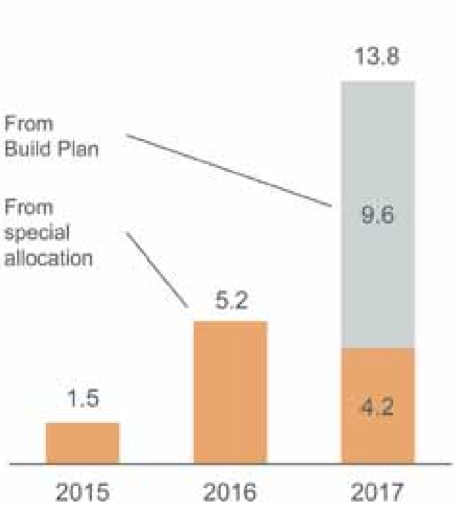
Furthermore, from where the industry currently stands, we observe several emerging trends that will be highly relevant as market drivers of the Chinese solar industry for the remainder of the 13th Five-Year Plan period:

- The Top Runner programme expands, raises requirements: the 2017-2020 Build Plan by the NEA upsized the Top Runner programme to 8GW/year while at the same time extending the completion period to three years. When the results for Round 3 were released in early December, however, the NEA had only approved 6.5GW for 2017, consisting of 10 x 500MW so-called "Application Bases" and 3 x 500MW "Technical Bases" [2], with different technical requirements for module efficiency and commissioning deadlines as shown in Figure 2. The prevailing sentiment is that the Top Runner programme is the lynchpin to achieving the greater objective of national PV grid parity by 2020. Thus the announcement of the 8 GW/year plan cements the Top Runner as a contiguous, sizeable programme and sends a strong signal to domestic players to continue the flurry of investments today into cutting edge R&D as well as high-efficiency production lines – application bases would provide the long-term market through, presumably, 2023 for the "new normal" of mass-market upgrades like PERC, while technical bases would ensure demand for the truly cutting-edge technology.
- Poverty Alleviation programme is integrated into the mainstream FiT, becomes a key part of ensuring popular support for PV domestically: instead of a separate programme like the 5.2GW allocated in 2016, the 2017-2020 Build Plan announced that utility-scale FiT projects from 2017 onwards would automatically prioritise poverty alleviation projects in the selection and disbursement of subsidies. Thus far, 12 provinces have either mandatorily or

Table 2. Top Runner programme minimum efficiency requirements 2018

	Module efficiency		Cell efficiency		
	Multi	Mono	Multi	Mono	Deadline
Application bases	17.0%	17.8%	19.3%	20.5%	31 Dec 2018
Technical bases	18.0%	18.9%	20.3%	21.6%	30 Jun 2019

Source: NEA



Province	2017 quota	For use in PA	Note on use in PA
Hebei	1,710	1,710	Mandatory all PA
Shandong	500	500	Mandatory all PA
Jiangxi	500	500	Mandatory all PA
Henan	900	900	Mandatory all PA
Hubei	500	500	Mandatory all PA
Hunan	500	500	Mandatory all PA
Yunnan	500	500	Mandatory all PA
Guangdong	500	500	Mandatory all PA
Shanxi	800	800	Voluntary all PA
Inner Mongolia	1,000	1,000	Voluntary all PA
Liaoning	500	500	Voluntary all PA
Jilin	500	500	Voluntary all PA
Sichuan	500	500	Voluntary partial PA
Jiangsu	1,200	200	Voluntary partial PA
Guizhou	300	30	Voluntary partial PA
Guangxi	500	86	Voluntary partial PA
Shaanxi	800	400	Voluntary partial PA
Other	4,400	-	No PA so far
Total	16,110	9,626	

Figure 3. Poverty Alleviation projects capacity allocation breakdown (GW). Source: NEA, local news reporting, Apricum analysis

voluntarily allocated the full amount of their 2017 Build Plan towards PA projects, and five provinces partially – this implies that of the 16.1GW utility-scale FiT projects to be constructed before 30 June 2018, 9.6GW will be for the purpose of poverty alleviation. The Poverty Alleviation programme is thus intended to become a core pillar of the PV industry, supporting both PV demand and ensuring popular political support.

- Margin squeeze as industry moves from subsidy to market-based pricing: Regulators have time and again reiterated their focus on reducing the cost of solar. The industry today in all four market segments highlighted is still almost entirely reliant on tariff subsidies. The competitive bidding implemented in the Top Runner programme today and in some select provinces are mostly still cases of bidding down the subsidy. Margin decreases at home have already pushed tier-one Chinese companies to expand aggressively abroad; greater margin squeeze means we will be seeing more international activities also from tier-two players. Industry consolidation may accelerate, but this will be moderated to some extent by smaller companies leveraging local content requirements in various provinces.
- Distributed PV to serve liberalised power market: On 31 October 2017, the NRDC and NEA announced plans to set up pilot programmes allowing distributed PV facilities to sell to nearby electricity consumers; such distributed projects will continue to enjoy FiT and priority in receiving FiT disbursements. "Distributed" PV here is also even more loosely defined to also include projects between 20-50MW under 110kV. These pilot programmes are to end, and actual implementation to begin, as early as June 30, 2018. While the surge in distributed PV may moderate after the FiT incentive is slashed, the liberalisation of the market means that private PPAs may become another demand driver in the near future – a key trend to watch.
- Green certificates pilot programme to replace FiT? In July this year, China issued its first batch of green power trading certificates to 20 pilot projects, to be available for purchase on a voluntary basis. Projects that receive green certificates would no longer benefit from FiT. As of October 2017, however, reception has been poor, with only 12,000 out of the 8 million issued certificates sold (or 0.15%; 90% sold to businesses, 10% to individuals). The government has however communicated the intention to implement mandatory green certificate purchase for certain industries as early as 2018 – another key trend to watch

Conclusion

In conclusion, we reiterate the importance of watching Chinese PV policies as one of the earliest predictors of short- to mid-term global PV trends, no matter whether in demand, prices, or technology.

On prices, for example, there are now some local news outlets reporting that from 2019 onwards, the NEA would no longer give utility FiT projects the half-year build time extension to June of the following year, which if true would mean global PV prices would no longer see the 2Q peak and 3Q plunge that has been the trend over the last two years.

On technology, it would be highly instructive to see how the Top Runner programme develops; it not only shapes the R&D investments today but will also to a large extent predict when and how much shortage/price hikes there would be for specific high-performance module types, based on Top Runner performance requirements and project deadlines. With the rooftop segment gaining traction, we see a fundamental shift in what the Chinese domestic industry values – the optimal product is now not only the one that is cheapest, but the one that is also space efficient. For years the global industry has predicted again and again that the continuous breakthroughs in mono technology would let mono demand overtake multi, but that did not happen until the Chinese market began to value mono, beginning with the Top Runner programme and now continuing to grow with its distributed PV segment.

In other words, it is key to remember that China is Chinese manufacturers' largest and possibly most profitable market, and this market is to a large extent state-controlled – small changes in policy thus have the potential to result in large ripple effects down the line, globally. ■

Authors

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References

[1] At a NEA press conference in October 2017, Li Chuangjun, the deputy director of New and Renewable Energies explained that the (ludicrously) low 105 GW target released in 2016 was based on 2015 data, determined at a time when the cost of PV was far higher than today and when the electricity demand growth rate was 0.5%, compared to today's 6.9%.

[2] A "base" being a cluster of projects organized and tendered in a specific region by the local authorities -- a regional tender, so to speak. In an uncommon stroke of planning, the NEA is holding the remaining 1.5GW in reserve to award to the three top-performing bases in meeting commissioning deadlines and technical requirements, and in securing the most discounted tariff rates to the local FiT. While the idea of "technical bases" had already been introduced in Round 2, it was then generally defined as projects utilising the most advanced technologies – Round 3 now establishes some quantitative criteria.

Business as usual

Japan | After the frenzied highs of several year ago, Japan's PV market has quietened down somewhat. But As Izumi Kaizuka writes, ongoing policy and market reforms and the evolution of new technologies look set to ensure strong continued growth for the foreseeable future

In the Japanese PV market in 2018, the business related to distribution, sales and construction of PV systems is expected to continue, as the construction of PV projects approved under the former feed-in tariff programme, which have not started operation for a long time, will begin; a large numbers of projects are expected to begin operation hereafter. Although the purchase prices will be reduced in FY 2018, the stronger companies which are able to keep profit will lead the market, with the further progress in innovation, improvement, rationalisation, optimisation, and development in various aspects of business. In terms of policies, discussions around increasing Japan's energy mix will advance, and measures to address the issues obstructing the large-volume introduction of renewable energy, with a particular focus on grid integration, are scheduled to be announced. As both the business environment in the industry and the business predictability will be improved under the anticipated policies, it is expected that engagement in the renewable energy business will expand further.

In terms of installation, it is expected that a certain amount of installation will be secured, due to the construction and operation of PV projects approved under the former FiT programme, but which have not started operation for a long time, the increase of the overpanelling ratio of PV modules, and the recovery of the residential market boosted by storage batteries and zero-energy homes (ZEH). The PV installed capacity in the Japanese market in 2018 (calendar year) is expected to decrease or increase a little year on year to between 6 and 7.5GWDC (according to the forecasts of several scenarios) as shown in Figure 1.

The main direction of each sector that supports the PV market in 2018 and beyond is expected to be as described below:

The national government will promote establishment of new rules to introduce cost-competitive renewable energy and to get over the grid restrictions, under the new FiT scheme. By presenting the efforts to address the issues towards large-volume introduction of renewable energy with a focus on the grid issues, and the policies for increasing the energy mix, the predictability of the power generation business will be improved, and the projects of renewable energy will start to move towards the realisation.

For local governments, the long-term stable operation and the co-existence with communities will be the most important theme of renewable energy, and efforts to promote orderly and proper installations will be advanced further. On top of these efforts, the movement to promote local production and local consumption of energy will expand in cooperation with private companies, and the services provided by the regional 'power producer and suppliers' (PPS) companies will be diversified. PPS companies were created as a result of Japan's electricity market deregulation.

Electric utilities will promote efforts to respond to the new market design and complete the electricity system reform process. Efforts will be made to activate the retail electricity market, while efficiency will be improved by cooperation among regions, with the enhanced adjustment function of supply and demand for the increasing installation of renewable energy. In some regions, output curtailment of PV systems is expected not only on Japan's more remote islands but also on the mainland.

In the PV cell/module and system business, major domestic companies will proceed with restructuring of the PV cell/module manufacturing framework to speed up improvement of profitability and enhancement of competitiveness. In Japan, progress will be made in cost reduction and performance improvement of products. In the market, in addition to the successive launches of new products mainly for residential applications, the proposals of solutions for residential applications will become more active. These solutions include integrated storage batteries and home energy management systems (HEMS) for self-consumption, which correspond to dissemination of the ZEH policy and the fact that in 2019 the first FiT recipients from 2009 will see the purchase period under the FiT end, meaning they will have to sell surplus power at a reduced rate or for free. In the non-residential sector, development of new applications will be enhanced such as floating PV systems and solar sharing, and efforts will be made for establishing 'virtual power plants' (VPPs) which include MW-scale PV power plants

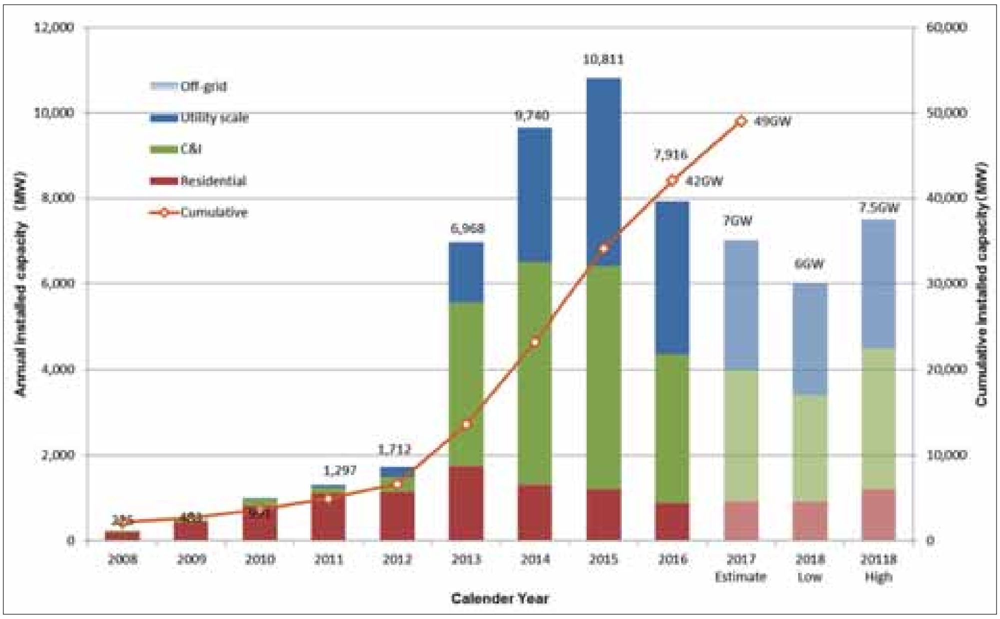

Figure 1. Possible scenarios for Japan's PV deployment in 2018. Source: RTS Corporation

Credit Kyocera

with 1,500V specifications and renewable energy. The market development will be enhanced, appealing the added values which correspond to the demands of users, such as bifacial power generation and high weather resistance, in addition to higher output and higher quality.

For the inverter business, while the residential applications are expected to recover, the industrial applications will be stable or decrease gradually. In the market of residential inverters, domestic manufacturers such as Omron, Panasonic and Tabuchi Electric will remain advantageous. Out of the two types of industrial inverters (the central inverters manufactured by TMEIC, Hitachi, Nissin Electric, Fuji Electric, DAIHEN, SMA, etc. and the distributed inverters manufactured by Delta Electronics, Huawei, SMA, Tabuchi Electric, Sungrow, etc.), the distributed inverters are expected to expand their market share. In terms of technology, 1,000VDC inverters for industrial use and the transition to smart inverters will advance.

In the supporting structure business, progress will be made in the improvement of material procurement and reduction of items, development of simpler construction methods, and rationalisation of business including distribution and sales, as the pressure to decrease the total cost is intensifying. The launches of new products with high added value, such as the durability against wind and snow, will increase as well.

In the storage battery business, as the market of residential storage batteries expanded in 2017, manufacturers such as SHARP, Choshu Industry, Panasonic and KYOCERA gained a significant market share. The market of storage batteries in FY 2018 is expected to expand as well, by encouraging the projects, whose FiT purchase period will expire in and after 2019, to shift to self-consumption. The installation of industrial storage batteries increased in the area of Hokkaido Electric as a measure to mitigate the sudden output fluctuations. Hereafter, as the price decreases, the use of storage batteries for self-consumption will increase.

In the housing business, with the trend of obligation for buildings to conform to energy conservation standards and the dissemination of ZEH policy, the standard installation of PV systems to newly built detached houses and collective housing (condominiums/apartments) will expand further. Also, in the existing housing market, the launches of cost-effective products will increase. As the 'Year 2019 issue' approaches, the coupling of PV systems with storage batteries and HEMS linked to smart devices will increase. It is expected that a variety of product lineups that correspond to the demands of users will be available, as the entries of overseas manufacturers into the market increase. It is forecasted that new business models will increase, such as the combination of electricity sales and other services.

In the EPC business, companies which deal with large-scale projects have large numbers of back orders, as many large-scale projects are remaining. Since the number of projects with revoked approval was smaller than expected, it is estimated that a certain portion of projects will make progress.

In the PV business support service segment, competitive conditions will remain the norm, because large numbers of companies are entering the market, drawn to the stable long-term prospects on offer in the operations and maintenance (O&M) business. Among these companies, some will take charge of O&M in addition to EPC, while others are from different industries. Progress will be made in the enhancement of the O&M function and ongoing cost reductions, utilising the Internet of Things and artificial intelligence.

In the PV business, the approval of PV project business plans was finalised, and the number of the projects whose business plans were finally approved after the deemed approval status, turned out to be larger than expected. Therefore, the construction and operation of large-scale projects is expected to increase. It is expected that the requirements for the tenders will be eased, in order to encourage the participation in the tenders for PV projects with a capacity of 2MW or more. The low-voltage projects, which are not applicable to the tender process to secure the grid connection capacity, are expected to increase as well.

In the area of the Power Producer and Supplier (PPS), the rush of new entries will slow down, and the services provided by the existing players will be diversified. With the start of the transaction of FiT electricity in the non-fossil value trading market, progress will be made especially in the electricity supply service, utilising non-fossil certificates (environmental values).

In the financial industry, active investment from overseas in renewable energy, including PV, will continue, with the growth of environmental, social and governance investment and the increasing attention to the infrastructure business. Domestic companies are also expected to promote business expansion, targeting the continuously growing overseas markets. ■

RTS Corporation will be at PV Expo Japan at booth E45-33

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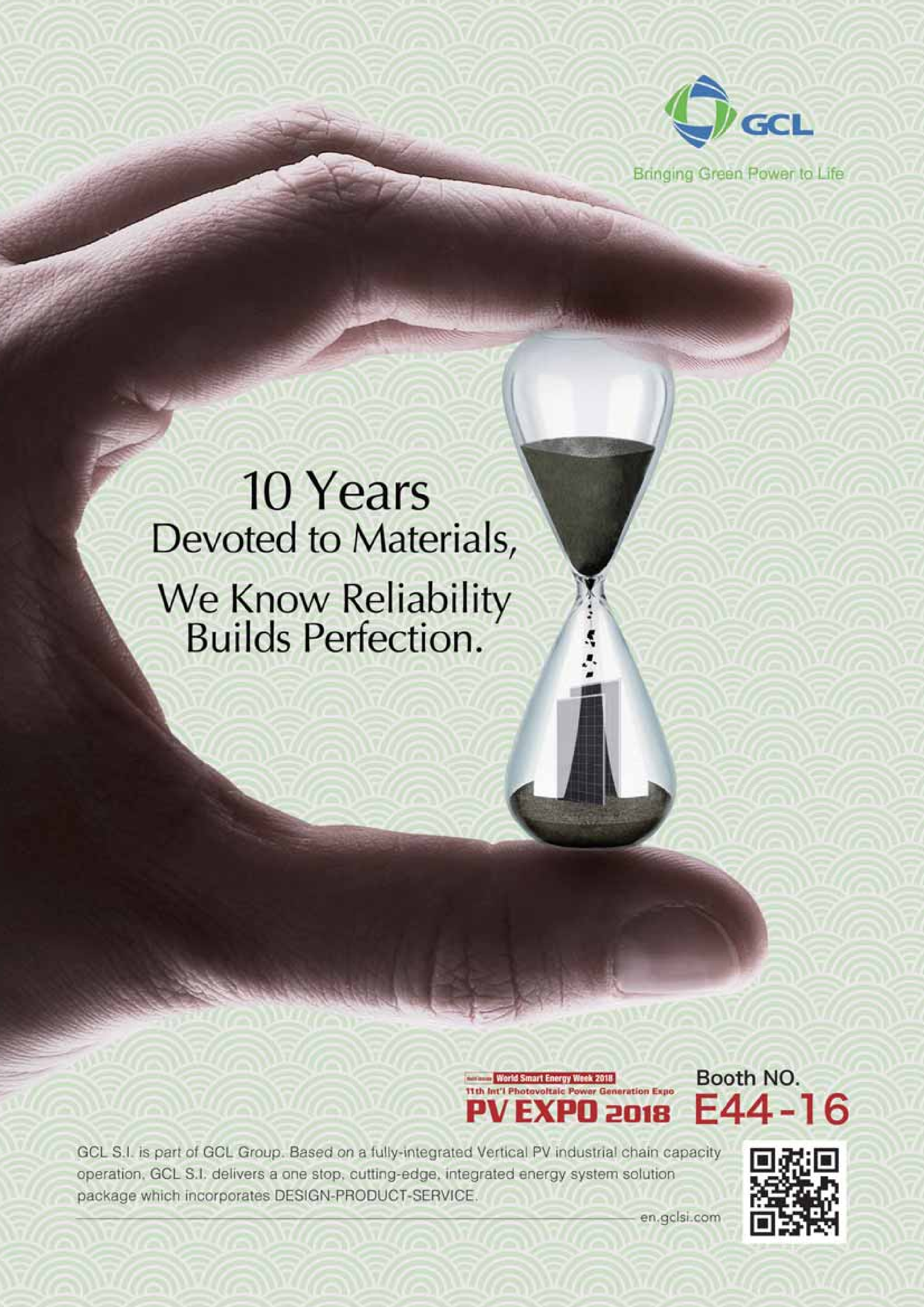
References

RTS Corporation, "PV Market in Japan 2017/2018", June 2017.
RTS Corporation, "PV Activities in Japan and Global Highlights", February 2018, Monthly Report.
RTS Corporation, "Forecasting PV Installed Capacity in Japan toward FY 2020 and FY 2030 (2017 Edition)".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Emerging market briefing

Ben Willis looks at the latest trends from some of the world's most promising emerging PV markets. This issue features Oman, Saudi Arabia, Kazakhstan and South Korea

South Korea prepares to take the next step up

With 6GW of PV installed by the end of 2017, South Korea is not strictly speaking an emerging solar market. Nevertheless, recent government plans for what would represent a step-change in the country's renewable energy ambitions make it worthy of a close look.

At the end of 2017, the South Korean government announced a target of meeting 20% of its power needs from renewables by 2030, rather than build a new generation of nuclear reactors. Within this, solar looks set to play a significant role, with a huge 30.8GW of new capacity planned – a fivefold increase on current levels.

"Considering South Korea's current level of renewable penetration (7% of total generation including waste biomass, which is not considered renewable in other countries), this is indeed a very significant and ambitious target," says Bloomberg New Energy Finance analyst David Kang.

The government's main policy instrument for driving such a high level of deployment would be its Renewable Portfolio Standard, which requires large-scale power companies to procure a set percentage of electricity generation from renewable sources, says Kang. "The annual RPS upward ratchet is currently set to rise from 4% in 2017 to 10% in 2023. RE3020 plans to increase this mandate to 28% (not decided) by 2030. The government also plans to temporarily (possibly only available during current President Moon's term) introduce a feed-in tariff for small-scale PV projects (sub-100kw)," he adds.

But Kang says Korea will be "challenged" to meet this goal as its new policies fail to provide solutions to two "key barriers" against large-scale solar and wind deployment in the country – namely the availability of suitable sites and permit challenges. Another impediment may be the relatively low penetration of foreign players in South Korea's solar market, a consequence of language barriers, among other things.

For South Korea to reach its target, "continuity in energy policy will be key", says Kang. "RE3020 defers over 70% (36.3GW) of its planned solar/wind capacities to post-2022, i.e. the next administration," he explains. "This leaves the roadmap vulnerable to future revisions which can be all-the-more critical since key impediments of solar deployment in Korea (site limitation, permit challenge) can only be resolved through strong policy support."

Credit Conergy

Solar is taking precedence over new nuclear capacity in South Korea's future energy plans

Headway at last for the Middle East's sleeping giant?

An analogy sometimes used for Saudi Arabia's as-yet untapped solar market is that of a 'sleeping giant', which, when it stirs, will become a force to be reckoned with.

Certainly there seems to be no limit to the international interest in the potentially huge opportunities for developing solar in the oil-rich gulf state. Yet so far the kingdom's solar sector has remained just that – potential rather than actual, much hyped but beset by a number of delays and false starts.

But that could be about to change. Shortly before this edition of *PV Tech Power* went to press, local developer ACWA Power won a tender to build the 300MW Sakaka project, the first time any large-scale PV project in Saudi had reached this stage of the development process. The project was set to reach financial close by the end of February 2018 and begin commercial operation in 2019.

The question now on the international PV community's lips is of course whether the progression of the Sakaka project is just a one-off or signifies the start of the Saudi giant's full awakening. Saudi Arabian authorities have certainly signalled their intent to diversify the country's energy mix away from oil, starting with a target of building 9.5GW of renewables by 2023. After Sakaka the next stage towards that target looks likely to be another solar tender round later in 2018, confirmed at the start of the year by the Saudi Renewable Energy Project Development Office (REDPO), this time for 3.3GW across seven projects. So the signs for a steady increase in deployment look positive.

But one note of caution sounded over the future development of the kingdom's solar industry concerns the very low bid price Sakaka attracted. Although the ACWA winning price of around US$2.342/kWh was not the lowest tendered, it was nonetheless extremely competitive. At the time the bid prices became public, industry observers questioned what sort of precedent this would set for future tenders, given that the involvement of international players perhaps unable to access similarly favourable sources of finance available as ACWA Power seems almost inevitable if the Saudi government's ambitions are to be realised.

To some extent that question remains and will need to be considered by REDPO and other authorities in future tenders, says Gurmeet Kaur, communications director at the Middle East Solar Industry Association (MESIA).

"If bidders form a view that only very low pricing is going to be accepted then it would discourage a lot of people from bidding in the next rounds," Kaur says. "It's not going to be the case that the winning bidder for this tender would necessarily have the capacity to build 9GW, so it's necessary to diversify and

Kazakhstan looks to break the oil habit

Kazakhstan may be a dyed-in-the-wool oil state, but its authoritarian government has nonetheless signalled its commitment to renewable energy, with an eye both on international climate change obligations and a need to diversify the local energy mix.

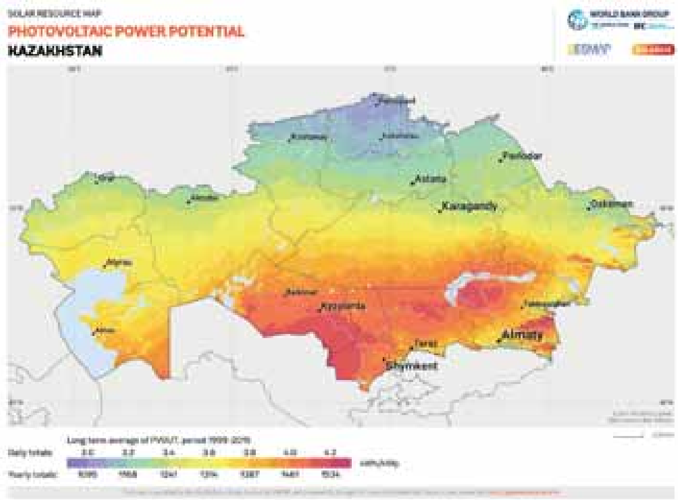
Under a plan published in 2013, a series of renewable energy targets were outlined, starting at 3% in 2020 before rising to 30% and 50% by 2030 and 2050 respectively. In 2014 tariffs for key technologies such as solar, and wind were enshrined in law, offering, for example, KZT34.41 (US$0.106) per kWh for PV.

Despite the relatively attractive tariffs, however, actual projects taking advantage of them have been slow to come forward. According to Luc Garé, managing director of QWAY energy, a newly launched renewables development company active in Kazakhstan, this has been a consequence of a lack of professional experience within the country to exploit the opportunities on offer.

"What we saw in the beginning, in 2014, 15, 16, was that many local Kazakhstan people just jumped on this opportunity to start developing solar projects," Garé says. "They said ok, we have a piece of land, it's not far from a substation I'm going to develop this project. But the problem was that those people, the majority of them, hardly speak any words of English; they have no exposure to an international community of investors. So they finally received their [power purchase agreement] from the government but then their projects were stuck, nothing happened, because they didn't have the capital and debt financing possibilities to build these projects. Their idea was to sell it to somebody then, but if you have no exposure to the international solar community you are stuck. And that's what's been happening."

Garé, a former senior executive with module manufacturer REC Solar, claims the combination of his international experience in the global PV business and strong local connections puts Qway in a strong position to break the deadlock in Kazakhstan. Already the company has developed a number of projects across various different technologies. Among these it has four PV projects – three of 125MWp and a fourth of 62MWp – ready to go, with the necessary grid licences, environmental impact assessments and other permits.

These projects will be entered into an auction planned for later this year. This will be Kazakhstan's first and signifies a change of tack by the government, away from the discredited system of simply offering PPAs to projects with the necessary licences, to a proper competitive bidding process aimed at attracting new players to the market. "By making this more international, they hope to get more international players into Kazakhstan and therefore get out of the status quo they're in now," Garé says, adding that he hopes all four of Qway's projects will be successful given the headstart the company has had on other international actors.



Credit SolarGIS

Kazakhstan's solar resources are similar to those found in southern Italy or Spain

Overall, the Kazakh government's 10% renewable energy target by 2020 represents around 3GW of new capacity across all technologies, so this debut auction, which Garé understands has been set at about 1GW, will be just the first step for the country. And given that the 2030 target is 50%, Garé believes that this is just the beginning of a steady scaling up renewables activity in Kazakhstan.

One advantage the country has is its location on the route of the old Silk Road, which is currently a target for Chinese overseas investment under its 'One Belt One Road' initiative. This is trying to enhance Chinese trade links with countries such as Kazakhstan through extensive infrastructure investment. According to Gare, renewable energy is one of the sectors that looks set to benefit from China's largesse, a factor that greatly increases its attractiveness for foreign investors.

"Those four projects we cannot build them all by ourselves; we started the company only 1.5 years ago," he says. "We see many potential Chinese investors very interested in jumping in this market; also because they are of course being pushed by their own government to start developing these [projects]."

therefore I think [the Saudi authorities] have to be realistic on the pricing you can get in future rounds. They need to be aware that the pricing achieved in this round is not necessarily going to be the same for the next ones."

Indeed, the fact that in the case of Sakaka the winning bid was not the lowest will have sent out an "important message" to the international solar community, Kaur adds. "I think that's what they need to continue to do – to send those messages that it is a transparent process, it's a fair process and that is important."

Another question mark concerns the local content rules that are being imposed on renewable energy project in the kingdom. These have started at 30% for solar, rising to 40-60% this year and ultimately to over 60% from 2019 onwards.

"That seems quite high; so I guess it needs to be monitored how international bidders are able to comply with the local content requirements," Kaur says.

These are undoubtedly questions that must be addressed as Saudi Arabia begins the long-awaited process of rolling out its renewable energy programme. But one certainty is that they are unlikely to deter the opportunity-hungry international developers who have waited patiently for this moment to come.

Credit Phoenix Solar AG

Saudi Arabia's tentative steps into the world of renewable energy look set to accelerate

Oman looks to the sun

While record-busting tender prices have become something of a hallmark of PV projects in the Middle East, one country that has yet to get caught up in the hype is Oman. This in spite of having some of the best solar resources in the world and a rapidly growing appetite for power to feed its developing economy.

In fact Oman's lateness to the table where solar is concerned is not so surprising when you consider its status as a leading exporter of natural gas and its heavily subsidised utility prices, which make it difficult for solar and other renewables to gain a foothold.

Nevertheless, the government has set a target of meeting 10% of Oman's power demands from renewables by 2025, equating to around 3GW of new capacity. That target is technology neutral, but recent indications suggest solar looks set to take a substantial slice of the pie, most likely sharing it with onshore wind.

For starters, at the end of last year the Oman Power and Water Procurement Company (OPWP), the government agency responsible for the sultanate's electricity infrastructure, announced a 500MW large-scale PV tender. The development will be run on a build-own-operate basis following the independent power producer (IPP) model that has delivered the record-low prices seen in neighbouring markets in the region. The tender, still being finalised, is seeking investment of US$500 million, with contracting slated for completion by the end of 2018 and completion of the final project by 2021.

Another significant project announcement followed swiftly on the heels of this one when, in early 2018, the government-owned oil and gas company Petroleum Development Oman (PDO) issued a call for expressions of interest to develop a 100MW PV power plant in the south of Oman near the city of Salalah. The full tender process for this project is due to be launched in February 2018, a contracted awarded in June and construction to take approximately 18 months therafter. As with the OPWP tender, the PDO project is being run on an IPP basis.

According to Haider Al-Zaabi of the Oman Solar Association, PDO is a "pioneer" of renewable energy in Oman, having already embraced technologies such as solar thermal to generate steam used in oil recovery as an alternative to burning natural gas. Notable among these is the Mirrah project built by the California-headquartered GlassPoint, which when fully complete will hit the 1GW mark (see image).

"That was [PDO's] first [renewable energy project], now it's undertaking the 100MW PV project," says Al-Zaabi. "They're moving towards being powered 100% by renewables, so they're one of the driving forces for renewable energy in Oman."

Despite some false starts on embracing the potential offered by solar PV, Al-Zaabi believes these recent tender announcements will come to fruition, marking Oman's first steps towards its 2025 goal.

And aside from large-scale projects, the Oman government last year launched a rooftop solar programme aimed at residential properties. The initiative, dubbed Sahim, will operate much like some of the early European feed-in tariff programmes, where rooftop solar system owners will be able to sell power to the grid at a predetermined tariff.

These are early days for this initiative, and one impediment is the heavily subsidised price of power in Oman, which makes solar less competitive for householders. But Al-Zaabi believes reform in this area could be around the corner, leading to a more level playing field for solar as an alternative to conventional sources of power.

An added impetus for Oman's solar ambitions, whether large or small scale, is the fact that in the coming decades, the prices of oil and natural gas are expected to become increasingly volatile, meaning Oman will by necessity need to diversify its economy. Alongside this, ongoing improvements in solar technology are pushing prices ever further downwards. "That's why interest in solar is increasing in Oman," Al-Zaabi says.

Already a significant adopter of solar thermal generation, Oman is now turning to solar PV to meet future power needs

Credit Glasspoint

Korea's Largest PV Trade Fair

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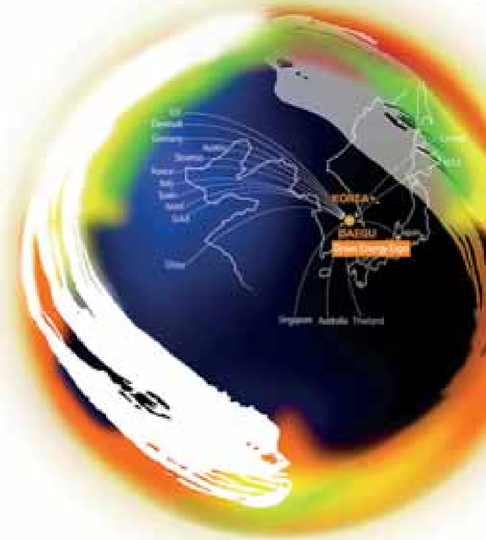

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The shifting sands of Australia's large-scale solar boom

Market drivers | Australia's large-scale PV segment has been one of the star performers of the past year. Vincent Dwyer and Jacqueline Fetchet look at the past and future drivers for this dynamic market and ask whether recent momentum can be maintained

Australia is experiencing a solar boom across the National Electricity Market (NEM) in the eastern States that has led to AU$1.3 billion invested in almost 2GW of utility-scale solar and the growth of rooftop solar capacity to well over 1GW installed in the last 12 months. In 2017 we saw the Australian Renewable Energy Agency (ARENA) provide grants to enable over 500MW worth of projects to reach financial close, the first corporate off-take agreements were signed, and major global players such as Enel and Blackrock entered the market to develop and acquire significant projects.

The sun will keep shining and 2018 will be a year of continued growth at scale as pipelines are financed. Yet the Australian market is not all golden and local developers and new market entrants will face challenges in this constantly shifting market where the energy sector continues to be mired in political tensions and divisive headlines. This year, project design will need to respond to continued policy uncertainty at the Federal level, driven by the introduction of the National Energy Guarantee (NEG) to take effect in 2019; corporate buyers will drive a new off-take market placing higher demands on developers; and grid issues and constraints will put pressure on connection against a politically delicate context.

State-based targets create certainty, with long-term NEM reform anticipated

Australia is fast approaching its Renewable Energy Target (RET) of 33,000GWh by 2020. New projects will soon cease to be accredited for the creation of large-scale generation certificates (LGCs) and the value of LGCs, currently bundled into many off-take agreements, is predicted to decrease. While the federal government pledges that the RET will not be replaced by a certificate trading scheme, the details of the NEG are being penned by the Australian Energy Market Commission (AEMC), creating policy uncertainty until the details of the reform and implementation strategy are revealed.

Credit First Solar

Large-scale PV is booming in Australia despite ongoing political challenges

With dual objectives to achieve reliability of supply and reduce emissions, the NEG will link the wholesale energy spot market and the longer-term energy contracts between generators and retailers through the imposition of a 'reliability guarantee' and an 'emissions guarantee'. The reliability guarantee aims to impose an obligation on retailers to meet a proportion of their customer's electricity load from flexible and dispatchable sources, likely increasing demand for storage, whether batteries, pumped hydro or even hydrogen. Under the emissions guarantee, retailers and large users would be given an emissions intensity level and will have to enter into contracts to meet this benchmark. It is contemplated that the NEG may take the form of a capacity market. This will potentially shift the design and mechanics of the purely financial NEM and push additional regulatory obligations on generators. The market continues to await more detail on the NEG before passing judgement, though the need for change is evident across the market.

The government is hoping that the NEG will drive market, as well as much needed network, reform. As we outline below, the grid is facing a variety of capacity constraints and a strategic vision for NEM infrastructure is required. AEMC is contemplating the design of Renewable Energy Zones (REZ) that will allow for targeted 'hubs' for large-scale generation, which is likely to drive network augmentation and line duplication. The REZ model is designed to provide additional capacity in the face of the closure of existing, and ageing, coal-fired generation while building on the momentum of development in areas that are currently capacity constrained.

Key regions for REZ locations are anticipated to include south western NSW and north western Victoria (linking in with the pumped hydro project, Snowy 2.0), far north Queensland, New England, NSW and the Eyre Peninsula in South Australia.

Despite ongoing political complexity around energy at all levels of government, states have taken the lead on creating an attractive investment environment by setting emissions reduction or renewable energy targets. In 2017, Queensland led the Solar150 and Solar400 reverse auction to support large-scale renewables, including 100MW of storage, with Solar400 receiving 115 responses to the tender. In February 2018 the Victorian Renewable Energy Auction Scheme will close, a further state-led reverse auction to procure up to 650MW of renewable generation, with a mandate for 100MW of solar. South Australia continues to drive innovation, recently installing a 100MW battery with Tesla in November 2017. The underwriting of renewables projects by governments will spur further development at scale.

Off-take market is shifting as corporates drive demand

Renewable energy corporate power purchase agreements (PPAs) now represent a major shift in the way electricity is procured by organisations. In 2017, Telstra's first corporate PPA resulted in the successful financing of the Emerald Solar Farm in Queensland. Similar deals were closed by SunMetals, Sunshine Coast Council, and Nectar Farms. In January 2018, the University of New South Wales signed a first-of-its kind corporate PPA, enabling the university to achieve carbon neutrality. These deals are opening up the Australian corporate PPA market. Throughout 2018, further corporates will look to sign PPAs as the likes of AB in-Bev, Coles and Monash University run tender processes as off-takers.

Retailer off-take has diminished so developers will increasingly rely on corporates to underwrite projects and attract finance. Corporates are often seeking specific requirements driven by internal objectives and constraints, making corporate PPAs new negotiating territory for developers and lenders alike. "Firm" supply volumes are often sought, creating an opportunity for hybrid renewable solutions to complement solar, wind and storage with back-up grid supply from a retailer.

Aggregate group buyers or "clubs" are also emerging as we have seen with the Melbourne Renewable Energy Project grouping the likes of the City of Melbourne, Australia Post and NAB to the 80MW Crowlands Wind Farm. In late 2017 Telstra signed its second corporate PPA that linked off-takers Melbourne University, Coca-Cola Amatil and ANZ under an arrangement with Telstra as the intermediary to the first stage of the 226MW Murra Warra Wind Farm.

Lenders to renewables projects signing up with a corporate are focused on a number of key risks. These include the credit worthiness of the off-taker which may be mitigated by credit support from a parent or bank guarantee; volume and supply delivery risk, where we are seeing fixed volumes rather than minimum generation requirements procured; and termination payments or "close-out amounts" if the deal terminates early, leaving the project

FINANCIAL, LEGAL, PROFESSIONAL

and the corporate exposed. "Change in law" continues to be a concern as bundled deals (for electricity and LGCs) may want rights to alternative green products without opening up the commercial deal if a new policy or scheme is introduced to replace the RET.

Electricity prices in the NEM are anticipated to stay high in the short term, making "merchant" revenue an attractive option for projects reaching commercial operations. Depending on the value of the PPA and the credit worthiness of the off-taker, lenders are still looking for a minimum 50% contracted off-take to underwrite a deal. Developers with strong equity backing may consider 'going merchant' for the medium term, as seen in ESCO Pacific's 2018 deal with Elliot. In December 2017, Wirsol successfully financed the first fully merchant solar deal with the Clean Energy Finance Corporation (CEFC) covering a total of 200MW across the Clermont and Wemen Solar Farms in Queensland and Victoria respectively. Although a well-contracted project remains the most attractive to lenders, with the right debt to equity ratio and a credit-worthy off-taker, we anticipate seeing more projects reach financial close with a higher merchant exposure throughout 2018.

Grid challenges create competition for connection and market risks

Grid stability is a paramount objective of the operation and regulation of the NEM as well as a major political concern to Australian governments. Major blackouts in South Australia in the summer of 2016-17 contributed to the urgency of the Finkel Review of the NEM as well as South Australia's battery build out mentioned above. More recently, Victoria experienced blackouts in response to a heatwave. Both events have been politically contentious. Closure of existing coal-fired generation is putting pressure on government, with the need to ensure sufficient incentives for the market to develop replacement supply. This has important implications for grid infrastructure network support and demand side management activities. Regardless of the technical or political issues, the increase in intermittency and the shift to greater decentralisation (whether utility-scale renewables, "behind-the-meter" or "private wire" solutions) is calling for strategic planning and a long-term vision for the grid.

Developers across the NEM are facing grid challenges on a day-to-day basis. Network service providers are struggling to keep up with the volume of connection enquiries and applications in the system. Generator performance standards, a crucial technical requirement as part of the connection process, are becoming more rigorous and costly in response to intermittency concerns and the increased oversight of the Australian Energy Market Operator (AEMO) on connection opportunities, from a whole of network perspective. Significant additional connections are also resulting in increased capacity constraints in the network. Once connected, generators across SA, QLD and more recently Victoria, have faced curtailment by AEMO, where generation is limited by the central operator to manage system stability and network issues. The combination of grid issues can materially impact both project timetables and financial models of developers.

The location of the project can also affect price and PPA risks, particularly in a network as large as Australia. In late November 2017, AEMO released its revised regional and marginal loss factors (MLF) for 2017-18. MLFs represent electrical transmission losses across the NEM. Significant changes to MLF were incurred due to major changes in load and generation patterns across the NEM, including the closure of the 1,600MW Hazelwood coal-fired power station in Victoria, decreased gas consumption in Queensland and regional electricity demand increasing in NSW and Victoria while decreasing in Queensland, South Australia and Tasmania. Adjustments to MLF are designed to mitigate uncertainty and volatility of electricity flows in the power system from AEMO's perspective. The practical and commercial impact of increasing or decreasing MLFs is directly felt by developers in their financial models. For example, a reduction in MLF by 0.1 could result in a 10% decrease in net revenue. Both load volumes and LGC calculations take MLF into account.

"Large-scale renewables will continue to shine in the dynamic, competitive and evolving Australian market in 2018. Developers will need to be responsive to changing policy settings, provide innovative solutions to diverse off-taker needs and use technical solutions to mitigate against market risks"

Hot tips?

Large-scale renewables will continue to shine in the dynamic, competitive and evolving Australian market in 2018. Developers will need to be responsive to changing policy settings, provide innovative solutions to diverse off-taker needs and use technical solutions to mitigate against market risks.

What's hot to watch? Hybrids of "solar + x", whether wind or storage, to meet market reliability and corporate "firming" requirements; corporate "club" buying arrangements where developers will navigate the needs of multiple off-takers; and strategic grid design creating an opportunity for developers to engage with policy and take advantage of grid "hubs" and REZs.

In Australia, the year ahead for solar looks bright. ■

Authors

Vincent Dwyer is an M&A lawyer based in Sydney. He is the head of the Norton Rose Fulbright's energy practice in the Asia-Pacific and has advised on numerous of the region's most significant cross border M&A transactions in the energy and infrastructure sectors for the last 25 years.

Jacqui Fetchet is a project finance lawyer at Norton Rose Fulbright working on renewable energy projects. She has worked in environmental law and climate change policy for the NSW government and is on the board of Pingala, Sydney's community energy co-operative. Jacqui has been the programme leader for the Renewable Cities Young Ambassadors Programme since its inception in June 2017.

A PV array in the US Virgin Islands destroyed by Hurricane Maria last October. The growing frequency of 'Nat Cat' events presents a challenge for the solar industry

Earth, wind and fire: mitigating natural catastrophe impacts on PV plants

Insurance | A spate of extreme natural disasters in 2017 have highlighted the vulnerability of PV power plants to damage. Becky Nace-Grover looks at how the PV and insurance industries should ready themselves for a future where such events are likely to become more frequent

Recent months have seen the US and the Caribbean experience devastating Natural Catastrophe (Nat Cat) events, ranging from hurricanes such as Maria and Irma to widespread flooding, the Mexican earthquakes and the most costly Californian wildfires in history with insured damages reaching US$8 billion. Aside from the terrible human losses sustained, the consequences have been keenly felt by developers and owners of solar PV plants.

Between 2011 and 2015, on average 49.8% of North American PV losses were caused by extreme weather, but these figures are predicted to be considerably higher for 2017. This, in turn, has inevitably affected the wider renewables market, as well as the logistical and financial sectors which intersect with it.

Many of the losses to GCube-insured PV assets are due to Hurricane Maria, which caused the majority of its damage through high wind speeds. This is in contrast to past hurricanes, such as Superstorm Sandy in 2012 and Hurricane Matthew in 2016, which wreaked havoc primarily through storm surge and the inundation of water from heavy rain over a short period of time. PV panels and other equipment on site are typically designed to withstand wind speeds of up to 120-140mph but Hurricane Maria, at its strongest point in the Caribbean, sustained speeds of up to 175mph.

The wider sector

Aside from the immediate, practical concerns relating to repairing damage and processing insurance claims, these recent catastrophic events are set to significantly affect the wider sector in the coming years. Over the past decade, new insurance providers have entered the market and caused an imbalance in supply and demand, leading to what we call a 'soft' market where premiums may be underpriced, leaving both insurers and insureds vulnerable. The extreme weather events of the summer and autumn have forced the industry to acknowledge that these low prices are not sustainable in the long term, and we are therefore likely to see a redressing of the balance.

Appropriate and sensible premium pricing is necessary to ensure that insurers have capacity margin not only for expected losses, but also for extreme events like those seen this past year. Risks located in areas more susceptible to catastrophic losses from extreme weather events will be particularly scrutinised, with rates set to rise for projects in these locations. As GCube has always done, we will be reviewing risks on an account-by-account basis with our underwriting decisions being informed by historical performance and relationship with the Insured. There will not be a simple, 'one-size-fits-all' solution; the goal will be to make sure we are achieving the premium volume necessary to sustain in the long run.

The sector should now be looking to benefit from lessons learned. Of GCube's exposure base in Puerto Rico, some projects performed well while others sustained near-total losses. We are working to establish the factors which led to these different outcomes, and this knowledge will be put to use in advising clients on future projects.

Nat Cat events worldwide

Learning from these losses is particularly crucial given the changing risk profile of projects, as Nat Cat events pose an increasingly potent threat to PV assets. This is partially due to the expansion of developers into emerging markets, often located in more Nat Cat-prone and remote regions, which also carry the risk of an increased impact, should damage occur, due to unestablished supply chains and inadequate infrastructure.

However, the events of recent months will force the market to acknowledge that established markets, such as the US, are far from immune from such damages.

In addition to repairing damages incurred from recent Nat Cat events, developers will now be looking to protect their assets – both existing and those in the development pipeline – from future extreme weather. Fortunately, the risks to projects can be considerably lowered through a mixture of practical considerations, varying by weather event, and financial risk transfer mechanisms.

For developers working in the US, these considerations are complicated by the country's size and geographic spread. With the American market exposed to so many different extreme weather events, insuring against Nat Cat poses particular challenges. US assets, depending on location, can be exposed to windstorms, earthquakes, flooding, tornados, hail, and hostile and rapidly spreading wildfires, unlike most foreign markets which do not experience such a wide range of exposure.

Practical risk mitigation

As such, US developers are under even greater pressure to develop a range of protections for their assets, ranging from the practical to the financial. In terms of practical risk mitigation, there is a lot that developers and asset owners can do to minimise the threat that future Nat Cat events pose to their assets and, ultimately, to their bottom-line.

Floods

Pre-emptive action against flood damage is a good example of the improvement in project security that can be achieved through comprehensive planning and increased risk aversion. Developers, while avoiding flood zones, often take advantage of the cheaper land prices adjacent to these zones, sometimes building projects so that they hug the flood zone boundary. This inevitably adds risk to the project. Insureds should understand that while there are cost benefits to this approach, it also introduces implications from an insurance standpoint, such as the need for higher deductibles or increased premiums.

Aside from these considerations, additional steps which can be taken to prevent losses due to flooding include land grading and trenching, enabling water diversion. It is essential to ensure that project sites are able to drain effectively and swiftly following heavy rains, particularly in dry, desert locations. Critical equipment should also be raised off the ground; GCube has seen a number of avoidable losses, primarily during construction, caused by equipment being left on the ground and in the path of moving water while being staged.

Wildfires

Practical measures to protect against Nat Cats vary by event, and wildfires carry their own unique risks. First, developers must remember to consider that assets do not have to be in the direct path of a wildfire to feel the effects of it. With PV plants, an issue is the tremendous amounts of smoke and ash which is created from wildfires and can travel a long way in the wind, ultimately settling on PV panels and blocking the sun from penetrating through to create power. Cleaning panels can be a costly endeavour, but it should be factored into budgeting from the very start.

As another example, for carport installations, an effective preventative action is moving all other items – such as cars – from underneath the systems. Carport assets are often elevated enough to escape unscathed, but the advantage of height can be compromised if the car or vegetation growth below catches fire and it is spread up to the PV system.

On utility-scale sites, a consideration often overlooked is the maintenance and length of grass on the site. This is of particular importance in hot regions and during the dry season. A small error, like the use of insubstantial zip ties to secure wiring on site, can lead to wires becoming loose and, ultimately, can lead to a fire breaking out. In these cases, overgrown, dry grass provides perfect fuel for the fire to spread.

Earthquakes

GCube has less experience dealing with claims from earthquakes than with other Nat Cat events. The expectation is that ground-mount installations should perform relatively well, unless located directly near the epicenter of an earthquake. Owners will still have to contend with damage to utility poles and T&D lines, which can threaten project economics through loss of revenue.

Rooftop installations are an entirely different matter, and are a greater cause of concern for insurers. The large variance in strength of the structures on which the panels are mounted presents challenges. For example, the elevated nature of the mounting structure and position of panels on carports leaves them more susceptible to damage. If the building or carport collapses due to an earthquake, rooftop installed PV assets face a high likelihood of a total loss.

Financial risk mitigation

As is clear from the many different practical considerations, outlined above, which are required to protect against various different natural disasters, insuring against Nat Cat events, in comparison to other project risks, introduces many complications.

This is no less the case for underwriters' own business; for insurers, one of the most important considerations regarding Nat Cat exposure is the aggregation of risk in specific locations. For example, for an insurance company which only underwrote assets in Puerto Rico, 2017 would prove a financially devastating year.

To minimize exposure, insurers tend to diversify their asset insurance portfolios geographically. However, in the recent spate of Nat Cat events, regions as diverse as Puerto Rico, Texas, Florida, Northern California and Mexico were affected by various events – and so a geographically diverse portfolio is no guarantee of security. This goes to prove the uncertain and unpredictable nature of Nat Cat events; Nat Cat events are called 'catastrophic' for a reason. Such events tend to strike less often than damage due to other risks, but when a Nat Cat event does occur, the consequences can often be devastating. Insurers can offer mechanisms to protect developers, but for the security of their own business, must often rely on reinsurance risk transfer mechanisms.

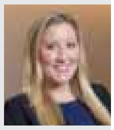
For developers, this highlights the importance of choosing an Insurer with a strong track record of supporting clients through Nat Cat losses, and with sufficient underwriting capacity to weather these losses with equanimity. With Nat Cat events only set to increase both in regularity and severity, developers are increasingly reliant on financial cover products to supplement the practical mechanisms they are implementing to minimise risk.

Insureds therefore need to work with their lenders' consultants and brokers, to determine the risk they are willing to take, and the minimum coverage they need to feel secure. Risk modelling companies often offer modelling based on past events, which can help insureds to settle on their 'probable maximum loss'. The insured and stakeholders must then determine the coverage required, balancing considerations of risk with budgeting for insurance premiums.

Moving forward

As developers and asset owners in the US and Caribbean recover from the devastating effects of recent Nat Cat events, the industry must look to the future and collaborate in order to minimise future risks from extreme weather events. This will require transparency and openness; developers, owners, investors and insurers alike have suffered from these events, but there is plenty that can be done to mitigate against future losses, from practical implementations to improved financial coverage mechanisms. With effective collaboration, the losses incurred need not have been meaningless; they can provide knowledge and inform decision making in the future, for the ultimate benefit of the industry as a whole.

Author



Becky Nace-Grover is an underwriter at GCube Insurance, having joined the New York office in 2012. Since then, she has helped to grow a large diversified book of wind and solar business on both the property and the liability side. She has worked on all size accounts ranging from small IPPs to large multinational energy and utility scale clients who operate renewable energy assets.

Reducing uncertainty in PV yield assessments

PV yield modelling | When estimating the expected yield of a PV plant for financial risk assessment purposes, understanding the uncertainties of any model is crucial. Mauricio Richter of 3E investigates some of the emerging practices for obtaining and interpreting data to ensure the most accurate results

The EU-funded Solar Bankability Project together with the IEA PVPS Task 13 group have analysed current practices of PV cost and energy yield modelling and the corresponding risk assessment [1] [2]. Present-day models were analysed to identify gaps in how technical assumptions are accounted in the various photovoltaic (PV) cost elements. This enables stakeholders to identify hidden technical risks and their potential impacts.

Project developers, banks and asset managers use PV financial models to evaluate the profitability of a PV project. The capital expenditure (CAPEX) is strongly influenced by the construction costs. In a few cases, the considered technical assumptions are clear before the final CAPEX value is determined. Furthermore, financial models normally only make use of a single number for the CAPEX value and it is not a common practice to account for the inherent uncertainties of the CAPEX value in the financial model.

Technical assumptions are also important when determining the operational expenditure (OPEX). OPEX values should reflect the expected wear-out profile of the individual components. Such expenditures should be calculated using technical parameters that describe the technical lifetime profile of the equipment instead of the financial lifetime of the project, as these can often differ significantly. Regarding the monitoring of the plant, this typically focuses on the performance ratio (PR) and technical availability as these key performance indicators are of high importance in ensuring the overall profitability of the project.

When estimating the expected yield of a PV plant for financial risk assessment purposes, the correct identification and quantification of uncertainties is crucial. The estimation and evaluation of the PV energy yield comes with large uncertainties introduced by the different elements in the PV energy conversion chain. It is also essential when comparing the measured versus expected values as indicators for O&M decisions. For both purposes, reliable uncertainty measures are essential.

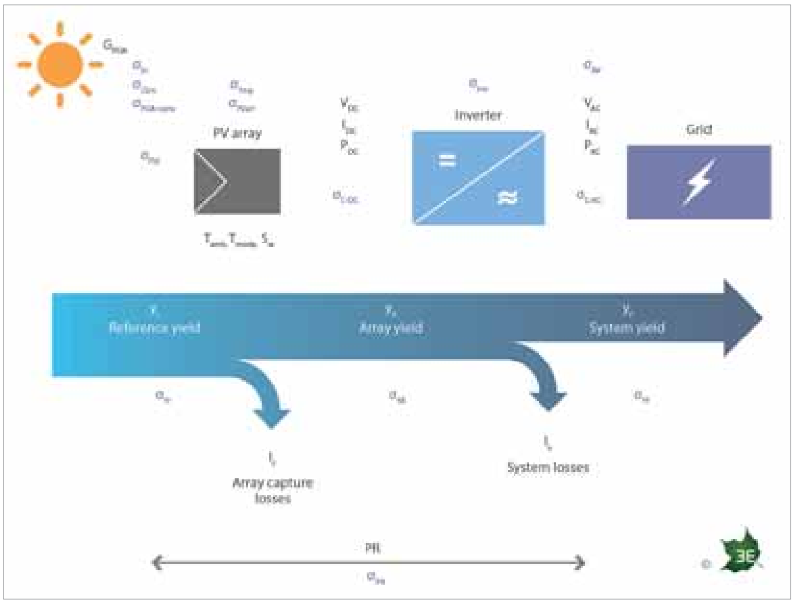


Figure 1. Energy flow diagram in a grid-connected photovoltaic system; in black, the measured/calculated parameters and in blue the related uncertainties

An overview of the energy flow in a grid-connected PV system with the uncertainties related to each conversion step is shown in Figure 1 as presented in [2]. The illustration highlights the importance of the correct uncertainty quantification when calculating the different performance indicators of a PV system. In general, the measured/expected electricity production or system yield is reported together with the PR, which quantifies the overall efficiency of energy conversion of the PV system under operating conditions. The PR is the ratio of the system yield Y_f to the reference yield Y_r. It should always be accompanied by an uncertainty, which in turn depends on the uncertainty in the final yield Y_f and reference yield Y_r quantification/estimation. Detailed explanation and examples of how these uncertainties are calculated and combined are available in the EU-funded Performance Plus Project report, "Best Practice Guide On Uncertainty in PV Modelling" [3] and further developed and complemented in [1] and [2].

Solar resource quantification uncertainties

One of the main risks during the operational phase of a PV project arises from the uncertainty on the estimates of energy yield done during design phase. If the actual energy yield does not meet the initial estimates, the entire investment can be compromised as less revenue from energy sales will directly impact the servicing of the debt or the investment return. This scenario can result from, among other factors, long-term solar resource effects, component failures, defects, forced outages, higher degradation rates than expected, etc.

The bankability of a PV project largely depends on the uncertainty of the solar irradiation data obtained during the solar resource assessment phase. The uncertainty of long-term average solar irradiation is therefore a dominating parameter in risk assessment of PV projects. This uncertainty depends in turn on several aspects such as the quantification of the solar resource, the models used, the long-term solar resource variability and trends, etc. To a large extent, the long-term irradiation uncertainty depends on the source of the data and the reference period used. A recently published white paper by Kipp & Zonen and 3E presents in greater detail the benefits of both pyranometer and satellite irradiance data for utility-scale solar energy parks and recommends the use of both sources as these are complementary [4].

While on-site, ground-measured irradiance data from a high accuracy pyranometer correctly installed and maintained is the most accurate solution even over short periods of time (as little as a minute to an hour), data derived from satellite measurements comes very close to the on-site measurement uncertainty over longer time periods such as months and years. Satellite irradiance data is increasingly being used in both utility-scale solar parks and in smaller installations since it is easy to acquire; just a subscription to a service provides a high availability of data with good time resolution and spatial coverage. For most locations on earth, satellite data provides a useful historical database for site prospecting and for optimising the site-specific design of solar power plants. This data is often used as an input for long-term yield assessment and to calculate a reference yield for monitoring and business reporting.

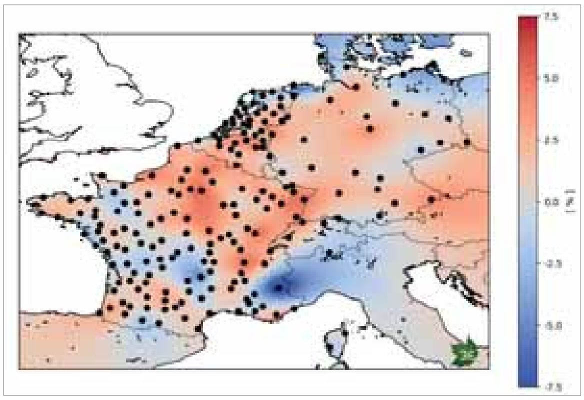


Figure 2. Percentage difference between state-of-the-art satellite irradiance data and ground station data in 2012 measured using high quality pyranometers maintained by the national public weather services

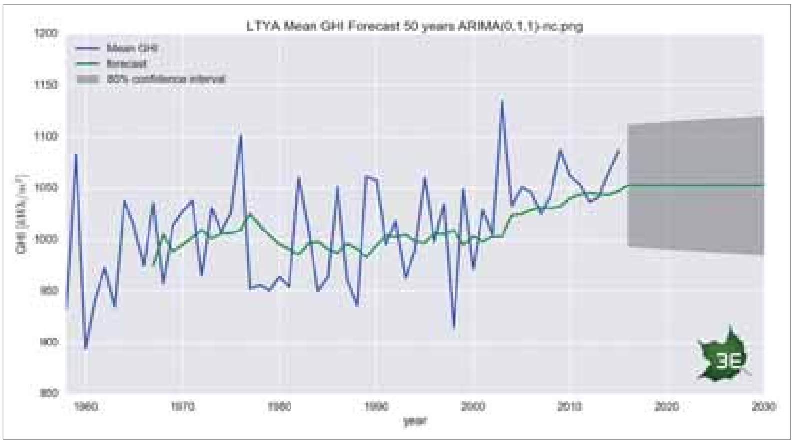


Figure 3. Forecast of future long-term irradiation based on the average of 32 meteorological stations in the Netherlands using the ARIMA (0,1,1) model without trend

State-of-the-art satellite irradiance data providers use advanced models which have increased significantly the accuracy of the data throughout the day and under complex cloudy conditions. However, as with any model, satellite irradiance data is subject to uncertainties. The yearly difference between state-of-the-art satellite irradiation data and on-site measured data collected by national weather services from over 200 meteorological stations is shown in Figure 2. The percentage difference between the satellite irradiation data and high accuracy on-site measured data over one year is in the order of ±2.5% to ±3% for many places across western Europe. Figure 2 also highlights the importance of having dense networks of high quality on-site measurements as this enables the continuous accuracy improvement of satellite irradiance data over complex conditions.

Reducing the uncertainty on long-term solar resource estimates by extrapolating short-term measured datasets

The use of long-term solar resource site adaptation techniques potentially mitigates the risk of an overestimation of the solar resource in the initial assessment during project development. An overestimation of energy yield will directly impact the estimated investment returns as the actual energy production may not meet the initial estimates.

The uncertainty of long-term satellite irradiation data can be further reduced with the help of high quality on-site measured irradiation, combining the data of a short period of record but with site-specific seasonal and diurnal characteristics with a data-set from a long period of record with not necessarily site-specific characteristics. Upon completion of the measurement campaign (typically one year), different methodologies can be applied between the measured data at the target site, spanning a relatively short period, and the satellite data, spanning a much longer period. The complete record of satellite data is then used in this relationship to predict the long-term solar resource at the target site, reducing the uncertainty on the long-term estimates.

Solar resource variability

The variability of the solar resource is defined as the ratio of the standard deviation to the average global horizontal irradiation over a long-term historical period of typically 10 to 20 years. For example, in Europe this can range from about ±4% up to ca. ±7% depending on weather conditions. This value is typically calculated from long-term databases providing yearly data over a historical period of at least 10 years.

Recent publications suggest the use of different methods to account for and to mitigate the impact of the long-term solar resource variability and trends in energy yield calculations [1]. For example, the proposed method in Figure 3 accounts for the effect of solar resource variability and a long-term trend as part of the uncertainty. This method is clear for cash flow analysis (uncertainty of single years). However, when assessing the risk of multiple year sums, the method still needs further development.

Independently of the statistical method used for the trend detection and future long-term irradiation prediction, the methodology must be clearly documented to allow the correct interpretation of the results, especially considering the increasing interest in financial models for PV plants beyond year 25.

Energy yield estimation

Further uncertainties arise from the estimation of the long-term yield of a PV

	Uncertainties	Range
Solar resource	Climate variability	±4% - ±7%
	Irradiation quantification	±2% - ±5%
	Conversion to POA	±2% - ±5%
PV modelling	Temperature model	1°C - 2°C
	PV array model	±1% - ±3%
	PV inverter model	±0.2% - ±0.5%
Other	Soiling, mismatch, degradation, cabling, availability, etc.	±5% - ±6%
Overall uncertainty on estimated yield		±5% - ±10%

Table 1. Typical uncertainties in the different conversion steps

plant during its financial lifetime. These uncertainties are related to the different modelling steps which rely on several user assumptions, often based on user experience or judgement. In general, technical project description parameters do not represent a significant uncertainty when the project is in an advanced design phase. However, some technical parameters, such as the nominal PV module power and tolerance, are based on approximations and therefore will have an impact on the overall uncertainty when calculating the expected energy yield of the PV plant.

Typical uncertainty ranges for the different elements involved in the overall estimation of the energy yield are summarised in Table 1. Further explanation and examples of how these uncertainties are calculated and combined are available in [1] and [3].

Several modelling steps, such as the calculation of the effective irradiance after reflection losses, thermal losses due to PV module physical characteristics and environmental conditions and conversion from DC to AC (i.e. inverter model), are well described and when using state-of-the-art models, the uncertainties of these modelling steps are rather small compared, for example, with the solar resource-related uncertainties. However, other additional losses occurring typically in the field, such as soiling, mismatch, degradation profile over time, snow effects and others, are often only partly simulated or accounted for by the simulation software. Therefore, users often have to estimate many of these losses and their effects based on the little information available and on their experience.

In general, it is not a simple task to evaluate several of the losses that occur in the field since they are often influenced by external parameters. Therefore, it becomes even more difficult to assess the uncertainty of these estimations. For example, when estimating soiling losses in addition to assessing the surrounding areas for the presence of potential soiling issues, one should also use models that account for monthly rainfall, humidity information and cleaning schedule, among others. Furthermore, a good alignment between the planning phase and the maintenance schedule during the operation phase can mitigate the risk of under/overestimating the effect of soiling losses considerably.

Table 2 presents some mitigation measures that can be applied to reduce the uncertainties, and therefore risks associated with the energy yield estima-

Mitigation measure	Impact/explanation
✓ Use state-of-the-art modelling software to calculate the expected energy yield of the system	Lower uncertainty in the overall energy yield estimation
✓ Verify nameplate power of the PV modules used in simulations with the flash test reports supplied with the modules	The uncertainty on the nominal PV module power and tolerance can be significantly decreased by performing flash tests. For example, independent test facilities typically guarantee the measured values to ±1.5 to ±2%.
✓ Use methods to account for the effect of different degradation behaviour over time (e.g. linear vs stepwise degradation)	PV module degradation over time may not always be linear. Using models to simulate the effect of different degradation profiles during the financial lifetime of the project can mitigate risks arising during the operation phase.
✓ When estimating soiling losses, use models that account for different factors including cleaning schedule, monthly rainfall profiles and humidity information among others	The use of models that account for monthly rainfall, humidity, and cleaning schedules can help to reduce significantly the uncertainty and to improve the OPEX during the operation phase. For example, for a PV plant located in a tropical desert climate (e.g. Dubai) the combination of the high occurrence of dust particles and high humidity may drastically reduce the yield, with soiling rates of up to 0.5%/day and up to 60% losses after a sand storm. The use of advanced models during the planning phase can help to determine a cost optimisation of the cleaning schedule.
✓ Use the expected overall unavailability for the calculation of the initial yield for the project investment financial model instead of the O&M guaranteed values	When calculating the financial income from electricity production of a PV plant, the availability assumption in the PV financial model should reflect the overall plant availability. This means an additional unavailability beyond the O&M service should be considered and added to the overall plant unavailability. This additional unavailability may be caused e.g. due to grid issues or other external factors that cannot be controlled by the operator, and thus may not be covered by guarantees.
✓ Take into account the technical lifetime of the devices as this can often be different than the financial lifetime of the project	The technical lifetime of some PV components may be shorter than the financial lifetime of the project. For example, PV inverters often have a technical lifetime of 10 years which in many cases would be shorter than the financial lifetime of the project.
✓ Use empirical methods for risk assessment calculations (e.g. P90) when possible	When calculating exceedance probabilities for risk assessment (e.g. P90), empirical methods based on actual available data should be used instead of assuming a normal distribution for all parameters. The assumption of a normal distribution does not necessarily apply to all parameters and assuming this behaviour can result in serious deviations.
✓ Consider re-assessing the long-term yield estimate of the plant using actual operational data	Using actual production once the PV plant is in operation can allow a very precise prediction of the long-term yield with a considerably reduced uncertainty. The adjustment of the financial models after e.g. one or two years of operation could potentially reduce the long-term estimation uncertainty by a factor of two.

Table 2. Mitigation measures for risks associated with the energy yield estimation during the planning phase of a PV project

tion during the planning phase as proposed by the IEA PVPS Task 13 group as presented in [2].

How accurate are PV yield estimates? Validation of long-term yield estimates and their level of confidence

The energy yield of a PV plant over its financial lifetime is estimated during the design phase with a long-term yield assessment. The long-term yield assessment usually returns the so-called P50 and P90 yields which represent the 50% and 90% exceedance probabilities, i.e., the energy yields that will be exceeded with a probability of 50% and 90%, respectively. These values are used as input for the financial model of the PV investment, and are usually evaluated for the first year of operation and for the overall financial lifetime of the plant. The correct calculation of the P90 considering all related uncertainties is essential for the evaluation of the PV investment. Moreover, when investing into larger portfolios of PV plants, the risk for the investor is finally expressed by the P90 yield of the portfolio rather than that of each individual plant. Up to now, for commercial projects little validated knowledge about the quality of their P50 and P90 yield estimates has been available in the public domain.

The Solar Bankability project together with IEA PVPS Task 13 group [1], [2] explored the quality of the initial P50 and P90 yield estimates on plant as well as on portfolio levels in order to further quantify the potential reduction of risk with larger portfolios. The purpose of this work was to validate the initial long-term yield estimates based on monitoring data over the first years under operation.

The correlation between P50 and P90 yield estimates and the actual electricity production were compared for a portfolio of over 40 PV plants. The sample comprises rooftop and ground-mounted systems and covers a wide range of plant size from 10kWp up to 12MWp. The data sets for the validation cover between one and four years of operational data. The PV plants with installation type and available data are listed in Figure 4.

Information on PV plant unavailability was collected for each individual plant and analysed. Figure 5 shows the actual percentage of unavailability (downtime) for most of the analysed PV plants. For most cases, the unavailability data comes directly from the detailed O&M reports. Moreover, when possible, the unavailability was calculated from measured 15-minute data. Unfortunately, it was not possible to determine the unavailability for all PV plants under study, since the detailed O&M report was not available for some plants and some plants only had monthly data available.

Figure 5 highlights that for some PV plants in the portfolio, the actual unavailability is very high compared with the initial expectations (e.g. PV plant number 28). Moreover, the mean yearly unavailability of the analysed portfolio is around 2%.

The main results are shown in Figure 6. The initial yield estimates for the first year of operation (P50) is represented by the zero line. The red and green background colours represent the initial P90 and P10 estimates, respectively. They are typically situated between ±7% and ± 9% from the P50 for a single site. The difference of the actual electricity production during the first year of operation from the P50 yield is represented by the blue bars. In this case, a negative blue bar means that less electricity was produced than initially expected. Statistically, eight out of 10 bars should lie

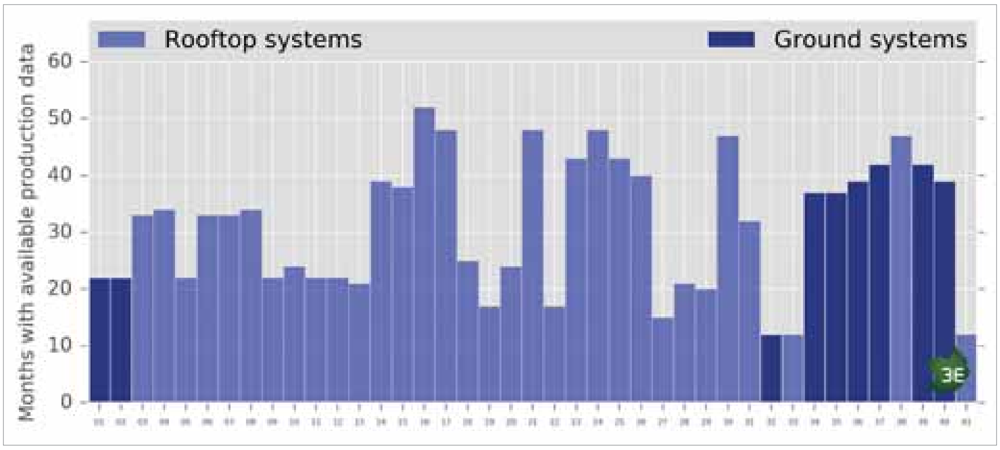


Figure 4. PV plants under study with available electricity production data and installation type

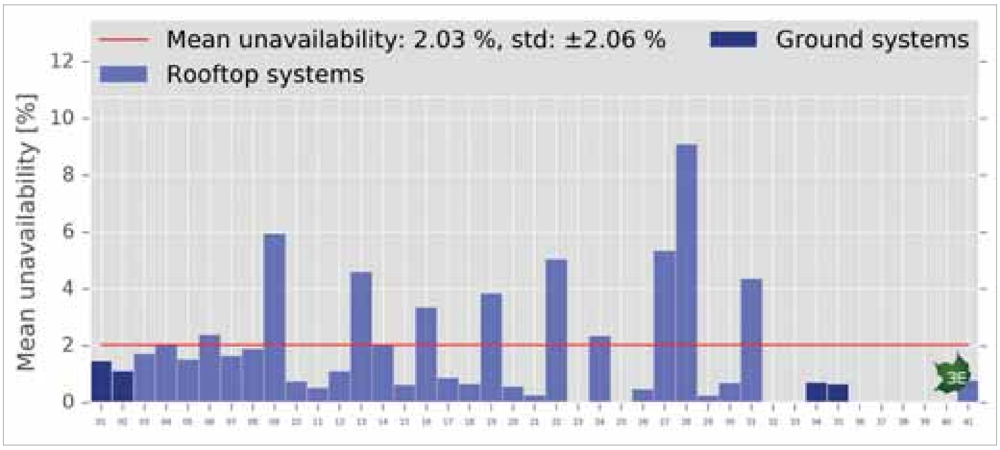


Figure 5. Actual time-based unavailability data from most of the PV plants in the portfolio

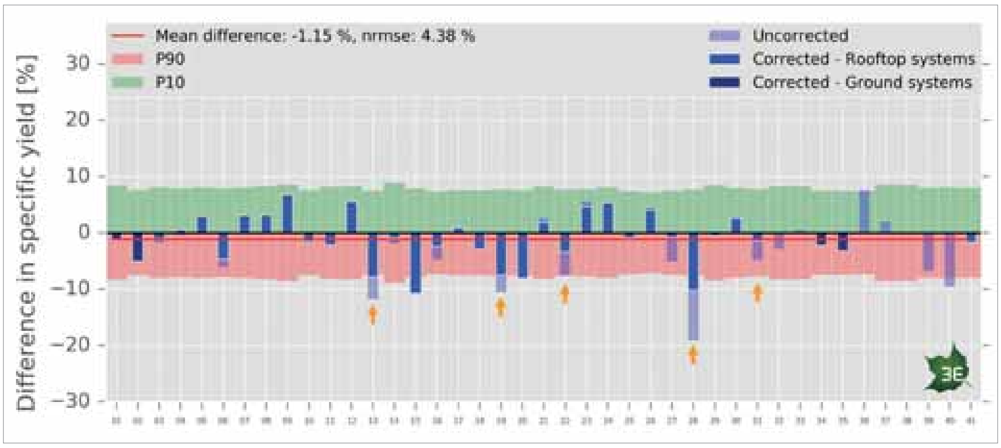


Figure 6. Difference in specific yield corrected for actual unavailability. The orange arrows highlight the effect of the unavailability correction for some examples

Figure 7. Violin plots for the difference in POA irradiation, PR and resulting specific yield between initial expected yield and actual yield for the analysed portfolio

within the red and green region, one should lie above and one below.

For most of the PV plants analysed across the portfolio, the actual electricity production during the first year of operation (blue bars) lies within the expected uncertainty range. At plant level, the yields are close to the ideal scenario but slightly biased negatively by -1.15%. However, while only one PV plant is situated above the P10 confidence interval , the portfolio contains six plants for which the actual production was below the P90 confidence interval. These deviations for some plants had to be further analysed to understand the gaps.

The orange arrows in Figure 6 point at the plants with significant durations of plant unavailability. When correcting the energy yield for the durations of unavailability, the actual electricity production for many of these plants remains within the anticipated confidence range. In other words, their initial long-term yield estimates did not account for the unexpectedly high losses due to the plants being unavailable. More generally speaking, the distribution of actual energy yields versus the initial long-term yield estimates is relatively narrow when excluding significant durations of unavailability and, hence, the initial long-term yield estimates were quite good.

At portfolio level, the overall (non-weighted) mean difference between initial long-term yield estimates and the actual yield over the portfolio is -1.15%. This means that, over the analysed portfolio, the yield is slightly lower than initially estimated during the design phase. Furthermore, as shown in Figure 7, the dispersion (NRMSE) is around 4.4% for the analyzed portfolio. These variations lie within the normal expected ranges as reported in scientific literature. These deviations are typically expected to be mainly due to the variability of the solar resource and other site-specific losses that are not precisely modelled during the design phase. Moreover, some overestimations are cancelled out with some other underestimations across the portfolio as shown in Figure 6.

The difference and its distribution for plane-of-array (POA) irradiation, performance ratio (PR) and specific yield for the entire portfolio are summarised in Figure 7. Such differences are represented using 'violin plots' which are a combination of box plots and kernel density plots. This kind of plot gives not only the valuable information of a box plot but also shows the probability distribution (density) of the data at different values.

As shown in Figure 7, the largest gap between initial expected and actual values comes from the performance ratio estimates. As previously highlighted, the initial estimates of system losses depend on several factors. In addition to the PV software modelling accuracy, several user estimates and assumptions affect the yield estimate. Regarding the POA irradiation, the results presented here are the outcome of comparing the initial estimate done during the initial yield estimation against the irradiation from state-of-the-art satellite-derived data for the first year of operation as, unfortunately, not all PV plants in the portfolio had good quality on-site solar irradiance sensor measurements.

In conclusion, the initial energy yield estimates for the portfolio under study generally agree quite well with the actual electricity production over the first years. The NRMSE across the analysed portfolio of over 40 PV plants is approximately 4.4%. By contrast, the uncertainty in long-term yield estimates for a single site is typically around ±5% to ±10%. The results of this PV portfolio use case show that this uncertainty range could decrease for a statistically meaningful portfolio of several PV systems down to around 4.4%. The outliers with energy yields below the P90 yield were largely caused by plant un-availabilities. Therefore, the risk of unavailability needs to be addressed next to the resource uncertainty and the uncertainty of the PV system model. This risk can be mitigated through good warranty conditions and operation and maintenance (O&M) contracts.

Investing in a big portfolio of PV plants may be seen as a risk mitigation strategy for investors through diversification of risks. For an entire portfolio of PV plants, the overall risk of not achieving the expected energy yield decreases with increasing size and spatial spread of the portfolio. Several variables such as the number of plants, their geographical spread, PV module technologies, the type of installations, system configuration, etc. will influence the resulting overall uncertainty. Nevertheless, the practices and potential sources of uncertainties highlighted in this text must be applied on a project-by-project basis to ensure best results.

Author

Mauricio Richter has worked as a PV expert in 3E's R&D team since 2012 and is currently the R&D product manager of 3E's data services. The scope of his work covers R&D topics in solar PV, with a focus on solar resource assessments, long-term yield estimates and performance analysis of PV systems. He is involved in several research projects including the recently finished EC FP7 funded project Performance Plus, the EC H2020 funded project Solar Bankability project and he is currently the activity leader in Subtask 1 of the IEA PVPS Task13.

References

[1] Tjengdrawira, C. and Richter, M. 2016, "Review and Gap Analyses of Technical Assumptions in PV Electricity Cost", Public report Solar Bankability WP3 Deliverable D3.1.

[2] Richter, M. *et al.* 2017, "Technical Assumptions Used in PV Financial Models - Review of Current Practices and Recommendations", IEA PVPS, Report IEA-PVPS T13-08:2017.

[3] Richter, M., De Brabandere, K., Kalisch, J., Schmidt, T., and Lorenz, E. 2015, "Best Practice Guide on Uncertainty in PV Modelling", Public report Performance Plus WP2 Deliverable D2.4, J.

[4] 3E and Kipp & Zonen. 2017, "Combining Pyranometer and Satellite Irradiance Data", 3E nv/sa - Kipp & Zonen, White Paper.

A walk in the park

Development | Shared facilities solar parks represent a huge chunk of the global pipeline taking risk and a degree of control out of the hands of developers. John Parnell explores how the model works and the prospects of its further growth

Credit: Fortum

Fortum's project within the Bhadla solar park in India

There are currently the best part of 50GW of solar parks built, planned, under construction or out for tender. Solar park is often used as a synonym for a solar farm so in the interests of clarity let's state from the outset that what we're discussing here is the solar park as a designated area of land established to house a collection of smaller PV power plants and with a degree of the supporting infrastructure already in place. Literally the provision of a (level playing) field and the systems required to convert it to a patchwork of functioning solar farms.

India doubled its solar park target from 20GW to 40GW, about 40% of its ambitious solar deployment targets. So far they have attracted competitive bids and financing support from a number of development banks including the World Bank itself.

When, not if, more emerging economies look to establish their own GW-scale deployment, the solar park model could well prove popular. Egypt and the UAE have both had success with their own initiatives. They provide an element of the central planning required by a large undertaking like transforming the power system for 96 million people, in the case of Egypt, 1.3 billion for India. At the same time they permit a plethora of private sector investors to take responsibility for more manageable chunks of solar capacity.

"We have done projects in each of the two situations," says Vahid Fotuhi, managing director of developer Access Power. "We've done a green-field project that we have had to source, originate and develop from scratch, in Uganda. We also have a project in round two of the Egyptian feed-in tariff at the Benban solar park.

"With our project in Uganda, we had to source our own land. This of course gave us more freedom to look for the best site in terms of solar irradiance, minimal losses and optimal grid integration. Essentially we had a blank sheet of paper. We weren't forced to work within certain boundaries," explains Fotuhi. However, this freedom comes at a price.

"The first fight of course is that there is a lot of paperwork involved in securing ownership of the land. Typically in emerging markets you are looking at land that is in rural areas, untitled or customary land tenure [managed more informally by local communities]. To get the land titled, documented and transferred to your company is at least a 6-12 month process. So that's 12 months of preliminary development work just to secure access to the project site," says Fotuhi. "You also have to either build the grid evacuation from scratch or upgrade it because often these areas don't have the availability of substations or transmission lines required for your solar plant. In Uganda we had to build a 33kV line for several kilometres and then upgrade the substation. So that's both added cost and added time."

Not a panacea

Fotuhi points out that the end consumers and the utilities contracted to buy the power from solar parks are the chief beneficiaries of the model with the work done by the government unlocking lower prices.

But while they can certainly deliver scale, he warns that they can't be treated as a quick fix.

"Shared facilities have their strengths and they are a way of streamlining the execution of these projects. But you have to remember that creating these shared facilities requires work too," he says.

"You have lower development costs with shared facilities. You spend less on development hours: to source the land, to do your geotechnical work and your topographical survey; these are all done for you. The data is handed over and you can plug them into your financial model. There is less development risk and less development premiums that go with shared facilities. The government foots the bill, but as an upside, they get the benefits of lower tariffs," he says.

Ultimately, however, all of the stages a private developer would go through on a greenfield site, must be carried out.

"The work still has to get done," says Fotuhi. "Sometimes it is more efficient to have the developer do it and sometimes it is more efficient to have the government do it. It just depends how switched on the government is and how capable it is to do this. It's not always easy. The government has to get the land, address settlement issues, do some zoning, set up a permit system and carry out all the studies," he points out.

The other capacity

Crucial to the suitability of any given market is the ability of the host government, and its relevant agencies, to deliver the work as described. Where issues around permitting, for example, are delegated to regional bodies, a central government may find that its expertise, and clout, is required to create infrastructure such as a GW-scale solar park.

This has frequently been the case in India where complex land ownership and lofty PV deployment targets do not make good bedfellows.

In 2014, India launched the Scheme for Development of Solar Parks and Ultra Mega Solar Power Projects.

"Unavailability of large tracts of suitable land; the lack of a single window for obtaining permits and clearances; limited access to the transmission network and the relatively low capacity of nascent agencies in the renewable energy sector made the Government of India move towards the development of large-scale solar parks in India," says Surbhi Goyal, senior energy specialist, World Bank. "The Ministry of New and Renewable Energy (MNRE) has come up with a list of 34 solar parks with a cumulative capacity of 20GW and keeps updating the list to achieve 40GW target set under the scheme."

With goals like that, India is by some distance the largest market for solar park developments with both local and central bodies playing their part.

"The central government provides policy guidance and central financial assistance (CFA), while the respective state provides land and shared infrastructure facilities, handles local coordination, and owns and manages the park; the state also selects developers (private or public players) on a competitive basis," explains Goyal.

The success of completed park's is illustrated by their share of utility-scale development. As Goyal points out, the consultancy Bridge to India estimated in March 2017 that 25% of tenders between July 2015 and December 2016 were in government-backed parks.

"Such tenders have seen huge interest from international players as land and evacuation is made available to such developers on a plug-and-play basis," says Goyal. "Local players find the shared infrastructure cost under the solar park schemes mostly at par with the costs incurred by them if they were to arrange for the infrastructure facilities but higher competition has also resulted in lower tariffs."

In November 2017 the World Bank provided a US$2 million grant and a US$98 million loan for a solar park development including a site in Rewa, India. The IFC, the World Bank's private sector arm, has invested more than US$650 million of debt financing for 13 projects to be installed at the Benban solar park in Egypt. The World Bank's role in India's solar parks goes beyond money.

"The due diligence provided on environment and social aspects has also brought confidence to the solar developers bidding for Rewa solar park and thereby increasing the confidence of the bidders, especially international players," says Goyal. "The IFC had helped Rewa Ultra Mega Solar Limited (RUMSL), the park's facilitator, in identifying the risks perceived by the private developers and proposed mitigation mechanism, which is now being replicated in the guidelines for tariff-based competitive bidding for solar projects recently issued by the MNRE."

Essentially, the work with IFC and the World Bank at large has given the entire procurement process a step up and allowed it to borrow the expertise, experience and time-proven processes that overseas investors are extremely comfortable with. The capacity of the local institutions receives a huge boost essentially.

Performance

Centralising solar capacity, particularly in rural areas away from existing sources of demand, increases the

Access Power's Soroti plant in Uganda, a greenfield development

Credit: Access Power

prospect of poor transmission infrastructure hampering the appetite of private sector investors to target certain geographies. Goyal says with curtailment issues having already hampered some solar plants in Tamil Nadu and other states, solar parks will always mitigate for this challenge. Depending on who is responsible, the national or local operator will conduct a load study to ensure there are no problems further down the line.

The Green Energy Corridor programme is reinforcing the network in key regions with around US$7.9 billion of investment set aside and more than US$1 billion of funding provided from development banks. The grid connection and its performance are effectively guaranteed for developers looking to take a slot at a central government-backed solar park.

Access Power's Fotuhi says despite plants within a solar park having near identical irradiance, performance differences are to be expected.

"It depends on the components that you bring into the park. If you bring tier one quality, the maintenance cost goes down and the longevity of the park goes up. Conversely, if the maintenance cost is high and you have a lot of untrained staff, that will drive the production down. Two tenants in a solar park could be right next to each other in a solar park and have totally different generation profiles purely on the back of the components and the quality of the O&M team that is in place," he says.

Once a few years of operation have gone by, these differences could offer up some interesting learning on the performance of different components.

"The manufacturers will point to the fact that it is not just what you install but how it is maintained, the balance of systems, and optimisation. It's not just one piece of kit it is also how that piece of kit is used. We could be able to see a comparison between CdTe and poly or between poly and mono and how they perform in near identical conditions," says Fotuhi.

Replication

At present, the majority of activity for solar parks is in India. The 1.8GW Benban site in Egypt, the 5GW Rashid Al Maktoum Solar Park in the UAE, albeit PV and CSP, and a smaller 100MW park in Cambodia show that India is not alone. Goyal says both Indonesia and Bangladesh are also assessing the possibility of going down the solar park route. With development banks happy to share the learning from each development, the model is only going to be refined. He says their ability to make use of barren land is key to their success in India. These benefits won't necessarily translate from one site to the next.

Fotuhi says other models may be better suited in some countries with the project-by-project approach of the GET FiT scheme in Uganda one example.

"I would emphasize that solar parks are not a panacea because establishing solar parks themselves is a lot of work and some governments don't have the resources to do the work, so you have to look on a market by market basis and see if it is a sophisticated country able to pull off the scheme," says Fotuhi.

Solar parks are another tool in the arsenal of the solar industry but in the wrong hands and with the wrong sponsor government, they could still backfire on developers. ■

Credit: Fortum

A different direction

System design | As Europe and other hot PV markets transition to low- or no-subsidy environments, could a different direction help improve solar economics? Liam Stoker looks at why east-west orientated projects are increasing in popularity

Credit: Neoen

Neoen's Cestas PV plant in Bordeaux, France, used an east-west design to cram 1MW of solar per 0.8 hectares of land

The vast majority of utility-scale solar farms across the world have been built facing just one way – south in the northern hemisphere, and vice versa – but, in the pursuit of greater economics, is a different direction emerging?

One major project planned for the UK could be leading the way, breaking the mould of the country's usual solar design by going east-west.

Cleve Hill Solar Park, a significant development planned by a joint venture including Hive and Wirsol, is earmarked for more than 400 hectares of land based on England's south eastern coast in Kent. Having originally intended to develop the site for the country's Contracts for Difference support scheme, solar PV's continued exclusion from it has forced the developers to pursue its development without government support.

The location is beneficial given that one of the UK's numerous offshore windfarms connects to a 150/400kV National Grid substation located just a stone's throw from it. This will allow the site to connect to the country's less-congested transmission grid, rather than the local distribution grid.

But in the absence of subsidy, the site's development has taken on a more complex and thought provoking nature. Hugh Brennan, managing director at Hive Energy, explains that the duo examined two different schools of thought before going east-west.

"One is that you feature south-facing panels, and each panel is working as efficiently as it can. You have a lower output, but your costs are lower and ultimately that's what you're trying to do. You're trying to provide each kilowatt for the lowest price," he says.

The other, ultimately more beneficial path in this case, is one wherein size matters. And in a big way.

"The other school of thought is that the bigger the output the better. Your headline output is going to guide the value of what you're doing," Brennan adds.

This is where the east-west orientation comes into effect. It's something that has been applied to commercial rooftop PV systems for some time and whilst not exactly unique in ground-mounted solar, is coming to the fore, particularly in post- or low-subsidy environments by squeezing in as much capacity as possible.

Brennan explains that having looked at where panel prices and efficiencies were headed – including some estimations out to the expected build-time of 2020/21 – east-west orientation made sense for Cleve Hill. "We just realised how much more we could get on the site for an east-west layout," he says.

Simon Turner, technical director, power and renewables, at RINA Consulting, which has worked on the modelling of some east-west farms, explains that it boils down to a cost benefit analysis.

"[It's] mainly due to material costs, you can get more megawatts in the same area as you can with a south facing one and you only have to have one row of piles for two sets of modules, so there's a lot less piping involved and you can squeeze them in a bit tighter," Turner says.

How much more? A significant amount, it turns out.

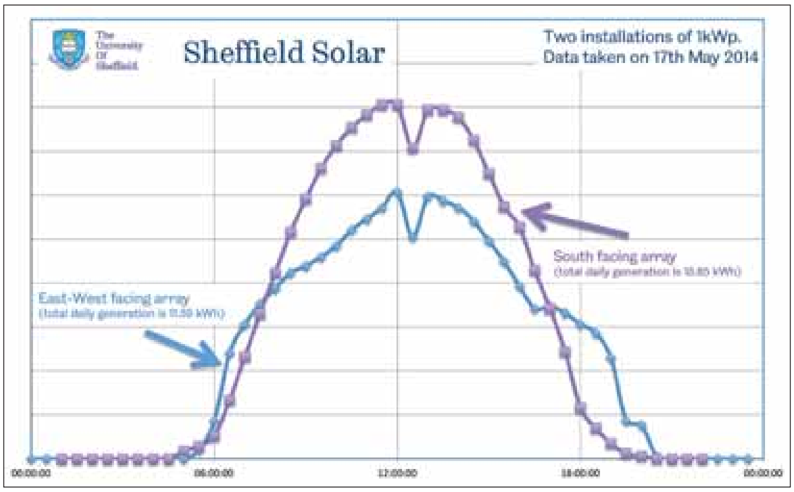
Every last kilowatt

Brennan says the capacity that has been added to Cleve Hill by adopting east-west has been "pretty dramatic". In its first iterations the project was expected to come in at around 250MWp, however the site now expects to come in at closer to 350MW, and potentially even greater if panel efficiencies continue to climb.

In essence, by switching to east-west Hive and Wirsol have managed to squeeze in around one million panels in a 400-hectare piece of land. "It's a huge difference, and to a degree we still don't know [the final size]… We're looking at a million panels and if the estimates [for panel efficiency] are 480/500W then suddenly it makes a big difference," he says.

Other east-west projects in Europe have experienced similar leaps in capacity. The 300MW Cestas project in Bordeaux, developed by Neoen, is particularly high-density, using just 0.8 hectares of land per megawatt of solar as opposed to the usual two hectares per megawatt.

It is not for everyone, however. INRG, another solar developer in the UK with eyes on subsidy-free developments, is sticking with its south-facing guns. Ian Gannon, commercial director at INRG, said that his firm had been able to max out its grid connection capacity with south-facing



Credit: Sheffield Solar

Sheffield Solar research into east-west orientation in 2014 showed the smoothed generation curve and impact on total output.

panels, hinting towards the still problematic nature of grid connections in the UK. East-west orientations might help smooth out the generation curve but there is a slight trade off in total capacity.

Sheffield Solar, the research division of the UK's University of Sheffield, has been noting the performance of different panel orientations since 2014. Aside from the obvious shift of load towards a smoother curve, total generation has also been found to dip. Results from a Sheffield Solar test on a 1kWp system in 2014 showed total generation fell by around 15%.

While that might be more problematic for rooftop installations backed by subsidies, the loss in generation seen in ground-mounted projects could be offset by other effects of shifting that load. Jamie Taylor, a research associate at Sheffield Solar, said that the boosted generation in the morning and evening hours – peak, and therefore more expensive, times – would see more "useful" energy generated.

But production capacity is not the only thing that has or will contribute towards Cleve Hill's final design.

Below biodiversity

What enables Cleve Hill to maximise its potential by going east-west is its topography. The land is essentially a large, flat, area described in the local council's own consultation as being largely barren. Brennan says this lends well to the east-west design and the only design impacts look likely to be access roads and overhead cables that run across the site, taking power from the on-site transformers.

In truth, it is something of a work in progress due to the UK's planning laws. As the project intends to be greater in capacity than 50MW, it must be signed off by the country's Planning Inspectorate as a nationally significant piece of infrastructure (PINS). This is a more complex and lengthy process than regular planning that comes with more scrutiny. Developers needing to go down this route end up jumping through more hoops than most.

One particular hoop thrown up by the developer's intent to go east-west is the potential impact of the design on the land underneath. By squeezing more rows of panels in, and the ground-covering apex that creates, there is scant evidence of what it will do to the ground due to the reduction in natural sunlight and rainwater. The land is still a habitat to an abundance of wildlife and Hive fully intends to have sheep graze around the panels once complete.

Hive has had to commission specialist university-backed studies into the impact to appease the planning bodies. "That's a body of work we're now commissioning because the other thing with PINS is you can't just say 'we think it'll be fine', somebody has to analyse light and water levels, the soil content and everything. Each part of the puzzle we have to get world class experts on it," Brennan explains. Wirsol, Hive's development partner, has previously developed a 30MW east-west site in the Netherlands (pictured below) and faced similar questions, findings from which are to feed into Hive's own research

Potential issues surrounding sub-panel biodiversity, or at least the lack of evidence in this field, is testament to the comparative lack of experience or expertise surrounding east-west installs in general. Taylor explains that this lack of evidence stems as far as the modelling software used by EPC firms around the world.

> "[East-west] is coming to the fore, particularly in post- or low-subsidy environments by squeezing in as much capacity as possible"

The very behaviour of east-west plants is more difficult to model, Taylor says, because of the way global horizontal irradiance figures usually supplied by meteorological stations is transposed onto the inclined plane of the modules. "When you do that for an east-west system, it's not particularly accurate because the bulk of the methodologies for conducting that transposition have been developed for south- or north-facing arrays. They tend to break down as you move towards east-west systems," Taylor says.

In truth, east-west is not a particularly new or innovative approach to solar deployment but it is one that's resonating in new markets. But far from being a cast-iron certainty it boils down to simple cost-benefit analyses to determine whether or not individual projects work. In that way they are almost emblematic of solar's growing maturity – it is no longer a question of where solar can work, but how it works best for that particular location. And it looks as if east-west will find resonance the world over. ■

Credit: Wirsol

Findings from Wirsol's project in Groningen, the Netherlands are feeding into its JV with Hive in Kent, England

Bifacial PV: comparing apples with apples sometimes does not make sense

Bifacial | Bifaciality is a complex area of PV technology and currently there is some confusion over what bifacial gains can be expected and how these transfer to system cost reductions. Radovan Kopecek and Joris Libal describe how bifacial gains are defined, what bifacial gains can be expected and what this means for real applications

Bifacial systems offer a very promising possibility to reduce the levelised cost of energy (LCOE) for many PV system applications. There is a huge application field for this new upcoming technology – such as large ground-mounted systems, flat reflective rooftops, sound blocking systems, floating systems or even in utility-scale systems using trackers. The last application is very interesting, these days achieving the lowest LCOE for many cases. The lowest bid ever for a PV system was announced recently in Saudi Arabia, offered by EDF and Masdar for first time below US$0.02/kWh and most likely using bifacial technology in conjunction with trackers [1].

Not only are there many potential application fields, there are also various mounting geometry possibilities: from standard slanted systems, to horizontal to even vertical bifacial installations with almost zero ground coverage. Three prominent examples are depicted in Figure 1.

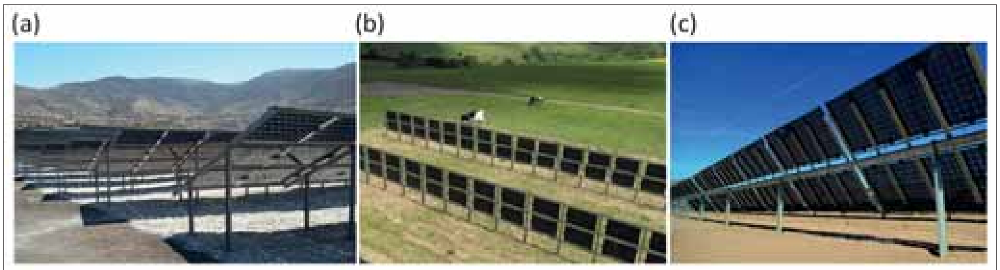


Figure 1. (a) La Hormiga fixed tilt bifacial PV plant in St Felipe, Chile (b): vertical bifacial PV plant by Next2sun in Germany and (c) a tracked bifacial PV plant in La Silla, Chile

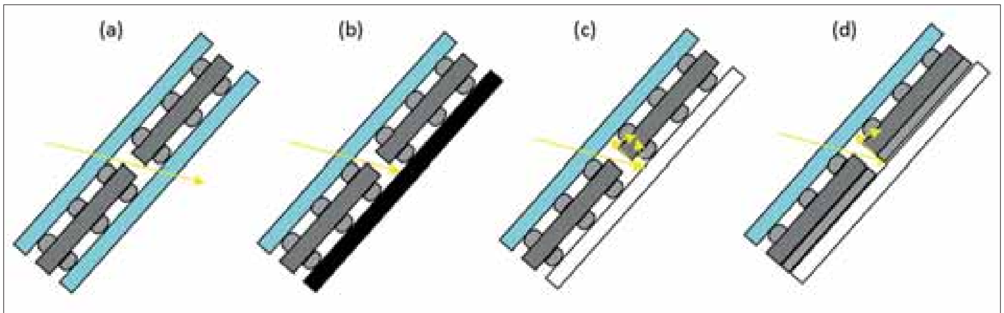


Figure 2. Schematic cross section of a (a) bifacial module and three possible monofacial reference modules with (b) bifacial cells and black backsheet, (c) bifacial cells and white backsheet and (d) monofacial cells and white backsheet

Definition of bifacial gain

An obvious way to visualise the benefits of bifaciality is to analyse the "bifacial gain", which means the difference in the energy yield if bifacial and monofacial devices with identical installation configurations are compared. The comparison can either include single modules or larger units of one or both device types, because typically the energy yield in kWh/kWp ratio is analysed. The kWp data usually reflects the STC front-side measurement of the bifacial module(s). In the most direct form, devices of similar type and with the same front-side efficiency are compared, for example if bifacial modules with covered rear sides are used as reference.

The bifacial gain is usually defined as:

$$g_{bifacial}\,[\%]=\left(\frac{(e_{bifacial}-e_{monofacial})}{e_{monofacial}}\right)\times 100$$

With

• $e_{bifacial}$: specific energy yield (kWh/kWp) of the PV system with bifacial modules

• $e_{monofacial}$: specific energy yield (kWh/kWp) of the PV system with monofacial modules on the same site, with the same configuration and during the same time period.

As the bifacial gain is another way to indicate the energy yield, it is the metric that determines – together with the total cost of installing and operating the bifacial PV system – the LCOE (€/kWh) and therefore the economic viability of bifacial PV.

The above mathematical definition of bifacial gain is quite simple – however there are different possibilities in terms of what module type can be chosen for the monofacial reference. Therefore sometimes the reported bifacial gains already differ there – even if at a first glance identical conditions are applied. Figure 2 depicts in (a) the bifacial module and three different monofacial references (b) to (d) which are very often used.

Many groups use standard white backsheet modules with monofacial cells for reference (Figure 2 (d)), some use monofacial white backsheet modules

with the same bifacial cells (Figure 2 (c)) and some monofacial black backsheet modules with the same bifacial cells (Figure 2 (b)). All three references will lead to different results, as the white backsheet is causing additional reflection of the front-incoming light into the solar cells. Even if the monofacial solar cell has similar properties as the bifacial (e.g. front-side power, voltage and temperature coefficient) the front side power of the module is increased by ca. 2% at STC (standard test conditions: 25°C, 1,000 W/m², AM 1.5 spectra) because of the additional reflection of light to the front side and during field measurements the energy harvest is increased more. An increased level of power can also be seen in the case of the bifacial cell and white backsheet: the total additional energy yield (kWh/kWp), also due to the scattering of the light into the solar cell rear side, can be up to 5%, as observed, for example, in LG NeON modules.

Therefore: if you want to observe bifacial gain only, as a reference the same bifacial cell in a module with a black rear cover or black backsheet is required.

This comparison reveals precisely what additional energy is provided by the rear side only. If you take for example a monofacial module with a bifacial solar cell and white backsheet as a reference, you will underestimate the bifacial gain by ca. 5%, as the rear side is already contributing in field measurements. Therefore the choice of different references leads already to different results reported in various publications.

Another important point is that the temperature coefficient of the monofacial reference module should be in the same range as for the bifacial ones. Otherwise, for example when comparing bifacial heterojunction modules (temperature coefficient for Pmpp around 0.30%/°C) with standard monofacial aluminium back surface field (Al-BSF) c-Si modules (temp coeff around 0.45%/°C), a significant part of the gain attributed to bifaciality will be due to the reduced temperature losses of the HJT module. Here, as a reference, the same HJT module with a black back cover would be the best choice leading to an "apple to apple" comparison.

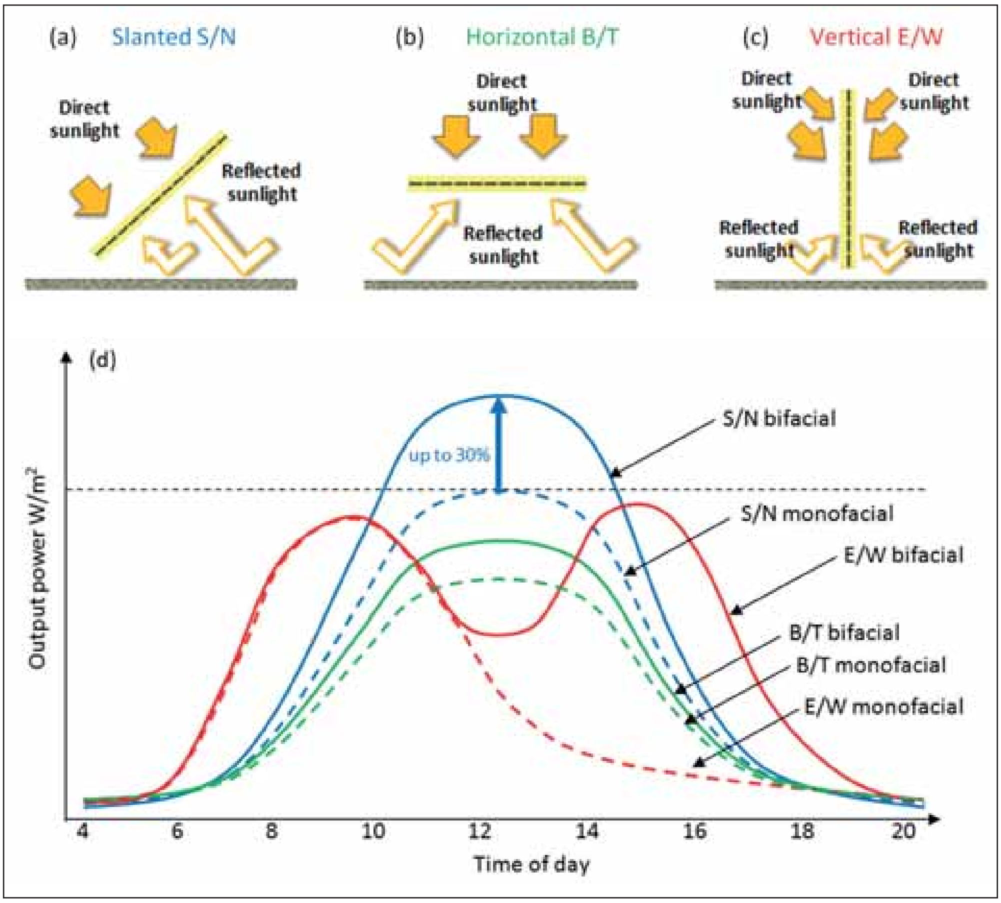


Figure 3. (a)-(c) Possible applications for bifacial modules and (d) resulting daily power generation curves compared to monofacial ones in the same configuration.

Examples of bifacial gains: comparison of apples with apples

Not only the choice of different references, but also different mounting geometries will lead to different bifacial gains – and as we will show, these can be even more than 100% in some cases. Figure 3 depicts different mounting geometries: (a) slanted S/N (south/north) oriented mounting, (b) horizontal B/T (bottom/top) and (c) vertical E/W (east/west) oriented mounting.

The slanted S/N-oriented mounting leads to the highest powers of the applied bifacial modules as the front side produces the highest possible power and the rear, depending on the albedo of the ground, can contribute up to 30% additional electricity. Here, a 300Wp module can behave as a module with an effective power of close to 400Wpe ('peak effective'). This relationship can be seen in Figure 3 (d) between the dotted and solid blue curve.

Horizontal B/T-oriented installations, used in car ports, for example, demonstrate very similar behaviour, only that the absolute energy production is reduced, as the module is – apart for sites located nearby the equator – not oriented at an optimal angle towards the sun. The monofacial and bifacial generation curve is demonstrated by the green dotted and solid lines respectively. The shape for all installations so far discussed is very similar, having a peak intensity around noon.

A completely different form (camel and dromedary curve) is generated by a vertical E/W-oriented installation. When you install a bifacial module with a high bifacial factor (b: rear power/front power >0.9, for example an nPERT BiSoN (Bifacial Solar Cells on N-type) or "HJT module" from Sunpreme) you end up with the solid red line. Much more electricity is generated during morning and evening as compared with the S/N-oriented case. During midday there is a generation dip, as the direct sunlight is shining on the frame and only diffuse light is hitting the module front and rear side. However, due to the ground coverage ratio close to zero and due to the broader generation peak this installation geometry is very interesting. Now: if you install a monofacial module in such a mounting geometry the generation peak moves to a dromedary-like (red dotted line) shape with generation energy less than 50% compared to the bifacial one. Here the bifacial gain is

therefore higher than 100%. However such a comparison does not make much sense as installing a monofacial module vertically with an E/W orientation is highly improbable. In this case the vertical bifacial modules have to be compared with a slanted monofacial equator-oriented module. Depending on the installation latitude the bifacial gain can be even negative – in this case, if modules are installed vertically in sun-belt regions. However this might make also sense in some cases, if the soiling can be reduced by the vertical installation.

Table I summarises several examples of various installation geometries and resulting 'bifacial gains' for BiSoN nPERT modules. Because in the large bifacial systems in Chile standard monofacial modules with white backsheet are used as a reference by developers MegaCell and Enel, the real physical bifacial gains would differ from there slightly.

In the case of the fixed-tilt S/N module system there are already many cases reported all around the world with different albedi. Depending on the ground albedi (25% for natural sand and 75% for white stones) bifacial gains from 15-30% can be achieved.

When it comes to vertical E/W systems things become more complex and also not so many reference systems exist. In these cases, not only are the module type and albedo of importance but so are the mounting geometry of the reference module and the installation latitude. If you compare with a vertical installed monofacial module, a bifacial gain of more than 100% can be observed. This comparison makes only little sense – here a comparison with a slanted equator-oriented monofacial module is more interesting as well. If you install such systems at high latitudes, where the amount of diffuse sunlight is higher and where the vertical mounting is less far away from the optimum slanted angle, an electrical gain of 10% is observable – however at low latitudes even an electrical loss of -5% was observed. Still this application remains interesting because of several reasons: the ground coverage is close to zero, the generation peak is broader and vertical installations have less soiling problems. However also some challenges have to be solved as the wind loads are high using this mounting configuration.

Within the last few months bifacial systems using single-axis tracking have gained more and more attention, as experimental results in large systems showed that the bifacial gain in those cases is also very high. This is because many tracking mounting systems are almost ideal for bifacial modules as they are mounted high from the ground with high row spacing. Therefore the bifacial gains – in this case, the gains compared to monofacial single-axis tracking – are very similar as for the fixed-tilt systems. The first one to report this behaviour was Enel in la Silla [7].

A combination of single-axis tracking with bifacial modules in systems with high albedo result in electrical gains of over 40% compared to fixed-tilt monofacial modules [8].

More and more large companies have realised this incredible increase and the companies building single-axis trackers are optimising their systems for bifaciality.

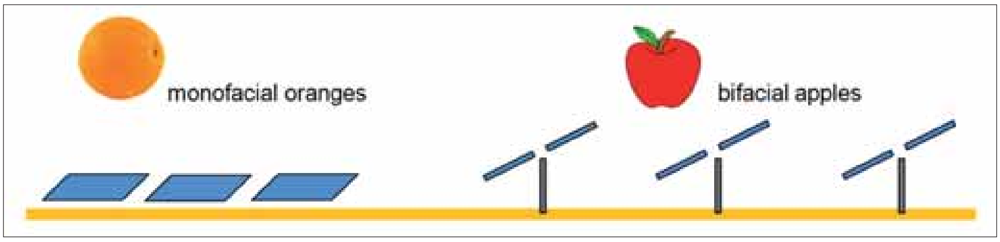


Figure 4. Schematic drawing of (a) a monofacial S/N oriented system and (b) an E/W-oriented bifacial single-axis tracked system

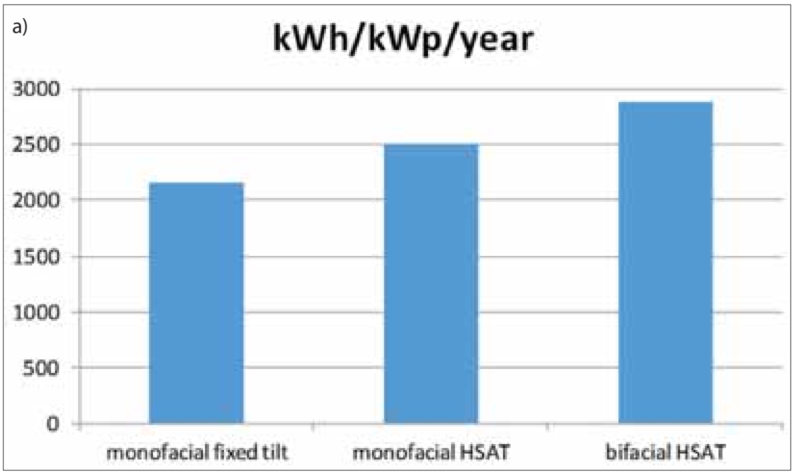
Bifacial applications in reality: comparison of apples with oranges

We have learned that bifacial gains, as they are defined, can reach values of more than 100%. However, this information is not very practical for system designers. The only interesting question for them is: how can a PV system with the lowest LCOEs be designed? Then the best possible monofacial installation has to be compared with the best bifacial one, as depicted, for example, in Figure 4.

Many PV system designers are using PVsyst for this purpose which is a simulation software generating bankable results. With all the necessary import parameters such as module properties, system geometry and data for specific local conditions, the energy output can be calculated which at the end leads to values for LCOE. PVsyst is also since September 2017 capable of running reliable bifacial simulations – however for systems with fixed-tilt mounting only. At ISC Konstanz we have developed a simulation program (MoBiDiG: Modeling of Bifacial Distributed Gain) which is capable of conducting reliable simulations for bifacial tracked systems

Bifacial module	Bifacial installation geometry and latitude	Installation geometry of monofacial reference	Albedo	"Bifacial gain" (rounded to 5% steps)
nPERT, BiSoN (b>0.9)	Slanted fixed tilt in San Felipe, Chile (32° south)	Slanted fixed tilt	25%	15% [2]
nPERT, BiSoN (b>0.9)	Slanted fixed tilt in San Felipe, Chile (32° south)	Slanted fixed tilt	65-75%	30% [2]
nPERT (b>0.9)	Vertical installation, USA	Vertical installation	Unknown	100+% [3]
nPERT, BiSoN (b>0.9)	Vertical installation in Winterthur, Switzerland (47° north)	Slanted fixed tilt	25%	10% [4]
nPERT (b>0.9)	Vertical installation in Saar, Germany (49° north)	Slanted fixed tilt	25%	10% [5]
nPERT, BiSoN (b>0.9)	Vertical installation in el Gouna, Egypt (27° north)	Slanted fixed tilt	25%	-5% [6]
nPERT, BiSoN (b>0.9)	Single-axis tracked in La Silla, Chile (29° south)	Single-axis tracked	25%	15% [7]

Table 1. Bifacial gains for nPERT modules (mostly BiSoN) with various installation geometries



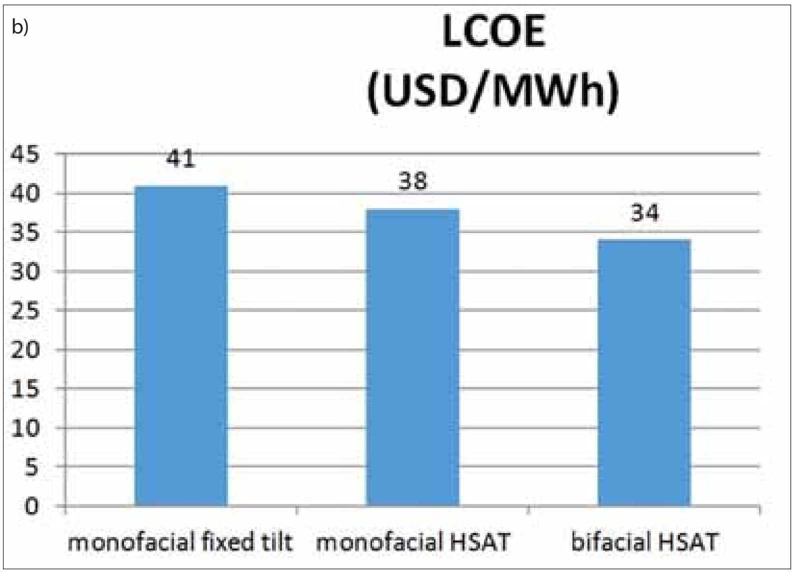


Figure 5. Examples of a) calculated energy yield and b) resulting LCOE for different module and system technologies when installed in Chile (assumption for monofacial installed fixed-tilt system cost: US$0.92/Wp and US$1.00/Wp for monofacial and bifacial horizontal single-axis tracker) with a ground albedo of 25%. In this case the tracking gain (monofacial horizontal axis tracking compared with monofacial fixed tilt) is 17%. Using bifacial instead of monofacial modules on the HSAT system results in an additional 14.7% (rel.) gain, leading to a combined gain (tracking + HSAT) of 34%

as well. Figure 5 depicts the result of three different systems at the same location in Chile.

Summary

Bifacial gains show how bifacial modules increase the electrical performance of a system when bifacial modules instead of reference monofacial modules are mounted. Depending on the choice of reference modules these values can differ by more than 5% (rel.), even when choosing the same installation configuration for the bifacial and the monofacial system. If you want to know the real bifacial gain – the additional power that the rear side is generating – then the easiest way is to use the bifacial module covered by a black sheet for reference. Bifacial gains are also dependent on module bifacial factor, b. Bifacial PERC modules at the moment have b<80%, nPERT and HJT b>90%. Therefore it has to be also stated which modules with which b were used in corresponding modelling or experiment.

In special configurations, bifacial gains of more than 100% can be measured, when e.g. bifacial vertical installations are compared with monofacial vertical installations. However in practice, for the optimal design of PV systems, it makes only sense to compare the energy output for an optimised monofacial versus an optimised bifacial system and at the end compare the resulting LCOEs. The meaning of "optimised" can be influenced by restrictions imposed by the specific application and by the available installation site.

In the bifacial area more standards and more advanced simulations programs are needed. Therefore we organise yearly bifacial workshops where the newest results are presented - this year 10-11 September in Denver, Colorado. Details on BifiPV2018 are at www.bifiPV-workshop.com ■

Authors

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References

[1] Parnell, J. 2017. "Bifacial technology was likely reason world's lowest ever solar bid was rejected", PV-Tech.org https://www.pv-tech.org/editors-blog/bifacial-technology-was-likely-reason-worlds-lowest-ever-solar-bid-was-reje

[2] Kopecek, R. and Libal, J. 2017. "Complex problems require simple solutions: how to measure bifacial devices correctly?" *Photovoltaics International 37*, pp.105-112.

[3] https://www.solarchoice.net.au/blog/news/bifacial-solar-cells-the-two-sides-of-the-story-050515

[4] https://www.slideshare.net/sandiaecis/5-hartmut-nussbaumer-bifi-psda-antofagasta-chile-2015

[5] Next2sun, internal presentation

[6] Shoukry, I. 2015. "Bifacial Modules - Simulation and Experiment", Master thesis, University of Stuttgart.

[7] Di Stefano, A. et al. 2017. "La Silla PV Plant as a utility-scale side-by-side test for innovative module technologies", 33rd EUPVSEC Amsterdam.

[8] Yong, L. 2017. "nPERT technology and its application", Bifacial PV workshop, Konstanz.

Failure assessments of PV systems demonstrate the importance of elective quality assurance

Quality | In a four-year project sponsored by the German Federal Ministry of Economics and Energy, a consortium of German experts assessed the quality of actual PV power installations. The researchers now report on how the effects of several common module failures on module and string performance highlight the importance of consistent quality assurance to prevent risks to financial success

Credit: TÜV Rheinland

The number of photovoltaic installations worldwide has increased exponentially over the last 10 years. The PV market has evolved from one of small-scale applications to a mainstream electricity source with a trend towards increasingly utility-scale PV systems, with investments totalling tens to hundreds of millions of dollars.

Whereas in 2017 PV power plants worldwide made up only approximately 2% of the total electricity mix, their role continues to increase, and as this trend continues, the reliability and predictability of power supply as well as yield optimisation will also become increasingly more important. Depending on the design and projected results, the potential for improvement may be as high as a two-digit percentage.

Especially when it comes to large-scale utility power plants, a seemingly small 1% optimisation will yield an improvement potential totaling approximately US$1 million for a 50MWdc power plant.

In the interest of reducing risks and optimising the technology and therefore financial performance, this paper discusses a two-level approach, namely a solid supply chain and operational quality assurance throughout the plant's service life, including novel procedures for related statistical quality control, especially on-site analyses, EL image analysis and real-time monitoring, from inception to decommissioning after 25+ years, and considers insurance options for countering financial risks as well.

Extensive testing of PV systems in Germany has revealed serious failures with potentially large cost implications

In this spirit, the German government sponsored a long-term study called "PVScan", the major goal of which was to analyse and carefully evaluate selected photovoltaic systems, in order to assist the assessment of technical defects and faults occurring in practice, their influence on actual energy yields under actual operating conditions and, more importantly, their potential for significant future incidents of damage and defects leading to performance losses relevant for operators and investors.

Quality scanning of large PV systems

A closer look at the general quality levels of large PV plants newly built or already in operation for several years reveals some widespread problems whose implications for future performance are unclear in part, but also some serious failures with enormous consequential costs and even relevance in part to safety have been found.

For example, just over the last two years various problems with the stability of backsheets have been recorded that affect PV modules commonly installed in PV power plants – an issue concerning the overall gigawatt range. So-called "whitening" or "yellowing" refers to embrittlement or crumbling of the affected backsheets. It is undoubtedly a serious safety issue and affects performance during continued operation. Current laboratory stress tests of the combined effects of UV radiation, temperature changes and high humidity reveals that the increased penetration of moisture related to failures leads to massive energy yield loss in the modules ranging to 30%.

For some years now, potential-induced degradation (PID) has been responsible for occasionally massive energy losses in large PV installations. Severely affected modules perform 50% or even 60% below their rated power on the nameplate. Even if only some parts of the module strings are affected, the overall performance loss can be dramatic. The light-induced degradation (LID) of newly built PV systems has been another source of concern for investors and operators of PV systems. LID can cause a massive power loss in the first few days of a module's service life.

A major issue is critically overheated cable connections or junction boxes. For example, temperatures of 100°C and above were measured in a large-scale, eight-year-old reference PV installation investigated in the PVScan project. Complete strings had already failed due to thermally destroyed connectors of the junction boxes. A complete infrared (IR) inspection showed that around 6% of the installed modules were affected by overheated junction boxes in the affected plant with the connection failure, resulting, in the worst case, in electric arc ignitions. The affected module types are installed not only in open-space systems but also on residential houses and public building roofs, where the defects cannot be detected during operation, so that prompt module replacement becomes necessary.

All the aforementioned issues were found at PV plants that had been in operation for one to eight years, so that the PV modules in these plants still had to perform for the greater part of their expected service life.

These examples indicate the enormous financial impact poor component or construction quality can have. New ways to ensure a consistently high quality over the service life of PV modules are therefore urgently needed.

In short, poor quality of installed components tremendously jeopardises the attainable energy yield and consequently the financial success of investment.

An internal TÜV Rheinland study conducted in 2014 and 2015 and involving the inspection of over 100 large-scale PV systems mainly installed in Germany and other European countries showed that:

"30% of all investigated plants had suffered failures with a need of immediate action to prevent a plant breakdown!"

"50% of all identified serious component failures were PV module issues accompanied by wiring and connection problems."

A closer look at the issues in these PV modules reveals a slew of known abnormalities that have already been dealt with in recent years and which are classified according to different criteria and are therefore not discussed here in more detail.

A comprehensive collection and analysis of the available statistical data on component failures in approximately 800 PV installations totaling around 0.5GWp in different market segments in several European countries can be found in the reports by the EU-funded "Solar Bankability" project [1].

The results of the "Solar Bankability" project and a TÜV Rheinland analysis of more than 400 inspected PV plants conducted between 2010 and 2016 show the most commonly found abnormalities including issues of planning, installation and operation, all resulting in significant plant yield losses.

Here, too, considerable yield potential usually remains untapped, resulting in sub-optimal financial returns in the PV projects in real terms at the end of the operating period of 25 years.

Table 1 below lists the top 10 deficiencies and their frequencies of occurrence in large PV systems.

Natural degradation and faulty degradation

PV modules are designed to convert incident sunlight to electricity. This conversion requires the occurrence of complex physical and chemical processes in the multilayered modules. Components are exposed to transport stress on the way to the final construction site, and are subsequently subject to long-term adverse environmental conditions such as frequent changes of ambient temperature, humidity, wind and snow loads, UV radiation and moisture during operational life.

All these stress factors lead to several

Failures	FR Total	FR Plant	Yield Loss	Potential
Soiled modules	8.1%	38%	10%	
Improperly installed modules	7.7%	23%	5%	
Shading	6.2%	50%	10%	
EVA discoloration	4.1%	30%	0%	
Glass breakage	2.5%	44%	10%	
PID	1.9%	5%	10%	
Defective backsheet	1.1%	42%	1%	
Delamination	0.9%	17%	1%	
Hotspots	0.8%	28%	2%	
Failure bypass diode in JB	0.4%	20%	33%	

Increase in losses is not expected
Moderate increase in losses is expected
Significant increase in losses is expected

Source: TÜV Rheinland

Table 1. Identified failure rates in terms of inspected modules (FR Total) along with rates of plants with this failure (FR Plant), the average detected power loss at inspection time and the estimated potential of further power loss.

Q&A: PV Tech Power caught up with Robert Goldstein, Chairman and CEO, Unique Surety and Insurance Services, to discuss surety bonds in the solar energy space.

1. What does your company do?
Unique Surety is a leading surety agency. We have a dedicated division serving renewable energy. We focus on mitigating risk and providing support for solar arrays and battery storage for commercial, industrial, institutional, manufacturing and wholesale suppliers, government and community solar projects. The bonds we issue assure the faithful performance of any type of energy contract. In the event of a participant's default, the bonding surety carrier then assumes the responsibility to fulfill the unsatisfied terms of the energy contract, including but not limited to hiring a substitute contractor if necessary to complete the described tasks.

2. How can your clients benefit from your service?
We can provide creative solutions to any surety bond request. Unique Surety has the Power of Attorney to issue bonds for nine of the top 10 carriers approved on circular 570 of the U.S. Treasury Department, the standard required to bond all government projects that require surety bonds, as well as bonds required by the U.S. federal and state court systems. Unique Surety represents more than a dozen U.S. Treasury-listed surety carriers enabling us to shop competitively to keep costs down and to produce surety bonds for applicants up to $350 million per project once approved by the carriers.

3. What is your message for the attendees at the Houston Solar and Battery Storage Finance Conference in April?
Every distributed solar and renewable energy project relies on critical interdependencies for success. Unique Surety issues surety bonds on behalf of U.S. Treasury-listed, top rated surety and insurance carriers that protect the interests of the various parties to these contracts. Besides helping avert potential financial calamities from contractual defaults, the bonds provide the gateway to help projects move forward. With the right bonding in place, tax equity funds, energy developers, corporate, government and other institutional energy project contract grantors or end users know they can proceed on renewable energy projects with confidence.

4. What is the biggest challenge for a bonding agent in the renewables sector – particularly solar?
A key challenge is making sure all parties involved in solar contracts understand the benefits of engaging in bonding agreements that protect their self-interests and the interests of parties providing services to them. For example, tax equity funds that lend to, invest in or purchase and operate solar installations either for community solar or various Commercial & Industrial arrangements might establish bonding requirements for individual participants in all phases of a project: from the initial site work to construction of the solar array to having an outsourced operations company providing a bond for faithful performance of the operational contract.

5. Does Unique Surety expect to break out of the US into other markets at any point?
Unique Surety currently bonds in all 50 states and anywhere the principal and the obligee enter into a solar contract, provided they both have a U.S. branch office and conduct banking in the United States. The contract must be subject to the laws of one of the 50 states. It does not make any difference where the project is being constructed.

6. What are the least expected areas of solar where surety bond backing and insurance are necessary? What are solar companies most ignorant about in this field?
Many parties to solar and other renewable energy contracts lack the experience or understanding of how surety bonds can be used to protect their contractual interests. While thousands of insurance agents are licensed to write surety bonds, only a few hundred agencies focus only on surety. My career has spanned four decades and encompassed all areas of commercial insurance and surety. Five years ago, I positioned Unique Surety to specialize exclusively in surety. Today, we are actively engaged in helping educate all participants in solar energy on how surety bonds can provide financial protection and mitigate risk in the event of contractual default.

7. Has business from solar boomed in recent years? What's driving that and what do solar customers most want out of Unique Surety?
Renewable energy producing clean air is now available at competitive prices. The solar investment community must create durable, financially responsible contracts with proper protection for all parties if something goes wrong. Investors would never buy income-producing real estate without protection from unexpected peril. Too often, energy contracts are entered into without risk mitigation protection, which can be provided by surety bonds, diminishing the investors' economic loss in the event of contractual default. This usually can be achieved inexpensively. U.S. solar participants seeking the protection and confidence of bonded contracts need surety specialists who understand the intricacies of the solar industry.

8. What factors tend to obstruct obtaining a surety bond in the solar space?
As a renewable energy distribution surety bond specialist, we first must know what surety carrier to approach to place a particular surety bond, as well as the appropriate pricing given the potential exposures and market conditions, and how much flexibility the surety carrier will have with respect to the language of the bond. Our experience in these matters translates to effective bonding solutions for our clients. And it often forms a solid foundation for the development of strong and ongoing relationships that empower fund investors and solar developers with the confidence to further expand their assets with better-protected portfolios.

9. Do you have to approach surety in a different way when it comes to your focus on energy storage batteries and solar films?
No, contracts involving energy storage batteries and solar films have essentially the same characteristics as other renewable contracts. Thus, they typically have similar bonding needs. An experienced bonding specialist can bridge the client's objectives, needs and expectations with what a surety carrier will find acceptable and desirable to bond.

10. What is the most necessary item when drafting an energy contract that will be bonded?
The level of clarity in an energy contract is critical when approaching a surety; a quality contract diminishes uncertainty about the outcome in the event of a contract default. It also sets expectations for the fund and/or developer regarding the surety's role when defining the scope, the rights to cure contractual setbacks, a clear definition and quantification for financial penalties, and a transparent understanding of the declaration of default. The intention of the parties entering into the contract with respect to the role of the surety are to avoid litigation, restore the completion of the project and the prompt payment of any penal sum.

Unique Surety and Insurance Services, LLC

Renewable Energy Distribution Surety Bond Specialists

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As a leading surety agency, Unique Surety has a dedicated division serving renewable energy. We focus on mitigating risk and providing support for solar arrays and battery storage for commercial, industrial, institutional, manufacturing and wholesale suppliers, government and community solar projects. The bonds we issue assure the faithful performance of any type of energy contract.

In the event of a participant's default, the bonding surety carrier then assumes the responsibility to fulfill the unsatisfied terms of the energy contract, including but not limited to hiring a substitute contractor if necessary to complete the described tasks. The surety carrier may also be required to pay stipulated damages up to the maximum penal sum of the bond.

As surety bond specialists, we work to protect the interest of the public, investors, developers, commercial, EPCs, industrial, manufacturing, government and educational institutions. Unique Surety offers a full spectrum of bonding options to indemnify contracts for renewables:

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- **Supply bonds**
- **Bid bonds**
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- **Maintenance bonds**
- **Reseller payment bonds**
- **Equipment parts supply bond**
- **SAM performance bonds**
- **Energy contract bond clause assistance**
- **Energy subscription and service management performance bonds for community solar**
- **Equipment lease bonds**
- **Advanced payment bonds**
- **Site-work bonds**
- **Battery storage contract performance bonds**
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degradation processes that influence the materials and their connections both within the module and in the exterior components of a PV system. Long-term irreversible decreases in PV module performance are therefore not preventable. Some of the known mechanisms responsible for performance loss are:

Degradation mechanisms

- Semi-conductor degradation
- Photo-degradation of polymeric materials
- Various thermal degradation mechanisms
- Diffusion processes, in particular water vapour ingress into the encapsulation
- Static and dynamical mechanical or thermo-mechanical stress
- Material interactions (selection of suitable materials)

The "natural" degradation rate depends on the specific module technology and the operating conditions of the PV system. For standard crystalline modules in moderate climates we may generally assume an average annual performance loss between 0.3% and 0.5%.

As already noted above, various types of failure can lead to a faulty, accelerated ageing process resulting in a higher degradation rate and in performance loss. The magnitude of this effect is still under discussion for many types of failure and was investigated as an important issue for investors and financial institutions in the PVScan project.

Detection of module failures in the field

The evaluation of a photovoltaic system requires expert knowledge as well as objective, data-based analyses. Concerning the latter, system-wide real data of a system under operating conditions is important, as is module-based data such as precise performance measurement data (STC) and electroluminescence images, which allow assessments of the occurrence of physical defects and damage.

Electroluminescence imaging is an established tool in the evaluation of modules in photovoltaic systems, but their analysis still relies mainly on personal expertise and experience, owing to the lack of automated assessment procedures. The PVScan project team developed novel statistical procedures to assess the significance of findings from electroluminescence imaging, including lower-quality images obtained under outdoor conditions.

The installation of data loggers to monitor performance and energy yield may be regarded as state of the art. The analysis of such data streams is challenging, however, given the large number of variables influencing actual energy production and its development over time, such as module characteristics, plant design, geographic location with its environment, ambient temperature, solar irradiance and angle of incidence as well as module soiling and temporary shading. For large-scale PV systems the number and positions of measuring devices will also influence results.

Novel statistical string-based monitoring schemes have therefore been developed and studied with the aim of monitoring the internal performance of a system in real time and reducing the probability of a false alarm.

This approach takes a reference string as a sort of gold standard and can therefore be applied without access to additional data sources. It also enables the detection of differences between strings of systems, which can be highly informative when identifying technical issues.

Methods for on-site data analyses

Sampling design for multi-site comparisons and analyses

To scan the quality of a large PV system, a sample of modules must be selected for on-site inspection and characterisation. Since application of the gold standard of randomly sampled modules is not feasible in practice, a cluster sampling approach was developed. Anchor modules are randomly selected and characterised together with their nearest neighbours from the same rack. The anchor modules may also form the core of a panel for a longitudinal study, in order to analyse medium and long-term degradation effects by re-measuring the panel (and its neighbours) at future time points.

For the statistical analysis of such a panel-based cluster sampling of PV measurements over time, an innovative comprehensive methodology has been developed. Quantitative data derived from EL imaging and IV curves, such as the mean EL intensity, number of detected abnormal cell areas, sizes of the inactive cell areas, fill factor and Pmax, as well as qualitative data, such as the presence of snail trails or damaged connectors, can be utilised. The new method can also take site-specific effects into account, such as the module type, the solar inverter and exposure to severe weather conditions. The source in [2] provides a comprehensive exposition of the method as well as Monte Carlo simulations investigating statistical quality in terms of real significance levels and the statistical effectiveness of effect detection.

The PVScan study began with the selection of a large cluster-based sample of modules among five PV systems located in different regions in Germany and the characterisation of these modules on site – without disassembly – through EL imaging as well as visual inspection and auditing, in order to obtain a comprehensive record summarising the technical quality of each system.

Automated EL image analysis

EL imaging is a challenging form of analysis usually performed in view of additional module characteristics, in particular, performance, fill factor and open-circuit voltage. Consequently, novel methods in automatic preprocessing and the analysis of lab and outdoor EL images have been developed. The first step involves specialised preprocessing in order to correct for optical distortions, especially pertaining to module orientation and perspective, and to enable automatic extraction of the cell areas from an image of the module; see [3] for some details.

Whereas recent work on infrared imaging as in [4] relies on segmentation procedures, improved and specialised procedures were employed to detect the boundaries of the module and to estimate the grid lines separating the cells and the grid fingers by means of nonparametric edge detectors and line estimations. This approach utilises known module parameters to improve stability and accuracy. This step results in standardised images of the cells with exactly the same pixel resolution to make valid statistical comparisons possible. In practice, a critical question is whether the focus areas of a cell are darker than properly working cell areas. A valid statistical image test has been developed in this regard. In addition, a fully automatic detector has been designed that scans the entire cell to determine the most suspicious (dark) areas and simultaneously conducts significance tests. In this way, the developed procedures deliver a statistically valid answer that can be reported as a p-value. Figure 1 illustrates the automatic detection applied to the extracted cell areas of a module. Suspicious lower-than-expected dark areas (in red) are frequently accompanied by nearby higher-than-expected bright areas (green),

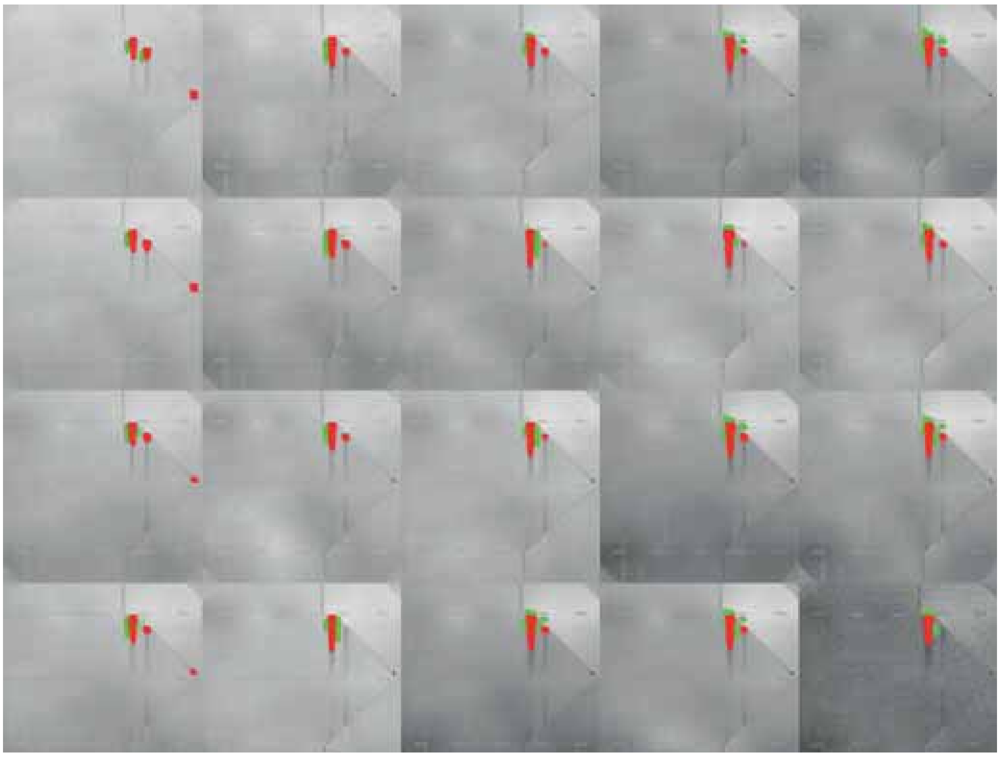


Figure 1. The automatic EL image detector can detect suspicious low-performing areas

degradation, PID or other defects.

Reliable and low false alarm rate monitoring of real-time high-frequency string difference data can detect underperforming strings and thus reveal faults instantly, but suffers somewhat from the noise present in such data, such that small effects are dominated by noise and are hard to detect. The learning sample needs to be carefully selected, as such difference data may still show a slight seasonal pattern. Aggregated performance measures operating on a coarse timescale allow assessment of the medium and long-term energy yield and can detect underperforming systems by calculating proper confidence intervals to evaluate these performance measures. Both statistical tools allow for systematic and cost-effective monitoring and evaluation in a targeted manner, avoiding unnecessary on-site inspections, and therefore provide an effective framework for objective data-driven quality control of PV systems.

where the electron-whole pairs bypass areas of increased resistance. The method controls the overall significance level α, i.e. an EL image of a properly operating cell or module shows any spuriously marked areas with probability α.

Monitoring for significant changes

Large-scale defects in and damage to modules, connectors, cables or other components typically lead to power losses. Weather data and variables such as current and voltage and of selected strings and solar inverters must be monitored. By noting differences from a reference string, underperforming strings or inverters can be detected.

To improve sensitivity and ensure that monitoring takes place at a controlled significance level, detectors were developed and optimised that are based on signal processing estimators and which substantially improve the sensitivity to critical events compared with existing methods. The results must still be evaluated with additional actual PV systems having specific failure characteristics.

Figure 2 shows differences of string currents to the reference string recorded in five-minute intervals. One can observe a notable degree of between-string variation at this high sampling rate. The first part (until the green vertical line) is used for learning and yields the control limit for 5% significance. The control statistic (black line) summarises the difference data and reduces the noise component. A signal indicating evidence for a change is raised if the control statistic exceeds the control limit. For the monitoring period shown in Figure 2 it does not cross the control limit meaning that there is no evidence for a significant change.

The substantial degree of noise in such high-frequency measurements can be reduced by considering the aggregated energy yield on a monthly or quarterly basis. To evaluate the differences in string performance relative to the reference string RWTH developed simulation-based confidence intervals taking into account serial correlations, which are shown in Figure 3 for the first quarter. This analysis reveals several statistically underperforming strings. These underperforming strings should be evaluated by experts to identify or exclude technical causes such as shading, dust,

Impact of module failures on performance

Quality assessment of reference systems

From the cluster-sampled on-site investigations, two common types of module errors were identified by the EL imaging method:

1. Micro cracks in different types and accumulations, from individual cracks up to 30% of affected cells in one module;
2. Discontinuities in grid fingers in the cell, resulting in interruptions of current flow in the affected cells. Occurrences ranged from individual production-related interruptions to half of affected areas in the cells and to two-thirds of the affected cells in one module.

The detected average failure rate for micro cracks was 4.9% and for grid finger breaks 3.3%. Other EL-visible abnormalities that were found were mainly darker cell

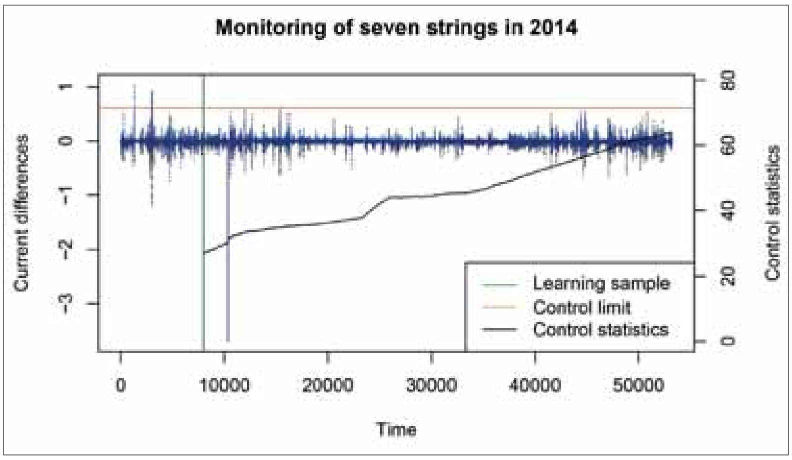


Figure 2. Detection of critical events with real monitoring data

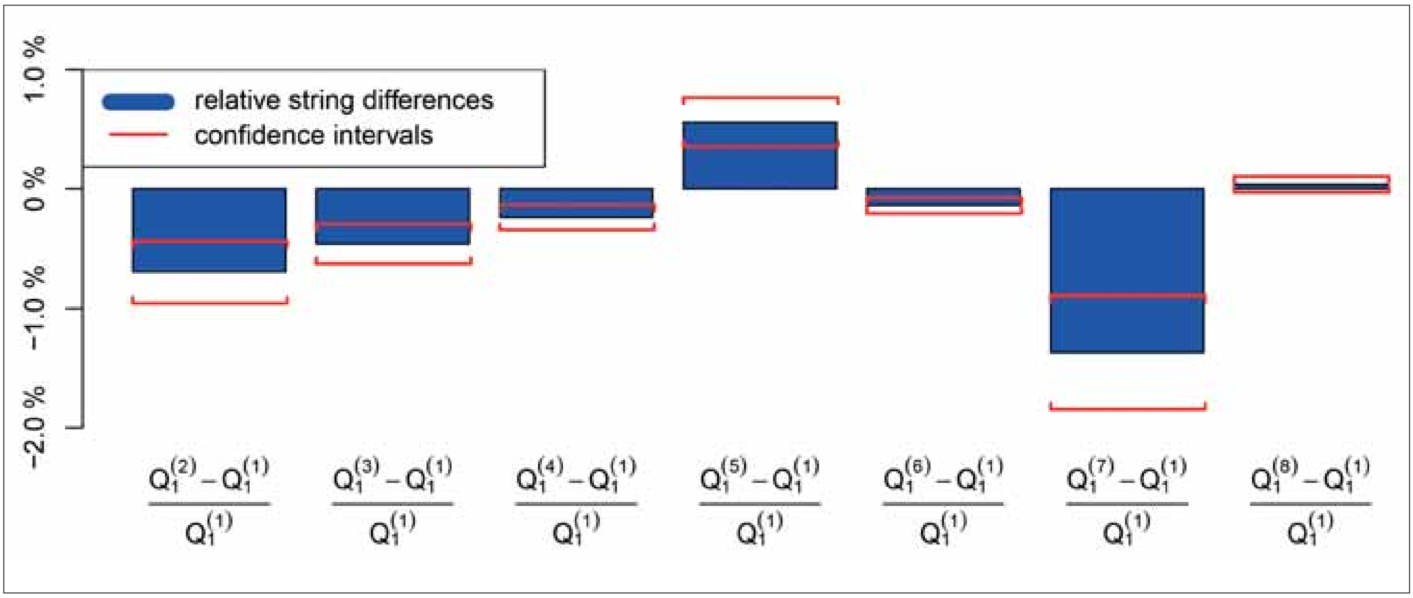


Figure 3. 95% confidence intervals of plant-specific normal performance values

areas, particularly on the edges, with a lower productivity, as well as mismatched cells and very uneven cell areas. Other types of failure were only occasionally found.

In one reference system, visual inspection showed "snail tracks" to be the failure type, an evident visual indication of micro cracks in the cells. The absence of this marker in the other systems is no indication of the absence of cell micro cracks, however.

Another, actually severe, type of failure was initially not identified. The module failure from overheated conductors is a typical self-reinforcing type of failure and can destroy contacts, interrupting current in the modules and thus in the string as a whole. Temperatures of up to 100°C have been measured in the large-scale reference PV installation (built in 2009) under medium irradiation conditions, as Figure 4 illustrates.

In the summer of 2017, complete strings had already failed due to several thermally destroyed junction box connectors. A complete IR inspection showed that about 6% of the installed modules were affected by overheated junction boxes. We may infer that hundreds of detected modules could have this progressive defect due to connection failure, which in the worst case can lead to the ignition of an electric arc. This type of failure can also lead to an increasing performance loss in the affected strings.

Performance measurements

The modules of the selected reference strings were characterised in the high-precision lab of TÜV Rheinland in Cologne, Germany. The results showed that beginning in 2014 most of the modules performed at a good level, given the operating period time of about five years. Only some modules of one installation performed less well than expected.

The EL imaging analysis showed that the underperforming modules in addition to single cell defects contained striking cell mismatches as shown in Figure 5.

The modules of the reference strings of the PVScan-investigated PV installations were precisely measured in the solar laboratory at a time interval of three years. The average annual degradation rate observed corresponds to the expected value of -0.3% (crystalline module type). However, individual modules showed a strong deviation up to more than -1%. Fluctuation varies between plants as shown in Figure 6.

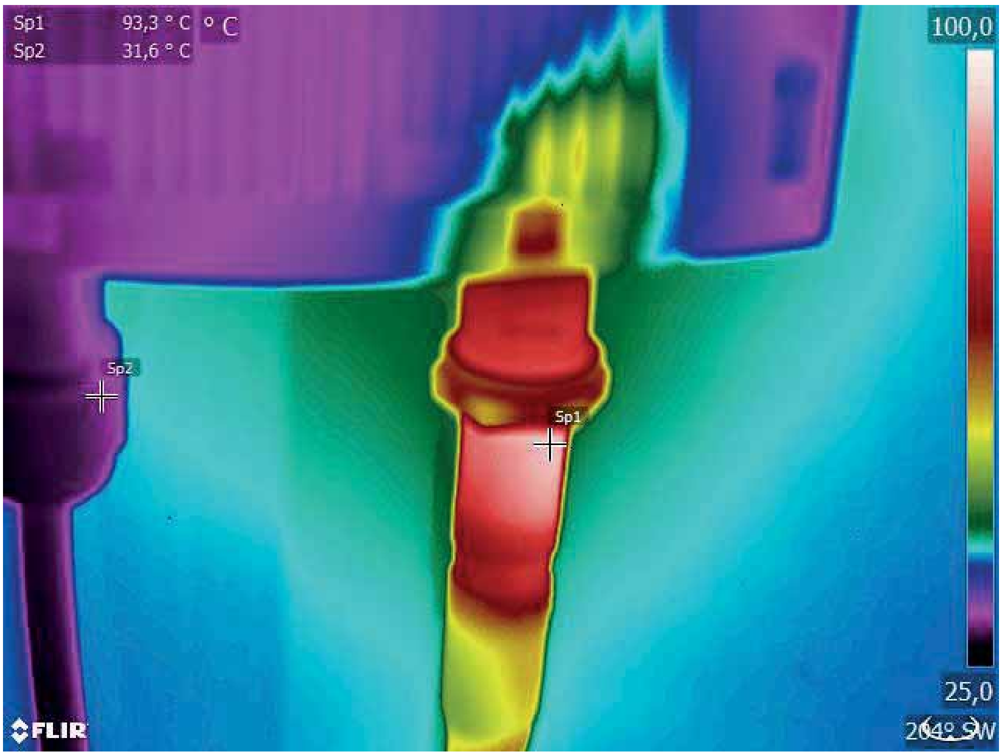
There was no significant correlation found between accumulated cell defects such as micro cracks or finger interruptions and increased degradation. In conclusion these module failures had not led to significant performance losses over the observation time of three years.

Development potential of failures

Degradation effects during project term

Various careful investigations of both brand new modules and modules removed from PV systems selected according to defined error types suggest that poor cell quality or cell mismatch can contribute to acceler-

Figure 4. On-site IR inspection revealed a greatly overheated junction box connection



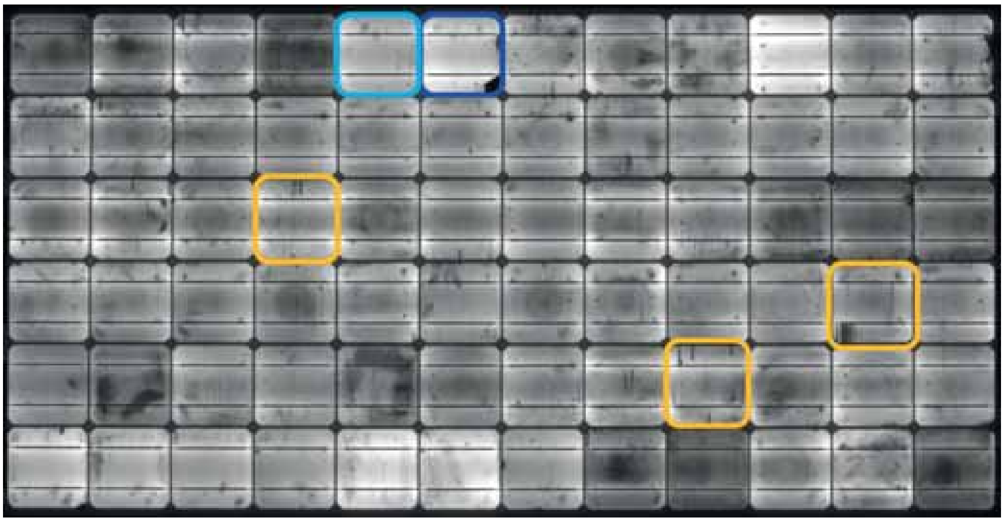


Figure 5. Sample of a poor module from the field after five years of operation: cell mismatch, micro cracks (light-blue), isolated cell area (blue) and finger interruptions (yellow), power loss: -5% in relation to data sheet (0 …+3%)

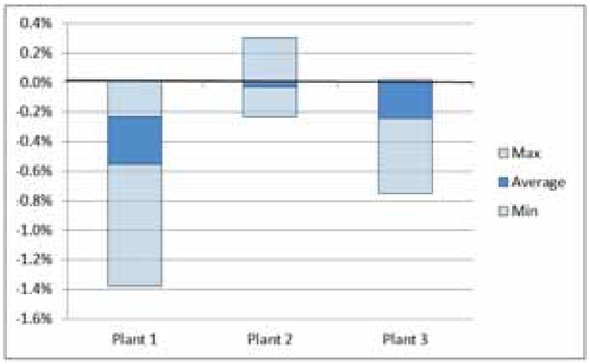


Figure 6. Annual module degradation rates of three reference strings

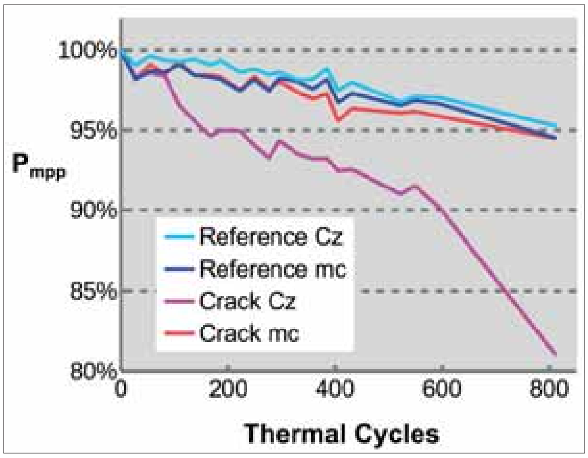


Figure 7. Degradation of test modules during extended thermal cycling testing. Reference samples without cell micro cracks (blue/cyan) show linear degradation of 0.5% per 100 TC. A mc module having a medium-sized cell micro crack (red) shows the same result, whereas a Cz module with a long micro crack (magenta) shows much stronger degradation

ated degradation while even significant micro cracks have a smaller impact on the performance loss discount in the observation period. It is assumed that contact resistances in the module connectors were increased by multiple opening (repeat measurements), which caused additional performance loss.

More detailed information will be published after completing the work on the PVScan project expected in the third quarter of 2018.

Development of micro cracks

The long-term degradation of solar panels is investigated in the lab by means of accelerated ageing testing.

The degradation of modules during thermal cycling testing (TC) according to EN 61215:2005 was investigated, but with the cycle count increased to >800.

Single-cell test modules from typically designed industrial solar panels served as samples. Figure 7 shows the results of power degradation for two reference modules and two modules affected by cell micro cracks. The reference modules exhibited a constant power degradation of -0.5% per 100 TC. The polycrystalline module affected by a medium-sized crack shows the same effect. The monocrystalline module having a long cell micro crack revealed increased degradation of -1.8% per 100 TC, however.

The good news is that the degradation rates in all cases did not increase over time. Degradation rates of standard 60-cell modules are expected to be slightly higher, since additional electrical degradation mechanisms exist compared with our samples. Further results can be found in [5].

In a second step, the degradation of some PV modules taken from the actual reference systems and exhibiting defects such as micro cracks, grid finger discontinuities or busbar failures have been investigated. These modules were stressed in thermal cycles and dynamic mechanical cycles simulating important natural stress factors for the purpose of accelerated aging. A stress intensity scheme based on data such as ambient temperatures and wind loads recorded over an entire year in Cologne was developed.

Module pairs with very similar failure characteristics were carefully chosen comparing the laboratory stressed modules with their outdoor counterparts. In terms of results, we often identified discontinuous developments in micro cracks, in particular in the case of large or branched cracks up to now isolated cell areas. New micro cracks were also observed.

The long-term further development of cracks is expected as in the aforementioned cell investigations. A quantitative statement on the further impact on module performance cannot be made at present. Overall, from our many investigations of micro cracks and bus finger discontinuities it was concluded that only massive failures in a large number of the cells will lead to measurable performance losses. It is a positive finding that the performance of the faulty modules under test proved to be unexpectedly stable.

Risk mitigation and hedging against the remaining risks

Manufacturing quality assurance gaps and proposals

The continued sharp decline in solar panel prices underscores the need to persuade manufacturers to performing a minimum of quality assurance (QA). Compared with other industrial sectors, solar panel production still presents the potential for advancement. Providing general QA recommendations can be tricky, since effective QA measures will always depend on the particular production situation. Production lines can vary from fully manual assembling to full automation.

As an industrial product, a solar panel has the peculiarity of a long service life with a manufacturer warranty of 20+ years. Feedback on customers' warranty claims can take between weeks (installation), months (medium-term defects, such as PID) and many years (long-term degradation). For the manufacturer it is helpful to be able to trace back a defective panel for even years and to have information about its production. Valuable informa-

tion includes characterisation and testing results, process parameters, component lists, etc. Yet providing this information is far from easy. Challenges lie in collecting this data, correlating the data with the panel and making the data accessible for many years to come. A large potential for improvement lies here.

In the field of inline process control, characterisation tools now exist for most processes.

As an extract of a large number of factory inspections the following tools may be considered useful:

- IV testing: final inspection
- EL: before lamination and at final inspection
- Visual inspection: before and directly after lamination and at final inspection
- EVA cross-linking testing: during or after lamination
- Insulation/high potential testing: at final inspection
- Reverse voltage/diode testing: at final inspection.

Besides inline testing, accelerated ageing testing performed in parallel with production is recommended, since medium and long-term defects like PID, discoloration and poor soldering cannot be detected during production. Testing can be performed with samples from production or with small test modules. PID testing can be reliably performed over 24 hours; most ageing tests unfortunately take several days, weeks or even months, however.

Identification of high-quality products

The aim for differentiation in this commoditised market continues to be strong, and high quality can be an important differentiator. Therefore, building on the results of the PVScan project as well as on the expertise in the field, a rating initiative has been launched that is expected to become an international standard at IECRE.

The rating system is built on several pillars illustrated in Figure 8. While the overall concept of PV power plant rating is not completely new, current rating systems so far concentrate the valuation mostly on financial metrics that reflect on historical performance data and project this performance into the future.

Adding a technical performance rating is supposed to add significant value as the viability of performance projection into the future is expected to increase substantially. The technical rating design aims to allow a PV power plant investor to better estimate the risk exposure of his current and future assets.

EPC / O&M contracts

Besides quality assurance for components, installation as well as the operation and maintenance are important for good performance and a long service life of the plant. Quality assurance accordingly forms part of EPC and O&M contracts as well. The EPC contract should stipulate detailed quality assurance measures such as checking product qualities and commissioning procedures, including final acceptance inspections. The O&M contract should describe all measures (such as monitoring and off-line measurements) and service intervals for visual inspection, module cleaning and grass cutting, spare parts stockpiling and message chains and responsibilities in case of failures or interruptions.

Professional, economically optimised system design and expert installation form the basis of an early return on investment. It is therefore recommended to include the review of the component selection and system design according to local environmental conditions, contracting of qualified staff, supervision of the installation work and professional project coordination. Any quality deterioration may have negative effects on performance and energy yield over the operating period and therefore on the return of investment. Well-defined O&M measures will preserve the performance level over the service life. Without a proper O&M strategy and measures there is a high risk of performance loss due to failures and downtimes and hence loss of revenue. An enhanced plant monitoring system will help assess plant performance and identify problems. Short reaction times will become possible and performance losses or downtimes can be limited. The experience and professionalism of EPC and O&M partners significantly affect quality. Special care must therefore be taken in selecting these partners.

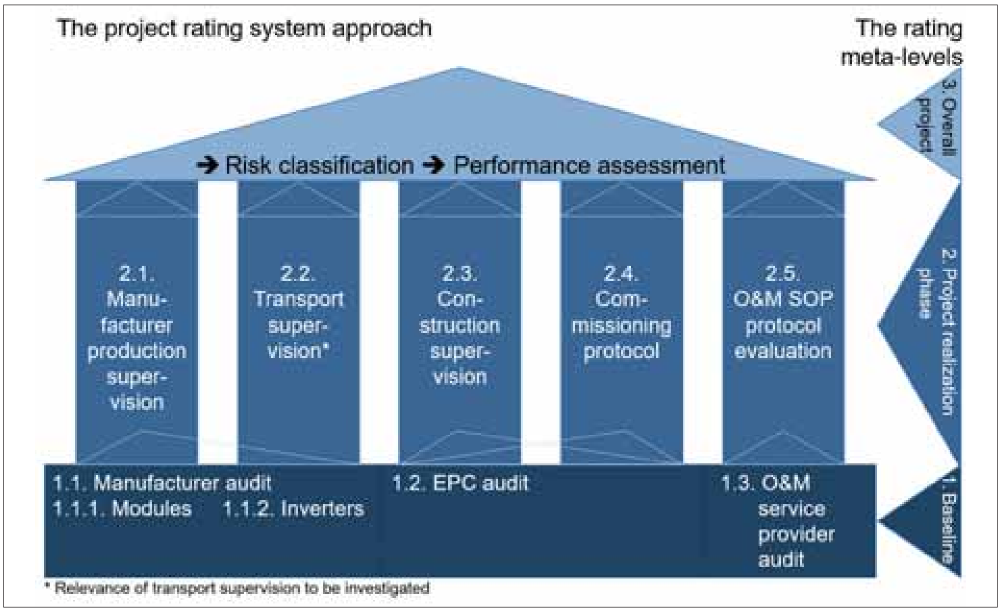


Figure 8. PV power plant rating pillar system

Hedging against the remaining risks – warranties and insurance

Regarding the performance warranty particularly of solar modules mentioned above, without going into detail on the possible variations of warranty and guarantee terms and on system interrelationships, it is to be pointed out that the viability of such warranties and guarantees significantly depends on the assessment of the manufacturer's financial strength. Many manufacturers (and EPC companies) find themselves in bleak financial situations that can be expressed in many different ways. Besides the fact that the risk of a manufacturer's insolvency will trigger a complete loss of value of the warranties and guarantees, the potential inclination to compromise on quality to reduce component manufacturing or construction costs may also prevail.

Quality defects deriving from possible deviations from the bill of materials or from standard operating procedures may be difficult to detect after component delivery and project completion, and may become evident only after several years of operation. As a consequence, a widely discussed solution to counteract (or mitigate) the risk of underperformance of PV power plants due to internal defects is performance warranty insurance.

Topic	Examples
PWI process management	One-stop shopping? Many partners?
Auditing	One-stop shopping or many partners? Validity and reliability of audit (i.e. expertise and scope)?
Insured entity	Manufacturer? Project owner?
Scope of insurance	Period insured? Which components are insured?
Obligation	Revocable? Irrevocable?
Coverage	What default cases are covered? Which components are insured?
Start of coverage	From day 1? Only during financing period? Only after initial period of operation?
Coverage amount	Full purchase price for new PV power plant or time value? Cash flow for PPA term?
Method of determining premiums, premium range	Various models (per project, up front, flat fee, annually, …)?
Deductibles, limits and quota shares	Deductibles: percentage, min. fixed amount, …? Limits: time limits, max. coverage limits, …?
Time and budget required	Duration of audits, shipping time, construction period?

Table 2. Examples of questions related to performance warranty insurances

Overall, the market offers a wide range of insurance solutions covering a variety of risks associated with owning and operating a PV power plant. Special insurance solutions such as performance warranty insurance vary quite substantially from one risk carrier to another. Some insurance solutions aim at hedging against the risk of a manufacturer's insolvency and therefore seem to eliminate the risk of the manufacturer becoming unable to meet the warranty obligations. We ascertained two insurance principles: policy contracted directly between the PV power plant owner and the insurance company; and an indirect policy whereby the component manufacturer provides insurance essentially covering the manufacturer's inability to meet the terms of the warranty, e. g. due to the manufacturer's insolvency.

The quality of the actual coverage under real conditions will vary, since some insurance solutions include a number of exclusion clauses in their terms and conditions or include withholdings or other measures in an effort to keep insurance premiums at an acceptable level. The key question accordingly arises as to how tangible insurance coverage may be when the case is foreseeable or has already occurred.

Table 2 indicates the complexity of assessing the risk mitigation value of an insurance solution, given the significant inter-relationships between the relevant factors.

A study analysing the root causes of insurance claim cases is currently in its final phase. Initial findings of this analysis suggest that statistically internal defects of a PV power plant are a significant source of power plant failures. More detailed results can be shared as soon as the study is completed.

In conclusion, our overall findings suggest that the avoidance of internal defects requires serious attention especially during the inception phase of a project. Moreover, the insurance solutions offered on the market should be evaluated in detail in the context of the overall project lifetime in order to assess the value of this risk mitigation method.

Finally, investing in solid quality assurance from the inception of the project through its lifecycle is not only a very important risk mitigation measure – it typically results in surplus performance relative to the nameplate that may in turn contribute to additional financial returns – and all the aforementioned measures can yield preferential financing terms. ■

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References

[1] Consortium, Solar Bakability, *Report on technical risks in PV project development and PV plant operation*, 2016/2017.

[2] RWTH Achen, Pepelyshev, A., Sovetkin, E. & Steland, A., *Panel-Based Stratified Cluster Sampling and Analysis for Photovoltaic Outdoor Measurements [Open Access]. Applied Stochastic Models in Business and Industry, 33* (1), 35-53., 2017.

[3] RWTH Aachen, Sovetkin, Evgenii and Steland, Ansgar (2015a). On statistical preprocessing of PV field image data using robust regression. In: Nikos E. Mastorakis, Adam Ding & Marina V. Shitikova (Hrsg.), Advances in Mathematics and Statistical Sciences, Vo.

[4] S. D. P. Guerriero, *"Automatic edge identification for accurate analysis of thermographic images of solar panels", Clean Electrical Power (ICCEP) 2017 6th International Conference on, pp. 768-772, 2017, ISSN 2474-9664.*

[5] ISC, Schmauder et al., *Extended Thermal Cycling Lifetime Testing on Crystalline Silicon Solar Modules with Artifically Introduced Defects, 33rd EUPVSEC, 5CO13.3,* Munich, 2016.

Towards a standardised contract for solar O&M

Operations & maintenance | In April an international working group will publish a bundle of standardised contracts aimed at aiding the rollout of PV worldwide. Sara Verbruggen previews the template contract for solar O&M and assesses its impact in streamlining this aspect of the business

Credit BayWa r.e.

To an observer today solar epitomises everything that a high-tech industry should be. Since its inception, upstream and downstream the solar value chain has undergone transformation, often through greater use of automation, in new areas like plant construction and maintenance. It's always with the aim of pushing down the cost of solar electricity.

With the accumulation of years of experience in mature markets, it is inevitable that soft costs too should be streamlined, especially if new markets with solar resources and demand for cheap electricity are to be tapped. Otherwise there might well be justification for a joke along the lines of: How many people does it take to build and manage a PV plant? Just robots, and a team of lawyers, of course.

The second quarter of 2018 will see the fruit of efforts by the Solar Energy Standardisation Initiative (SESI) to condense and streamline the legal documentation required in the process of developing, constructing and operating large-scale solar power plants. SESI will publish seven template contracts, providing a standardised legal framework, free of charge, applicable to any solar market in the world.

Formed by the International Renewable Energy Agency (IRENA) and the Terawatt Initiative, SESI draws on the input of all stakeholders involved in the development and operation of solar plants. Lenders, developers, asset managers, operations and maintenance (O&M) service providers and others have all been consulted so that the template contracts reflect years of accumulated practical experience by the industry.

The evolution of solar O&M has created a need for greater standardisation in contracts and other practices

A template contract that reflects the state of O&M today

In more mature PV markets, like Europe, O&M has emerged as a valued sub-sector of the industry in its own right. When the first solar installations were built several years ago O&M used to be something the original engineering, procurement and construction (EPC) firm took care of and largely involved vegetation clearing and panel cleaning.

Operating and managing these assets to perform optimally throughout their lifetime has since evolved into a more complex task, relying on scheduled maintenance activities, weather forecasting, equipment monitoring and strict data recording and analysis.

Specialist O&M service providers compete for tenders, and their services are often procured by asset owners that are not the original developer/owner, with the objective of ensuring that plant performance can be sustained or increased to generate returns for their own shareholders.

The industry's early O&M contracts reflected the previous over-simplification of O&M activity.

"In most cases the O&M contract was signed together with the EPC contract and included basic activities done by the EPC or its subcontractor, with a performance ratio guarantee, amongst others," says Vassilis Papaeconomou, managing director of O&M specialist Alectris and until recently chair of trade body SolarPower Europe's O&M Task Force. "It was also common for asset owners to be tied into fairly onerous long-term contracts usually with the company that developed the project. It was difficult to get out of these, even if the O&M service was poor."

Paolo Chiantore, managing director of operation services at Germany-based BayWa r.e., who recently took over from Papaeconomou as the task force chair, points out that in the intervening years, as the secondary solar market began

to emerge, the new owners of assets, quite legitimately, renegotiated O&M contracts, defining new conditions, price limits, liabilities and so on.

"In some cases the O&M contracts then became unbalanced but in favour of the asset owner. A key part of SESI's work has been to make sure these contracts reflect a fair balance of liabilities and risks between parties," Chiantore says.

As development of solar in Europe indicates, a mature PV market has two definitive parties: the long-term plant owners, with their own departments for managing these assets, and the specialised O&M contractors, which have emerged as a result of M&A activity and improvements in technology for operating and maintaining these assets, explains Chiantore.

Simplifying negotiations

While the SESI template contracts won't put lawyers out of a job, they will simplify contractual negotiations. Chiantore explains: "Just recently, I got a call from a new client that our company had been awarded an O&M tender with. After that news the client asked me to send over my contract and he would send over his. When we negotiate a new O&M mandate we often have to draft a new and dedicated contract each time. That means lots of negotiations, exchange of marked up files, involvement of legal departments and so on. With a template O&M contract we can both work off it, making adaptations of course. It might take a few weeks to get to the point of signing, instead of a few months."

The initiative has drawn on the services of several corporate law firms, with practices in relevant fields, such as energy and project finance, to produce template contracts designed to provide a full legal framework for delivering bankable PV projects. This means having contracts that ensure risk is properly allocated and proportioned among the different parties.

While a bankability perspective from the outset is more evident in mature PV markets, it will be critical also for projects to proceed smoothly and successfully in emerging markets, where debt is the main source of finance, according to Elizabeth Reid, an energy law partner at Bird & Bird.

This bankability perspective has been baked into the O&M contract template. For example the template includes two contract term options. One is for five years, with automatic extensions, or there is one for 15 years to match the debt term.

Reid says: "Certain aspects of an O&M contract are fundamentally important to achieve a bankable contract. One is the term of the contract, with term matching the tenor of the debt, for example. Others include ensuring there are adequate liquidated damage remedies if the contractor is not performing.

"Often response time liquidated damages are a better way of ensuring this, certainly when compared to a performance ratio (PR) guarantee or an often easy-to-hit availability threshold. The position on who pays for spare parts on corrective maintenance is also key for lenders – they will want to see either a full wrap from the O&M contractor, giving the contractor the right to rely on manufacturer warranties, or if the owner is taking the risk then a maintenance reserve account in place."

> "A key part of this work has been to make sure O&M contracts reflect a fair balance of liabilities and risks between parties"

Standardised contracts with sufficient flexibility

A challenge for the SESI initiative has been producing a suite of contract templates that are standardised but also flexible enough to account for the variations between different markets, particularly those that are more mature as well as new, emerging ones. The latter can often be in developing markets, which can carry more risk for investing. Typically project lenders will want to see full risk transfer to the O&M service provider, and this is particularly the case in project-financed deals in emerging markets.

Reid uses as an example, spare parts management: usually the asset owner procures an agreed spares stock initially for the first two years. After this period, the O&M service provider will maintain, store and replenish spares but with the asset owner paying the cost of the spare part replacement or the materials cost.

"In a developing market the lender will often want to see a full-wrap on corrective maintenance by the O&M provider. The lender will not want a special purpose vehicle to take on that risk. It has been harder to be really innovative in contract terms when developing markets are considered, due to the risks," says Reid.

Template contract aspects

So while the contract includes standard features found in many O&M contracts, such as term of agreement, scope of services and so on, it has to be flexible and some degree of optionality is inevitable. The fact that the optionality is kept to a minimum is credit to the efforts by legal advisers, according to Papaeconomou.

Again there is a degree of optionality in the section on plant takeover, which differentiates between a scenario where the O&M contract was set up before or during construction, or the EPC's two-year warranty period, and the other where a new O&M service provider takes over after the initial two-year warranty period.

The template also accounts for the fact that subcontracting out certain aspects of O&M has to happen. In the area of security, for example, the O&M provider is the interface between the subcontractor and asset owner but is not held liable for performance of that subcontractor.

One important outcome of the new O&M contract template will be the clarification in terms of the most appropriate key performance indicators (KPIs) to measure the service provider's performance.

The template contract considers the availability guarantee – in conjunction with response times, where relevant – as the most accurate and fairest performance indicators for the O&M service provider, instead of the performance ratio (PR).

"The prevalence of PR as the main KPI goes back to the early days of the market, when the EPC, which designed and built the plant, also carried out the O&M tasks. The PR made sense because a performance guarantee is connected to the equipment choice, the design and construction, all decided by the EPC. But PR doesn't make sense for plants that are six, seven, eight years old, when the O&M provider is not responsible for

Performance versus availability

Agreeing the most suitable O&M key performance indicators (KPIs) has been one of the main challenges of drawing up a template contract

The logic behind replacing the performance ratio (PR) – the historical method of measuring the O&M service provider's performance – with availability guarantees and response times is that the latter are based on what is within the O&M provider's control.

Often, O&M service providers taking care of PV plants are not the original EPC; therefore the argument runs that they should be liable for availability, which is something they can influence, not performance, which is down to the plant design, construction and equipment choice.

The response time covers areas that the availability guarantee does not. For example, at a large PV plant an inverter might fail. This may have little, or negligible impact on plant performance but with a response time guarantee the O&M provider is still contractually obliged to fix it or replace it within a certain timeframe.

Using availability guarantees, instead of PRs, as KPIs also allows for smoother switching between providers and smoother hand over processes, according to Vassilis Papaeconomou. "Because the new contractor is not in a position to influence the PR they would need to undertake measurements and evaluations of the plant and its performance, all of which can take several months to accomplish," he says.

That said, unanimity in favour of doing away with PR altogether is not forthcoming from the solar industry.

According to Elizabeth Reid, energy law partner at Bird & Bird in London, in a detailed consultation in recent weeks with a cross section of the sector, including lenders, some insisted that the PR guarantee must appear in their contracts. "We therefore still haven't come to a landing on this point in the contract – we may need to include a PR guarantee as an option, explaining that it is not recommended as the best measure of plant performance in the context of O&M," says Reid.

Furthermore, general feedback has been that if there is a bonus at all in O&M contracts it should be linked to performance, not availability.

According to Santiago Estrada from 3E, in his experience PR continues to be an important parameter that lenders and asset owners like to see for new plants, definitely during the EPC warranty period, which is typically for the first two years. "Availability-related KPIs are increasingly accepted for O&M contracts after that period."

However, ultimately preference depends on the individual lender and asset owner.

historical choices that impact performance," says Papaeconomou.

However, during the final period of consultation it seems that many of respondents, including lenders, do want to see a PR guarantee appear in the contract.

Taking best practices to new markets

The template contract follows the work by the Solar Power Europe O&M task force that has recently resulted in the second version of its "O&M Best Practices Guidelines" first published in 2016 (see *PV Tech Power* Volume 8, September 2016).

The guidelines are also an important piece of standardising documentation and function as a technical support and manual, to be used together with the O&M template contract.

Consultancy 3E acts as a technical adviser in the development and construction phases of PV plants, with responsibilities that include assisting clients with reviewing contracts. The company also provides software and related services for managing PV plants, which are used by PV plant asset owners, operators and O&M service providers.

3E has worked with SolarPower Europe on putting together the O&M taskforce and also assisting SESI on the O&M contract template.

According to Santiago Estrada, lead consultant, international business development at 3e, when his company reviews contracts for clients the objective is to try to standardise from a technical advisory point of view.

"We try to even out, or equalise, the O&M contracts that we review, where required," Estrada says. "Having a standard template that the whole global PV industry can use for O&M is good for owners and lenders as well as O&M service providers, as it will help, for example when portfolios change hands, that you have a standardised set of contracts for each project."

While in Europe's solar market SESI's template contracts will help reinforce work already well underway to formalise best practice, it is new solar markets that may benefit the most.

"In Europe, we are at a good level of understanding. All of this doesn't sound that strange or new, but if you go somewhere in sub-Saharan Africa, say, where local developers, banks and other stakeholders have no experience in solar, then the value of the SESI template contracts and the supporting guidelines, will be highly appreciated," says Papaeconomou.

Chiantore adds: "Mature markets such as the European pioneers, including Germany, Spain and Italy, have accumulated more experience. More lessons have been learnt here…That's why people from these countries have given more support and contributions to the templates. Emerging solar markets will not need to start from scratch when defining contractual structures for development of new sites."

The template has to be flexible enough to account for differences between markets. In Europe, for example, panel cleaning is a fairly basic and standardised O&M procedure, but in other markets may not be so straightforward. "Take a new market in Africa," says Estrada. "You have to account for local conditions. It may be drier and dustier so panels may need cleaning more often, but water is not going to be so abundant nor cheap, so you have to factor these considerations in. That means in reality having a clause about panel cleaning but depending on the asset's location, how frequently this occurs is agreed between the parties."

Before the seven template contracts are published, final reviews are taking place. Dissemination will take place at key global solar events and SESI is working with solar and renewable energy associations in various countries to promote the initiative.

While the initiative's success will be measured in the adoption of the template contracts, it relies on voluntary adoption.

The contracts will be promoted as a set and cherry picking is not advised, as so much work has gone into harmonising the contracts, which include the power purchase agreement, installation agreement and finance facility agreement, to ensure consistency in aspects, such as liabilities, health and safety, force majeure definitions and so on.

In countries that are in desperate need of new sources of electricity to power their economic growth, a simplified legal framework for large-scale solar investments will help ensure solar electricity is as competitive as other forms of power generation, focusing all parties' efforts on bankable projects more likely to see successful development and execution. ■

End of warranty inspections in solar PV power plants

Asset management | Examining a PV power plant to ascertain its health is a key measure when warranties for components expire. Romain Elsair and Marcos Blanco of Greensolver outline some of the main steps involved in effective end of warranty inspections

Credit Getty Images

The huge volumes of PV capacity deployed around the world in the past five years have necessarily shone a spotlight on how the industry manages solar power plants over their operational lifetime. A concerted effort is underway in mature markets in Europe, North America and elsewhere to standardise the approach taken to solar operations and maintenance and ensure that the most efficient, transparent and effective practices are being adopted universally by the industry.

One area that is growing in importance is the management of operational assets that come to the 'end of warranty' (EoW) period – when the warranties for individual components expire. With key power plant technologies having only a finite warranty period, each year multiple gigawatts of plants' components reach EoW, a figure that is only going to rise as the global installed base increases. When a plant's EoW period passes, new contractual arrangements may have to be renegotiated based on the current status of the main equipment, namely the solar modules, the inverters (string or central), the transformers and the mounting structure.

One source of learning for the solar industry has been onshore wind, a more mature renewable energy technology, where end-of-warranty inspections are a common practice. It is important for asset managers to have a clear understanding of the current state of the asset and overall performance linked to equipment condition. Our main role is to optimise assets under long-term contracts and therefore organising and conducting the appraisal of EoW inspections is of utmost importance.

Greensolver has been running EoW inspections on wind farms across Europe and we have been able to help and support our clients when renegotiating warranty contracts and recommend equipment improvement. As such, we believe that a similar approach can be followed when conducting EoW inspections for solar PV plants. Based on the lessons learned from its experience in managing European wind and solar assets, Greensolver wishes to share its technical views.

End of warranty inspections of a solar plant's main componentry help with any renegotiation of contractual arrangements

Solar modules

Solar modules constitute the bulk of the BoP cost for solar projects in Europe, sometimes up to 50%. This trend is constantly decreasing due to falling prices of silicon. Therefore, it is of utter importance to understand and follow the behaviour and performance of solar modules, something that asset managers are constantly required to do.

Solar modules are typically under warranty for 25 years (that will be the peak power warranty), which is directly based on the power output of the module and a linear degradation factor applied on an annual basis (typically 80% after 25 years of operation). Filing a claim against the module manufacturer for linear degradation is a fairly complex task as the asset owner is required to use accredited laboratories which can measure module degradation with very low uncertainty. This process requires removing the modules, sending them to the lab (note: mobile labs do not currently use equipment which present measurement uncertainties low enough to provide relevant results), wait for the measurements to be performed, send the modules back and mount them back. Therefore, this is a very costly requirement, normally with a low success rate.

Solar modules also have a limited power warranty against defects for five or even 10 years. At the end of this warranty, the owner has the possibility to extend it for another five or 10 years, until the solar plant's end of life. It is worth noting that there are currently no solar plants in the UK for example (location is important as we need a benchmark, which does not exist yet) which have been operating for 20 years or more. Therefore, it can be fairly complex to forecast the future behaviour and performance of solar modules. How can the existing business model in place

take into account issues that will take place in hypothetically 10 years? There is no simple answer but experienced asset managers can help with the technical assumptions used and adjust the model taking into account module pricing, best maintenance practice, etc. and conduct EoW inspections.

These inspections will help the asset owners assess the current condition of the solar modules, focussing on cracks, thermal imaging, snail trails, yellowing/browning, potential-induced degradation (PID) issues, general state and cleanliness of the modules, MC4 connectors, back cable, maintenance history, spare parts, humidity ingress, etc.

Inverters

Inverters make up 20 to 30% of the BoP cost. Inverters are typically robust pieces of equipment and are designed to operate under changing conditions. This is especially true in the UK where cloudy skies are common features. The amount of irradiation hitting the solar plant will then vary swiftly as clouds pass away. Inverters need to respond to such conditions by having complex built-in algorithms, which attempt to maximise both voltage and current, a feature known as multi power point tracking (MPPT). Depending on the type of inverters (i.e. either central inverters, or string inverters), problems that can arise are different.

Central inverters

Solar modules are linearly connected in strings (typically a number comprised between 15 and 25) and the current and voltage of several strings are sent to the central inverters. Central inverters collect data from a large number of strings.

Central inverters can be problematic to replace or repair, especially if the issue occurs in the height of summer when production is at its peak. As a matter of fact, a large portion of the solar plant will require to be shut down for a significant amount of time to carry out the repairs, which will have consequences on the business model in place. Asset managers can anticipate when the need for such remedy happens by estimating performance of each central inverter, following the downtimes, and use internal tools for forecasting and keeping losses to a minimum.

String inverters

String inverters collect electrical data directly from module strings. For 5MWp solar plants built in the UK, it is not unusual to find about 1,000 strings and up to 250 strings inverters at one site. Therefore, chances to have issues increase as the number of individual components increases too. However, maintenance and replacement of string inverters are considerably simpler than of central inverters. String inverters are modular in nature and their repair is usually not "worth it". Each string inverter can be replaced without shutting down a significant portion of the plant as explained above.

In terms of contractual warranty, both central and string inverters are under warranty for an initial period of five years, which can then readily be extended by another five years. This process can normally be repeated until the 20th or 25th year of plant operation where the inverter manufacturer has the possibility to repair, replace or repay in case of fault/defect. However, it can become quite complicated to determine the reason for the fault/defect. Hence, asset managers can help asset owners with this task. In particular, right before the first warranty extension, it is strongly advised to run an EoW inspection and follow the current applicable standards.

EoW inspections of inverters will focus on the general state of the cabinets, check the maintenance logbook, check the SCADA system, and check and analyse the downtimes linked to inverters.

Transformers

Transformer units are bespoke pieces of equipment which are very robust in nature and designed for the long term, in principle they are not subject to motion, so many problems due to vibrations or mechanical adjustments normally do not affect transformers. Transformers for a 5MWp solar plant will generally have a capacity of 5MVA, but obviously other configurations do exist. In particular it is very common to find "plug and play" transformer cabinets which did not require any on-site assembly.

In terms of warranty, since fewer players are active in this side of the market, warranty can vary from 1 to 5 years. Extended warranty packages also exist to renew the terms.

At Greensolver, we have not yet met any solar PV project in the UK where transformers have suffered major incidents. However, in other jurisdictions, we can confirm that this has already happened. Therefore, a special interest should be given to the EoW inspection to analyse the state of the transformers.

Mounting structures

Mounting structures are the fundamental building blocks of a solar plant and are often neglected by technical advisors when conducting due diligence analysis. It is clear that if any serious issue arises with the mounting structures, there is no possibility to swiftly implement solutions and significant losses will occur. In particular, the galvanisation strength of the poles is of utmost importance, especially in locations where the plants can suffer from particular meteorological conditions potentially impacting its lifetime. This could be the case in places where high levels of humidity or extreme temperature ranges (for example very dry places or close to desert areas) are frequently reached, or which are subject to ice/snow during winter periods. Additionally, different metal-metal connections can often be observed (for example, steel and aluminium) and give rise to unwanted oxidation, especially in areas located close to the sea with higher levels of saline particles.

The asset manager should analyse the way the structure manufacturers have taken into account the corrosivity of the terrain leading to a defined galvanisation thickness to be coated. For example, if the lifetime of the asset is 20 years, the

PV module warranties are among the key components that should fall under EoW inspections

Credit: Greensolver.

warranted galvanisation thickness should be provided for 25 years. EoW inspections can help detect issues arising from galvanisation and corrosion on the mounting structures.

Emerging best practices in EoW inspections

EoW inspections driven according to the needs of the plant become very helpful for influencing the future behaviour of the plant and can help minimise costs connected to possible future failures. The possible scope of the inspection can be broad, but as best practices we recommend that the following topics are to be covered:

- **Technical design:** review of as-built documentation to ensure that the project has been constructed in accordance with the engineering design, relevant standards and regulations, EPC contract and owner's requirements; verification that the contractor has provided all documentation in accordance with the EPC contract and IEC standards.
- **Electro-mechanical installation:** inspection sampling of the plant installation, according to ISO sampling procedure standards (ISO 2859-1). This must include modules, mounting structure, DC cabling and combiner boxes, AC cabling and combiner boxes, inverters and inverter stations, security system, monitoring and SCADA systems, substation building inspection of monitoring and measurement station to be used for acquisition of on-site data and calculation of performance ratio. This can be driven by visual inspection.
- **Commissioning – functionality and safety:** review of all commissioning protocols to ensure the project has been commissioned according to the minimum requirements of IEC standards (IEC 62446) and in terms of safety for the DC and AC side, inverter functionality and grid connection.
- **System performance:** evaluation of the original yield assessment and comparison with actual as-built installation such as shading, cable laying, soiling or module handling. Completion of performance ratio tests in accordance with EPC contracts using project monitoring and measurement station.
- **O&M competency:** evaluation of O&M providers with respect to experience, references and quality assurance, as well as evaluation of corrective and scheduled maintenance programme and reports; evaluation of system availability.
- **Tests of PV plant equipment:** several tests can be driven on site or even sending some samples to accredited laboratories. In this way, the inspection reports issued can be used afterwards as a base for filing claims with product manufacturers if defects are found in the equipment. A wide range of tests can be carried out, including:
  - o Infrared tests of modules with documentation of all conspicuous or defective modules and photos of representative failures only. It must be taken into account that this test is weather dependant and a minimum solar irradiation of 500W/m^2 is required to be carried out.
  - o Electroluminescence tests on site with photo documentation of all tested modules and categorisation of potential defects. IV curve tracing on site with correction to STC conditions. Depending on the type of the mobile laboratory available on site, this test can also be weather dependant and a minimum solar irradiation of 700W/m^2 is required to be carried out.

  This type of tests must establish the location of conspicuous or defective modules, marking it clearly on plant layout, joining with the identification of its serial numbers.

Table 1. Average warranty period for key solar power plant components

Equipment	Average warranty period
Solar modules – peak power	25 years
Solar modules defects	5-10 years
Inverters	5 years
Transformers	1-5 years
Mounting structure	Should be 5+ years more than of the asset lifetime

As a conclusion, depending on the historical overview of the plant and/or if major issues happened, it can be adapted to the needs and particularities of each plant.

Conclusion and recommendations

Each component in a solar plant presents its own issues. Modules bought from experienced manufacturers are less likely to present severe issues. However, it is important for the owner to understand the manufacturing practice implemented for the batch purchased. Warranties provided are very standard throughout the market but filing claims against manufacturers has proven challenging. Inverters purchased from reputable manufacturers will be proven, robust pieces of equipment. However, when failing their financial obligations, impacts will be significant and can sometimes last longer than accounted for. Transformers are also robust pieces of equipment where few instances of severe issues have been recorded in the UK. Mounting structures often appear as the "last worry" but are crucial to the correct behaviour and long-term performance of the asset.

As a recommendation, portfolio owners should be aware of each of their existing warranty contracts in place and not delay the EoW inspections of their assets, especially as their termination is on average after five years (see Table 1). EoW inspection costs are relatively low compared to the financial and production losses that could occur in the event of component failures.

Moreover, it is a common practice for large portfolio owners to have Maintenance Reserve Accounts (MRAs) in place to deal with unexpected drawbacks.

Asset managers, by conducting EoW inspections, will help asset owners take the necessary measures to mitigate risks linked to equipment warranties during the re-negotiation of each contract.

Authors

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Mobile PV testing in India

Testing | With India going all out to achieve its target of 100GW of PV by the year 2022, the quality of equipment used in installations is becoming increasingly important. Satish Pandey and Abhishek Sharma of Mahindra Susten explore the role of on-site testing in quality control, based on the early results from India's first mobile PV lab

Credit Mahindra Susten

India's Ministry of New and Renewable Energy (MNRE) is rolling out a new order seeking to improve the quality of solar components. From later this year, all PV modules, inverters and batteries manufactured in or imported into India must obtain a new Indian 'standard mark' certifying that they have satisfied certain quality requirements [1]. In the case of PV modules every module supplied/used must qualify under IS14286/IEC61215 or IS/IEC 16077/61646 and IS/IEC 61730(PART 1, 2), IS/IEC 61701 and also IEC 61804 PID [1] {3.7.1 PV Modules}. The standard will be administered by the Bureau of Indian Standards and require equipment samples to be taken at least every two years to ensure compliance of products [2]. Non-compliant equipment will be subject to confiscation and disposal.

Meanwhile, degradation over time is an issue known to affect PV modules for a variety of reasons. Degradation studies have been made throughout the world indicating different values of degradation percentages and their impact on the PV plant performance. The difference generally occurs due to the weather conditions and the topography of that particular location; for example a soiling loss of 2-3% is generally assumed while performing analysis of solar power plants in the Indian sub-continent. The performance of a module is generally also affected by factors such as operating temperatures, shading, vegetation, humidity, presence of any abrasive chemicals and varying irradiance levels.

Mobile module testing will help India drive up quality standards

Quality checks and the need for mobile testing

As per the MNRE's order, it will become mandatory to do regular quality checks of PV modules which are either manufac-

Sr. No	Location	Installation year	Module type	Module country of origin	Sample Size	Nameplate power (Wp)	Measured PIV value in Mobile Lab (Wp)	Deviation from rated power (%)	Annual degradation rate (%)
1	Mumbai (MH)	2013	Polycrystalline	India	10	250	238.94	-4.42%	-1.1%
		2017	Polycrystalline	India	10	250	240.48	-3.81%	NA
2	Charanka (GJ)	2012	Polycrystalline	China	10	235	219.08	-6.77%	-1.4%
		2017	Polycrystalline	China	10	320	319.73	-0.08%	NA
3	Rawra (RJ)	2012	Polycrystalline	India	10	235	228.11	-2.93%	-0.6%
	Phalodi (RJ)	2014	Polycrystalline	China	10	250	227.35	-9.06%	-3.0%
	Bikaner (RJ)	2017	Polycrystalline	China	10	320	321.91	0.60%	NA

Table 1. Flash test results from Mahindra Susten mobile PV lab

tured in India or being imported from other countries, more so for the imported PV modules as they need to pertain to Indian climatic conditions for reliability and sustainability for a long lifetime performance. And with India's specific climatic conditions, modules will also need to be tested regularly to monitor degradation rates and performance losses over their typical 25-year design lifetimes.

A network of accredited laboratories with expert manpower adhering to IEC/ISO 17025 is in place in India to offer the necessary quality assurance infrastructure. But since the accredited labs present in the country are situated away from the active solar parks, it's not always feasible to transit large numbers of modules from sites to the labs. The sample size of PV modules shared for testing is thus frequently low, undermining its viability as an effective quality control on PV modules.

Mahindra Susten mobile PV lab has been developed for conducting qualification testing. It is a robust test lab which can move across various geographies and produce reports on the health status of modules in fewer than three days. The lab is the first of its kind in India, providing a range of electrical and visual tests of PV modules as per IS14286/IEC61215. The mobile PV lab has applied for accreditation from the National Accreditation Board for Testing and Calibration Laboratories (NABL), which is an autonomous body under the aegis of Department of Science & Technology, Government of India, and is registered under the Societies Act. It is the only one of its kind to assess laboratories in India for quality and consistency in the results.

The mobile PV lab can mitigate the problems associated with remote testing as it can travel to a plant or manufacturer location and thus the sampling rate of the PV modules to be tested can be increased significantly. This process is feasible techno-commercially as testing can be done in non-generation hours, thereby no generation loss occurs. Also, since handling and transit costs are mitigated, the process is more commercially feasible. We believe that the MNRE will enforce and promote testing processes to be more robust and quick. In the current scenario the turnaround time for testing PV modules is roughly about a week, which the same in the mobile PV lab can be completed in about one day with the test reports for 10 times the number of modules.

It offers a comprehensive as well as à-la-carte testing solution for both plant developers and module manufacturers, thus its results can be inferred both for benchmarking and qualification testing as required for PV modules, thus catering towards the goal of MNRE, of seeking quality assurance in solar PV modules.

Experimental testing

To give a better understanding of the working of the mobile PV lab we have compiled results in which observations from various sites and of various tests are shared, stating the percentage of degradation of PV modules along with EL test and thermographic inspection which was observed during the testing in the Mobile PV Lab. The results include various tests conducted in Maharashtra, Gujarat and Rajasthan. The mobile lab consists of essentially three major pieces of equipment namely flash tester, electroluminescence (EL) tester and thermal imaging cameras. The flash test is achieved with the help of an AAA-class sun simulator, which comprises of a flash lamp, flash generator and an electronic unit. The flash test gives the IV characteristics of the PV module. Thermal imaging is done for finding hotspots using a thermal camera while the EL test helps us to identify micro cracks & PID-affected modules, both of which have a separate housing space in the lab.

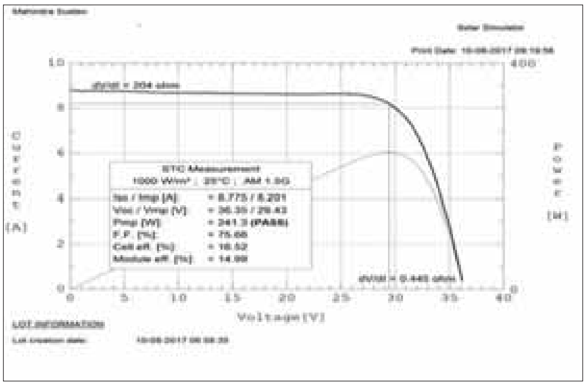
In our case studies, we have taken the mobile PV lab to sites in Gujarat, Rajasthan and Maharashtra covering 280MWp of installed capacity with projects ranging from 1MW-80MWp. Following visual inspection, 10 modules were selected from each site for flash testing, EL testing and thermography. The results compiled here show modules of

Sr. No	Location	Installation year	Module type	Module country of origin	Sample size	Nameplate power (Wp)	Cell crack observed	% of modules affected from cell crack (%)
1	Mumbai (MH)	2013	Polycrystalline	India	10	250	No	Nil
		2017	Polycrystalline	India	10	250	No	Nil
2	Charanka (GJ)	2012	Polycrystalline	China	10	235	No	Nil
		2017	Polycrystalline	China	10	320	No	Nil
3	Rawra (RJ)	2012	Polycrystalline	India	10	235	No	Nil
	Phalodi (RJ)	2014	Polycrystalline	China	10	250	Yes	10%
	Bikaner (RJ)	2017	Polycrystalline	China	10	320	No	Nil

Table 2. EL test results from mobile test lab

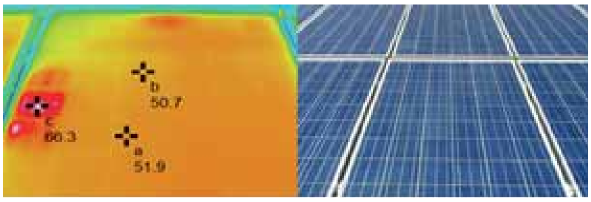
Sr. No	Location	Installation year	Module type	Module country of origin	Sample size	Nameplate Power (Wp)	Hotspot symptoms	% of modules affected from hotspot
1	Mumbai (MH)	2013	Polycrystalline	India	10	250	No	Nil
		2017	Polycrystalline	India	10	250	No	Nil
2	Charanka (GJ)	2012	Polycrystalline	China	10	235	No	Nil
		2017	Polycrystalline	China	10	320	No	Nil
3	Rawra (RJ)	2012	Polycrystalline	India	10	235	No	Nil
	Phalodi (RJ)	2014	Polycrystalline	China	10	250	Yes	10%
	Bikaner (RJ)	2017	Polycrystalline	China	10	320	No	Nil

Table 3. Thermography results from mobile PV lab



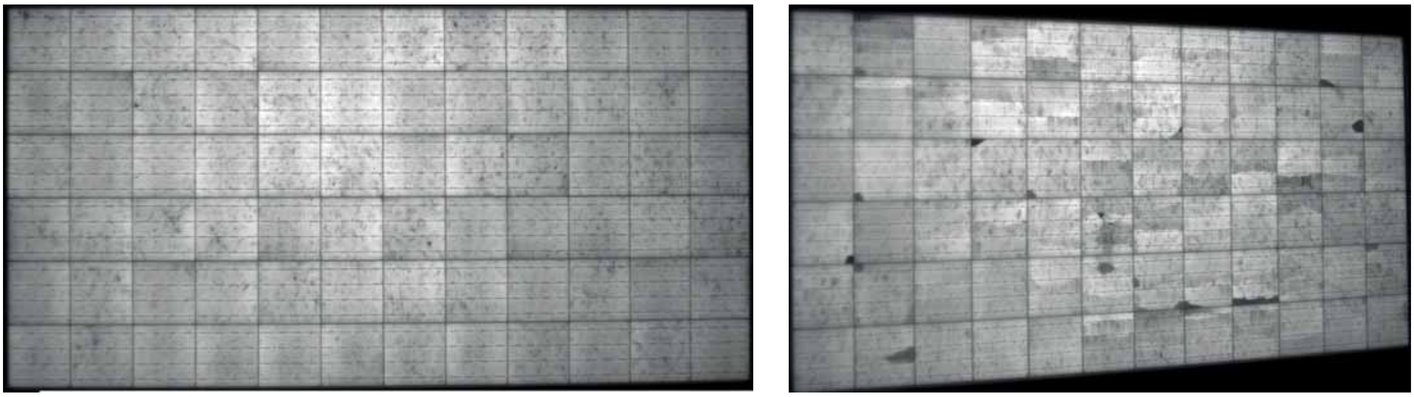
Credit Mahindra Susten

IV curve (flash test)



Credit Mahindra Susten

Sample image of thermography inspection



Credit Mahindra Susten

EL image of healthy module (left) and unhealthy module

different makes at diverse locations of the sites. The module age at the various installations varied from one to six years, with the earliest installation from 2012.

Results

The results have been compiled in a series of comparative tables, which give us an overview of how degradation varies with respect to the year of installation and location. Table 1 shows the comparative analysis of all the flash test results as obtained by the mobile PV lab, Table 2 the results from EL testing and Table 3 from thermography.

Summary of test results of samples

1. The maximum deviation was found to be 10.59% in first six years of operation for the modules installed in the year 2012. Out of total 100 modules sampled 15% had degradation higher than warranty expectation.
2. Cell crack was evident on one of the modules installed in 2012, EL image of the same has been attached.
3. Sample thermography image of the module in which hotspot was found is attached; the rest of the modules were found OK during testing.

Conclusions

The mobile PV lab can help the testing domain of the Indian solar industry with its quick results and preciseness. Once it gets accredited from NABL, and its empanelment with MNRE is done it will change the PV module testing domain in the market. Precise and quick results are its forte, and reports can be submitted in two to three days. Since the testing can be done in non-generation hours, no generation losses occur. The testing cost of PV modules will be reduced as transportation and handling cost is minimised.

So far we have tested only polycrystalline modules; moving ahead we will include thin-film module technology covering all the regions of India. The commercial analysis shows, that for sample sizes exceeding 10 modules the mobile lab testing is commercially more viable than transportation to a laboratory. The preventive analysis of the module performance based on the test reports of the lab can be done and same can be shared with module supplier for corrective action under warranty terms.

The author would like to thank co-author Abhishek Sharma for the on-site testing work he carried out for this assignment.

References

[1]. Kenning, T. 2017, "India details compulsory new solar component quality standards". Published on PV Tech https://www.pv-tech.org/news/india-details-new-solar-component-qaultiy-standards

[2] Solar Photovoltaics, Systems, Devices and Components Goods (Requirements for Compulsory Registration) Order, 2017. Ministry of New and Renewable Energy, India, 2016. http://mnre.gov.in/file-manager/UserFiles/Draft-Quality-Control-SPV-Systems_%20Devices_&_Components-goods-order.pdf

Author

Lead author Satish Pandey is the head of solar plant performance analysis and PV testing at Mahindra Susten, the clean-tech arm of the Mahindra group and a leading player in the Indian solar energy sector, with over 1,090MWp commissioned to date and over 502MWp under execution. He holds both an M.Tech and MSc in physics and has over 10 years' experience working in the solar industry. He worked with PV manufacturer Moser Baer Solar from 2008-2013 before joining Mahindra Susten in 2013.

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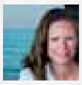

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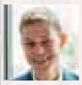

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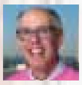

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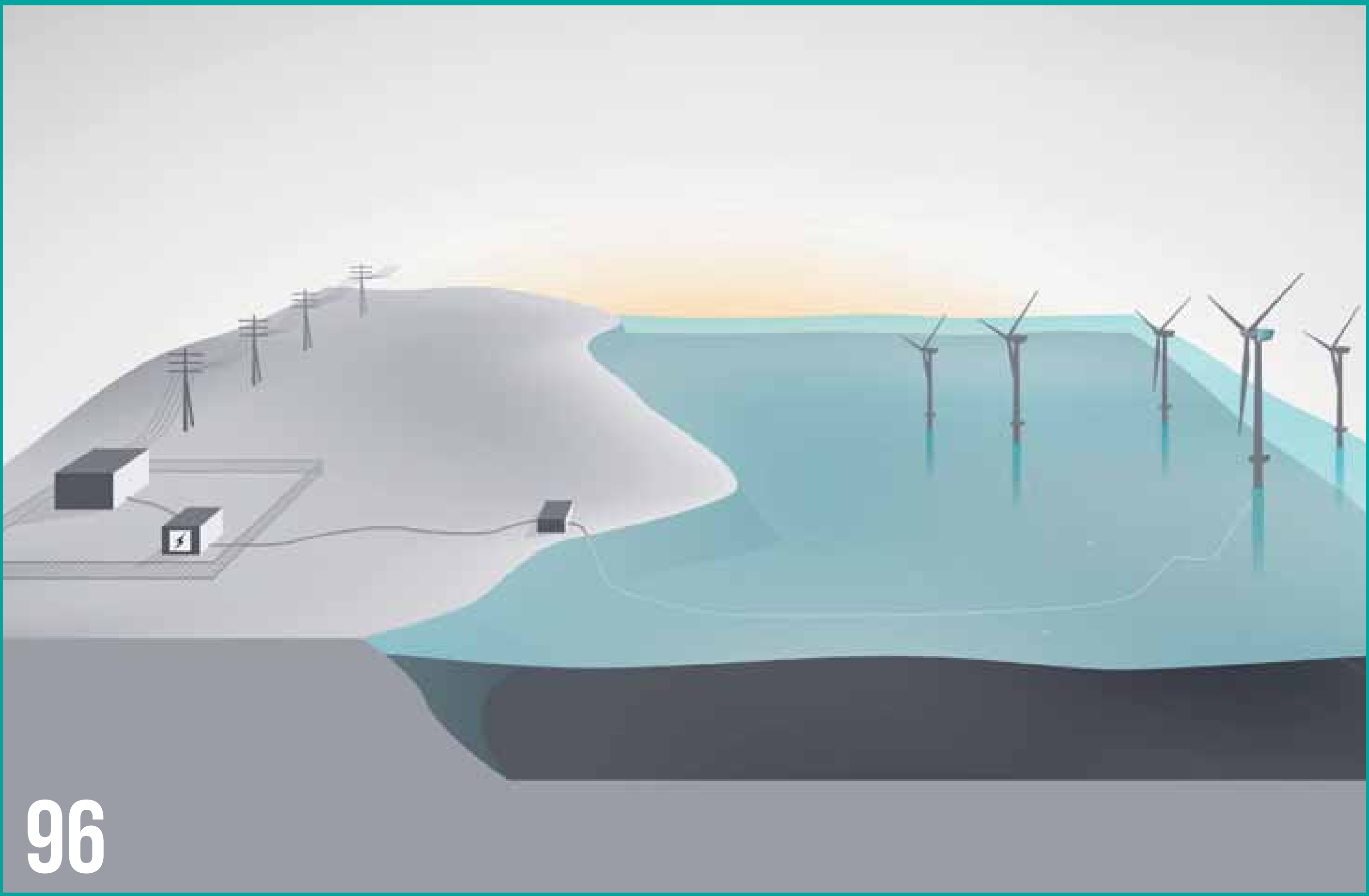

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Energy Storage NEWS

Introduction

As before, 'Storage & Smart Power', this section of the journal proudly presented to you by the team at Solar Media's Energy-Storage.News, brings you some of the biggest topics and best minds in the industry.

This issue, we've canvassed the opinions of trade association chiefs from around the world in the year just gone and looking to the year ahead. The responses, from the US, Australia, India, Europe and the UK all come from different angles but have one thing in common: they all say energy storage is here and now and the industry is ready to meet the challenges 2018 will throw at it, however unexpected. From European dreams to interconnect a whole continent, India's nascent lithium battery manufacturing ambitions and a "game-changing, breakout year" in Australia, to say there's a lot going on out there would be an enormous understatement.

In terms of current opportunity, the commercial and industrial (C&I) sector of the US continues to grow and driven by a strong business case, at least in some key regions today, the opportunity to help businesses decarbonise while cutting their own costs and benefiting the grid is a clear win-win. Nonetheless, it's one of the most under-appreciated and under-analysed segments of the entire energy storage market, IHS Markit analyst Julian Jansen believes.

Jansen and IHS Markit recently published what is claimed to be the most comprehensive modelling and analysis of the sector so far and I was lucky enough to have some in-depth conversations with Julian about his work, from which we've created this issue's feature focusing on those opportunities, the challenges and profiling what makes a successful C&I company, from proposition to execution.

We also bring you a technical piece from Ideal Power director of applications engineering John Merrit, who focuses on the role of the company's patented multiport power conversion technology in recent microgrid projects.

This edition of *PV Tech Power* comes to you just a couple of weeks before Solar Media's Energy Storage Summit, taking place in London at the end of February and now in its successful third year. We look forward to seeing some of you there hopefully.

Also worth a mention on the other side of the globe at around the same time will be PV Expo in Tokyo, part of the mammoth Smart Energy Week. I've been to that show in previous years and it is certainly worth attending – if you're not in London for the summit!

While we might still be fighting the same battles for our industry, for our planet and for our futures as we've always seen in renewable energy, in an age marked with political and regulatory uncertainty and populist 'dumbing down' of public debate, there are still a lot of things worth celebrating. The ability for energy storage to cut through the noise and make a positive different to the world is definitely one of them.

Andy Colthorpe
Solar Media

Tesla confirms 50,000 home virtual power plant is on the way in South Australia

Members of the public in South Australia are being given the chance to participate in creating the biggest 'virtual power plant' of solar PV and batteries the world has ever seen.

Virtual power plants (VPP) take the capabilities of several home or commercial solar-plus-storage systems and aggregate them together to form a bigger grid or capacity resource than would otherwise be possible.

Starting with 600 homes this year, South Australia's government wants to install 50,000 solar and battery storage systems in the region and connect them to form a VPP with 250MW of solar energy and 650MWh of battery storage.

The project begins on a trial basis, with each home to be fitted with 5kW of solar PV and a 13.5kWh Tesla Powerwall 2 battery system. The project will be paid for through electricity sales and households will not be charged for taking part.

Record low prices in UK Capacity Market auction trigger concerns

The latest auction for the UK's Capacity Market cleared at a record low price in early February as battery storage projects seemingly struggled to compete.

A total of 50.4GW of capacity was procured in National Grid's T-4 auction to ensure capacity meets expected demand for the 2021/22 winter period, at a clearing price of just £8.40 (US$11.59) /kW per year, a record low and nearly one-third of last year's clearing price.

Battery storage only won 153MW of contracts with both the low clearing price and new de-rating factors combining to make it more difficult for the technology to compete.

A total of 3.3GW of battery storage was prequalified for the T-4 auction, de-rated to 1.344GW to account for their duration.

Arizona's 3GW energy storage target and 'Clean Peak plan'

A 3,000MW energy storage target has been proposed in Arizona as part of a grid modernisation policy. Andy Tobin of the state's regulator, the Corporation Commission, presented a plan that includes a goal to generate 80% of Arizona's power from renewable sources by 2050, a commitment to review the existing Renewable Energy Standard and Tariff (REST) policy, to use renewables to mitigate peaks establishing a 'Clean Peak' standard and to deploy 3,000MW of energy storage to "leverage low priced energy during the day".

The regulatory proposal, issued in January, could be made legally binding within six months to a year, a consultant said.

Industry reacts positively to New York's 1,500MW energy storage target

Trade associations NY BEST and the Energy Storage Association were quick to applaud New York Governor Andrew Cuomo's historic setting of a 1,500MW energy storage procurement target for his state.

Cuomo, in his annual State of the State address at the beginning of the year, set out plans for US$200 million to be invested via New York's NY Green Bank and US$65 million via NYSERDA in the development and deployment of energy storage projects, while the 1,500MW target should be reached by 2025.

The announcement was made along with a raft of other environmental, energy and sustainability policy measures as Cuomo attempted to set out a "comprehensive agenda to combat climate change".

India's largest energy storage project is of 'strategic importance' for regulators

AES India, a subsidiary of AES Corporation, and Mitsubishi Corporation started work in January on the 10MW project that will support the network operated by Tata Power Delhi Distribution Limited (Tata Power-DDL), a distribution company (Discom) that serves the North and North-West parts of Delhi. What is claimed to be India's first grid-scale energy battery storage project is designed to aid the integration of rooftop solar in particular.

"The AES project is expected to demonstrate the multiple value proposition of energy storage for the distribution grid," Rahul Walawalkar, head of the India Energy Storage Alliance, said.

RES and ADS-TEC among latest to deliver grid-balancing batteries in Germany

ADS-TEC has completed and connected a 2.5MW energy storage system in Germany, designed to smooth the variable output of wind power generation, while RES Group has just been awarded a 10MW energy storage project contract in the same country. The ADS-Tec project will regulate the grid by matching imbalances between load and demand, as well as smoothing the energy flowing into the network from sources including a nearby 15MW wind power plant, while RES' project will be a 10MW / 15MWh frequency-stabilising lithium battery system.

World Bank plans 'Scaling Solar and Storage' program

The World Bank plans to make energy storage an integral part of its 'Scaling Solar' program, that until now has been focused purely on facilitating large-scale solar tendering, predominantly in Africa.

The new Scaling Solar and Storage (SSS) program, which has yet to be formally announced, is expected to be rolled out over the next couple of years and would work on utility-scale tenders that pair solar PV with battery storage.

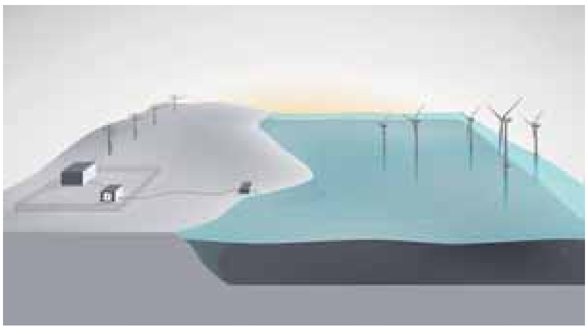
The World Bank engaged Italy-based technical advisory RINA to explore the feasibility of such tenders.

Floating wind farm battery could teach lessons for 'renewables as baseload'

The real-world performance of batteries paired with "Hywind" - the world's first floating wind farm - will be analysed by the wind project's owners, Masdar and Statoil.

Batwind, as the battery part of the project is known, pairs six 5MW Siemens Gamesa wind turbines with 1MW/1.3MWh of batteries, with system integrator Younicos deploying the energy storage solution. The project was green-lit in March that year, after the signing of a memorandum of understanding (MoU) between parties including Statoil and the Scottish government.

The wind project floats on the North Sea some 25km off Scotland's eastern coast.



Batwind, an energy storage system to be deployed at Scotland's floating wind farm, Hywind.

Credit: Statoil

The case for C&I storage investigated

Market | The commercial and industrial segment is one of the most promising sub-sectors of the energy storage space. Julian Jansen of IHS Markit describes recent efforts to model the US C&I storage landscape and what it reveals about this dynamic emerging market. As told to Andy Colthorpe

Credit: Green Charge/ENGIE

It took a long time for commercial solar installations to take off. In fact, despite an increasing tendency for big corporations, big box retailers and vast data centres to make high profile, headline-grabbing long-term commitments on rooftop PV, you could see why many businesses, often going from short-term lease to lease on their properties, weren't as keen to take the plunge.

By contrast, on paper at least, even at this relatively early stage of its market development, energy storage could have instant appeal for a broad range of companies – and is already doing so. Over five years, commercial and industrial (C&I) energy storage in the US is forecast by IHS Markit to grow from 60MW of annual installations in 2017 to 400MW in 2022.

That would mean the market reaching a total installed base of more than 1,500MW by then. With the cost of this once-expensive and no-longer-so-exotic (at least as far as the finance community is concerned) set of technologies falling, C&I energy storage can enable benefits to the customer, and even when installed behind the meter in this way can offer benefits to utilities and the grid in front of the meter.

Behind-the-meter (BTM) energy storage systems at C&I sites are well positioned to provide benefits to the end customer (e.g., demand charge management and back-up power) and utilities (e.g., meet capacity requirements and provide demand response). As such, they form a crucial part of a more decentralised energy system. From the commercial customer's point of view, signing a relatively flexible contract for a service-based proposition – where the provider takes care of even the economic modelling of the system throughout the life of the contract simplifies the whole process. And unlike rooftop solar, the customer does not have to effectively take custody of a huge structural addition to their building, batteries are perhaps more like industry equipment that can be deployed – or removed again – fairly easily.

The C&I storage space in the US offers the promise of significant growth in the coming years

Not to mention that while economics vary hugely from project to project, in some specific cases, a C&I energy storage system in the US could achieve payback in not much longer than a year.

IHS C&I study

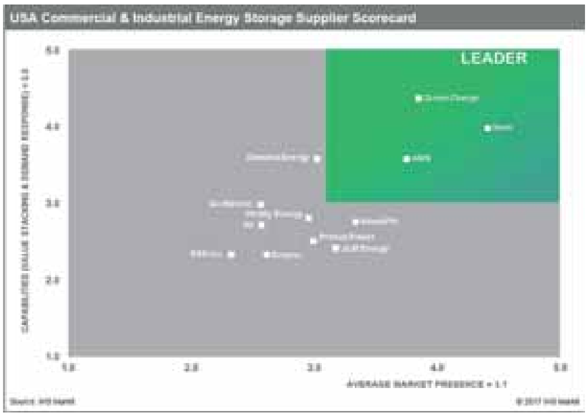
The premise

C&I BTM storage is often under-analysed and doesn't get the attention it deserves based on the opportunity that is in this segment. IHS Markit set out to undertake some analysis of the present-day US market, although globally, C&I BTM storage will be a very crucial segment of the overall market in the long run.

In the US, C&I users of electricity, from retailers to factories are charged premiums for the portion of their power drawn from the grid during peak times on a monthly basis. These so-called demand charges can make up more than 50% of a C&I customer's total energy bill in specific cases. Storing energy in batteries and discharging them to mitigate those peaks is one way that energy storage companies can earn money. The customer pays a fee to the energy storage provider, who in turn commits to delivering bigger energy savings to the customer via demand charge reduction or management.

Modelling and analysis

In our proprietary economic modelling we took specific customer demand – looking at average load profiles for different customers: medium to large offices, hotels,



Source: IHS Markit

IHS Markit's ranking of the top US C&I energy storage suppliers.

schools, retailers to give a few examples. We've taken hourly data for an entire year, so 24 data points per day, and calculated demand; in other words, the electricity cost for those types of customers in certain states or cities based on local utility tariffs.

What we wanted to do was look at where the best opportunities are, based on demand charge reduction. The modelling really focuses on that rather than other elements, say solar-plus-storage.

Using the different demand charge bands that occur on different days and different seasons, we put those against the customer load profiles and then through the modelling establish what peaks are most effective to cut, what the savings are on an annual basis and then what the payback period and return on investment would be.

The players

IHS Markit identified what it perceived to be the leaders of the early market, creating a scorecard for its study.

We ranked the players against 11 different metrics to arrive at composite scores around the average market presence and growth potential and basically what we've framed as capabilities; but it's actually capabilities and experience around stacking multiple values and providing demand response with aggregated energy storage assets.

What we focused on was not the hardware manufacturers, so to speak, but really on those suppliers who are exploiting the opportunity on a customer-focused side. So while you might expect to see a lot of Tesla Powerpacks installed in California, including as a supplier to the likes of AMS – one of the leading C&I players themselves – we've tried to focus on is those that have an end customer focus rather than those who sell hardware to the likes of Stem, AMS or Green Charge.

Obviously all of these players work with a lot of partners and different channels to get to market. But the leaders we've identified are the ones who operate, optimise and deploy storage systems on different levels. Within the C&I space there are a lot of different players along different parts of the value chain. It becomes a difficult exercise to map that because some players go all the way down to actual battery module assembly and then integration, installation, optimisation and the software side of things down to operations and maintenance (O&M), whereas others just focus on very specific aspects of that value chain.

What the three leading companies have in common

'As-a-service' is a buzzphrase in the industry right now. For the three leading players, it's a major part of their business proposition. If you go into a lot of depth they do target slightly different segments in each case and their business models do vary but fundamentally that idea of providing storage 'as-a-service' to the customer has been absolutely crucial to building that leading position.

Providing energy storage – and other energy resources – as a service, brings the supplier-customer relationship into something more like a subscription to an app that saves the C&I customer energy and money. It's a perfect fit for the age of Uber and Airbnb, where you don't need to own a fleet of cars or expensive hotel real estate to provide that service. Or the age of Netflix and Amazon, where tying a growing customer base in on a reasonably priced contract helps you continue to build scale and confidence to invest back in your own operations. In the case of energy storage, it's about providing a full service proposition to the customer that the customer doesn't even have to understand. You save me energy costs and I pay you x and the energy cost goes higher than x, so I win.

What's absolutely central to their success is significant investment by all three companies in terms of their software, their aggregation capabilities, and really evolving those and learning by doing throughout this continued investment into software, machine learning techniques, data analysis, real-time optimisation and response. They're all elements that have become crucial for them to actually provide that type of service model in a cost-effective way.

Digging even deeper into that earlier tech analogy, it's perhaps not surprising that much of the technology being developed and deployed in this segment of energy storage is coming straight out of Silicon Valley.

You've probably guessed by now – all three leaders are based in California, giving them immediate access to what appears to be the most attractive regional market. More on that later.

It's important to note that this is an early market; while we've ranked these players, the market is still highly competitive and not a single player there is hugely falling behind. You get quite a big grouping of players that are at a very similar stage in terms of their market presence and then with some variations in terms of software, demand response capabilities and often a big difference in strategy.

For instance, some players are very much targeting technology leadership around solar-plus-storage or resiliency applications. Fundamentally they're going after different markets than some of the leaders, which makes comparison between them all difficult. Some are targeting a larger number of smaller energy storage systems, to be installed alongside commercial solar. Others, such as Go Electric, have identified specific opportunities. Go Electric develops commercial microgrids and with recent projects has focused on providing UPS to US Military Forces operations, gaining market presence in the process through that focus on the resiliency and backup power capabilities of storage.

You've also got the flow battery guys like Primus Power or ESS and we wanted to include them because it's important to show you need to be technology-agnostic. Especially targeting microgrid applications with longer duration systems, some of these flow battery players are making headway in the C&I segment as well.

It's a bit more hardware and technology led than the 'as-a-service' model, but it's still creating that end customer relationship.

The stakes in the states

Indeed, California is the market that will lead growth – and we don't expect to see that contested. To date around 70% of the US' installed C&I storage is in California. IHS Markit is forecasting 880MW/2,463MWh of BTM C&I battery storage to get deployed in the state from 2017 to 2022. SGIP (Self-Generation Incentive Program, applicable subsidy for solar and solar-plus-storage) has been probably the number one reason for the C&I market to develop as strongly as it has in the past and we do expect it to be the strongest driver in the short term, although this could change going forward. Propositions have been made on the legislative side for the continuation of some form of a support programme in California – but nothing has been decided yet.

Medium to longer-term drivers include utility capacity procurement and other utility services that are needed, which will be procured under mandates in California. We're already seeing pretty encouraging signs on that, primarily from Southern California Edison's local capacity requirement and preferred resource pilot but also recently results were announced on a PG&E request for offers. Only a small proportion of that was BTM energy storage, about 10MW, but it's still kicking off utility-led procurement in new territories.

Over the coming five years we are expecting other markets to open up, especially NY and Massachusetts because they have a very attractive combination of drivers, which while different (different regulation, market) are kind of mimicking some of the early development in California. Between them we consider that more than 230MW/600MWh of C&I BTM storage will go online in that five-year forecast period. You've got strong economics, customers eligible for high demand charges, you have additional propositions around resiliency in those states plus you've now got the introduction of energy storage targets in both states.

The economics are looking very strong in specific states and territories and can vary hugely from individual customer to customer – so making sweeping assumptions is very difficult. Nonetheless the best-looking areas for demand charge management for us at the moment are California, including southern and northern but especially southern; also in New York it's looking very promising and increasingly part of Massachusetts for specific customers as well.

Hawaii is obviously also an attractive market for solar-plus-storage and there you have the Self-supply tariff programme to reward solar self-consumption. So far it's not had a huge impact but going forward we certainly expect that solar will continue to grow in Hawaii and be a crucial part of the energy system there and storage becomes a natural addition, you have higher prices, more frequent outages and from the utility side there's an interest in having storage BTM to manage distributed PV. That obviously makes that state interesting.

Other states are so far a bit more behind in terms of actual deployments but certain changes in states like Arizona could make a difference.

The state's demand response energy storage and load management programme will include C&I customers. Net metering has been eliminated and that could incentivise self-consumption. Obviously it will hit the solar market initially but will increase the attractiveness of self-consumption with storage. The Grand Canyon State also proposed a mammoth 3,000MW energy storage target to be made law later this year, just as this article was going to press.

"We definitely see a clear trend for commercial energy users to want long-term price security, to have security of supply and they are looking to decarbonise or at least reduce emissions from their energy supply"

Nevada is another one to watch – with certain programmes to encourage solar-plus-storage for BTM applications being considered while a reinstated net metering scheme is structured specifically to not punish solar self-consumption.

Changes in the medium-term across important states on the solar front will certainly filter down and create new opportunities for solar-plus-storage – rather than keeping all of the focus on demand charge aspects.

But what does it all mean?

We definitely see a clear trend for commercial energy users to want long-term price security, to have security of supply and they are looking to decarbonise or at least reduce emissions from their energy supply i.e. promoting renewables for their own sustainability goals.

They don't necessarily want to be in the business of managing their own energy. They are active as a business in their own field, so they're looking for companies that can provide fully integrated energy services solutions. So far that's included elements like solar, energy efficiency, like LED lighting etc. (the typical energy service company model). Increasingly, the investments that have been made in energy storage point in this direction: that if required you will manage and provide entire energy solutions to a customer that will include energy storage where it makes sense.

In terms of additional value drivers or business cases that are coming in, we see reliability playing a much stronger part in the proposition for many US customers. That can also be seen in the increasing interest in commercial renewable-plus-storage microgrids, especially for large industrial customers. We see that as being a very good addition to the proposition. There is variation depending on where you are. In some states the reliability element plays a bigger part, in other areas it's less relevant.

We are also seeing solar-plus-storage potentially increasing in terms of a market base for C&I customers; it's going to be increasingly attractive to small or medium-sized commercial customers that have PV, and here, again, it's more around specific pockets.

For the companies identified in the scorecard, there will be some consolidation in the US market and of course the growth that IHS Markit forecasts, but the goal has to be internationalisation for these companies. Green Charge, which recently rebranded as ENGIE Storage Services NA, while Stem just won its first project in Japan and netted investment for a push into Canada. It's always a question of where to invest and also how you can transport a model that works in one state to a different state, where value drivers might fundamentally be different, or the energy market structure varies. Companies might need to rethink their approach or integrate new assumptions and new data points into their software and data optimisation.

The market's early leaders obviously have a strong position to build on but the market opportunity is growing quite significantly, allowing new players to come in and potentially move themselves up within that ranking.

Also going back to that observation that state by state, energy storage somewhat follows in the path of solar, while demand charge management and creating that storage 'as-a-service' model has been the most attractive economic proposition for the C&I market so far, with those three leading players having benefitted the most, going forward if players are concentrating on the technology element of solar-plus-storage as those markets open up that obviously can put them into a stronger position as well. ■

Flexible multiport power conversion systems deliver resilient hybrid microgrids

Microgrids | Islands are particularly vulnerable to the impacts of natural disasters such as hurricanes. John Merritt looks at some of the emerging solutions to building more resilient energy systems through the deployment of microgrids that combine multiple energy generation and storage technologies

The unprecedented natural disasters that took place in 2017 are bringing greater attention to the importance of resilient energy systems. Disasters cost the United States a record-breaking US$306 billion in damages last year alone, according to recent figures from the National Oceanic and Atmospheric Administration. While these disasters did not discriminate by geography, and many parts of the country and the world were impacted, island nations such as Puerto Rico were hit especially hard and are still in need of power for basic and critical services many months later.

Hybrid microgrids connecting renewable energy and distributed energy resources such as diesel generators are a cost-effective and adaptable option for providing power in these extreme-weather prone, remote areas. While conventional equipment is cumbersome, complex and inefficient with high upfront costs, advanced multiport power conversion systems provide unprecedented flexibility and adaptability, overcoming barriers to meet unique island energy needs. Most importantly, when critical facilities – such as schools, hospitals and municipal buildings – are offline and in need of power quickly, hybrid microgrids with seamless multiport power conversion can effectively deliver or return power to communities following a storm or another type of power disruption.

Credit: Ideal Power.

Recently commissioned Ideal Power project with JLM Energy at Carilion Roanoke Memorial Hospital

Challenges with traditional integration

System integrators and project developers have historically faced the challenge of power conversion technologies that fall short when it comes to stability, efficiency and flexibility. Bulky and inefficient components have been the mainstay of power conversion for decades. A conventional converter can weigh upwards of 700 pounds, with limited compatibility for outdoor installation – the significant size and weight of that type of equipment makes installation costs very high and laborious.

Cost is a significant barrier for islands in particular, as they already experience disparately high energy costs. The cost of electricity on the Caribbean islands averages about 50 cents per kilowatt-hour (kWh) – about three to five times that of the mainland US. If a project developer isn't aware that cost-effective solutions are available and can be adapted for island needs, this is the most significant hindrance to implementing microgrid projects.

Cumbersome and complex equipment can also be a major hurdle. Traditional solar-plus-storage microgrids require two separate power converters, making the management and integration of the hardware and software much more difficult. Connecting multiple resources can involve devices that are large in size and difficult to place, which is especially challenging for island communities with space limitations. Systems that require multiple power conversion boxes required complex and real-time embedded controls, complicating ongoing management. Additionally, it can be difficult to identify integrators and project managers with the technical abilities to develop, deploy, commission and manage such control systems.

For any system that includes storage, power converters without proper operational control systems can cause significant wear and tear on batteries. Putting stress on a battery is not only inefficient, but it also shortens the lifespan of a system. Storage efficiency is essential because solar

From 'squishy batteries' to pre-packaged systems - how the times are changing

ELM FieldSight has partnered with Ideal Power on a number of microgrid and related projects, designing and supplying the control system that makes the system tick, balancing the different distributed energy sources plugged into it. Vice president of operations Jason Petermeier shared his thoughts

We got introduced to Ideal Power about two-and-a-half years ago. The first project that we got involved with was in northern California where there is a customer at the very end of the grid. His utility power frequently came on and off. He was looking to supplement that with some backup, with regards to solar and batteries. He commissioned us and Ideal to design and install a system that would utilise utility power – and any solar he was able to produce we could apply to the load or put back to the utility power. The battery bank topped off from the solar. Any time the grid went away we would switch it to power from the batteries, we would monitor the batteries until they got below a certain charge level and you also had a startup generator onsite.

From high-end residential installations today, solar-plus-storage will gradually reach the mass market

Until fairly recently, it was common for microgrids to perhaps use lead acid and/or diesel, but lithium-ion has obviously changed the game. We've done three different types of battery with Ideal: Aqueon saltwater batteries, some advanced lead acid and also lithium and from my perspective the lithium-ion has really changed the game. Because it puts a lot more power in a smaller footprint and at a cheaper price for the customers so it really makes a return on investment much more achievable because prices have come down considerably over the last three to five years as that technology has evolved.

What we have found is that lithium-ion batteries have been a lot more stable and easy to monitor so when we charge and discharge them they're much more predictable. From a controls perspective that has been much easier for us. Some of the other battery systems that we've worked with, that we call 'squishy' batteries, we see their voltages drop and increase much more rapidly whatever discharges are applied to it. With the lithium-ions we don't tend to see that.

The more predictable everything can be in a system, the much easier it is to control. So the control algorithms behind all of this become much more simplified.

We see a wide range of project opportunities in the market today and in the future. Our projects with Ideal Power have ranged from: a vineyard, a movie theatre and high-end residential, as well as industrial companies that just look for a battery backup and solar option to supplement their utility power.

There are a lot of different paths microgrids are taking – there's the community aspect, where a community comes together wanting to supplement their utility power. Or there are remote communities – in Africa, Central America – that have no power, that are running off diesel generators and now looking to bring a microgrid-type system to their community.

You've also got high-end businesses looking to reduce their costs as well as improve their energy backup capabilities, for power outages.

The niche marketplace that our company and I think Ideal has found a niche in as well is the high-end residential and small industrial business.

While costs have come down significantly, they are still not quite affordable to the average person. What we've found, however, is that costs have come down enough for high-end residential houses (perhaps 10-15,000 square foot in size) where the owners aren't necessarily looking for return on investment but are more interested in energy independence and creating a green footprint.

So that's been our primary focus in the last 12 months, targeting that industry – with the goal that as the technology matures and costs come down, we can apply what we've learned from high-end projects. In the next 12-36 months it will only continue to get more affordable and we'll have learned so much by that time that it will be a lot more pre-packaged systems that actually could be deployed for more average homes at that time.

We see the growth of standardisation and 'pre-packaged systems' as an important driver for cost reduction. Over the last two years, everything that's been done has been kind of an engineering project. Everybody kind of hand-picked their components, had to design their architecture from scratch and then installed it. Then it takes two to three months to get everything working and talking together.

We've learned enough in the last few years that people have started to pre-package complete systems with inverters, batteries, switchgear and then you tie that in with the generator and you drop-ship pretty much a complete system to a site where you're then just making external connections rather than wiring the entire system onsite. We see that industry growing and going in that direction and as that enables other cost reductions, installation costs will come down while installation and commissioning times will also come down.

energy is an intermittent resource and on its own cannot be relied upon as a resilient power supply.

Finding the right technology

Emerging power conversion technologies allow for direct current (DC), alternating current (AC) and hybrid microgrid solar-plus-storage systems, with options to integrate solar photovoltaics (PV), diesel, energy storage and other distributed energy resources into a single hybrid microgrid project. Each system has benefits for various project types, but hybrid multiport power conversion systems are the clear solution for providing off-grid backup power. While hybrid microgrids come in different shapes and sizes, they have a few defining features. A hybrid microgrid includes solar-plus-energy storage, coupled with diesel generator sets that are strategically controlled and can operate in both "islanded" and/or grid connected mode when a grid connection is available.

Multiport power conversion allows multiple power inputs to be integrated through a single power processing stage to remove redundancies that exist with conventional single-port converters. Compact hybrid multiport converters save space, weight and dramatically simplify wiring interconnection and installation. The most effective multiport solutions also include embedded key control functions, which further simplify management.

US Virgin Islands: putting concepts into practice

Ideal Power and its integration partners deployed a hybrid microgrid system in Saint Croix in the US Virgin Islands in June 2017. On this site, six Stabiliti 30C3 multiport power conversion systems operate in parallel to integrate solar, storage and diesel into a hybrid 180kW microgrid powering a local entertainment facility. Similar to many commercial sites in the Caribbean, the facility was never connected to the central power grid and prior to the solar-plus-storage microgrid implementation, the site relied entirely on diesel generators for its power needs 24/7. Diesel generators are common in island nations with unpredictable and costly grid-supplied power, but these generators can be paired with solar-plus-storage to create a more affordable, and green microgrid solution.

The facility experiences peak load – its greatest energy use – during the late after-noon and early evening when customer traffic and air conditioning demands are highest. Solar on its own could not be relied upon to deliver enough power during peak hours and moving the site from a 24/7 diesel-powered microgrid to a 24/7 solar-plus-storage microgrid was cost prohibitive for the site owners. Ideal Power's project team determined that integrating solar-plus-storage alongside diesel would slash operating costs and pollution by reducing annual diesel fuel consumption by 30%. The right multiport power conversion system made this possible by connecting diesel, solar and storage in a compact and modular solution. Lastly, the six-converter configuration provides a robust level of redundancy. If a single converter faults and trips offline, the remaining five systems will support the building in a seamless manner – resulting in lights that never flicker.

Unfortunately, shortly after the Saint Croix project was deployed, the project site was impacted by Hurricane Maria. The storm's high winds ripped off most of the rooftop solar panels, but the batteries, control equipment, generators and converters remained intact. The team will restore and rebuild the rooftop solar array using new mounting hardware designed to better withstand high winds. In the interim, the power converters will continue to offset fuel use by paralleling the batteries with generators. Eventually, the goal is for the facility to run on batteries alone from late night until early morning. This capability will require intelligent load management equipment, such as HVAC and lighting controls, to ensure building loads are minimised during unoccupied periods. When considering opportunities for future project sites that rely on diesel generators, even greater fuel savings of 60% or more could be achieved by increasing battery capacity.

The existing system will reduce emissions and energy costs while post-hurricane repairs take place. The Saint Croix site has the potential to achieve greater efficiencies once solar panels are replaced and integrated back into the system. Through effective technologies that meet unique island community challenges and needs, the Saint Croix project site has proven that multiport power conversion capabilities that support a hybrid microgrid are an effective solution for day-to-day operations and also in the face of a devastating storm.

Key factors for resilience

The flexibility and adaptability of multiport conversion technology supports effective hybrid microgrid sites, which in turn offer island nations, isolated communities and any area vulnerable to natural disasters with resilient, cost-effective and green power generation. As a changing climate means years like 2017 become more of the norm rather than the exception, hybrid microgrids will play a growing role in the future of energy use for island nations, rural areas and beyond.

Author

John Merritt helps deliver next-generation power conversion technologies to remote and island communities as Ideal Power's director of applications engineering. He has more than 30 years of technical marketing experience spanning product marketing, product development, engineering and project management in both high-tech and clean-tech companies.

What a difference a year makes

Storage market | 2017 was tet another record-breaking year for energy storage. Riding high on expectation, the industry is braced for challenges and successes in equal measure this year too. We canvassed opinions from some of the world's leading trade associations and representative bodies on the year just gone and what 2018 could bring

Kelly Speakes-Backman, CEO, Energy Storage Association (USA)

Did 2017 meet your expectations or surpass them?

The cost of storage has dropped much faster than most predictions. The installed cost of battery grid storage has dropped 50% in the last four years and this rate is likely to continue for the next several years. The result is that project economics are increasingly competitive. We've seen reported median bids from the Xcel Colorado all-source solicitation for combined wind-plus-storage PPAs at US$21/MWh and solar-plus-storage PPAs at US$36/MWh for delivery before 2023. As costs come down, new megawatt-scale battery storage projects are arriving with longer durations; while the over 90MW of four-hour batteries deployed in California to make up capacity shortfalls from Aliso Canyon was the big news in 2017, now in 2018 there are already two eight-hour grid battery projects under development in New York and Massachusetts. And that Xcel Colorado RFP solicited bids of 10-hour batteries!

What are expecting to see for 2018, and what would you hope to see this year?

We're focused on three fundamental goals for 2018. First, we are working to establish mechanisms such as market designs, programmes or rates that compensate storage for the flexibility it provides. Second, we are making every effort to ensure that storage is included in all power sector planning and procurement processes as a regular course of business. Third, we are focused on enabling storage to better interconnect with the grid and operate flexibly, under a variety of business models.

What will be the biggest challenges to face the industry for 2018?

Even as prices for energy storage systems have plummeted in recent years, policy has yet to catch up with technology. The electric system was designed before storage was a commonly available and widespread resource, and so the rules governing the grid and electricity markets were developed without contemplating the role of storage. Current rules do not capture the full economic, operational efficiency and societal value of energy storage, and therefore there are not effective market signals to encourage customers and utilities to deploy energy storage. The most straightforward example of this is in rate design, as price signals do not exist in many states to encourage customers to shift consumption of energy to times when there is the least stress on the grid. Second, storage is not included in all utility grid planning and resource procurements, and therefore cannot compete effectively with traditional resources under consideration. Distribution planning, for example, does not require utilities to consider energy storage or other "non-wires" solutions to traditional reliability investments. Third, numerous barriers to market and grid access limit the ability of energy storage systems to interconnect and offer their full range of services. The challenge is not about cost, but about value, competition, and access.

Georgina Penfold, CEO, Electricity Storage Network (UK)

Did 2017 meet your expectations or surpass them?

Riding on the back of the EFR (Enhanced Frequency Response) tender, large-scale storage hit the big time in 2017 with storage competing successfully in Capacity Market auctions. Behind-the-meter storage gained traction and it is now commonplace to find storage talked about throughout the industry – as if we have always had it. But expectations are hard to manage, and the law of unintended consequences came into play. So much interest in ancillary services depressed prices substantially, making the business case for many battery projects rather uncertain. We hoped for increased interest in longer duration storage, and our expectations were surpassed by the change in the de-rating factors for the Capacity Market, which brings a more realistic approach to the introduction of storage.

What are you expecting to see and what would you hope to see in 2018?

Of course, there will be more interest in storage. EV infrastructure and V2G (vehicle-to-grid) will be major disruptions to the whole electricity sector, but this won't be without some considerable change to the way the system will operate. The current electricity market is not functioning well, and we hope for some major changes to the way that the electricity market is configured, not least a more rational approach to dynamic pricing.

What will be the biggest challenges to face the industry for 2018?

There is a risk that the storage industry follows solar with a sudden and sad decline in the number of participants as companies realise that there is a limited market, with limited revenues. However, the transition of the UK's distribution network operators (DNOs) to distribution system operators (DSOs) will mean that storage is an essential part of the smart grid – so bulk storage should remain a growth area.

John Grimes, CEO, Smart Energy Council (Australia)

Did 2017 meet your expectations or surpass them?

It was a game-changing year. We saw a number of new products on the market, and prices continue to fall for behind the meter battery systems. It was also a breakout year for large-scale energy storage with the world's biggest lithium-ion battery installed in under 100 days on the South Australian network. In small scale energy storage over 20,000 battery systems were installed.

What are you expecting to see and what would you hope to see in 2018?

Commitments to major battery programmes have been made by a number of state governments, while Queensland has announced low interest loans for batteries in low-income households. This year will see substantive work done on large-scale pumped hydro projects in Queensland, South Australia and early stage planning continue towards Snowy Hydro 2.0 in New South Wales. Large-scale storage projects are emerging, and there is policy work happening towards a long-term energy storage target in Australia.

What will be the biggest challenges to face the industry for 2018?
Lack of a national energy policy and lack of support for renewable energy policy post-2020 are major barriers. Energy market rules need reform to unlock the true value of energy storage assets – and there is an ongoing need to continue to drive down costs, for quicker take-up.

Dr Rahul Walawalkar, CEO, India Energy Storage Alliance (IESA, INDIA)

Did 2017 meet your expectations or surpass them?
The industry will look back on 2017 as a year when India crossed 2GWh of deployment of advanced energy storage solutions. Also Indian industries have started investing in setting up manufacturing capabilities for developing li-ion battery packs in India. EVs also got significant boost with clear support from the Indian government and committees were created for developing standards for batteries, charging infrastructure and stationary energy storage systems.

The only disappointment for the industry was the flip-flops from various government agencies on large-scale renewables integration projects. There were over 100MWh of grid-scale energy storage project RFPs released during 2017; unfortunately most have been stuck due to mixed signals from MNRE (Ministry of New and Renewable Energy). IESA is working closely with all the policy makers and we anticipate most of these projects can move forward in 2018.

What are you expecting to see and what would you hope to see in 2018?
We anticipate that with global scale-up in manufacturing, advanced energy storage prices will drop by over 10% in 2018. India will also start witnessing adoption of EVs in 2018, fuelled by central procurement led by EESL [the Indian government's energy service company] and various state agencies. The stationary energy storage market will also start seeing traction with MW-scale deployments for both renewable integration and C&I applications.

If we start deploying energy storage projects in a systematic manner this can create a huge interest for local manufacturing and system integration capabilities.

By mid-2018, India will have over 1GWh of li-ion battery pack manufacturing capacity. We also anticipate that in 2018 at least two li-ion cell manufacturing plants with capacity of 1GWh or more will start construction in India with anticipated completion for early 2020.

What will be the biggest challenges to face the industry for 2018?
As with any fast growing area, we anticipate some teething pains for the industry as we develop the skills and capabilities for large-scale adoption of energy storage, microgrids and EVs.

India has significant engineering capabilities, but qualified resources for deployment, operations and managing advanced energy storage solutions will need some time. In the meantime, with the growing pressure of cost reduction, we hope the industry does not take shortcuts to compromise on safety.

Credit WEMAG/Younicos

Storage looks set to build on a record-breaking 2017 with further steps forward this year

Patrick Clerens, Secretary General, EASE (European Association for Storage of Energy, EUROPE)

Did 2017 meet your expectations or surpass them?
It was a record-breaking year for the energy storage industry in terms of new installations. We are seeing more and more innovative technologies and storage projects coming onto the market across Europe, demonstrating the value energy storage can provide at all levels of the system. Not only are technologies developing much more rapidly than previously thought possible, new business models and applications are also emerging. Meanwhile, in discussions around the 'Clean Energy for All Europeans' package, we saw more and more stakeholders advocating for policies that will support storage deployment.

What are you expecting to see and what would you hope to see in 2018?
We will continue to see more and more deployments of energy storage technologies across Europe, particularly in front of the meter, but also behind-the-meter. Hopefully we will see an agreement on the final "Clean Energy for All Europeans" package that contains supportive policies for energy storage. This would be a major step forward for the industry. We also hope to see more discussions about energy storage business cases, how to monetise flexibility services, the role of storage in supporting the decarbonisation of transport, and efforts to improve investment security.

What will be the biggest challenges to face the industry for 2018?
The biggest challenge for the industry in 2018 continues to be the uncertainty about the role of storage in the EU regulatory framework and, as a result, the lack of long-term investment security. Another challenge is to further clarify the different applications storage can provide as well as how to monetise these different services. On the R&D side, the biggest challenges are to deliver continued performance improvements and cost reductions across all storage technologies.

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